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Pathways 2015
Pathways towards
habitable planets
13-17 July 2015
Bern, Switzerland

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(as of July 1st, 2015)

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PROGRAM

Monday, July 13, 2015

TIME	EVENT
8:00 am - 8:55 am	Registration - Registration
9:00 am - 9:20 am	Welcome, logistics, agenda, meeting plans (Aula (Room 210))
9:20 am - 10:40 am	Introduction (Aula (Room 210))
09:20 - 10:00	› Understanding habitability on the pathways to habitable planets - *François Forget, Laboratoire de Meteorologie Dynamique*
10:00 - 10:40	› Biodiversities and habitabilities : a biologist view - *Marie-Christine MAUREL, Institut of Systematic, Evolution, Biodiversity, OSEB*
10:40 am - 11:10 am	Coffee break (Corridors)

11:10 am - 12:30 pm	KQ1 - Is the Sun-Earth pair a good paradigm for an inhabited system ? (Aula (Room 210))
11:10 - 11:50	› Seek a Minor Sun: The Distribution of Habitable Planets in the Hertzsprung-Russell-Rosenberg Diagram - *Gaidos Eric, University of Hawaii at Manoa*
11:50 - 12:10	› Earths In Other Solar Systems: The Formation of Habitable Zone Earth-Like Planets With Biocritical Ingredients - *Daniel Apai, Earths in Other Solar Systems Team, Lunar and Planetary Laboratory, University of Arizona, Steward Observatory, University of Arizona*
12:10 - 12:30	› High-energy irradiances of Sun-like stars - *Jorge Sanz-Forcada, Centro de Astrobiología (INTA-CSIC)*
12:35 pm - 1:55 pm	Lunch
2:00 pm - 4:30 pm	SatMeet1 : Laboratory Analogues of Exoplanetary Environments (Meeting room 115) - Emmanuele Pace (Chair)
2:00 pm - 4:30 pm	SatMeet2 : Mission concepts and measurement requirements for a future far-infrared space mission (Meeting room 105) - Dave Leisawitz (Chair)
2:00 pm - 4:30 pm	SatMeet5 : Validation and Compilation of Kepler Habitable Zone Candidates (Lecture room 205) - Nader Haghighipour (Chair)
2:00 pm - 4:30 pm	SatMeet8 : Connecting Stellar Abundances and Planet Habitability (Lecture room 206) - Natalie Hinkel (Chair)
2:00 pm - 4:30 pm	SatMeet10 : Future Plans and Potential Collaborations for Ground- and Space-Based Imaging of Exo-Earths (Lecture room 106) - Avi Mandell (Chair)
2:00 pm - 4:30 pm	Poster viewing (Cuppola 501) - Click on file icon to download poster abstracts

4:30 pm - 5:00 pm	Coffee break (Corridors)
5:00 pm - 5:40 pm	KQ1 - Is the Sun-Earth pair a good paradigm for an inhabited system ? (Aula (Room 210))
17:00 - 17:20	› The impact story for exo-Earths - *Jane Greaves, University of S Andrews*
17:20 - 17:40	› C/O ratios for planet hosts: comparing two oxygen indicators - *Elisa Delgado Mena, Instituto de Astrofisica e Ciencias do Espaço*
5:40 pm - 6:00 pm	Posters pop-up (10x2mn) (Aula (Room 210))
6:00 pm - 7:00 pm	KQ1 - Is the Sun-Earth pair a good paradigm for an inhabited system ? (Aula (Room 210))
18:00 - 18:20	› Brown dwarfs versus exoplanets: two different mass functions - *Hans Zinnecker, Deutsches SOFIA Institut*
18:20 - 18:40	› Water Contents of Habitable Zone Rocky Planets and Biosignature Detection around M dwarfs - *Feng Tian, Center for Earth System Science, Tsinghua University*
6:40 pm - 7:00 pm	KQ1 discussion (Aula (Room 210))

Tuesday, July 14, 2015

TIME	EVENT
9:00 am - 10:40 am	KQ3 - Is the habitable zone a well defined concept ? (Aula (Room 210))
09:00 - 09:20	› Definitions and Caveats of the Habitable Zone - *Stephen Kane, San Francisco State University*
09:20 - 10:00	› Is there an Unhabitable Zone? - *Leconte Jérémy, Center for Planetary Science, Canadian Institute for Theoretical Astrophysics, Laboratoire de Météorologie Dynamique*
10:00 - 10:20	› Prospect of Finding Habitable Planets in Binary Stars - *Ji Wang, Yale University*
10:20 - 10:40	› Adaptable habitability, niche filling and exo-climate change - *Hagai Perets, Department of Physics*
10:40 am - 11:10 am	Coffee break (Corridors)
11:10 am - 11:50 am	KQ3 - Is the habitable zone a well defined concept ? (Aula (Room 210))
11:10 - 11:30	› Habitability of planets on eccentric orbits: limits of the mean flux approximation? - *Emeline Bolmont, Département de Mathématique [Namur]*
11:30 am - 11:50 am	KQ3 discussion (Aula (Room 210))
11:50 am - 12:30 pm	KQ2 - How do we define meaningful biomarkers ? (Aula (Room 210))
11:50 - 12:30	› Biosignatures in context - *Franck Selsis, Laboratoire d'Astrophysique de Bordeaux*
12:35 pm - 1:55 pm	Lunch
2:00 pm - 4:30 pm	SatMeet1 : Laboratory Analogues of Exoplanetary Environments (Meeting room 115) - Emmanuele Pace (Chair)

2:00 pm - 4:30 pm	SatMeet4 : Habitable planets, M dwarfs and NIR spectrographs (Lecture room 205) - José Caballero (Chair)
2:00 pm - 4:30 pm	SatMeet8 : Connecting Stellar Abundances and Planet Habitability (Meeting room 105) - Natalie Hinkel (Chair)
2:00 pm - 4:30 pm	SatMeet9 : Mapping Other Worlds: Spatial Studies of Exoplanets and Ultracool Atmospheres (Lecture room 206) - Daniel Apai and Nicolas Cowan (Chairs)
2:00 pm - 4:30 pm	Poster viewing (Cuppola 501) - Click on file icon to download poster abstracts
4:30 pm - 5:00 pm	Coffee break (Corridors)
5:00 pm - 5:40 pm	KQ2 - How do we define meaningful biomarkers ? (Aula (Room 210))
17:00 - 17:20	› Constraining Oxygen False Positives for Terrestrial Planets around F, G, and K Stars - *Sonny Harman, NAI Virtual Planetary Laboratory, Penn State Astrobiology Research Center, Pennsylvania State University, Geosciences Department*
17:20 - 17:40	› Remote sensing of extraterrestrial life: Complexity as the key characteristics of living systems - *Sebastian Wolf, Kiel University, Institute of Theoretical Physics and Astrophysics*
5:40 pm - 6:00 pm	Posters pop-up (10x2mn) (Aula (Room 210))
6:00 pm - 7:00 pm	KQ2 - How do we define meaningful biomarkers ? (Aula (Room 210))
18:00 - 18:20	› Titania may act as a potential source of false signs of life on habitable exoplanets - *Norio Narita, SOKENDAI, Astrobiology Center, National Astronomical Observatory of Japan*

18:20 - 18:40	› What you need to know to use the ExoMol Line Lists. - *Laura McKemmish, University College London*
6:40 pm - 7:00 pm	KQ2 discussion (Aula (Room 210))

Wednesday, July 15, 2015

TIME	EVENT
9:00 am - 10:40 am	KQ4 - What can we learn from solar system synergies ? (Aula (Room 210))
09:00 - 09:40	› The exploration of exoplanets: What can we learn from solar system synergies? - *Therese Encrenaz, Laboratoire d'études spatiales et d'instrumentation en astrophysique*
09:40 - 10:00	› Extrasolar Cosmochemistry - *Siyi Xu, European Southern Observatory*
10:00 - 10:20	› What can we learn from atmospheres of transiting low-mass exoplanets as a stepping-stone towards habitable planets ? - *Masahiro Ikoma, The University of Tokyo [Toyo]*
10:20 am - 10:40 am	KQ4 Discussion (Aula (Room 210))
10:40 am - 11:10 am	Coffee break
11:10 am - 12:30 pm	KQ5 - How do we build synergies between ground and space ? (Aula (Room 210))
11:10 - 11:50	› Detection and characterization of exoplanets: possible synergies between ground and space based approaches - *Jean-Luc Beuzit, Institut de Planétologie et d'Astrophysique de Grenoble*
11:50 - 12:10	› The Hunt for Planets in Open Clusters with HARPS and HARPS-N - *Malavolta Luca, Dipartimento di Fisica e Astronomia, Università di Padova*
12:10 - 12:30	› Exoplanets mass measurement using gravitational microlensing - *Clément Ranc, Institut d'Astrophysique de Paris*
12:35 pm - 1:55 pm	Lunch

2:00 pm - 4:30 pm	SatMeet1 : Laboratory Analogues of Exoplanetary Environments (Meeting room 115) - Emmanuele Pace (Chair)	
2:00 pm - 4:30 pm	SatMeet3 : Pathways Towards Exomoons (Lecture room 106) - David Kipping (Chair)	
2:00 pm - 4:30 pm	SatMeet4 : Habitable planets, M dwarfs and NIR spectrographs (Lecture room 205) - José Caballero (Chair)	
2:00 pm - 4:30 pm	SatMeet6 : Prevalence of exozodiacal dust (Lecture room 206) - Denis Defrère (Chair)	
2:00 pm - 4:30 pm	Poster viewing (Cuppola 501) - Click on file icon to download poster abstracts	
4:30 pm - 5:00 pm	Coffee break	
5:00 pm - 5:40 pm	KQ5 - How do we build synergies between ground and space ? (Aula (Room 210))	
17:00 - 17:20	› Blazing the Trail: Resolving Terrestrial Planets with ELTs? - *Michael Meyer, Institute of Astronomy, ETH Zurich*	
5:20 pm - 5:40 pm	KQ5 Discussion (Aula (Room 210))	
5:40 pm - 7:00 pm	KQ6 - What can we expect from approved projects ? (Aula (Room 210))	
17:40 - 18:20	› Towards the detection of nearby exoEarths - *Alexandre Santerne, Instituto de Astrofísica e Ciências do Espaço, Universidade do Porto*	
18:20 - 18:40	› CHEOPS: towards exoplanet characterization - *Andrea Fortier, Physics Institute, University of Bern*	
18:40 - 19:00	› The PLATO 2.0 Mission - *Mareike Godolt, German Aerospace Center*	

Thursday, July 16, 2015

TIME	EVENT
9:00 am - 10:40 am	KQ6 - What can we expect from approved projects ? (Aula (Room 210))
09:00 - 09:20	› Exoplanetary System Reconnaissance with LBTI: Warm Dust and Giant Planets - *Philip Hinz, University of Arizona*
09:20 - 09:40	› The James Webb Space Telescope: Capabilities for Transiting Exoplanet Observations - *Mark Clampin, Goddard Space Flight Center*
09:40 - 10:00	› Characterization of exoplanet atmospheres with the JWST MIRI instrument - *Pierre-Olivier Lagage, Laboratory of Astrophysics, Instrumentation-Modelisation, at Paris-Saclay*
10:00 - 10:20	› How stellar activity affects exoplanet's parameters estimation and exoplanet's atmosphere characterization - *Mahmoudreza Oshagh, Centro de Astrofísica da Universidade do Porto*
10:20 am - 10:40 am	KQ6 discussion (Aula (Room 210))
10:40 am - 11:10 am	Coffee break (Corridors)
11:10 am - 11:50 am	Satellite meetings feedback (Aula (Room 210))
11:10 - 11:30	› SatMeet5 - Validation and Compilation of Kepler Habitable Zone Candidates - *Nader Haghighipour, Institute for Astronomy, University of Hawaii*

11:30 - 11:50	› SatMeet10 - Ground- and Space-Based Imaging of Exo-Earths: Opportunities for Synergy and Collaboration over the Coming Two Decades - *Avi Mandell, NASA Goddard Space Flight Center - William Sparks, Space Telescope Science Institute - Michael Meyer, Institute of Astronomy, ETH Zurich - Stephen Unwin, Jet Propulsion Laboratory - Giovanna Tinetti, University College London - London's Global University*
11:50 am - 12:30 pm	KQ7 - What future capacity is needed ? (Aula (Room 210))
11:50 - 12:10	› Missions and Technology in NASA's Exoplanet Exploration Program - *Stephen Unwin, Jet Propulsion Laboratory - California Institute of Technology*
12:10 - 12:30	› ARIEL - *Giovanna Tinetti, University College London - London's Global University*
12:35 pm - 1:55 pm	Lunch
2:00 pm - 4:20 pm	KQ7 - What future capacity is needed ? (Aula (Room 210))
14:00 - 14:20	› Robustly searching for Earth-like biosignatures - *Ian Parry, IoA, Cambridge University*
14:20 - 14:40	› Recognizing and characterizing terrestrial planets - *William Sparks, Space Telescope Science Institute*
14:40 - 15:00	› Developing an integrated analysis approach to explanetary spectroscopy - *Ingo Waldmann, University College London - London's Global University*
15:00 - 15:20	› Direct exoplanet imaging with small-angle Vortex coronagraphs - *Denis Defrère, University of Arizona*
15:20 - 15:40	› Exo-Earth Discovery and Characterization with Large UV-Optical-IR Observatories - *Avi Mandell, NASA Goddard Space Flight Center*

15:40 - 16:00	› SPICA mission - *Hiroshi Shibai, Osaka University*
16:00 - 16:20	› Scientific Opportunities for a Starshade Working with a 2.4 m Telescope at L2 - *Aki Roberge, NASA Goddard Space Flight Center*
4:20 pm - 4:30 pm	Posters pop-up (5x2mn) (Aula (Room 210))
4:30 pm - 5:00 pm	Coffee break (Corridors)
5:00 pm - 6:00 pm	KQ7 - What future capacity is needed ? (Aula (Room 210))
17:00 - 17:20	› Measuring the masses of the habitable planets around the 50 closest solar-type stars with Theia. - *Fabien Malbet, Institut de Planétologie et d'Astrophysique de Grenoble*
17:20 - 17:40	› Respective capabilities of affordable Coronagraphs and Interferometers searching for Biosignatures - *Alain Léger, IAS - CNRS*
17:40 - 18:00	› How to Directly Image a Habitable Planet Around Alpha Centauri with a ~30-45cm Space Telescope - *Ruslan Belikov, NASA Ames Research Center*
7:00 pm - 9:45 pm	Conference dinner

Friday, July 17, 2015

TIME	EVENT
9:00 am - 10:40 am	Satellite meetings feedback (Aula (Room 210))
09:00 - 09:20	› SatMeet2 - Mission Concepts and Measurement Requirements for a Future Far-Infrared Space Mission - *David Leisawitz, NASA Goddard Space Flight Center*
09:20 - 09:40	› SatMeet3 - Pathways Towards Exomoons - *Kipping David, Harvard University*
09:40 - 10:00	› SatMeet4 - Habitable planets, M dwarfs and NIR spectrographs - *José Caballero, Centro de Astrobiología*
10:00 - 10:20	› SatMeet6 - Prevalence of exozodiacal dust - *Defrère Denis, University of Arizona*
10:20 - 10:40	› SatMeet8 - Connecting Stellar Abundances and Planet Habitability - *Hinkel Natalie, Arizona State University, USA*
10:40 am - 11:10 am	Coffee break
11:10 am - 11:30 am	Satellite meetings feedback (Aula (Room 210))
11:10 - 11:30	› SatMeet9 - Mapping Other Worlds - *Daniel Apai, Steward Observatory, University of Arizona, Lunar and Planetary Laboratory, University of Arizona, Earths in Other Solar Systems Team - Nicolas Cowan, Amherst College*
11:30 am - 12:40 pm	Concluding discussion (Aula (Room 210)) - Michel Blanc (ISSI)
12:40 pm - 12:45 pm	Adjourn (Aula (Room 210))

ABSTRACTS

Introductive session

Understanding habitability on the pathways to habitable planets

François Forget*[1]

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Abstract

While we develop the observation tools that will, someday, characterize habitable planets, the concept of habitability is regularly challenged. It not easy to define life and what is needed for it, so drawing a line between ”habitable” and ”not-habitable” is difficult. We usually postulate that ”habitable = liquid water available” because liquid water seems required for life as we can imagine it. However, worlds with liquid water can be seen as more or less habitable, depending on 1) the available molecules and energy sources (notably light), 2) the time available for life to emerge and evolve. Different class of habitability can be defined, ranging, from worlds with liquid water only in the deep interior, to Earth-like cases with surface liquid water enabling photosynthetic life to modify the atmosphere in a detectable way. Within that context, we can agree to define the ”Habitable zone” as the region outside which it is impossible for a rocky planet to maintain liquid water on its surface. Even this is not without ambiguity, since ”exotic” configuration (e.g. a thick H2-rich atmosphere) can extend the habitable zone beyond what could be estimated assuming an ”expected” terrestrial atmosphere composition. But what atmospheres can we expect? Which processes control their evolution? These are the key questions. Our solar system experience is too limited and observations are needed. Much can be learned even by characterizing atmospheres outside the habitable zone.

*Speaker

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Biodiversities and habitabilities : a biologist view

Marie-Christine Maurel*[1,2]

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Abstract

If life were to again take the path it followed billion years ago, nobody can certify that it would take the same path, leading to the same species, the same types of cells, the same organisation. This implies that if life exists - or existed - elsewhere, benefiting from the same initial planetary conditions, it most likely does would not have the same history, or would not have followed the same itinerary. Thus, how can we possibly recognize and/or identify something new, probably completely new that we are unable to conceive and/or to conceptualize?
From a materialistic point of view, there is no frontier between what is alive and what is not; this is a basic question for the biology community, mainly via the question of viruses and viroids. It is thus very ambiguous to define the meaning of biomarkers, and even more to search for life elsewhere based strictly on the observations of what we know occurs on Earth.

Just as what is 'pathological' in biology provides us with an insight on what is 'normal', the space that lies at the border between the living and the non-living will maybe allow us to envisage other forms of life (that we cannot imagine to-day).

*Speaker

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Key Question 1 :

Is the Sun-Earth pair a good paradigm for an inhabited system ?

Oral presentations

Seek a Minor Sun: The Distribution of Habitable Planets in the Hertzsprung-Russell-Rosenberg Diagram

Gaidos Eric*[1]

[1]University of Hawaii at Manoa – United States

Abstract

The Sun-Earth systems has long been used as a template to understand habitable planets around other stars and to develop missions to seek them. However, two decades of exoplanet studies have shown that many, if not most planetary systems around G dwarf stars do not resemble the Solar System. Moreover, an objective census of our Galaxy might ignore solar-type stars and focus on M dwarfs, which constitute some 80% of all stars in the neighborhood. Recent work has shown that M dwarfs have more close-in planets than solar-type stars, and perhaps more planets in the "habitable zone" defined by stellar irradiation. M dwarfs also burn hydrogen over a vastly longer time; slow evolution on the main sequence means a planet can remain habitable for much longer, providing a more permissive environment for the evolution of life and intelligence. If M dwarfs are such compelling locales to look for life, why are we ourselves not orbiting a red Sun?

*Speaker

sciencesconf.org:pathways2015:73934

Earths In Other Solar Systems: The Formation of Habitable Zone Earth-Like Planets With Biocritical Ingredients

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Abstract

The past decade has opened our eyes on the unexpected and dramatic diversity of the physical properties of exoplanetary systems. The different planetary architectures and physical planet properties argue for formation pathways that are in many ways different from the Solar System's formation. The physical differences also foreshadow possible major compositional and dynamical differences between our own planetary system and those in which we will search for biosignatures.

In this talk I will briefly introduce evidence for the different plantary architectures and formation histories between sun-like stars and low-mass stars, some of which are host stars of relatively easily accessible habitable zone earth-sized planets. I will argue that the assumption that habitable zone earth-sized planets are identical around stars of different masses is probably incorrect.

I will introduce a major NASA-funded 5 yr-long project, Earths in Other Solar Systems, that coordinates the interdisciplinary reearch of fourteen teams addressing the compositional diversity and range of volatiles and organics budgets of earth-sized planets around different host stars. I will describe the goals and first results from our team and place this project in the endeavor to identify the most promising nearby stars for future atmospheric biosignature surveys.

*Speaker

sciencesconf.org:pathways2015:66450

High-energy irradiances of Sun-like stars

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Abstract

Research on exoplanetary atmospheres has developed an increasing interest. Astrobiology has put its eyes on the effects that stellar irradiance may have on the atmosphere of planets, and on the early development of life. The high energy (XUV and UV) part of the spectrum is of special interest for this purpose. Part of this spectral range, the EUV is of no access to current telescopes, hampering the studies that intend to model planetary atmospheres. A program was developed to to circumvent this problem, and to provide with spectral energy distributions of stars hosting exoplanets (X-exoplanets) in the XUV range. We present here a work in which we develop further this program to create a semiempirical grid of models of emission of Sun-like stars, based on real data and coronal models, covering the XUV and UV ranges. These models will represent a great improvement with respect to currently used models of the solar irradiance at different ages, and intend to be the reference for the years to come. These models will be of special interest to reproduce the conditions of the Earth and solar system planets during different stages of the evolution, and can be safely exported to exoplanets orbiting Sun-like stars.

*Speaker

sciencesconf.org:pathways2015:66356

The impact story for exo-Earths

Jane Greaves*[1]

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Abstract

The history of asteroid and comet bombardment of the Earth will not be typical. It is important to quantify this in relation to the emergence of life, for example if stimulated by the creation of hot basins or hindered by abrupt environmental change. Surveys have recently been completed of nearby stars, imaging the belts of collisional debris that trace the underlying asteroid and comet populations. The Sun appears to be one of the most 'cleared' systems at its present age, but also one with stong dynamical connections between different orbits doe the presence of multiple giant planets. I will discuss how this affects our habitability, and that of other now-known rocky planets around nearby stars.

*Speaker

sciencesconf.org:pathways2015:65438

C/O ratios for planet hosts: comparing two oxygen indicators

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Abstract

The variation of C/O ratios among solar-type stars may have important implications on the composition and structure of planets. Thus, the determination of this ratio in planet hosts is a first approximation of the bulk composition of a planet, assuming that the composition of the host stars and its proto-planetary disk is the same.
In this work we present C and O abundances for a sample of 110 and 648 stars with and without detected planets, respectively. We find that the mean [C/Fe] at different metallicity bins for planet hosts and non-hosts is very similar at [Fe/H] $>$ -0.3. However, for more metal poor bins, the planet hosts present higher [C/Fe], which are larger for the stars with less massive planets. These stars also show an overabundance of alpha elements pointing to the importance of other elements to form planets when the amount of Fe is low.
We derive C/O ratios using O abundances with the 6300A [OI] forbidden line and with the 6158A line. We find that C/O ratios slightly increase with metallicity and that there are not significant differences between planet hosts and non-hosts. The ratios provided by 6158A line are ~0.05 dex lower than with the forbidden line but we still find some stars with C/O $>$ 0.8, impliying a possible formation of carbon-rich planets. Nevertheless, these ratios strongly depend on the errors of O abundances that are important because the O lines are very weak. For some stars the differences between C/O ratios from both indicators can be up to ~0.5 dex (even for very high S/N spectra), therefore, we ask for a word of caution when using these ratios with an absolute meaning.
We also discuss the implications of using different set of models. We find differences of up to 0.16 dex on the C/O ratios depending on whether you use marcs or kurucz models.

*Speaker

sciencesconf.org:pathways2015:66628

Brown dwarfs versus exoplanets: two different mass functions

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Abstract

Very low-mass stars including brown dwarfs are likely to have a completely different mass function from that of exoplanets due to different formation processes, one being gravitational fragmentation (declining log-normal) and the other being collisional coagulation (rising power law). Observational evidence for two non-overlapping processes and mass functions is the presence of a brown dwarf desert. We discuss ideas how to predict the planetary mass function which we model as a convolution of the planetary object mass distribution in protoplanetary disks (a function of stellar mass) and the mass function of stars in which planets can form. We assume that planets can only arise in disks around stars between a minimum (~0.3Mo) and maximum mass (~3.0 Mo). We realize we are speculating here, but with this contribution we want to stimulate discussion about the planetary mass function, which should also depend on the heavy element abundance (i.e. dust/gas ratio) in galaxies.

*Speaker
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sciencesconf.org:pathways2015:68164

Water Contents of Habitable Zone Rocky Planets and Biosignature Detection around M dwarfs

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[2]Earth Life Science Institute, Tokyo Institute of Technology (ELSI TIT) – Japan

Abstract

The searches for habitable planets currently focus on M dwarfs because of observation feasibility considerations. However, the early evolution of M dwarfs are quite different from that of Sun-like stars. In the first part of this presentation we will report how early evolution of rocky planets around M dwarfs would change their water contents. In addition we will also discuss the probability of observing on-going water loss and oxygen dominated atmospheres on rocky planets around M dwarfs.
Water could be delivered by impacts of small bodies after the planet formation and early evolution phase. This process depends on dynamic interactions between small bodies and larger planets. In the second part of this presentaion we will report statistic results on the delivery of water to habitable zone rocky planets around stars with different masses and discuss the impact on planet habitability.

*Speaker

sciencesconf.org:pathways2015:66458

Key Question 1 :

Is the Sun-Earth pair a good paradigm for an inhabited system ?

Posters

A Mathematical Model for Life on Bioplanets

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Abstract

In two recent papers (Refs. [1], [2]) this author modelled Darwinian evolution as a stochastic process in the number of living Species since 3.5 billion years ago. After the first Species (RNA?) the number of living Species increased in a stochastic fashion and nowadays roughly 50 million Species live on Earth. The mean value of this stochastic process might be:
1) An exponential increasing in time: the process would then be a Geometric Brownian Motion.

2) Or otherwise a generic, increasing function of the time such that the probability density function (pdf) of the stochastic process still is a lognormal starting in time about 3.5 billion years ago and reaching now the value of 50 million plus or minus an assigned and known standard deviation.

This author's idea is that each new Species created at time b ("birth") is represented by a lognormal pdf starting at time b (rather than zero) called a b-lognormal: it starts at b, then reaches its peak at time p, and then starts declining, since superseded by other new b-lognormals (i.e. new Species) more and more peaked until we reach Homo Sapiens. Thus, one is led to consider the "envelope" of them, or, more appropriately, the geometric locus of all the b-lognormal peaks, that is just the mean value (exponential or otherwise) of the general lognormal stochastic process representing Darwinian evolution over the last 3.5 billion years. The same curve of Life Evolution might apply to Exoplanets also, with a different timing, either faster of slowlier, depending on the physical conditions of the exoplanet.

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*Speaker

sciencesconf.org:pathways2015:61797

Stabilization of CO_2 Atmospheres on Exoplanets around M Dwarf Stars

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Abstract

We investigate the chemical stability of CO2-dominated atmospheres of M dwarf terrestrial exoplanets using a 1-dimensional photochemical model. Around Sun-like stars, CO2 photolysis by Far-UV (FUV) radiation is balanced by recombination reactions that depend on water abundance. By comparison, planets orbiting M dwarf stars experience more FUV radiation, and could be depleted in water due to M dwarfs having prolonged, high-luminosity pre-main sequences (Luger & Barnes 2015). We show that, for water-depleted planets around M dwarfs, a catalytic cycle relying on H2O2 photolysis can maintain a CO2 atmosphere. However, this cycle breaks down for atmospheric hydrogen mixing ratios below ~1 ppm, resulting in ~40% of the atmospheric CO2 being converted to CO and O2 on a time scale of 1 Myr. The increased abundance of O2 leads to high O3 concentrations, the photolysis of which forms another catalytic cycle capable of stabilizing CO2. For atmospheres with $<$ 0.1 ppm hydrogen, CO2 is produced directly from the recombination of CO and O. These catalytic cycles place an upper limit of ~50% on the amount of CO2 that can be destroyed via photolysis, which is enough to generate Earth-like abundances of (abiotic) O2 and O3. Discrimination between biological and abiotic O2 and O3 in this case can perhaps be accomplished by noting the lack of water features in the spectra of these planets, which necessitates observations at wavelengths longer than 0.95 microns.

*Speaker

sciencesconf.org:pathways2015:63429

Spectroscopic characterization of M dwarfs in the J- and H-band

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[2]Instituto de Astrofísica e Ciências do Espaço, Universidade do Porto – Portugal

Abstract

M dwarfs are in the focus of ongoing and planned planet surveys. The knowledge of fundamental stellar parameters is essential for our understanding of the star-planet systems, in particular to determine the mass of planets around these stars. Spectroscopic features in the J- and H-bands are particularly suited to determine fundamental stellar parameters. We use state-of-the-art PHOENIX-ACES model atmospheres together with a downhill-simplex method and chi2-minimization to determine effective temperature, surface gravity, metallicity, and rotational velocity for M stars from mid- and high-resolution near-infrared spectra taken with X-Shooter. Focusing on the J- and H-bands, we show the performance of our algorithm and present first results for a number of M dwarfs. Our analysis shows that the models provide good information regarding temperature and gravity while metallicity remains problematic. Our project also serves as preparation for the CARMENES sample where we will obtain hundreds of high-resolution spectra (R = 82,000) at these wavelengths.

*Speaker
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sciencesconf.org:pathways2015:63874

Same but different: a comparison of the transiting planet population found by existing survey projects

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Abstract

The search for transiting extrasolar planets is now mature, with over 1200 specimens known of which approximately 200 are Hot Jupiters. These have been discovered by a multitude of projects based both below Earth's atmosphere (e.g. WASP, HAT, HATS, KELT) and above it (Kepler and CoRoT). Differing stellar and planetary populations are probed by individual surveys, due to variations in apparent magnitude, galactic latitude, photometric precision, and duration of observations. I present a study of the population of planets discovered by several successful search projects, finding statistically significant variations in their properties (mass, radius) as well as those of the parent stars (mass, temperature, metallicity).

*Speaker

sciencesconf.org:pathways2015:64057

The Size Distribution of Inhabited Planets

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Abstract

Earth-like planets are expected to provide the greatest opportunity for the detection of life beyond the Solar System.
However, in the event that other intelligent life exists, our planet should not be considered a fair sample. Just as a person's country of origin is a biased sample among countries, so too their planet of origin is a biased sample among planets. The magnitude of this effect can be substantial: over 98% of the world's population live in a country larger than the median.
In the context of a simple model where the mean population density is invariant to planet size, we infer that an inhabited planet selected at random (such as our nearest neighbour) has a radius r < 1.2 r_Earth (95% confidence bound). If the permitted range of habitable radii is sufficiently broad, most inhabited planets are likely to be closer in size to Mars than the Earth. Our conclusions are applicable to all life-bearing planets, provided the probability with which advanced life emerges from primitive forms is not strongly correlated with planet size.

*Speaker

sciencesconf.org:pathways2015:64189

CELESTA: A Catalog of Earth-Like Exoplanet Survey Targets

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[2]San Francisco State University (SFSU) – United States

Abstract

Rocketing numbers of exoplanet discoveries continue, and locating planets in the Habitable Zone is a significant priority for many exoplanet surveys. Space-based and ground-based surveys alike require robust toolsets to aid in target selection and mission planning, incorporating data from dynamic sources. We present the Catalog of Earth-Like Exoplanet Survey Targets (CELESTA), a database of prospective Habitable Zones around 36 thousand nearby stars. CELESTA yields a return on investment by computing the number of Habitable Zones probed for a given survey duration. We calculated stellar parameters such as effective temperature, mass, and radius, and we quantified hypothetical star-planet separations and orbital periods. We gauged the accuracy of our predictions by contrasting CELESTA's parameters to observational data. A versatile framework for extending CELESTA's functionality into the future enables ongoing comparisons to new observations, and recalculations when updates to Habitable Zone models, parallax data, or stellar temperatures become available.

*Speaker

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sciencesconf.org:pathways2015:64307

Stellar parameters and chemical abundances of 223 evolved stars with and without planets

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Abstract

Nowadays it is widely accepted that main-sequence stars with giant planets are, on average, more metal-rich than stars without planets. However, the results for giant stars with planets have been more controversial and the issue of the planet-metallicity connection for this kind of stars remains open. Here we present homogeneous spectroscopic stellar parameters and chemical abundances for a sample of 86 evolved stars with planets (56 giants; 30 subgiants), and for a sample of 137 stars without planets. We investigate chemical differences between evolved stars with and without planets and search for possible relations between the properties of planets and the chemical abundances of the host stars. We find that subgiant stars reproduce the planet-metallicity correlation found for main-sequence stars, however we do not find any clear difference between the [Fe/H] distributions of giant stars with and without planets. On the other hand, giants with and without planets show differences in the abundances of V, Mn, Co, and Ba. Finally, analyzing the planet properties, some trends might be emerging: i) multi-planet systems show a slight metallicity enhancement compared with single-planet systems; ii) planets with orbital distances larger than 0.5 AU are orbiting subgiants with a wide range of [Fe/H], but those planets with shorter semimajor axes are only around subgiants with [Fe/H] $>$ 0; iii) planets with semimajor axes smaller than 1 AU are orbiting giants with [Fe/H] $<$ 0 whereas those with larger semimajor axes orbit not only subsolar metallicity giants but also those with [Fe/H] $>$ 0; iii) higher-mass planets tend to orbit more metal-poor giants; iv) planets orbiting giants show lower orbital eccentricities than those orbiting subgiants and dwarfs.

*Speaker

sciencesconf.org:pathways2015:66172

Radio observations of stellar winds of young solar-type stars

Bibiana Fichtinger*[1]

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Abstract

Stellar winds play an important role in stellar evolution for main-sequence stars like the Sun. Stars spin down with increasing age, because magnetized, ionized winds carry away angular momentum. To understand the mechanism of the interaction between the stellar wind and the magnetic field for stars of various ages, the knowledge of how winds evolve with time is necessary. The evolution of stellar winds is also important for the evolution of planetary atmospheres of potentially habitable planets and the influence of winds to eroding atmospheres. We observed four young solar analogues of different ages on the main sequence with the Karl G. Jansky Very Large Array (JVLA) and the Atacama Large Millimeter/Submillimeter Array (ALMA), trying to detect signatures of thermal emission in form of radio bremsstrahlung which is emitted by the ionized wind. With the detection or at least upper limits of free-free radio emission, we are able to determine mass loss rates for these young stars assuming an ionized, anisotropic and conical jet flow and hence, we can predict an early mass loss for the young Sun. To potentially solve the so-called Faint Young Sun Paradox, an initial solar mass of 1.02 – 1.07 Msun would be required, thus suggesting an enhanced early mass loss of the order of 10 – 10 Msun /yr.

*Speaker

sciencesconf.org:pathways2015:66206

Coronal magnetic field and wind of an aging K-type star

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Abstract

Created at the base of the convective envelope by a nonlinear dynamo process, the large scale magnetic field of a star evolves with its rotational history. Beyond the photosphere, magnetic processes heat the corona above one million Kelvin hence driving a magnetized wind responsible for the braking of main sequence stars. Hence a feedback loop tie those processes. Development of Zeeman-Doppler imaging through spectropolarimetry allows to precisely describe the surface magnetic field of a large sample of stars. Thus the study of the coronal structure and magnetic field with age, magnetochoronology, has developed to extend and complete gyrochronology. We propose a study of the corona and the wind of a sample of K-type stars of different age to follow the evolution of its properties from 20 Myr to 8 Gyr thanks to a set of 3D MHD simulations with the PLUTO code constrained by spectropolarimetric maps of the surface magnetic field obtained by the BCool consortium. To perform those simulations we developed a coherent framework to assess various stellar parameters such as the equilibrium coronal temperature driving the wind. Those assumptions have consequences on UV emission, wind terminal speed and mass loss that impact planetary systems that could potentially host life.

*Speaker

sciencesconf.org:pathways2015:66329

Stellar Winds on the Main-Sequence

Colin Johnstone*[1]

[1]University of Vienna – Austria

Abstract

Stellar winds influence planetary atmospheres in two important ways. Firstly, by removing angular momentum, they cause their stars to rotate slower as they age. This spin down causes a decrease of the star's emission of X-ray and EUV radiation, which are crucial for driving the erosion of planetary atmospheres. Secondly, the winds themselves impact planetary atmospheres and magnetospheres, and in certain cases, can directly erode a planetary atmosphere. The winds themselves likely also decay in time as a result of stellar spin down. In this talk, I discuss the links between stellar rotational evolution and winds, and I explore the main-sequence evolution of wind properties for stars with a range of masses. Understanding stellar wind evolution is fundamental in exploring the formation and evolution of habitable planetary environments.

*Speaker

sciencesconf.org:pathways2015:66498

Exploring Earth-like planetary atmospheres with a real time 1D GCM : an educational tool.

Martin Turbet*[1,2], Forget Francois[1], Leconte Jérémy[1], and Cédric Schott[3]

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Abstract

Using a 1D version of the LMD GCM, we have developed a new educational tool which provides an accelerated simulation of the climate of terrestrial planets. This tool was designed for students to explore the "classical habitable zone", defined as the range of orbital distances within which a planet can maintain liquid water on its surface (Kasting et al. 1993).

For Earth-like planets with high stellar flux, surface liquid water tends to evaporate efficiently, releasing water vapor which is a strong greenhouse gas. For earth-like planets with low stellar flux, at the limit where surface liquid water starts to freeze, ice forms, albedo increases and thus, the amount of energy absorbed by the planet decreases. The 3D LMD GCM was previously used to successfully reproduce these "runaway greenhouse" effect (Leconte et al. 2013) and "runaway glaciation" effect (Charnay et al. 2013).

To illustrate these concepts, we developed an educational – easy to use - 1D LMD GCM able to model these two limits and their dependencies with the type of star and the gas composition.

This GCM was designed for Earth-like atmospheres made of variable compositions of N2/O2/CO2/H2O and includes a radiative transfer (correlated k method), a water cycle and a multiple-layers soil model. Wavelength dependency of ice albedo was parameterized according to Joshi et al.(2012). An empirical law between surface albedo and surface temperature was built from previous 3D LMD GCM simulations (Leconte et al. 2013, Charnay et al. 2013).

The tool, available soon online, will be presented during the poster session.

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*Speaker

sciencesconf.org:pathways2015:66551

Stellar high-energy luminosity evolution for pre-main sequence and main-sequence stars

Lin Tu*[1], Colin Johnstone[1], Manuel Güdel , Theresa Rank - Lüftinger[2], and Bibiana Fichtinger[3]

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[3]University of Vienna – Austria

Abstract

For solar-like main-sequence stars, high-energy radiation decays in time owing to stellar spin-down. The early Sun's X-ray (1 100 Å) and extreme-ultraviolet (100 900 Å) emissions could thus have exceeded the present-day Sun's level by orders of magnitude (Ribas et al. 2005), which drives atmospheric erosion. Such extreme radiation levels were critically important for both the primordial hydrogen atmospheres (e.g., Lammer et al. 2014) and the secondary nitrogen atmospheres (Lichtenegger et al. 2010) of solar system planets. We use a rotational evolution model to predict such luminosity distributions as a function of age, based on a range of initial , and we show that these predictions agree with the observed time-dependent scatter of X-ray luminosity. We derive a radiative evolution model based on the full range of rotation histories for a solar-mass star, and thus find a description of the possible past histories of our own Sun, which is useful to model the corresponding evolution of solar-system planetary atmospheres. We also extend this evolutionary model to stars of lower mass.

*Speaker

sciencesconf.org:pathways2015:66618

The principle of the homogeneity of nature and the conviction that life is a cosmic imperative

Ludwik Kostro*[1]

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Abstract

Ludwik Kostro

Abstract

We have not yet any direct or indirect observational evidence that in our galaxy there is extraterrestrial life. In looking for such an evidence we've chosen the investigations of the atmospheres of transiting planets. Why? On the basis of the homogeneity principle, consciously or perhaps still unconsciously but certainly instinctively, we've arrived to the conclusion that, if we will discover in the atmospheres of an exoplanet the same chemical components like on our Earth then we can be sure that there is life and that these components have to be considered as biomarkers. The homogeneity principle states: what the laws of nature as described by physics, chemistry, biology and other sciences admit necessarily happens, under competent conditions. In other words: the same physical phenomena given the same circumstances run the same way. The homogeneity principle plays a fundamental part in scientific thinking. The purpose of this paper is to show that it conducts us even to the statement that life is a comic imperative. It will be shown that the principle in consideration is already inscribed in the mathematical structures of the different branches of natural sciences: classic and relativity physics, quantum physics and chemistry, quantum biochemistry etc. The part played in the scientific debate by the homogeneity principle will be stressed not only from the scientific but also from the philosophical and logical point of view.

*Speaker

sciencesconf.org:pathways2015:72043

Key Question 3 :

Is the habitable zone
a well defined concept ?

Oral presentations

Definitions and Caveats of the Habitable Zone

Stephen Kane*[1]

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Abstract

The field of exoplanets has rapidly expanded from the exclusivity of exoplanet detection to include exoplanet characterization. A key step towards this characterization is the determination of which planets occupy the Habitable Zone (HZ) of their host stars. As the Kepler data continues to be processed, the orbital period sensitivity is increasing and there are now numerous exoplanets known to occupy the HZ of their host stars. In this talk I will describe the properties of the HZ, the dependence on stellar and planetary parameters, and the current state of exoplanet detections in the HZ. Along the way I will describe some common misconceptions regarding the Habitable Zone and detail caveats to the model. I will conclude with a pathway for testing the Habitable Zone model and answering the question: What is the purpose of the Habitable Zone?

*Speaker

sciencesconf.org:pathways2015:66512

Is there an Unhabitable Zone?

Leconte Jérémy*[1,2,3]

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Abstract

The universe is a vast place, and a blind search for life out there is short of impossible. Therefore, it is only natural to try and reduce the area to explore by putting in some additional assumptions based on a few educated guesses and a lot of "a priori" experience from what is life here on Earth. On our way along this appealing path, we have come up with a working definition of where life should be looked for: the so-called Traditional Habitable Zone (THZ). But as this concept has taken what seems to be an ever increasing significance in mission design and selection, it is important to understand the limitations to its definition and usefulness. To do so, I will thus try to address the following questions: Is a planet inside the THZ habitable? Is a planet outside this zone necessarily unhabitable? In fact, is there anything like an Unhabitable Zone, and don't we risk to miss the unexpected if we try too hard to find another version of ourselves among the stars?

*Speaker

sciencesconf.org:pathways2015:74575

Prospect of Finding Habitable Planets in Binary Stars

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Abstract

One third of stellar systems in the solar neighborhood are binay star systems. In such systems unlike our solar system, planet formation is under the influence of a companion star, which may result in a different process of planet formation and thus a different outcome. The difference has been noted and has not been quantified yet. For example, a companion star can trancate protoplanetary disk, perturb planetesimals, and eject planets, but it is unknown how these effects translate into a different planet occurrence rate. We conduct observations to study the difference of planet occurrence rate between single and binary stars. The planet occurrene rate is an important metric in determining the prospect of finding habitable planets in binary stars.

*Speaker

sciencesconf.org:pathways2015:53149

Adaptable habitability, niche filling and exo-climate change

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Abstract

Planetary orbits may change due to gravitational perturbations by external bodies. Such changes can occur both on short and long timescales, and give rise to significant changes in the planetary climate and habitability. Such changes may render the climate inhabitable for any original pre-existing organisms. However, if the climate change timescale is longer than the timescale for organism genetic adaptation over several generations, the population of pre-existing organisms may evolve and adapt to the new conditions. This raises the possibility for the existence of planets in which life formed and evolved under favorable conditions, and then adapted to extreme conditions once significant climate-change occured. Such planets may therefore appear today as having too-extreme conditions as to allow for the emergence of life, even though life could have formed at ealier epoch at which time the planet climate differed. One can therefore discuss the possibility of "adaptable habitability", which relies not only on the current conditions but on the climate history and the dynamics of the planetary system. Moreover, once life emerges and evolves to the stage in which rapid adaptababilty is possible, organisms may adapt as to fill extreme environmental nches (e.g. extremophiles on Earth). Once climate-change leads to overall extreme planetary conditions, such originally extreme-niche filling organisms can prevail and occupy the main environments of the planets, where as such extreme planetary conditions, if they existed primordially, wouldn't have allowed for the emergence of life to begin with. We discuss these issues, and provide detailed planetary dynamics examples for such adaptable habitability to occur.

*Speaker

sciencesconf.org:pathways2015:66991

Habitability of planets on eccentric orbits: limits of the mean flux approximation?

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Abstract

A few of the planets found in the insolation habitable zone (as defined by Kasting et al. 1993) are on eccentric orbits, such as HD 136118 b (eccentricity of ˜0.3, Wittenmyer et al. 2009). This raises the question of the potential habitability of planets that only spend a fraction of their orbit in the habitable zone.
Usually for a planet of semi-major axis a and eccentricity e, the averaged flux over one orbit received by the planet is considered. This averaged flux corresponds to the flux received by a planet on a circular orbit of radius r = a(1-eˆ2)ˆ1/4. If this orbital distance is within the habitable zone, the planet is considered "habitable". However, for a hot star, for which the habitable zone is far from the star, the climate can be degraded when the planet is temporarily outside the habitable zone.

The influence of the orbital eccentricity of a planet on its climate has already been studied for Earth-like conditions (same star, same rotation period), with Global Climate Models (GCM) such as in Williams & Pollard 2002 and Linsenmeier et al. 2014. Spiegel 2010 and Dressing et al. 2010 have also studied the effect of eccentricity for more diverse conditions with energy-balanced models.
We performed a set of simulations using the Global Climate Model LMDz (Wordsworth et al. 2011, Forget et al. 2013, Leconte et al. 2013). We computed the climate of aqua planets receiving a mean flux equal to Earth's, around stars of luminosity ranging from 1 Lsun to 10-4 Lsun and of orbital eccentricity from 0 to 0.9. We show the limits of the mean flux approximation, depending on the previous parameters and also the thermal inertia of oceans.

*Speaker

sciencesconf.org:pathways2015:66126

Key Question 3 :

Is the habitable zone
a well defined concept ?

Posters

The Energetic Radiation Environment in the Habitable Zones Around Low-Mass Exoplanet Host Stars

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Abstract

The spectral and temporal behavior of exoplanet host stars is a critical input to models of the chemistry and evolution of planetary atmospheres. High-energy photons (X-ray to NUV) from these stars regulate the atmospheric temperature profiles and photochemistry on orbiting planets, influencing the production of potential "biomarker" gases. In this talk, I will present results from an ongoing study of the panchromatic SEDs of nearby M dwarf planet hosts. I will present results from the MUSCLES pilot program of six M dwarf exoplanet host stars (GJ 581, GJ 876, GJ 436, GJ 832, GJ 667C, and GJ 1214) and describe the MUSCLES (Hubble/Chandra/XMM/optical) Treasury program that is underway now. We find that all exoplanet host stars observed to date exhibit some level of chromospheric and transition region UV emission. No "UV quiet" M dwarfs are observed. The F(FUV)/F(NUV) flux ratio, a driver for possible abiotic production of the suggested biomarkers O2 and O3, is shown to be ~ 0.5 – 3 for all M dwarfs in our sample, > 1000 times the solar ratio. For all M dwarf exoplanet host stars observed with time-resolved spectroscopy, we find 30 – 1000% amplitude variations on timescales of minutes-to-hours. We conclude that strong flares and stochastic variability are common, even on "optically inactive" M dwarfs hosting planetary systems.

*Speaker

sciencesconf.org:pathways2015:59220

Quiescent and Flaring Lyman-alpha Radiation of Host Stars and Effects on Exoplanet Atmospheres

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Abstract

Lyman-alpha radiation dominates the ultraviolet spectra of stars with spectral types G, K, and M, and is a major contributor to the photodissociation of important molecules including water, CO2, and CH4 in the upper atmospheres of exoplanets. We obtain intrinsic Lyman-alpha line fluxes for late-type stars by either correcting for interstellar absorption or by scaling from other spectroscopic observables and broadband fluxes. When stars flare, all emission lines brighten by large factors (Parke Loyd & France ApJS 211, 9 (2014)) as shown by HST spectra of G-M dwarf stars. We estimate the enhancement factors in the Lyman-alpha flux during M dwarf flares by scaling from the observed flux in C II and other UV emission lines. We then describe photochemical models of the atmospheres of the mini-Neptune GJ 436b (Miguel et al. MNRAS 446, 345 (2015)) and super-Earths (Rugheimer et al. preprint) that show the effects of flaring Lyman-alpha fluxes on atmospheric chemical abundances.

*Speaker
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sciencesconf.org:pathways2015:62099

Effect of Initial Stellar Metallicity and He Abundance on the Evolution of the Habitable Zone and the Search for Life

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Abstract

During the course of stellar evolution, the location and width of the habitable zone changes as the luminosity and radius of the star evolves. The duration of habitability for a planet located at a given distance from a star is greatly affected by the characteristics of the host star. A quantification of these effects can be used observationally in the search for life around nearby stars. The longer the duration of habitability, the more likely it is that life has evolved. The evolution of the habitable zone imposes some important requirements for detecting life around various types of stars. We present a study of the evolution of the habitable zone around stars of 1.0, 1.5, and 2.0 Msun for metallicities ranging from Z= 0.0001 to Z= 0.070. We also consider the evolution of the habitable zone from the pre-main sequence until the asymptotic giant branch is reached. We find that metallicity strongly affects the duration of the habitable zone for a planet as well as the distance from the host star where the duration is maximized. For a 1.0 Msun star with near solar metallicity, Z = 0.017, the duration of the habitable zone is $>$ 10 Gyr at distances 1.2–2.0AU from the star, whereas the duration is $>$ 20 Gyr for high-metallicity stars (Z = 0.070) at distances of 0.7–1.8AU, and 4 Gyr at distances of 1.8–3.3AU for low-metallicity stars (Z = 0.0001). Corresponding results have been obtained for stars of up to 2.0 solar masses. We report recent progress on studies of the duration of habitability as it is affected by the He abundance as well as metallicity. We discuss the implications of these results from the standpoint of the evolution of life.

*Speaker

sciencesconf.org:pathways2015:63951

Space Weather as Energy Source For The Origin of Pre-biotic Chemistry on Early Earth and Its Twins

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Abstract

The discovery of frequent superflares on active solar-type stars by Kepler mission suggests that stellar activity may profoundly effect the physical and chemical evolution of exoplanetary atmospheres. Pre-biotic chemistry on early Earth and its twins can be mediated by ionizing radiation due to extreme space weather. Specifically, we simulate the effects of coronal mass ejections (CMEs) on the chemistry of early Earth's and exoplanetary atmospheres using a three-dimensional (3D) magnetohydrodynamic code (MHD) code. We show that Super-Carrington scale CMEs (SCME) significantly perturb the magnetosphere of the early Earth by compressing it to ~ 2 Earth radii or smaller, substantially opening the geomagnetic field lines on the day side to reach as much as 65% of the surface. This provides favorable conditions for energetic protons associated with CMEs to penetrate the molecular nitrogen-rich atmosphere of primitive Earth's extended polar caps. Our atmospheric modeling results show that this process causes destruction of molecular nitrogen into molecules containing an odd number of nitrogen atoms (odd nitrogen) with maximum rate of ~ 10ˆ7 atoms cmˆ-3 sˆ-1. We also discuss its implication for the formation of a chain of pre-biotic chemistry producing complex organic compounds. Our results suggest that the formation of nitrous oxide (N2O), in the lower atmosphere, a very potent greenhouse gas, can potentially explain the faint Young Sun Paradox (YSP) in the Earth's early history. Nitrous oxide's strong absorption band at 4.5 microns can be a new important observational signature of the atmosphere of exoplanets around young active solar-like stars. We discuss the implications of these results on habitability of exoplanets around M and G-type stars.

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†Speaker

sciencesconf.org:pathways2015:63970

Host's stars and habitability

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Abstract

With more than 2000 exoplanets discovered within a bunch of quite different configuration of distance from the star, size, mass, and atmospheric conditions, the probability to found habitable planets should increase dramatically. While the habitable zone is usually only seen as a snapshot to assess habitability, the intrinsic evolution of the stellar parameters must be taken into account to study the past and future evolution of the habitable zone limits. Indeed, this evolution can strongly affect habitability, especially through the continuous habitable zone required for the emergence of complex life.

The aim of this talk is to highlight the impact of stellar parameter such as metallicity, mass, and rotation on the habitable zone limits and to show that the intrinsic evolution of the stellar parameters should not been neglected anymore.

*Speaker

sciencesconf.org:pathways2015:65143

Limited habitability of ocean planets by an unstable CO2 feedback cycle

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Abstract

Ocean planets are volatile rich planets, not present in our Solar System, which are dominated by deep, global oceans. Theoretical considerations and planet formation modeling studies suggest that ocean planets should be a very common type of exoplanet. One might therefore expect that low-mass ocean planets would be ideal candidates when searching for habitable exoplanets, since water is considered to be an essential requirement for life. However, a very large global ocean can also have a strong impact on the planetary climate. Therefore, we focus in our study on the CO2 cycle between the atmosphere and the ocean which determines the atmospheric CO2 content. The atmospheric amount of CO2 is a fundamental quantity for assessing the potential habitability of the planet's surface because of its strong greenhouse effect, which determines the planetary surface temperature to a large degree. In contrast to the stabilising carbonate-silicate cycle regulating the long-term CO2 inventory of the Earth atmosphere, we find that the CO2 cycle on ocean planets is negative and has strong destabilising effects on the planetary climate. By using a chemistry model for oceanic CO2 dissolution and an atmospheric model for exoplanets, we show that the CO2 feedback cycle is severely limiting the extension of the habitable zone for ocean planets.

*Speaker

sciencesconf.org:pathways2015:65805

Habitable planets and dynamics in stellar binaries

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Abstract

Today, almost two thousands planets are known to revolve around stars other than our Sun. About one hundred of them have been found to orbit either one or both components of stellar binaries. An issue of great scientific as well as public interest is whether Earth-analogues capable of hosting liquid water near their surface can be found in such systems. In contrast to single-star single-planet configurations, orbits of planets in binary star environments are subject to constant changes due to the gravitational perturbations of the stellar companion leading to complex insolation patterns. Here, we present an analytical method to estimate the corresponding habitable zone limits in stellar binaries. Contrary to other approaches, we take into account both the radiative and the gravitational effects of the second star on the planet and its orbit.

*Speaker

sciencesconf.org:pathways2015:65855

Water transport into circumprimary habitable zones in binary star systems

David Bancelin*[1], Elke Pilat-Lohinger[1], Siegfried Eggl[2], Helmut Lammer[3], Colin Jonhston[1], Thomas Maindl[1], and Rudolf Dvorak[1]

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Abstract

So far, multiple stellar systems harbor more than 100 extra solar planets. Dynamical simulations show that the outcome of planetary formation process can lead to various planetary architectures (i.e. location, size, mass and water content) when the star system is single or double. In the late phase of planetary formation, when embryos-sized objects dominate the inner region of the system, asteroids are also present and can provide additional material for objects inside the habitable zone (HZ). In this study, we make a comparison of several binary star systems and their efficiency to move icy asteroids from beyond the snow-line into orbits crossing the HZ. We modeled a belt of 10000 asteroids (remnants from the late phase of planetary formation process) beyond the snow-line. The planetesimals are placed randomly around the primary star and move under the gravitational influence of the two stars and a gas giant. In our results, we highlight the key role of secular and mean motion resonances, causing an efficient flux of asteroids to the HZ on a short timescale. This in turn leads to asteroids bearing a non negligeable amount of water to the HZ and for any planets or embryos moving in this area. We also discuss how mass loss mechanisms can alter the water content on asteroids' surface.

*Speaker

sciencesconf.org:pathways2015:66426

Planetary habitability: constraints from stellar evolution

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Abstract

Stellar high-energy radiation and winds interact with upper planetary atmospheres, driving thermal and non-thermal mass-loss processes that may fundamentally affect planetary habitability; in extreme situations, entire atmospheres may be removed, or large amounts of water may be lost to space after photodissociation of water vapor in the upper atmospheres. Even for planets in habitable zones around their host stars, truly habitable conditions may not be sustainable to the end of the main-sequence life of the host star. To assess whether a planet can develop a life-friendly environment in the habitable zone, a full understanding of the entire evolution of radiation and winds from the host star is required, starting in the early phases of planet formation. The radiative and wind evolution of the host star determines the time scale of atmospheric evolution and erosion, while the planetary mass determines the retention potential for the atmosphere. The end product for a planet around an older main sequence star therefore requires comprehensive calculations of losses in the context of the host star's evolution. We present results based on rotation/wind/activity evolution models we have recently developed based on empirical stellar properties. We demonstrate that the fate of an atmosphere formed on a young planet critically depends on its mass and the evolution of stellar magnetic activity.

*Speaker

sciencesconf.org:pathways2015:66505

Binary star systems and habitability

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Abstract

Space missions like Cheops, Tess or Plato will explore the solar neighborhood when searching for other Earth-like worlds. As we know from observations that most of the stars in this area build double or multiple star systems, studies of planetary motion in such systems will provide important information for these missions. It is well known that a stellar companion could perturb the planetary motion in the habitable zone (HZ). Therefore, gravitational interactions between celestial bodies play an important role in multi-planetary systems as well as in binary stars hosting planets. Phenomena like (i) mean motion resonances or (ii) secular resonances can be sources of both stability and instability and influence therefore the architecture of a planetary system significantly. In our solar system the motion of the terrestrial planets is also influenced by the two giant planets Jupiter and Saturn. The planetary motion in binary star systems depends strongly on parameters of the stellar system (stellar separation and eccentricity) and the architecture of the planetary system (number of planets and their orbital behavior). In case a terrestrial planet moves in the HZ of its host star, the dynamical constraints for habitability of such a planet depend on many parameters and therefore, it is difficult to have general stability studies for such complex systems. Such studies exist mainly for a single planet moving in a binary star system. In this study, we present a semi-analytical approach for circum-stellar motion in a binary, which allows to define the location of the linear secular resonance in binary stars hosting a giant planet. Applying this method, we get information whether the HZ is perturbed by the giant planet and the secondary star or not.

*Speaker

sciencesconf.org:pathways2015:66558

The potential habitability of rocky planets within the habitable zone

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Abstract

The potential habitability of a terrestrial planet is usually defined by the possible existence of liquid water on its surface, since all life as we know it needs liquid water at least during part of its life cycle. The potential presence of liquid water on a planetary surface depends on many factors, of which surface temperature is one of the key variables. The habitable zone describes the range of orbital distances around a star, where surface temperatures allowing for liquid surface water are in principle possible. Which surface temperatures are realized however depends on various planetary and atmospheric parameters, e.g. atmospheric mass and composition, size and mass of the planet or surface albedo. One-dimensional (1D) climate models are often applied study extrasolar planets due to the large possible range of these parameters. We will show how surface temperatures depend on the assumptions of the relative humidity and surface albedo in 1D modelling studies of extrasolar Earth-like planets. These two parameters have a strong impact on the planetary climate. They are furthermore influenced via complex processes such as the ice-albedo and the water vapor feedback as has been shown by various 3D climate studies. We compare the results of the 1D model to those of 3D climate models to investigate whether and how the applied 1D model can estimate the mean surface temperatures, hence the habitability of Earth-like planets within the habitable zone.

*Speaker
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sciencesconf.org:pathways2015:66566

Magnetic fields of stars and their influence on the habitability of Exoplanets

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Abstract

Stellar magnetism is a crucial driver of activity, ionization, photodissociation, chemistry and winds in stellar environments. Thus it has an enormous impact on the atmospheres and the magnetospheres of surrounding planets. Modelling of stellar magnetic fields and their winds is extremely challenging, both from the observational and the theoretical points of view, and only recent ground breaking advances in observational instrumentation (high-resolution spectropolarimeters like ESPaDoNS@CFHT, NARVAL@TBL, and HARP-Spol@ESO) and a deeper theoretical understanding of magnetohydrodynamic processes in stars enable us to model stellar magnetic fields and winds – and the resulting influence on surrounding planets – in more and more detail.
In this talk, we will address questions on the formation and habitability of environments in (young) stellar-planetary systems in the light of stellar activity. In particular, we will discuss, how stellar magnetic fields and their winds are assessed observationally with relevant techniques such as Zeeman Doppler Imaging (ZDI), field extrapolation and wind simulations, and we will present results based on newly obtained spectropolarimetric data of young solar type stars.

*Speaker

sciencesconf.org:pathways2015:66598

Habitability of Exoplanets: What can we learn in the next 10 years?

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Abstract

For the first time in human history, the detection of habitats beyond Earth is within our reach. Utilizing the MassSpec method (de Wit & Seager, 2013), we show that the James Webb Space Telescope (JWST) has the potential to lead to the first identification of a habitable exoplanet within the next decade. In particular, we show that, over its lifetime, JWST could determine the mass and atmospheric properties of half a dozen Earth-sized planets in their host's habitable zones (assuming 3% allocation time).
Here, I propose to (1) introduce MassSpec's concept and key role in that venture, (2) discuss its potential for different classes of mission (e.g., an EChO-class), and (3) provide general recommendations to optimize the scientific return of future missions (e.g., building an accurate and complete cross section database). I also aim to emphasize that a planet's mass has to be accounted for by atmospheric retrieval methods to ensure unbiased estimates of atmospheric properties. Finally, I wish to point out that 80% of the Earth-sized exoplanets with assessable habitability will orbit late M dwarfs. Therefore, our quickest, cheapest, and most efficient pathway towards habitable planets requires promptly dedicating more efforts to monitor late M dwarfs in order to secure the detection of a sufficient sample of potentially habitable planets to be later characterized by JWST.

MassSpec is a method to determine transiting planet masses and atmospheric properties solely from transmission spectra—hence, providing the mass of planets that might be out of reach using RV measurements, which are not suited for planets with low masses and large semi-major axes (e.g., habitable Earth-sized planets).

*Speaker

What Can The Habitable Zone Gallery Do For You?

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Abstract

The Habitable Zone Gallery (www.hzgallery.org) came online in August 2011 as a service to the exoplanet community that provides Habitable Zone (HZ) information for each of the exoplanetary systems with known planetary orbital parameters. The service includes a sortable table, a plot with the period and eccentricity of each of the planets with respect to their time spent in the HZ, a gallery of known systems which plot the orbits and the location of the HZ with respect to those orbits, and orbital movies. Recently, we have added new features including: implementation of both conservative and optimisticHZs, more user-friendly table and movies, movies for circumbinaryplanets, and a count of planets whose orbits lie entirely within the system's HZ. Here we discuss various educational and scientific applications of the site such as target selection, exploring planets with eccentric or circumbinary orbits, and investigating habitability.

*Speaker
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sciencesconf.org:pathways2015:67237

A population-based Habitable Zone perspective

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Abstract

What can we tell about exoplanet habitability if only the stellar properties, planet radius, and the incoming stellar flux are known? The Habitable Zone (HZ) is the region around stars where planets can harbor liquid water on their surfaces. The HZ is traditionally conceived as a sharp region around the star because it is calculated for one planet with specific properties e.g., Earth-like planets. Such a planet-specific approach is limiting because the planets' atmospheric and geophysical properties, which influence the surface climate and the presence of liquid water, are currently unknown but expected to be diverse.
I outline a statistical HZ description which does not select one specific planet type. Instead the atmospheric and surface properties of exoplanets are treated as random variables and a continuous range of planet scenarios are considered. Various probability density functions are assigned to each observationally unconstrained random variable, and a combination of Monte Carlo sampling and climate modeling is used to generate synthetic exoplanet populations with known surface climates. Then, the properties of the liquid water bearing subpopulation is analyzed.

Given our current observational knowledge, the HZ takes the form of a weakly-constrained but smooth probability function. The HZ has an inner edge but a clear outer edge is not seen. Currently only optimistic upper limits can be derived for the HZ occurrence rate. Finally, the surface pressure and the atmosphere type have the strongest impact on the surface climate. If we want to better constrain the habitability of exoplanets, it is important to know these atmosphere properties.

*Speaker

sciencesconf.org:pathways2015:69917

Key Question 2 :

How do we define meaningful biomarkers ?

Oral presentations

Biosignatures in context

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Abstract

Biological activity has changed the Earth environment on a global scale. One metabolism - oxygenic photosynthesis - is responsible for changing the face of the Earth by converting 0.1% of the solar flux received at the surface into chemical energy. Most of the biosphere depends on this primary production of organic matter. Alternative primary biological production by chemo-autotrophic life relying on the internal heat flux has a negligible impact on the global geochemical cycles.
Considering life as we know it, global-scale biosignatures are thus expected to be linked with the possibility for life to use starlight. As a consequence, the surface liquid water "Habitable Zone" - while narrower than the region where life can exist - corresponds to the region where remote spatially-unresolved characterization could reveal signs of biological activity.
Knowing where to search does not, however, mean that we know what to look for. The most general way to search for signs of life may be to search for a strong thermodynamical disequilibrium in the atmosphere, which cannot be maintained by non-biological processes only. This being said, measuring this disequilibrium requires the knowledge of the elemental atmospheric composition, pressure and temperature. Detecting, or even measuring the amount of one or a few atmospheric species is in general insufficient to quantify this disequilibrium. Therefore, we emphasize that a detailed characterization of a planetary environment must precede any attempt to identify biosignatures. The fact that spectral features are known to be of biological origin on Earth (e.g. O3/O2 bands) should not interfere with the choice of future instruments for characterizing exoplanets. An in-depth exploration of the existing diversity of planetary environments/atmospheres should be seen as a prerequisite for the search for biosignatures.

*Speaker

sciencesconf.org:pathways2015:74138

Constraining Oxygen False Positives for Terrestrial Planets around F, G, and K Stars

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Abstract

On the Earth, oxygen represents a dramatic disequilibrium fueled by photosynthesis that has lasted for billions of years. Since oxygen is so pervasive and persistent here, is it safe for us to extrapolate? Oxygen as a remotely detectable biosignature has been knocked down, amended, and resurrected several times during the last 50 years. Recently, a number of authors have weighed in and come to very different conclusions – some pointing to a potential false positive, while others failing to reproduce those results. The problem of false positives has recently become more difficult, as new estimates of Proterozoic O2 levels on Earth put this value at 0.001 PAL (times the Present Atmospheric Level). Any abiotic O2 concentration above this value could potentially constitute a false positive for life. We have used our 1-D photochemical model to calculate abiotic O2 concentrations for rocky planets with CO2-rich atmospheres orbiting G, K, and M stars. For late-K and M stars, the ratio of far-UV to near-UV (FUV/NUV) increases, changing the production and loss rates of CO and O2. The fate of CO and O2 is strongly dependent on the assumed lower boundary conditions. These boundary conditions, in turn, depend on how fast O2 and CO react in solution with each other and with other dissolved species that may be present in the ocean. Faster chemical reactions in the ocean correspond to higher deposition velocities and lower concentrations of these gases within the model atmosphere. Reliable predictions of deposition velocities may require laboratory investigations of aqueous chemical reaction rates, particularly the reaction between dissolved CO and O2. Work on this problem should proceed well before spectroscopic data on Earth-like exoplanets become available.

*Speaker
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sciencesconf.org:pathways2015:63288

Remote sensing of extraterrestrial life: Complexity as the key characteristics of living systems

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Abstract

Motivated by the detection of planetary candidates around more than one thousand stars since 1995 and the beginning characterization of their major properties (orbit, mass, physical conditions and chemical composition of their atmosphere), the quest for understanding the origin and evolution of life from the broadest possible perspective comes into reach of scientific exploration. Due to the apparent lack of a better starting point, the search for life outside Earth is strongly influenced and guided by biological and biochemical studies of life on our planet so far. Furthermore, this search is built on the assumption that life – in the sense of animated matter – is qualitatively different from inanimate matter. However, the first constraint might unnecessarily limit our search, while the latter underlying assumption is not justified. In this study, a more general approach to search for life in the universe with astrophysical means is proposed, which is not based on the above constraint and assumption. More specifically, the property of living systems to possess a high degree of complexity in structure and its response to the environment is discussed in view of its potential to be used for remote sensing of extraterrestrial life.

*Speaker

sciencesconf.org:pathways2015:64055

Titania may act as a potential source of false signs of life on habitable exoplanets

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Abstract

Searching habitable exoplanets in the Universe is actively ongoing. The biggest future milestone would be discriminating whether life exists on such habitable exoplanets. In that context, existence of oxygen in the atmosphere has been considered as strong evidence for existence of photosynthetic organisms. We show that a previously unconsidered photochemical mechanism by titanium(IV) oxide (alias, titania) can produce abiotic oxygen from liquid water under near ultraviolet (NUV) lights on the surface of exoplanets. Titania works as photocatalyst to dissociate liquid water in this effect. This mechanism offers a different source of a possibility of abiotic oxygen in atmospheres of exoplanets from previously considered photodissociation of water vapor in upper atmospheres by extreme ultraviolet (XUV) lights. Our order-of-magnitude estimation shows that possible amounts of oxygen produced by this abiotic mechanism can be comparable with or even more than that in the atmosphere of the current Earth, depending on the amount of active surface area for this mechanism. We thus conclude that titania may act as a potential source of false signs of life on habitable exoplanets.

*Speaker

sciencesconf.org:pathways2015:66507

What you need to know to use the ExoMol Line Lists.

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Abstract

ExoMol has made a name in producing high quality, complete high-temperature line lists for a wide variety of astrophysically relevant molecules, including biomarkers. These line lists (specifying the frequency and intensity of absorption lines in molecules) are used in complex atmospheric models to predict absorption based on temperature, pressure, atmospheric composition and other factors. But what if your observed spectrum doesn't match your model? Have you used the wrong input parameters? Is the atmospheric model wrong? Or is the underlying line list wrong?

As a producer of line lists in the ExoMol group, I can help you answer the last question. I will tell you how we produce these line lists and, most importantly, where we expect errors to occur and where they will not occur (as well as tell you about what sort of errors and their magnitude). For example, if you are looking at water absorption around 3000 cm-1, then the line lists will be near perfect. Looking at VO at 17,000 cm-1 (in the visible) - not so much. Why? I will tell you what molecules, parameters and spectral regions are easy for us to study, and which are difficult, and why this is the case. I will explain where experimental data is critical, the accuracy with which different input parameters can be calculated by ab initio theory, and how experiment and theory can be used together to build a more complete picture of the spectroscopy of molecules.

And, if nothing else, you should come to my talk to hear why the ExoMol group talks (and thinks) in cm-1.

*Speaker

sciencesconf.org:pathways2015:64567

Key Question 2 :

How do we define meaningful biomarkers ?

Posters

Absorption efficiencies of light-harvesting complexes in photosynthetic organisms exposed to the photoenvironment of exoplanets

Yu Komatsu*[1], Masayuki Umemura , Mitsuo Shoji , Megumi Kayanuma , and Yasuteru Shigeta

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Abstract

The surface vegetation on exoplanets is considered as a trace of life. However, the signatures of the vegetation are uncertain, when the primal star is different from the Sun. Before detecting the trace of the vegetation on the planets, it should be examined what kinds of photoenvironments are acceptable for photosynthetic organisms that inhabit in the earth. We model the light-harvesting complexes of a purple bacteria (LH2s), which absorb longer wavelength light than that of plants, since the planets around M dwarfs will be the observational targets. We investigate how effectively the LH2 system absorbs light energies depending on stellar radiation using the quantum chemical calculations.

We evaluate the absorption efficiencies using an estimated spectrum of 19 LH2s at the top of the atmosphere (TOA) and the planetary surface (using radiation transfer calculations) of Earth-like planets. The LH2 has three major absorption bands, Soret, the Qx and the Qy bands with increasing wavelength. We found that Soret band contributes to the efficiency around the Sun because the band is just around the 4000 Å break both at TOA and the surface, while around M dwarfs the bands do not contribute anymore. Furthermore, to examine conditions which would enhance the efficiencies around M dwarfs, several possible factors are changed. As a result, the wavelength of absorption can shift about 120 nm longer in a 19 LH2 system whose central metal of the pigments is Pd than that with no metals.

*Speaker

sciencesconf.org:pathways2015:64359

Towards identifying biological processes with transit spectroscopy

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Abstract

Over the past decades transit spectroscopy has become one of the pioneering methods to characterise exoplanetary atmospheres. With the increasing number of observations, and the advent of new ground and spaced based instruments, it is now crucial to find the most optimal and objective methodologies to interpret these data, and understand the information content they convey. This is particularly true for smaller and fainter Earth like type planets, where atmospheric spectroscopy represents a unique way to detect biomarkers such as Ozone or the vegetation's red edge. In this conference we will present a new take on the spectral retrieval of transiting planets, with particular focus on super-Earth and Earth atmospheres, and the potential to detect biological processes. Using TauREx (Waldmann et al. 2015a,b.), a new line-by-line radiative transfer atmospheric retrieval framework for transmission and emission spectroscopy of exoplanetary atmospheres, we investigate the impact of signal to noise, spectral resolution and wavelength coverage on the retrievability of individual model parameters from transit spectra of exoplanets, and put our models to test (Rocchetto et al. 2015). For the first time, we analyse in a systematic way large grids of spectra generated for different observing scenarios. We perform thousands of retrievals aimed to fully map the degeneracies and understand the statistics of current exoplanetary retrieval models, in the limiting signal-to-noise regime of super-Earth and Earth observations. This work allows us to understand the fundamental observational thresholds required to constrain the properties of these foreign worlds, and to identify possible biological signatures.

*Speaker
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sciencesconf.org:pathways2015:66597

Circular polarization and the search for life signatures

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Abstract

Circular polarization (CP) is a robust life indicator because living organisms produce distinct CP signatures. However, and up to this point, the viability of using CP for remote life sensing has not received detailed and quantitative attention. In particular, there are no previous studies of the diluting effect that multiple scattering by clouds/haze will have on the life-associated CP signal. The problem is relevant to future life searches on exoplanets, but also to similar and probably earlier attempts to be made in the Solar System. In ongoing work, I am simulating the CP signal detected by a virtual instrument for various viewing (i.e. with spatial resolution or integrated over the planet disk) and Earth atmospheric (i.e. cloud/haze composition, optical thickness, etc.) conditions. As part of the same exercise, I am also revisiting the few existing CP measurements in the Solar System planets. The presentation will report the current status of the project.

*Speaker

sciencesconf.org:pathways2015:66616

Remote sensing of potential biosignatures from rocky, liquid or icy surfaces

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Abstract

The possibility to detect signs of life from remote celestial bodies is a major issue of exoplanetary observations. The characterization of atmospheric compositions may give clues on the presence of life via the detection of life-related gases. The characterization of the reflected light from surfaces could provide further evidence for the presence of life, via detection of photons which have directly interacted with surface material from live organisms. In order to provide indications on the nature of signals to expect from potential surface biosignatures, we performed a comparative study assessing the detectability of a pigmented microorganism (Deinococcus radiodurans) on diverse planetary surfaces, from minerals to liquid water, including water ice particles, representative of the diversity of habitable world's surfaces. We measured the visible to near infrared reflectance spectra and the visible phase curves of the mixtures to assess how the surface medium and the viewing geometry affect the detectability of the microorganisms. We show the favorability of water ice and we investigate the potential of glint over liquid surfaces for the detection of biopigments.

*Speaker

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sciencesconf.org:pathways2015:74871

Key Question 4 :

What can we learn
from solar system synergies ?

Oral presentations

The exploration of exoplanets: What can we learn from solar system synergies?

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Abstract

Most of the discovered exoplanets are "exotic" with regard to the Solar system, with characteristics that are very different from our own planets. Still, we can use the experience gained in the study of the solar system planets for trying to understand the physical nature of exoplanets. The properties of their atmospheres are, as in the case of the Solar system, constrained by a few parameters: their mass and radius, the stellar radiation flux (and thus the star's properties and its distance to the planet), the planet's ellipticity, its inclination, its rotation, the presence or absence of a magnetosphere... Under some simple hypotheses (thermochemical equilibrium and absence of migration), it is possible to make simple predictions about the nature of the exoplanet's atmospheric composition, on the basis of the planet's mass and its equilibrium temperature. The study of solar system planets also tells us which other mechanisms may lead to a departure from thermochemical equilibrium, in particular photochemistry and transport-induced quenching. The study of planetary spectra is a good starting point to try to understand the spectra of exoplanets that now become available through transit spectroscopy observations. From the spectral type of the hosting star and its distance to the exoplanet, one can estimate the spectral ranges where reflected/scattered stellar radiation and thermal emission dominate. In the thermal regime, the observation of a given molecule in different bands of different intensities may provide constraints on the vertical thermal profile and the vertical distribution of the molecule.

*Speaker

sciencesconf.org:pathways2015:71259

Extrasolar Cosmochemistry

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Abstract

Cosmochemistry within the solar system is mostly performed through analyzing the chemical compositions of meteorites, which can shed light upon the formation and evolution of the solar system. We have a program that uniquely measures the chemical compositions of extrasolar rocky objects, which brings us into a new area of extrasolar cosmochemistry. Specifically, we perform high-resolution spectroscopic observations on some white dwarfs, whose atmospheres were enriched with heavy elements by accreting from their own asteroids. Highlights of the field includes: (i) to zeroth order, the compositions of extrasolar planetesimals resemble rocky solar system objects. In almost all cases, O, Mg, Si and Fe make up more than 85% of the total mass. (ii) There is strong evidence that extrasolar asteroids have gone through additional processing, such as differentiation, collisions and meltings. Looking into the future, we have initiated a pilot search for evidence of Earth-analog plate tectonics in extrasolar planetesimals.

*Speaker

sciencesconf.org:pathways2015:66483

What can we learn from atmospheres of transiting low-mass exoplanets as a stepping-stone towards habitable planets ?

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Abstract

Transit observations with the Kepler space telescope revealed that planets smaller than Neptune are much more abundant than gas giants beyond our Solar System. The observed mass-radius relationships for such small planets are known to be diverse, which may mean that the amount of the atmospheric gas differs from planet to planet. Also, recent observational characterization of atmospheres of some transiting low-mass exoplanets suggests that the atmospheric composition is also diverse. Thus, understanding the diversity of atmospheres of transiting low-mass planets and their origins must be a key to predicting possible diversity of planets in habitable zones. In this paper, I will overview recent theories of the formation and evolution of planetary atmosphere. I will also discuss what we can learn from on-going and future observations for characterizing transiting planet atmospheres.

*Speaker

sciencesconf.org:pathways2015:66588

Key Question 4 :

What can we learn
from solar system synergies ?

Posters

Detection of the Tools and Ingredients of Water Delivery in the Terrestrial Zone of a Former A-type Star

Jay Farihi*[1]

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Abstract

I will discuss the identification of a warm circumstellar disk that resulted from the destruction of a water-rich and rocky extrasolar minor planet. The parent body formed and evolved around an early A-type star, and the debris now closely orbits the white dwarf remnant. The stellar atmosphere is polluted with metals accreted from the disk, including oxygen in excess of that expected for oxide minerals, indicating that the parent body was originally composed of 26% water by mass. The absence of detectable carbon indicates that the parent body of the debris was not an icy planetesimal analogous to comets, but was instead similar in overall composition to asteroids in the outer main belt of the Solar System.

There are additional, promising examples of large, water-bearing planetesimals originating in the terrestrial zones of their host stars, identified using this unconventional technique. Notably, these remnant planetary systems imply architectures similar to the Solar System, where a giant planet exterior to a snowline perturbs rocky asteroids on the interior. Thus, they appear to share basic characteristics with HR 8799, Vega, Fomalhaut, and epsilon Eridani where two disks of debris are separated by giant planet(s), with one belt inside the snow line. If such archictectures are as common as implied by polluted white dwarfs, then at least 30% of 1.2-3.0 Msun stars have both the tools and ingredentients for water delivery in their terrestrial planet zones.

*Speaker

sciencesconf.org:pathways2015:58622

Habitable Zones of Pre-Main-Sequence Stars

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[3]Institute for Pale Blue Dots – United States

Abstract

We calculate the pre-main-sequence habitable zone (HZ) for stars of spectral classes F–M. The spatial distributionof liquid water and its change during the pre-main-sequence phase of protoplanetary systems is important forunderstanding how planets become habitable. Such worlds are interesting targets for future missions because thecoolest stars could provide habitable conditions for up to 2.5 billion years post-accretion. Moreover, for a given startype, planetary systems aremore easily resolved because of higher pre-main-sequence stellar luminosities, resultingin larger planet–star separation for cool stars than is the case for the traditional main-sequence (MS) HZ. We useone-dimensional radiative–convective climate and stellar evolutionary models to calculate pre-main-sequence HZdistances for F1-M8 stellar types.We also show that accreting planets that are later located in the traditional MS HZorbiting stars cooler than a K5 (including the full range of M stars) receive stellar fluxes that exceed the runawaygreenhouse threshold, and thus may lose substantial amounts of water initially delivered to them. We predict thatM-star planets need to initially accrete more water than Earth did, or, alternatively, have additional water deliveredlater during the long pre-MS phase to remain habitable. Our findings are also consistent with recent claims that Venus lost its water during accretion.

*Speaker

sciencesconf.org:pathways2015:60557

Effects of clouds on reflection properties of hot Jupiters

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Abstract

Polarimetry is capable to directly detect reflected light from an exoplanetary atmosphere even if the planet is spatially unresolved from the star and does not transit it.
In this work we will present how polarimetric techniques are applied to characterize atmospheres of hot Jupiters that contain clouds.

Clouds represent the main opacity source in the atmosphere of an exoplanet. The presence of clouds and the chemical composition of the atmosphere can be studied with polarimetric methods which are independent of planet transits in front of their host stars. Various molecules (H2O, CO, CO2, CH4) in the atmosphere of hot Jupiters (the type of exoplanet that is similar to Jupiter but with higher surface temperatures due to a closer orbit to their parent star) were detected with differential spectroscopy. However, this method can only be applied to transiting planets.

Here, we present the theory to model molecular polarization due to scattering in selected molecular bands for a range of parameters of hot Jupiter atmospheres. We model various scenarios of different atmospheres with varying temperature/pressure profiles including clouds. We study how the polarization signal of the light reflected by the planet's atmosphere that contains cloud is changed due to scattering in molecular lines that are dominant in the atmospheres of hot Jupiters (e.g. WASP 19b) as dust or in the gas phase (such as H2O, OH, H2, CO, CO2, CH4, NH3, MgO, MgSiO3, Mg2SiO4, Al2O3).

This method represents a powerful tool for detecting molecules in exoplanets (and other objects) and shows how decoding polarimetric signals in a spectrum of an exoplanet can reveal its orbit, mass, and chemical composition.

*Speaker

sciencesconf.org:pathways2015:63341

Dust from impacts on exoplanets

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Abstract

We present preliminary result from our investigation of the possibility of detecting dust generated in an impact event on an exoplanet. Dust originating from an exoplanetary surface could potentially give information on its composition, habitability or even hint to the presence of life. Indeed, certain minerals or rocks (e.g. granite) have been suggested as biomarkers.

We first estimate the amount of escaping mass for different impact parameters (size and density of the impactor, size of the exoplanet, etc.). We then assess the collisional evolution of the resulting circumstellar debris belt with a simplified analytical model. Although an exoplanetary atmosphere would prevent dust from escaping, dust can be produced subsequently from mutual collisions of the larger debris. The timescale for the belt to attain its brightest state as well as the overall lifetime of the belt are estimated. The fractional luminosity of the belt is calculated and compared to background noise such as exozodiacal dust. Note: I can also present the project with a poster if a talk is not possible.

*Speaker

sciencesconf.org:pathways2015:64434

On the chemical composition in the formation of terrestrial planets.

María Paula Ronco[1], Amaury Thiabaud[2], Ulysse Marboeuf[2], Yann Alibert[2,3], Gonzalo De Elía[1], and Octavio Guilera*[1]

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[2]Physics Institute and Center for Space and Habitability, University of Bern – Switzerland
[3]Observatoire de Besancon – Observatoire de Besancon – France

Abstract

Most of the models of planet formation focus on the accretion and dynamical processes of the planets, neglecting their chemical composition. Here, we incorporate the condensation sequence of the different chemical elements in our semi-analytical model of planet formation. We apply our model to calculate the formation of a planetary system during its gaseous phase. The results of the semi-analytical model (distributions of embryos and planetesimals) are used as initial conditions to develope N-body simulations that compute the post-oligarchic formation of terrestrial-type planets. Our results show that, for a low-mass protoplanetary disk around a solar-type star, the chemical composition of the planets that remain in the habitable zone has similar characteristics to the chemical composition of the Earth.

*Speaker

sciencesconf.org:pathways2015:64520

Abundances of CNO in planet harbouring stars

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[2]Centro de Astrofísica da Universidade do Porto (CAUP) – Portugal

Abstract

CNO elements possible play the most important role in the formation and evolution of planets and their atmospheres. Surface CNO abundances of planet hosts stars are used by planet formation models as input parameters to study the evolution of these elements in planetary interiors and atmospheres. Obviously formation of organic life in the Universe is related to this issue in a most direct way. Nevertheless, we are still not able to obtain precise abundance measurements of these elements in the atmospheres of sun-like stars. There are serious concerns about the validity of several absorption lines of CNO as abundance indicators. The problem is not new.

It has been outlined and studied in metal poor stars since 1980s. Today we know that this issue is unsolved in solar type metal rich stars as well. Our group has undertaken a vigorous program to make a uniform and homogenous study of CNO in a large sample solar type stars with and without known planets using all available CNO abundance indicators between 3100 and 9000 A. We study atomic lines and molecular bands using standard 1D LTE models of atmospheres.

Recently we obtained precise N abundances from the near UV NH band 3360 A for a sample of 90 solar-type stars, from which 50 are known to harbour extrasolar planets. We are also studying abundance of C from the CH band at 4300 and several atomic lines. We will present our latest results and will outline a future work undertaken by our group.

*Speaker
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sciencesconf.org:pathways2015:64720

First spatially resolved image at 1.1 mm of the debris disc around the multi-planet hosting M dwarf Gliese 581

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Abstract

We have for the first time detected and spatially resolved the debris disc around Gliese (GJ) 581 at 1.1 mm using LMT/AzTEC small map observations. This is a remarkable M3 spectral type, old, X-ray quiet, long-term stable cool dwarf, which hosts the second ever resolved debris disc around an M dwarf and multiple planets, including the first exoplanet found in an habitable zone. Our resolved image proves the disc's structure, constrains its inclination to ~75 degrees, and provides the first ever determination of the sub-mm slope for a better characterisation of the disc's spectral energy distribution. These results have allowed us to significantly improve the GJ 581's disc's modeling, limiting the dust size distribution, which is key to investigate the dynamical and collisional state of this transport-dominated disc. We present a detailed analysis of the resolved structure, providing a spatial constraint on the location of the largest dust grains in the debris disc and the parent bodies producing them, and investigate the presence of as yet undetected exoplanet(s) stirring up the dusty debris disc. These findings are compared with those of the young AU Mic's debris disc (the other disc resolved around an M-dwarf), leading to our conclusions about the formation and evolution scenario of both systems, very different in age (12 Myr versus 2-8 Gyr). Our results are also relevant for a better understanding of the formation and evolution of the Solar system's Edgeworth-Kuiper belt, which is also a transport dominated system, but its low mass analogues around sun-like stars are generally too faint to be detected.

*Speaker

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sciencesconf.org:pathways2015:65661

Jupiter as an exoplanet: a sodium layer and stratospheric crystallized H2O ice in the transmission spectrum

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Abstract

Currently, the analysis of transmission spectra is the most successful technique to probe the chemical composition of exoplanet atmospheres. But the accuracy of these measurements is constrained by observational limitations and the diversity of possible atmospheric compositions. We have recently show the UV-VIS-IR transmission spectrum of Jupiter, as if it were a transiting exoplanet, obtained by observing one of its satellites, Ganymede, while passing through Jupiter's shadow – i.e., during a solar eclipse from Ganymede. The spectrum shows strong extinction due to the presence of clouds (aerosols) and haze in the atmosphere, and strong absorption features from CH$ 4$. More interestingly, the comparison with radiative transfer models revealed a Jupiter stratospheric layer of crystalline H$ 2$O ice. The atomic transition of Na is also present in these data, which allows an estimation of sodium contend. These results are relevant for the modeling and interpretation of giant transiting exoplanets. They also open a new technique to explore the atmospheric composition of the upper layers of Jupiter's atmosphere.

*Speaker
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sciencesconf.org:pathways2015:65699

Protostellar disk simulations including large-scale magnetic fields

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Abstract

Most protostellar disks are believed to have a large-scale magnetic field, which is inherited from the primordial cloud and amplified during pre-stellar collapse phase. These fields are collimated due to the accretion flow (to first order axisymmetric) towards the disk center.

The inclination angle of the magnetic field lines with respect to the disk mid plane is a crucial parameter in determining the efficiency of magneto-centrifugally accelerated winds launched from the disk. These winds probably affect (though it is not yet clear to what degree) the inner disk by removing both mass and angular momentum.

The determination of the inclination angle necessitates a dynamical description of the gas flow and the magnetic fields simultaneously, since winds launched from the disk bend the magnetic field and therefore cause a magnetic torque feedback on the disk.

Furthermore, in the outer parts of the disk, where photoevaporative winds are assumed to play the most crucial role in extracting mass and angular momentum from the disk, magnetic fields can nevertheless support the gas in overcoming the gravitational potential barrier and stream off as a photoevaporative wind.

Our scientific goal is the determination of the importance of the two wind driving mechanisms and their feedback on the disk in terms of angular momentum transport and final evaporation. To be able to simulate the whole disk lifetime of a few Myrs, we are using an implicit time-evolution scheme and concentrate on the most important physical processes.

The simulation covers the radial 1D radiation-hydrodynamic evolution of a gas disk employing a vertical hydrostatic equilibrium. The magnetic field and its feedback on the gas is included using an axisymmetric description.

*Speaker

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ATMOSPHERE IN A TEST TUBE

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Abstract

Space missions, as JWST and the very recently proposed ARIEL (ESA M-Class Mission) or ground based instruments like SPHERE@VLT, GPI@GEMINI and EPICS@ELT, have been proposed and built to measure the exoplanetary atmospheric transmission, reflection and emission spectra over a wide wavelength range. Exoplanets are unique objects in astronomy be-cause they have local counterparts—the Solar System planets—available for comparative planetology studies but also outsider case like Super Earths. In our own system, proto-planets evolution was flanked by an active prebiotic chemistry that brought to the emergency of life on the Earth. The search for life signature requires as first step the knowledge of planet atmospheres, main objective of future exoplanetary space explorations. The planet atmosphere characteristics and biosignatures will be inferred by studying such composite spectrum in order to identify the atmospheric molecules such as H2O, CO, CH4, NH3 etc. In particular, it is important to know in detail the optical characteristics of gases in the typical physical conditions of the planetary atmospheres and how those characteristics could be affected by radiation driven photochemical and bio-chemical reaction. Insights in this direction can be achieved from laboratory studies of simulated planetary atmosphere of different pressure and temperature conditions under the effects of radiation sources, used as proxies of different bands of the stellar emission. A number of Italian institutes gave life to a collaboration to perform laboratory experiments concerning extrasolar planet Atmospheres. In this paper we describe the scientific case, the net of institutes and their main activities that go under the name of "Atmosphere in a Test Tube".

*Speaker

sciencesconf.org:pathways2015:66372

The solar system planets as a paradigm for the search of exobiospheres

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Abstract

Over the past decades a large diversity in planetary systems, accompanied by a large diversity of planetary natures, have been discovered. Nevertheless, despite probable surprises, our knowledge of the solar system planets will be our guidance in the interpretation of the physical properties of extrasolar planet atmospheres. Thus, the solar system offers a unique playground to determine the best observables for such planet characterization. In the past few years, our group has performed observations aimed at retrieving the reflection and transmission spectrum of some of the solar systems planets. These observations include the transmission spectrum of Earth (via a lunar eclipse), the transmission spectrum of Venus (via the transit of Venus in 2012 observed from SOFI) and the transmission spectrum of Jupiter (via a Ganymedes eclipse). Together they have revealed a wealth of new information, such as the detectability of dimer bands (usable as tracers of atmospheric pressure) in earth-like planets, or the signatures of aerosols, hazes and metallic layers in giant planets. Here I am planning to offer a review of the observational setup of these observations, and what they have revealed about Earth, Venus and Jupiter.

*Speaker

sciencesconf.org:pathways2015:66417

Accumulation and evolution of primordial atmospheres around terrestrial planets

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Abstract

In the early, embedded phase of evolution of Earth-like planets, planetary cores can accumulate gas from the circumstellar disk into a planetary envelope. To study the interdependence of the atmospheric evolution and the cooling planetary core, we performed time-dependent radiation hydrodynamics simulations of the planetary envelope coupled to a simple model for the core temperature based on the internal energy budget of the planetary core. Our 1D-spherical symmetric atmosphere models range from the surface of the planetary core up to the Hill radius and include the hydrodynamics equations, gray radiative transport and convective energy transport. Planetary cores with masses between 0.1 and 5 Earth masses have been investigated.

The results for different core masses show a systematic pattern of evolution tracks, largely following the outline of a sequence of stationary models. The time scale of gas capturing and atmospheric growth depends on the mass of the solid core. The amount of atmosphere accumulated during the lifetime of the protoplanetary disk thus also varies with the mass of the planet. For sufficiently massive cores, this evolution can ultimately lead to runaway accretion and the formation of a gas planet.

In most studies of embedded planetary envelopes, a steady accretion flux of planetesimals is assumed to provide the luminosity required to construct stationary atmosphere models.For comparison, we therefore also included two equations describing the motion and erosion of infalling planetesimals through the atmosphere.Despite the uncertainty in frequency, size, and mechanical properties of the planetesimals, we conclude that the accretion of planetesimals is only of minor significance in our evolution scenario.

*Speaker

sciencesconf.org:pathways2015:66474

Stellar wind induced ENA heating as an additional power for thermal escape of outgassed volatiles from early terrestrial planets

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Abstract

In this study, we consider the atmospheric evolution of a terrestrial exoplanet that outgassed a dense steam atmosphere (H2O, CO2) after the solidification of its magma ocean that occurred within the first 100 Myr after the origin of the planet. The influence of different rotation rates and corresponding different XUV radiation levels and stellar winds of solar like stars are considered. The high EUV flux of the young host star dissociates the water molecules of the hot steam atmosphere so that the upper atmosphere is dominated by atomic hydrogen. Besides the stellar EUV radiation and its absorption in the upper atmosphere our study indicates that the additional heating due to the precipitation of energetic neutral atoms (ENAs) that are produced by charge exchange with the stellar wind interaction of the planets exosphere can significantly contribute to the energy budget of the atmosphere and enhance the atmospheric escape rate to values that in some cases the drag from the escaping hydrogen atoms is so strong that even CO2 molecules with a partial pressure of up to 100 bar can be lost during the saturation phase of the host star. Our results favor initial stellar conditions of slow rotating young stars for the evolution of Venus and Earth-like planetary atmospheres.

*Speaker

sciencesconf.org:pathways2015:66504

Hypothetical living forms on Venus

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Abstract

Keywords: Extraterrestrial life; Hypothetical Venus flora; Terramorphism; VENERA missions Hypothetical habitability of some of extrasolar planets is a fundamental question of science. Some of exoplanets possess physical conditions close to those of Venus. Therefore, the planet Venus, with its dense and hot (735 K) oxygen-free atmosphere of CO2, having a high pressure of 9.2 MPa at the surface, can be a natural laboratory for this kind of studies. The only existing data on the planet's surface are still the results obtained by the Soviet VENERA landers in the 1970s and 1980s. The TV experiments of Venera-9 and 10 (October, 1975) and Venera-13 and 14 (March, 1982) delivered 41 panoramas of Venus surface (or their fragments). There have not been any similar missions to Venus in the subsequent 39 and 32 years. In the absence of new landing missions to Venus, the VENERA panoramas have been re-processed. The results of these missions are studied anew. A dozen of relatively large objects, from a decimeter to half a meter in size, with an unusual morphology have been found which moved very slowly or changed slightly their shape. Their emergence by chance could hardly be explained by noise. Certain unusual findings that have similar structure were found in different areas of the planet. This paper presents the last results obtained of a search for hypothetical flora and fauna of Venus.

*Speaker

sciencesconf.org:pathways2015:66506

Decoding Lights from Exotic Worlds: the ExoLights and ExoMol projects

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Abstract

It is now accepted that exoplanets are ubiquitous. However we are still far from a hypothetical Hertzsprung–Russell diagram for planets and we do not even know whether there ever will be such classification for planets. The chemical composition of these planets is needed to trace back their formation history and evolution – as was the case for the Solar System – and understand the observed diversity. The ExoLights and ExoMol teams at UCL have been funded by the European Research Council to develop novel techniques for data analysis and interpretation of exoplanet atmospheres as well as new space mission concepts for exoplanet spectroscopy. In this presentation we will report the many progresses we made during the past year, which include new non parametric, machine-learning techniques to detrend more objectively exoplanet spectroscopic data, state of the art spectral retrieval algorithms, new calculated molecular line-lists of unprecedented precision and new dedicated space instruments.

*Speaker
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Characterizing the three-dimensional ozone distribution of a tidally locked Earth-like planet

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Abstract

We simulate the 3D ozone distribution of a tidally locked Earth-like exoplanet using the high-resolution, 3D chemistry-climate model CESM1(WACCM) to study how the ozone layer of a tidally locked Earth (TLE) (Omega_TLE = 1/365 days) differs from that of our present day Earth (PDE) (Omega_PDE= 1/1 day). The middle atmosphere reaches a steady state within 70ˆth days. In the mesosphere, the global ozone distributions for the TLE and the PDE are quite similar with decreased ozone present on the day side and enhanced ozone on the night side. Due to the short lifetime (< 1 hour) of odd oxygen in the mesosphere, the transport processes of odd oxygen can be neglected and therefore the ozone distribution mainly depends on the photochemistry. In the middle stratosphere due to the longer lifetime of odd oxygen (˜16 hours), the transport processes of odd oxygen depend on the Coriolis force which is weaker by a factor of 365 for the TLE compared to the PDE. In the PDE's stratosphere enhanced ozone is present at low latitudes with small differences between the daytime and night-time and the Coriolis force acts as a mixing barrier between tropical and extra-tropical air masses. In the TLE, we find high ozone values on the stratospheric day side and a good mixing between tropical and extratropical air masses. The total ozone column density global and hemisphere mean is reduced by ˜10% compared to the PDE and is therefore not critical for observations performed with our existing telescopes and data analysis methods.

*Speaker

sciencesconf.org:pathways2015:72000

Discs and stable orbits around the planet-hosting triple star 94 Ceti

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Abstract

Debris discs are sign posts of planetary formation and provide important insights in the configurations and evolution of planetary systems. These are observed through the detection of excess emission at far-infrared wavelengths, attribution and interpretation of the measured excess is complicated by potential contamination from e.g. background galaxies or galactic cirrus.

94 Ceti is a triple star system hosting a circumprimary gas giant and was part of the Herschel (Pilbratt et al. 2010) key project DUNES (DUst around NEarby Stars, Eiroa et al. 2013). It was primarily observed at 100 and 160 micrometers, and we add here additional observations using APEX-LABOCA (the Atacama Pathfinder EXperiment) at 870 micrometers.

DUNES detected an 15 sigma excess at 100 micrometers. However, the background is confusing and the inferred dust temperature would not correspond with stable orbits. Further modelling was required. With detailed modelling and radiative transfer simulations we find dynamically stable discs and evidence for a circumbinary dust disc around the two secondary stars that would fit the observations. We also investigated the possibility that some of the confusing background is due to a circumtertiary ring, however, the evidence is inconclusive and we only set an upper limit.

*Speaker

sciencesconf.org:pathways2015:74153

Key Question 5 :

How do we build synergies between ground and space ?

Oral presentations

Detection and characterization of exoplanets: possible synergies between ground and space based approaches

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Abstract

I will review possible synergies and complementarities between ground-based and space-based approaches to detect and characterize exoplanets.

*Speaker

sciencesconf.org:pathways2015:74541

The Hunt for Planets in Open Clusters with HARPS and HARPS-N

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Abstract

Thousands of extrasolar planets have been discovered so far, and after the pioneer era, when the discovery of a single planet was a notable event, the interest is moving to the more complex work of planet and planetary system taxonomy, trying to put some order and eventually understand why they are so different from each others. The characterization of planets is tied to the knowledge of their host stars. Nearly all planets known so far however belong to isolated field stars, and their mass and radius are affected by large errors that transfer directly onto the precision of the planet parameters. On the contrary, distances, ages, mass and overall characteristics of stars in Open Clusters are much better measured than for field stars. OC stars are chemically homogeneous, so we can effectively investigate the effect of the presence of a planetary systems on the host star chemistry, e.g. if the observed trend of chemical elements with respect to their condensation temperature is effectively related to the presence planets. Curiously, at the present time, only less than ten planets have been confirmed or validated around Main Sequence stars in OCs. In this proposed talk I will give a short historical review on previous searches for exoplanets in OCs, then I will introduce our on-going survey aimed at detecting Neptune-mass planets around close, intermediate-age OC stars with HARPS (8 night/year) and HARPS-N (5 nights/semester, within the GAPS program). I will discuss our observational strategy and how we are dealing with activity, the main limiting factor in this kind of research, and the impact of the forth-coming K2 observations on our search. I will finally present our latest discoveries, including the first planetary multiple system around a OC star.

*Speaker

sciencesconf.org:pathways2015:66634

Exoplanets mass measurement using gravitational microlensing

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Abstract

Galactic gravitational microlensing is a very efficient technique to detect brown dwarfs and extrasolar planets at large orbital distances from their stars, and down to Earth-mass planets. The exoplanets discovered are beyond the snow line and typically close to the habitable zone of their host stars. I will present the specificity of the microlensing method to detect exoplanets, discuss the detections made so far, and present the different methods to constrain the mass of the lens hosting a planet. Finally, I will describe how can interferometry lead to an independent mass determining through the measurement of the lens Einstein radius.

*Speaker

sciencesconf.org:pathways2015:66490

Blazing the Trail: Resolving Terrestrial Planets with ELTs?

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Abstract

A picture is worth a thousand words (but a spectrum is worth a million).
We explore the potential of the next generation ELTs for discovery and characterization of (potentially habitable) terrestrial planets around a small sample of the very nearest stars. Very high spatial resolution imaging
of the thermal emission of planetary bodies with radius > 1 R_earth is possible potentially in the habitable zone (under very demanding performance requirements). Using complementary techniques requiring very high spectral resolution, one can characterize the atmospheres of such bodies. Finally, with differential polarization imaging techniques, one can also study these objects in reflected light. It is likely that the first direct detection of a terrestrial planet around a nearby star will be done with ground-based ELTs before the end of the next decade. However, in order to study a large enough sample of terrestrial planets in the habitable zone around Sun-like stars to enable establishing the mean (and dispersion) of their properties, one must be able to extend the sample beyond 10 pc. That requires a) resolution corresponding to l/D < 4 x 10-9 with wavefront control and stability enabling very high contrast at 10l/D; b) sensitivity greater than can be achieved with currently envisioned ground-based telescopes < 40 meters diameter; and c) access to broad wavelength coverage at modest resolution for full characterization. These requirements define the parameters of space-based platforms with baselines of > 300 meters at 10 mm and diameters > 8 meters for 0.3 microns.

*Speaker

sciencesconf.org:pathways2015:66390

Key Question 5 :

How do we build synergies between ground and space ?

Posters

Line Profile Variations of Solar Analog Stars: Chromospheric Indexes vs. Li Abundance. The Host Star Search - Extending the sample

Eliana Amazo-Gomez*[1], J. D. Alvarado-Gómez†[2], Klaus Strassmeier[3], and Thomas Preibisch

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Abstract

PolarBase contains stellar spectropolarimetric data collected with the NARVAL and ESPaDOnS instruments, (Petit et al. 2014). Their respective spectral resolutions are 65.000 and 68.000, in spectropolarimetric mode. As the first part of this work, we use the NARVAL spectropolarimetric repositories. We selected spectra from a sample of cool stars with effective Temperature (T_eff) ranging between 4900 to 6000 K. This sample contains stellar systems with and without reported exoplanets. We exploit the full wavelength range from 380 to 900 nm in order to obtain chromospheric indexes such as the Ca ii H&K S-Index, and a Ca ii IRT and Halpha index. We calibrated our measurements using the Mount Wilson S-Index values. Furthermore, we employ lithium (Li) abundance measurements from the literature (Gonzalez, et al. 2010, Delgado Mena, et al. 2014, Israelian, et al. 2004), investigating in this way a possible correlation between the chromospheric activity measurements and the Li abundance in 52 selected cool stars.

*Speaker
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sciencesconf.org:pathways2015:62060

Transmission photometry to study hot-Jupiter atmospheres

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Abstract

Photometric multi-band observations of planetary transits events allow us to probe the chemical composition of the atmosphere of transiting exoplanets in a way similar to transmission spectroscopy. The idea is to simultaneously observe planetary transits through different filters, each covering a different region of the electromagnetic spectrum, and measure a possible variation of the planet radius as a function of the wavelength. Thanks to differential photometry, this technique is much less affected by variations in telluric transparency than single-slit transmission spectroscopy performed by the ground. Another advantage is the possibility to study the atmosphere of exoplanets orbiting faint stars, whereas transmission spectroscopy is a technique limited to bright stars and requires high-resolution cryogenic spectrographs on large-aperture telescopes. I will present our recent results concerning the study of the atmosphere of several hot Jupiters with the GROND multi-imaging camera.

*Speaker

sciencesconf.org:pathways2015:64145

CARMENES: first light next month

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Abstract

CARMENES stands for "Calar Alto high-Resolution search for M dwarfs with Exoearths with Near-infrared and optical Échelle Spectrographs". It is a new instrument built by a consortium of German and Spanish institutions, which will see its first light in September 2015. With a wide wavelength coverage from 550 to 1700 nm at R=82000, an appropriate thermo-mechanical stability and state-of-the-art wavelength calibration, CARMENES at the 3.5 m Calar Alto telescope is especially designed for detecting Earth-like planets in the habitable zone around mid- and late-type M dwarfs. I will present a brief review of the instrument and science project, and of the current status after the assembly, integration and verification phase and just before commissioning.

*Speaker

sciencesconf.org:pathways2015:64337

A needed step to discover other Earths: understanding the stellar activity impact on radial-velocity measurements - HARPS-Pol observations of the solar-type star HD209100

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Abstract

The appearance and variability of spots and plage faculae, which is an outcome of stellar activity, result in radial-velocity signals that have an amplitude that is typically an order of magnitude higher than the gravitational perturbations induced by Earth-like planets orbiting far from their host stars.
We monitored with HARPS-Pol a K-dwarf, HD209100, that show an activity similar to the Sun, to understand simultaneously in spectropolarimetry and radial-velocity the behaviour of stellar activity on a rotational period timescale. The obtained measurements give us an unprecedented global picture of the activity of a solar-like star, and help us to understand with a high-accuracy the impact of the stellar activity on radial-velocity measurements.
This improved knowledge allow us to derive better efficient ways of correcting stellar activity signals, and thus enable the detection of Earth-like planets orbiting far from their host stars.

*Speaker

sciencesconf.org:pathways2015:65861

Korea Microlensing Telescope Network

Chung-Uk Lee*[1,2], Seung-Lee Kim[1,2], Sang-Mok Cha[1], Yongseok Lee[1], Dong-Jin Kim[1], Byeong-Gon Park[1,2], Dong-Joo Lee[1], Jae-Rim Koo[1], Kyeongsoo Hong[1], Jae Woo Lee[1,2], Yoon-Hyun Ryu[1], Beomdu Lim[1], Jin-Sun Lim[1], Seung-Won Gho[1], and Min-Jun Kim[1]

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Abstract

Korea Astronomy and Space Science Institute (KASI) have installed three identical 1.6-m telescopes at three observatories - CTIO, SSO and SAAO in southern hemisphere. The 18k x 18k CCD camera of the Korea Microlensing Telescope Network (KMTNet) covers 2 x 2 deg field of view with the plate scale of 0.4 arcsec/pixel. Since three telescopes are installed at three observatories where are well spaced in longitudinally at southern hemisphere, uninterupted 24-hour monitoring observation is available. The optical system of the telescope consists of a parabolic mirror and four spherical field flattening lenses which form a prime focus at the top of the telescope. The structural design and driving system of the telescope are succeeded from the design of the 2MASS telescope. The filter-shutter assembly which has a sliding shutter and four 310-mm square filters located between two lenses L3 and L4. Each observation system produces a 680MB size image file at site and the images are transfered to KASI data center using the Global Ring Network for Advanced Application Development (GLORIAD) network with the band width of 50Mbps in average at three observatories. The main science goal of the KMTNet is to discover Earth like extrasolar planet using the microlensing technique during bulge season, and 50% of the total observation time is solely allocated for the science program only. From the test observation, we verify that the most important two requirements are satisfied: 10 arcsec in RMS for the pointing accuracy and 1 arcsec of delivered image quality in I-band. We introduce finally installed system at each observatory and its observational performance obtained from the test observation.

*Speaker

sciencesconf.org:pathways2015:66117

Optical ground-based transmission spectroscopy with VLT+FORS2

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Abstract

In the past few years, the study of exoplanets has evolved from being pure discovery, then being more exploratory in nature and finally becoming very quantitative. In particular, transmission spectroscopy now allows the study of exoplanetary atmospheres. Such studies rely heavily on space-based or large ground-based facilities, because one needs to perform time-resolved, high signal-to-noise spectroscopy. The very recent exchange of the prisms of the FORS2 atmospheric diffraction corrector on ESO's Very Large Telescope should allow us to reach higher data quality than was ever possible before. With FORS2, we have obtained the first optical ground-based transmission spectrum of WASP-19b, with 20 nm resolution in the 550–830 nm range. For this planet, the data set represents the highest resolution transmission spectrum obtained to date. I will present our results, which show large unexplained deviations from planetary atmospheric models in the transmission spectrum redwards of 790 nm, indicating either additional sources of opacity not included in the current atmospheric models for WASP-19b or additional, unexplored sources of systematics. I will highlight our detailed analysis of the systematics present in the data and the careful estimation of planetary parameter determination.

*Speaker

sciencesconf.org:pathways2015:66283

ACCESS: The Arizona-CfA-Catolica Exoplanet Spectroscopy Survey

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Abstract

ACCESS (The Arizona-CfA-Catolica Exoplanet Spectroscopy Survey) is a collaboration between members of the Harvard-Smithsonian Center for Astrophysics, the University of Arizona, and the Pontifícia Universidad Católica in Chile to generate the first uniform observationalset of ~ 0.4 – 0.95 m transmission spectra of exoplanets, from hot Jupiters to super-Earths. The goals of ACCESS are 1) to answer outstanding key questions about exoplanetary atmospheres, 2) to contribute to the improvement of exoplanet atmosphere models, and 3) to refine ground-based exoplanet atmospheres characterization techniques in anticipation of the TESS era. In this contribution we will describe ACCESS in detail and will present its first results. The ACCESS collaboration also includes members from the STScI, UC Santa Cruz, and the Carnegie Institution for Science.

*Speaker

sciencesconf.org:pathways2015:66478

HARPS-N M-dwarf RV Program: A super Earth orbiting a nearby M-Dwarf

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Abstract

We present the detection of a ~4 Earth-Masses super Earth orbiting a nearby M-Dwarf, on a ~11 days orbit, using data from the HARPS-N M-dwarf RV Program, a collaboration between the IAC, IEEC and the GAPS Consortium aimed to search for terrestrial planets in the habitable zone of M-dwarfs. During the last 2.5 years this project has accumulated more than 3000 high resolution spectra using the ultra-stable HARPS-N spectrograph at the 3.5m TNG (ORM, La Palma), finding several of interesting planet candidates ranging from 4 to 12 Earth-Masses. Individual radial velocity measurements are obtained with a precision ranging from 2 m/s to better than 1 m/s. From the spectroscopic series we study the time variation of the chromospheric activity indicators Ca II H&K and Halpha determining the rotation period of the star and its long term magnetic behaviour and disentangle activity induced radial velocity variations from those caused by the planetary companion.

*Speaker
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Transmission spectroscopy observations of Qatar-1b with GTC/OSIRIS

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Abstract

We present spectroscopic observation during a transit of the Qatar-1b exoplanet using the OSIRIS instrument at GTC. This observation allows us to probe the atmospheric composition of the exoplanet in the 5500-9000 angstrom wavelength range. Up to 24 different wavelength regions are used to build color light curves with per point dispersion of less than 1-mmag. These are used to measure the wavelength dependent relative size of the exoplanet obtaining precisions of about 2% on each wavelength bin. We present the final transmission spectrum and discuss the limiting noise sources. In addition, we have obtained a high quality white light curve with a residual dispersion of only 400 ppm per minute. With this light curve we have improved the orbital and physical parameters of the system.

*Speaker

sciencesconf.org:pathways2015:66521

Measuring masses of planetary systems discovered by microlensing thanks to adaptative optics observations

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Abstract

Ground based microlensing mostly probes the unique niche of exoplanets outside the snow line down to Earth masses. The star and planet parameters are extracted after a complex modeling procedure of light curve data collected by a worldwide network of telescopes. Nevertheless, additional high angular resolution can greatly improve our knowledge of the systems, by confirming the models, and/or giving additional constraints to refine their properties. First, in most cases it is possible to detect and study (or to put upper limits on) the host lens stars with Adaptive Optics observations on 8m class telescopes or using HST. A complete understanding of the physical properties of the microlensing systems is possible when the source and the lens are separated enough (50+ mas) on adaptive optics images. Indeed this enables both the measurements of the lens flux and the amplitude and direction of the relative lens-source proper motion. This provides the lens mass and distance unambiguously. Using KECK and HST, we clearly resolved the lens and the source for the microlensing event OGLE-2005-BLG-169, harboring a Neptune-like planet detected in 2005. This is the first case where source and lens of a planetary microlensing events are resolved and the amplitude and direction of the proper motion are measured. We confirm the original discovery (Gould et al. (2006), and then we refine the properties of the system (Batista et al. 2015, Bennett et al., 2015). This is a new opportunity to refine the physical parameters of the planets discovered by microlensing, bringing down the uncertainties of the parameter of the system below 10 %. EUCLID and WFIRST microlensing programs which will do such measurements in a routine way for a large number of their detected systems.

*Speaker

sciencesconf.org:pathways2015:66691

What the NASA Exoplanet Science Institute Can Do For You

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Abstract

The NASA Exoplanet Science Institute (NExScI) is a key portal for the astronomical community involved in NASA's exoplanet scientific endeavors. Specifically, NExScI administers NASA's portion of time on the Keck telescopes; develops and operates the NASA Exoplanet Archive; administers the Sagan Postdoctoral Fellowship Program and runs the Sagan Summer Workshop; supports community exoplanet related workshops and meetings; supports the Large Binocular Telescope Interferometer (LBTI) and the Keck Observatory Archive, as well as additional projects in the Exoplanet Exploration Program. Here, I describe the opportunities available to you and the exoplanet community made available through the NASA Exoplanet Science Institute. http://nexsci.caltech.edu/

*Speaker

sciencesconf.org:pathways2015:66761

Probing exoplanet atmospheres through their Rayleigh scattering signatures

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Abstract

Low-resolution transit spectroscopy of the handful of small exoplanets suitable for such observations has until now mostly resulted in flat, featureless infrared spectra, indicative of high-altitude hazes or clouds. This makes it difficult to constrain the properties of these planets' atmospheres. However, transmission spectra obtained blueward of 1 micron may reveal a Rayleigh scattering signature which can then be used to determine the atmospheric scale height and composition, even in the presence of hazes or clouds that may obscure features at longer wavelengths. We present new LCOGT multi-band photometry acquired during several transits of GJ 3470b, a warm, Neptune-size planet orbiting a nearby M dwarf star. The resulting transmission spectrum clearly shows a strong Rayleigh scattering slope. Our analysis indicates that a hydrogen-dominated atmosphere with clouds is the best fit to these data. We use our measurement of the Rayleigh scattering slope to constrain the atmospheric scale height, and thus the mean molecular weight of GJ 3470b's atmosphere. We give a brief overview of the status of our ongoing Hubble Space Telescope transmission spectroscopy campaign for this planet, aiming to better characterize its atmosphere through the visible and near-IR wavelength regimes, and we show preliminary results. We discuss future prospects for using short-wavelength observations to reveal the atmospheric properties of exoplanets, even when spectral features at longer wavelengths are obscured by clouds or hazes. This is particularly relevant for exoplanets in the habitable zone because their relatively low temperatures mean that species that would exist in vapor form on hotter planets are now likely to condense into clouds.

*Speaker

sciencesconf.org:pathways2015:66781

High-resolution transmission spectroscopy of exoplanets with the ground-based instruments

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Abstract

We will present a novel approach to analysis of high-resolution spectroscopic data of transiting systems. This appoach, based on inverse problem solution, is capable of keeping the resolution of the recovered planetary atmosphere spectrum without the need to have a model for the exoatmosphere. It also naturally combining data from different transits using the orbital velocity of the Earth to "look between" the telluric absorption lines. We will show the results of numerical simulations, the first applicatons to the real data and discuss the data requirements imposed by this techniques.

*Speaker

sciencesconf.org:pathways2015:73927

Key Question 6 :

What can we expect
from approved projects ?

Oral presentations

Towards the detection of nearby exoEarths

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Abstract

The discovery of an habitable planet orbiting a nearby star is the most exiting challenge of the next decades. An arsenal of new telescopes and instruments will be devoted to this quest. From space or the ground, using high-resolution spectroscopy or high-precision photometry, in the optical or near-infrared, all techniques are being explored. I will review the main projects currently in preparation that will have the capability to discover nearby exoEarths. I will also discuss the limitations they will encoutered in the unambigious detection of such planets. Finally, I will draw my conclusions about what are the most important aspects that need to be solved in the next years to allow the exploration of habitable planets.

*Speaker

sciencesconf.org:pathways2015:74003

CHEOPS: towards exoplanet characterization

Andrea Fortier*[1], Thomas Beck , Willy Benz , Chrsitopher Broeg , Virginie Cessa , David Ehrenreich , Roland Ottensamer , Isabella Pagano , Gisbert Peter , Jean-Yves Plesseria , Roberto Ragazzoni , Francesco Ratti , Manfred Steller , and Janos Szòke

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Abstract

The CHaracterising ExOPlanet Satellite (CHEOPS) is a joint ESA-Switzerland space mission dedicated to search for exoplanet transits by means of ultra-high precision photometry. It is expected to be launch-ready at the end of 2017.
CHEOPS will be the first space observatory dedicated to search for transits on bright stars already known to host planets. It will have access to more than 70% of the sky. This will provide the unique capability of determining accurate radii for planets for which the mass has already been estimated from ground-based spectroscopic surveys and for new planets discovered by the next generation ground-based transits surveys (Neptune-size and smaller). The measurement of the radius of a planet from its transit combined with the determination of its mass through radial velocity techniques gives the bulk density of the planet, which provides direct insights into the structure and/or composition of the body. In order to meet the scientific objectives, a number of requirements have been derived that drive the design of CHEOPS. For the detection of Earth and super-Earth planets orbiting G5 dwarf stars with V-band magnitudes in the range 6 V 9 mag, a photometric precision of 20 ppm in 6 hours of integration time must be reached. This time corresponds to the transit duration of a planet with a revolution period of 50 days. In the case of Neptune-size planets orbiting K-type dwarf with magnitudes as faint as V=12 mag, a photometric precision of 85 ppm in 3 hours of integration time must be reached.
The CHEOPS mission payload consists of only one instrument, a space telescope of 30 cm clear aperture, which has a single CCD focal plane detector. The total required duration of the CHEOPS mission is estimated to be 3.5 years (goal: 5 years).

*Speaker

sciencesconf.org:pathways2015:65150

The PLATO 2.0 Mission

Mareike Godolt*[1], Heike Rauer†[2,1], and And The Plato Consortium

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Abstract

The PLATO Mission has been selected for ESA's M3 launch opportunity. PLATO will discover and bulk characterise extrasolar planets around hundreds of thousands of stars. With launch foreseen in early 2024, PLATO will follow the very successful space missions CoRoT and Kepler, as well as ESA's first small mission CHEOPS and NASA's mission TESS. PLATO will carry out high-precision, long-term photometric and astroseismic monitoring of up to a million of stars covering over 50% of the sky, and significantly increase the number of characterized small planets around bright stars in comparison to the previous missions. Its exquisite sensitivity will ensure that it detects hundreds of small planets at intermediate distances, up to the habitable zone around solar-like stars. PLATO will characterize planets for their radius, mass, and age. It will provide the first large-scale catalogue of well-characterized small planets at intermediate orbital periods, relevant for a meaningful comparison to planet formation theories and providing targets for future atmosphere spectroscopy. This data base of bulk characterized small planets will provide a solid basis to put the Solar System into a wider context and allow for comparative exo-planetology.

*Speaker
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sciencesconf.org:pathways2015:71594

Exoplanetary System Reconnaissance with LBTI: Warm Dust and Giant Planets

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Abstract

Emission from zodiacal dust disks in other planetary systems, is both a noise source for future exoplanet imaging missions and a signpost of rocky material in, or near, the habitable zone. The LBT Interferometer has been designed to discover and characterize faint exozodiacal dust around nearby stars. I will summarize what we currently know about this dust and what we aim to learn with the LBTI's survey, the Hunt for Observable Signatures of Terrestrial Planets (HOSTS), along with its companion survey, LEECH, designed to identify wide-orbit giant planets a similar sample of stars. As an example of this, I will discuss the characterization the beta Leo system with both HOSTS and LEECH.

*Speaker

sciencesconf.org:pathways2015:66496

The James Webb Space Telescope: Capabilities for Transiting Exoplanet Observations

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Abstract

The James Webb Space Telescope (JWST) is a large aperture, infrared telescope planned for launch in 2018. JWST is a facility observatory that will address a broad range of science goals covering four major themes: First light and Re-Ionization, the Assembly of Galaxies, the Birth of Stars and Protoplanetary Systems, and Planetary Systems and the Origins of Life. With a 6.5 meter diameter mirror it will be the largest space telescope ever flown, and is the first cryogenic telescope to incorporate passive cooling, achieved by means of a large sunshade, to reach its -40 K operating temperature. I will present an overview of the observatory design, highlighting recent progress towards integration and testing. In the context of testing, I will discuss the predicted performance of the observatory, including image quality, stray light and stability. JWST offers a wide range of instrumental capabilities for observations of transiting exoplanets. I will summarize these capabilities, including wavelength coverage, bright limits, instrumental strengths (which mode to use) and show simulated performance. A key issue that bears upon transiting exoplanet observations are operational constraints. I will review JWST's operational constraints and the role they play in designing transit observation programs such as full phase curve spectroscopy. Finally, I will address the planned deployment and commissioning activities for the observatory, including observations designed to baseline the performance of exoplanet observational capabilities.

*Speaker

sciencesconf.org:pathways2015:66278

Characterization of exoplanet atmospheres with the JWST MIRI instrument

Pierre-Olivier Lagage[*][†][1] and Miri Team

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Abstract

The next large facility with the potential to characterize the atmosphere of exoplanets will be the James Webb Space Telescope (JWST), a 6.5 m telescope to be launched in 2018. The JWST will be equipped with four instruments; three in the near InfaRed (1-5 microns): NIRCAM, NIRSPEC and NIRISS, and one in the mid-InfraRed (5-28 microns): MIRI. MIRI is of particular interest to characterize temperate exoplanets; it includes an imager with three observing modes: imagery, coronagraphy and low resolution (R=100) spectroscopy, and an Integral Field Spectrometer with a spectral resolution around 3000. I will discuss the capabilities of the instrument to characterize exoplanets, showing simulations of transit observations, as well as direct imaging observations, which include instrumental test results. It should be stressed that the JWST is not dedicated to exoplanets and we can expect a large pressure on the observing time.

[*]Speaker

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sciencesconf.org:pathways2015:66514

How stellar activity affects exoplanet's parameters estimation and exoplanet's atmosphere characterization

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Abstract

Stellar activity features such as spots and plages can create complications in determining planetary parameters through spectroscopic and photometric observations. The overlap of a transiting planet and stellar spots/plages can produce anomalies in the transit light-curves that may lead to inaccurate estimation of the transit duration, depth and timing. We found that spot anomalies can lead to the transit duration be 4%, overestimated or underestimated, which can affect the planet orbital inclination estimation. The anomalies can also produce transit timing variations (TTV) with significant amplitudes of 200 seconds. Such a large TTV is similar to that induced by an Earth-mass planet on a transiting Jupiter in a three-day orbit. The transmission spectroscopy method, which is based on the measurements of the variations of planet-to-star radius ratio as a function of wavelength, is a powerful technique to study the atmospheric properties of transiting planets. Results of our simulations indicated that transit anomalies can lead to a significant underestimation or overestimation of the planet-to-star radius ratio as a function of wavelength. At short wavelengths, the effect can reach to difference of up to 10% in the planet-to-star radius ratio, mimicking the signature of Rayleigh scattering in the planetary atmosphere. Application of our calculations to HD 189733b and GJ 3470b transmission spectroscopy measurements and especially the reported excess in their planet-to-star radius ratio in the bluer part of the spectra, which were interpreted as the signature of blue sky, can exactly be reproduced by assuming that the planet occults a plage on the surface of these stars.

*Speaker

sciencesconf.org:pathways2015:66231

Key Question 6 :

What can we expect
from approved projects ?

Posters

TTV signals of terrestrial Trojan planets

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Abstract

In the quest for new exoplanets, Trojan planets are promising candidates also in case of habitable planets. The habitable zone is defined as a region around a star, where the radiation for an earh-like planet is such that the planet can maintain liquid water on the surface and a stable atmosphere. In the case when a giant planet itself moves in the HZ, a Trojan-like terrestrial planet may move in a stable orbit around the Lagrangian equilibrium points L4 or L5 as shown in the Figure (e.g. the Trojan asteroids in the Solar system).

Our work is dedicated to the dynamics and the theory of observations of Trojan planets. With the help of stability studies we want to identify regions in the orbital parameter space where possible Trojan planets can have stable orbits and may be observed. This will be realized via investigations of transit timing variations (TTV). With the TTVs we will show whether it is possible to detect planet induced perturbations in the transit signal of giant planet or a brown dwarf.

*Speaker

sciencesconf.org:pathways2015:52029

Characterising early-M dwarfs from high-resolution optical spectra

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Abstract

The discovery and characterisation of small, rocky planets with the potential capability of hosting life is one of the major scientific endeavours of modern Science. While most of the planets discovered so far have been found orbiting around solar-type stars, low-mass stars have recently been recognised as a "shortcut" to glance into an exo-life laboratory. The radial velocity searches currently ongoing with HARPS at La Silla and HARPS-N at the Telescopio Nazionale Galileo are producing a large quantity of high-resolution and high signal-to-noise ratio spectra of the targets that are being monitored. In this contribution we present empirical relationships to determine stellar parameters for early-M dwarfs (spectral types M0-M4.5) using the same spectra that are used for the radial velocity determinations. Our methodology consists in the use of ratios of pseudo-equivalent widths of spectral features as a temperature diagnostic. Stars with effective temperatures obtained from interferometric estimates of their radii are used as calibrators. Empirical calibrations for the spectral type are also provided. Combinations of features and ratios of features are used to derive calibrations for the stellar metallicity. We provide our own empirical calibrations for stellar mass, radius, and surface gravity.

*Speaker

sciencesconf.org:pathways2015:63547

New view on exoplanet transits: describing the granulation pattern with three-dimensional hydrodynamical simulations of stellar convection

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Abstract

A potential complication to planet detection technique is caused by stellar surface inhomogeneities (due to the presence of stellar granulation, magnetic spots, dust, etc.) of the host star.
Large efforts have been made in recent decades to use theoretical modelling of stellar atmospheres to solve multidimensional radiative hydrodynamic (RHD) equations in which convection emerges naturally. These simulations take surface inhomogeneities into account (e.g., granulation pattern) and velocity fields and are used to predict reliable observables.
3D RHD grid of simulations cover a substantial portion of the Hertzsprung-Russell diagram, including the evolutionary phases from the main sequence over the turnoff up to the red giant branch for low-mass stars.
Modeling the transit light curves implies the importance to have a good representation of the background stellar disk. I will present how the RHD simulations are used to model the temporal fluctuations of the granulation pattern for different kind of stars and how this affect the depth, the ingress/egress causing fluctuations that have to be considered as an intrinsic incertitude, due to the stellar variability, on precise measurements of exoplanet transits of planets with small diameters. In this context, 3D RHD simulations are essential for a detailed quantitative analysis of the transits.
In this context, 3D RHD simulations are essential for a detailed quantitative analysis of the transits. - Comments:
Two recent references to this work:
1) Chiavassa, Pere, Faurobert et al. 2015, A&A, 576, A13
2) Chiavassa, Ligi, Magic et al. 2014, A&A, 567, A115

*Speaker

sciencesconf.org:pathways2015:63905

Precise activity measurements from high-resolution spectra

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Abstract

Discovering Earth-like exoplanets using the radial velocity (RV) technique is being challenged by stellar activity. Only by understanding the variable signals imposed by the star itself will we be able to find the underlying planetary signals. Activity indicators, such as the FWHM of the spectral lines and the Ca II H&K emission, are already being used to understand the stellar variations. However, the high-resolution spectra that we have from the RV searches contain much more information.
In this talk I will explain about our work on extracting precise RV's simultaneously with information on the stellar magnetic field strength. We apply this new technique to the high-resolution spectra timeseries taken with HARPS-N in order to discover Earth-like planets around solar-type stars.

*Speaker

sciencesconf.org:pathways2015:64004

Magnetic Fields and Circumstellar Environment around Planet-Hosting Stars

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Abstract

Recent developments in instrumentation and observational techniques have opened a new window for stellar magnetic field studies. In particular Zeeman Doppler imaging (ZDI) techniques are now routinely used to recover the large scale magnetic field topologies of stars different from the Sun, including several planet-hosting stars.

These stellar magnetic fields in turn intimately affect the environment around late-type stars. This is observed in the form of transient events such as flares and coronal mass ejections, and the development of stellar winds and astrospheres. These elements can have a strong impact in the evolution of planetary systems via star-planet interactions and erosion of exoplanetary atmospheres driven by the stellar wind. In this context, the initial results from ZDI data-driven, detailed modelling of the coronal conditions and circumstellar environment around three planet hosting stars will be presented. In particular, the predicted mass loss rates for these systems and their impact on the orbiting exoplanets will be discussed.

*Speaker

sciencesconf.org:pathways2015:64374

CHEOPS performance for exomoons

Attila Simon*[1], Gyula Szabó[2], László Kiss[3], Andrea Fortier[1], and Willy Benz[1]

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[2]Gothard Astrophysical Observatory – Hungary
[3]Konkoly Observatory – Hungary

Abstract

Many attempts have already been made for detecting exomoons around transiting exoplanet but the first confirmed discovery is still pending. In our study we focus on the forthcoming CHaraterising ExOPlanet Satellite (CHEOPS), giving an optimized decision algorithm with step-by-step evaluation, and calculate the number of required transits to an exomoon detection for plausible planet-moon configurations that can be observable by CHEOPS. Our study is based on PTV observations (photocentric timing variation, Szabó et al. 2006) in simulated CHEOPS data. In the case of favorable spatial configurations, systems with at least Earth-sized moon and with at least Neptune-sized planet that can be detected with 80% detection rate need at least 5-6 transit observations on average. There is also non-zero chance in the case of smaller moons, but the detection statistics deteriorates rapidly, while the necessary transit measurements increase fast. Although CHEOPS has smaller aperture than Kepler and is mounted with a CCD that is similar to Kepler's, it will observe brighter stars and operate with larger sampling rate, therefore the detection limit for an exomoon can be the same as or better, which will make CHEOPS a competitive instruments in the quest for exomoons.

*Speaker

sciencesconf.org:pathways2015:64415

Inferring Planetary Obliquity Using Rotational Photometry

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Abstract

The obliquity of terrestrial planets provides an important clue to their formation, and is a critical input parameter for models of planetary climate. Kawahara & Fujii (2010, 2011) showed how to extract a planet's obliquity from orbital and rotational photometry of reflected light. This approach is attractive because it also yields a two-dimensional planetary surface map, but it requires obtaining high-cadence observations spanning most of a planet's orbit. Time-resolved disk-integrated thermal emission, on the other hand, could reveal a planet's obliquity in a single rotation (de Kok, Stam, & Karalidi 2011; Cowan, Fuentes & Haggard 2013). We now extend the latter technique to reflected light, demonstrating that the obliquity of a planet can be retrieved from time-resolved photometry of a single planetary rotation. We explore the degeneracies involved in such inferences, and test the method on multiband disk-integrated rotational photometry of Mars obtained with the Deep Impact spacecraft. Our approach could be used to determine the obliquity of Jupiter analogs with next-generation direct-imaging missions, and may be used to measure terrestrial planet obliquities when flagship direct-imaging missions are eventually launched.

*Speaker

sciencesconf.org:pathways2015:64594

The Replicable High-resolution and Exoplanets Spectrograph

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Abstract

The definition of the habitable zone is naturally tied to the age and evolution of the host star. The current limitations with detecting exoplanets using Radial Velocity (RV) measurements include temperature stability of spectrographs and efficient fibre scrambling in the quest for sub metre/sec precision. However, an astrophysical fundamental limitation is also present, in the form of noise from stellar activity. This is particularly true for giant stars, where the amplitude of pulsations is comparable with RV signals from hot-Jupiters. Long-baseline RV measurements are required to measure the intrinsic pulsations of the host star and de-correlate them to look for the planetary signals. This process uses these data for asteroseismological analysis, which also provides improved precision on the stellar mass and density. This is impractical using large telescopes, but possible to do on bright stars with 0.3-1m class telescopes. This poster presents the current status of the Replicable High-Resolution Exoplanets and Asteroseismology (RHEA) spectrograph, a compact single-mode fibre-fed spectrograph being developed at Macquarie University and the Australian National University. It will serve the basis of a series of cheap spectrographs, composed of many "off the shelf" items, to be deployed on small telescopes for exoplanet and asteroseismological studies of giant stars, providing accessible technology to address this exciting problem.

*Speaker
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sciencesconf.org:pathways2015:65336

Unveiling exoplanetary atmospheres through LBC/MODS spectrophotometry

Valerio Nascimbeni*[1], Giampaolo Piotto[2], Isabella Pagano[3], Gaetano Scandariato[3], and Lorenzo Pino[2]

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Abstract

The Large Binocular Telescope (LBT), with its 12-m equivalent double mirror, high efficiency and cutting-edge technology, offers a unique opportunity to probe planetary atmospheres. Our group already exploited the dual-channel cameras (LBC-B, LBC-R) mounted at the prime foci of LBT to gather simultaneous transit light curves of GJ3470b and GJ1214, and to detect or constrain Rayleigh scattering signatures on their transmission spectrum. We pushed this approach further by taking advantage of a newly-available instrumental setup, i.e. observing the same transit with MODS (intermediate-resolution spectra) through the blue channel, and with LBC-R (broad-band photometry) trough the red one. We present preliminary results from our first observing runs.

*Speaker

sciencesconf.org:pathways2015:65439

Mapping ultracool atmospheres with Aeolus

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Abstract

No telescope is large enough to spatially resolve the disk of extrasolar planets, yet spatial information on habitable zone earth-like planets (e.g. presence of clouds, continents, oceans, vegetation) can provide valuable and unique information on targets for biosignature searches. Such spatial maps can be derived from time-resolved precision observations of rotating objects. Here we demonstrate a novel method to interpret rotational phase mapping information, by creating atmospheric maps via forward modeling of the observed planetary spectra and phase curves using an MCMC code, Aeolus. We present our validation of Aeoluson a set of unique Jupiter light curves acquired with HST. Aeolus will provide helpful insight into dynamics governing exoplanet atmospheres. Brown dwarf atmospheres have comparable sizes and temperatures to warm and hot jupiters, but are easier to observe than transiting planets due to the usual lack of a bright host star. Brown dwarfs provide us with high quality time-resolved data, offering a unique testbed for our characterization techniques and are the first targets on which we apply Aeolus. We present the first Aeolus maps of brown dwarfs observed with HST from Apai et al. 2013, which provides us with unprecedented detail and wavelength coverage observations of brown dwarfs. Aeolus retrieves multiple heterogeneities on each brown dwarf atmosphere we map, in agreement with Apai et al. 2013. We will finally discuss the implications of Aeolus for exoplanetary atmosphere characterization and the optimal exoplanet datasets for Aeolus.

*Speaker

sciencesconf.org:pathways2015:65988

Imperfect Pre-coronagraph for additional contrast

Jun Nishikawa*[1,2], Masahito Oya[1,3], Naoshi Murakami[4], Takashi Kurokawa[5,1], Yosuke Tanaka[5], Motohide Tamura[6,1], Takayuki Kotani[1], and Shiomi Kumagai[7]

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Abstract

We have studied a coronagraph system with an unbalanced nulling interferometer (UNI) which considered to be an imperfect (low-contrast) pre-coronagraph. The system consists of an upstream deformable mirror, the pre-coronagraph, a deformable mirror, and a main coronagraph, in sequence. A pre-reduction of the star light to 1/100 at the pre-coronagraph stage enables to enhance the final contrast by 100. It was not operated by the dark-hole control before but a wavefront sensor. We found that the dark-hole control was possible when the pre-coronagraph status could be exchanged between perfect and imperfect nulling. In the style of the nulling interferometer, it could be obtained by phase shift operations. In the case of a focal-plane mask coronagraph it could be obtained by exchanging the masks with a small difference of transmittance pattern. Although we do not make the dark-hole control for the pre-coronagraph, yet, but only for the main coronagraph, it would be promising to implement the dark-hole control for the pre-coronagraph. We are planning to construct an experimental optics with two vortex mask coronagraphs and two deformable mirrors to validate the techniques. We obtained a contrast of 8E-8 with a vortex mask coronagraph without the pre-coronagraph method where a 12x12 deformable mirror was used. We expect a better contrast if we can use a deformable mirror with more actuators as well as the pre-coronagraph.

*Speaker

sciencesconf.org:pathways2015:66149

Designing Real Instruments Around the Search for Habitable Worlds

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Abstract

In designing the next generation of exoplanet imaging and characterization instruments, one key question is how to efficiently descriminate exoplanets from the myriad of faint background sources likely to be found in each field. This question depends very much on instrument performance and limitations in spectral resolution and signal to noise that can be achieved in a reasonable integration time. Furthermore, the question of how much can be learned in a single image is important given the chance that a follow-up observations to establish common proper motions may not always be possible. In this talk, I describe how we are approaching this problem with theory, observations, and instrument performance metrics to pave the way for an WFIRST AFTA exoplanetary imaging campaign.

*Speaker

sciencesconf.org:pathways2015:66288

TTVs analysis in Southern Stars

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Abstract

The transit timing variations technique has become one of the most promising methods to detect another planetary mass bodies in systems with an already known transiting planet. However, a huge number of planetary transits is needed to confirm the existence of TTVs. Since June 2011 we are carrying on a photometric follow-up of stars with transiting planets from the South Hemisphere with the aim of searching for TTVs (Petrucci et al. 2013, 2015) employing two argentinian telescopes: the 40 cm telescope "Horacio Ghielmetti" (CASLEO) and the 1.54 m telescope at "Estación Astrofísica de Bosque Alegre".
In this work we present the results of a TTVs analysis for one of the late-type stars of the sample. We also study the long-term variability of the orbital inclination and the depth of the transits. Finally, we search for intrinsic variability in the star.

*Speaker
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Rotation periods, activity-induced RV signals, and detection of habitable planets

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Abstract

It is well known that stellar activity induces relatively significant offsets on stellar radial velocity (RV) measurements that probably affects the detection of planets. This is particularly relevant for the detection of Earth-mass planets, especially if they are located in the habitable zone of the host star. To investigate this aspect, we have been analyzing time series of several chromospheric activity indicators such as Ca HK and Halpha, using HARPS high-resolution spectra extracted from the ESO public archive. We have been able to measure stellar rotation periods of about 50 relatively low-activity FGKM stars from the modulation of both activity indicators and to quantify the induced global RV signals as a function of stellar activity level and spectral type. We will present these results and discuss possible implications on the detection of Earth-mass exoplanets in the habitable zone.

*Speaker

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SIMULTANEOUS VISIBLE AND INFRARED OBSERVATIONS OF STELLAR ACTIVITY.

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Abstract

High-precision photometric surveys from space, together with discoveries of ground-based RV programs show that the occurrence rate of low-mass planets increases as stellar temperature and mass decrease. For these reasons M dwarfs are the best candidates for hosting super-Earths and Earth-sized planets. Moreover, the fact that they are the vast majority in the solar neighbourhood increases the probability of finding a low-mass planet in our proximities, possibly in its habitable zone. Nevertheless, M dwarfs are known to be very active stars and their activity-related phenomena are matter of concern for planetary detection and characterisation studies. For both RV and transit measurements, the intrinsic variation of the host star can indeed affect the estimate of the planetary system parameters.

In the case of transit spectroscopy it is then important to determine and remove the photospheric stellar activity, in order to recover the uncontaminated planetary signal. This is particular crucial when combining transit measurements obtained at different epochs and at different wavelengths.

The precise understanding of the stellar activity over a wide spectral range is therefore fundamental for the study of exoplanetary atmospheres. In this framework we present here continuous 30 day optical and infrared photometric observations of a sample of +180 mains sequence stars recorded simultaneously with CoRoT and the Spitzer Space Telescope. We analyse the degree of correlation between stellar backgrounds at the available wavelengths, evaluate the visible-to-infrared variability scaling factor as a function of the stellar spectral type and discuss how the stellar spectral information in the visible band can be used to correct the IR spectrum.

*Speaker

sciencesconf.org:pathways2015:66481

FITE optical adjustment tolerance

Satoshi Itoh*[1], Hiroshi Shibai[1], Ayana Sasaki[1], Minori Nakamichi[1], Teruhira Oyama[1], Takahiro Sumi[1], Yoshihiro Kuwada[1], Mihoko Konishi[1], Jun Sudo[1], Kodai Yamamoto[2], Masanao Narita[3], Akihiro Doi[3], and Yusuke Kono[4]

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Abstract

FITE is a two-beam Fizeau type balloon-borne far-infrared interferometer with its baseline of 8m, which is the first technology demonstration for future space-borne infrared interferometers and also has the intrinsic scientific purpose. The optical adjustment in the sky as compensation for deformation of optics by gravity or change of temperature requires valid knowledge of optical adjustment tolerance.
Therefore, we firstly reconsidered the imaging performance we need, and secondly executed Monte Carlo Tolerance Analysis of Zemax to estimate the influence of each degrees of freedom of optics on the imaging performance.

As a result, we decided to require that the whole optics is under the condition that fringe pattern can be detected in the MIR array for adjustment. And we obtained useful criteria to determine whether the whole optics is under the condition that the fringe pattern can be detected in a given wavelength: (RMS spot radius when we consider two beams simultaneously) $<$ 0.28 (Airy disk radius for single beam), which is expected to fulfill two conditions: (1) Each beam has good spatial coherence in its own diffraction image. In other words, each beam can be considered to have its diffraction limited quality. (2) The diffraction images of the two beams overlap each other well enough so that visibility of the fringe pattern is larger than 0.6 times of that of ideal case.
In addition, as a result of Monte Carlo Tolerance Analysis of Zemax, it was suggested that, with given region of parameters that is realistic now, the RMS spot radius can be dominated by the accuracy of individual optical elements rather than the accuracy of alignment of them.

*Speaker

sciencesconf.org:pathways2015:66544

Managing the wavefront for high contrast exoplanet imaging from space

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Abstract

The prospect of extreme high contrast astronomical imaging from space has inspired detailed studies of coronagraph methods for exoplanet imaging and spectroscopy. However, the requisite contrast, at levels of a billion to one or better for the direct imaging of cool mature exoplanets in reflected starlight, leads to challenging new requirements on the stability and control of the optical wavefront, at levels currently beyond the reach of ground based telescopes. We briefly review the designs, laboratory validations, and science prospects for the direct imaging and spectroscopic characterization of exoplanet systems with an actively corrected Lyot coronagraph. We review predictions for exoplanet science performance with NASA's AFTA/WFIRST coronagraph as well as smaller dedicated coronagraphic space observatories. Together with a pair of deformable mirrors for optical wavefront control, the Lyot coronagraph creates high contrast dark fields of view extending to within angular separations of 2.5 lambda/D from the central star at visible wavelengths. Performance metrics are presented, including image contrast, spectral bandwidth, overall efficiency and throughput, and laboratory demonstrations.

*Speaker

sciencesconf.org:pathways2015:66579

The Habitable Zone Planet Finder Spectrograph for the Hobby-Eberly Telescope

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Abstract

In the quest for low mass planets around M dwarfs we are developing the near-infrared (HPF) Habitable Zone Planet Finder Spectrograph (HPF) for the Hobby Eberly Telescope. HPF will be capable of discovering low mass planets in the Habitable Zones of mid-late M dwarfs via radial velocity (RV). We discuss the development of critical sub-systems like our high-stability temperature control system, vacuum cryostat, and implementation of new wavelength calibration techniques. The design of the HET enables queue-scheduled operation, but its variable pupil requires attention to both near- and far-field fiber scrambling. We present a novel double-scrambler concept that enables high-scrambling gain with simple optics. HPF covers parts of the information-rich z, Y and J NIR bands at a spectral resolving power of R$∼ $50, 000.*WhileweshowthatstellaractivityinducedRVnoiseislowerintheNIR, wearecarefultoincludeNIRactivityindica*

*Speaker

sciencesconf.org:pathways2015:66630

Space based microlensing planet searches

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Abstract

The discovery of extra-solar planets is arguably the most exciting development in astrophysics during the past 15 years, rivalled only by the detection of dark energy. Two projects unite the communities of exoplanet scientists and cosmologists: the proposed ESA M class mission EUCLID and the large space mission WFIRST, top ranked by the Astronomy 2010 Decadal Survey report. The later states that: "Space-based microlensing is the optimal approach to providing a true statistical census of planetary systems in the Galaxy, over a range of likely semi-major axes". They also add: "This census, combined with that made by the Kepler mission, will determine how common Earth-like planets are over a wide range of orbital parameters". We will present a status report of the results obtained by microlensing on exoplanets in particular about the mass function of cold planets. We will finally discuss the fantastic prospect offered by space based microlensing at the horizon 2020-2025.

*Speaker

sciencesconf.org:pathways2015:66696

Far-Infrared Interferometric Telescope Experiment: FITE

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Abstract

We have developed a balloon-borne far-infrared interferometer, FITE (Far- Infrared Interferometric Telescope Experiment). FITE is a two-beam Fizeau type interferometer with the baseline of 8m. The aperture diameter is 40cm for each beam. The optical system of FITE consists of the interferometer optics, which includes four plane mirrors and two off-axis parabolic mirrors, and the cold sensor optics in aliquid helium cooled cryostat. The purpose is to achieve 1 arc second spatial resolution at the wavelength of 100 μm by using the baseline of 20m. This resolution will enable us to measure thermal structures proto-planetary disks and circumstellar disks, star-forming molecular cores, and so on. Moreover, FITE provides a technical demonstration of space-borne interferometer for the first time, which will be an important first step toward finding extraterrestrial life by means of infrared spectroscopy of exoplanetary atmosphere. For the next launch opportunity, we made a CFRP gondola. In addition, we have developed a new two-dimensional stressed Ge:Ga array with high sensitivity, an optical adjustment system, a quasi-parallel mechanism as an alignment mechanism of the off-axis parabolic mirrors. We are planning to make its first flight as soon as possible in Australia.

*Speaker

sciencesconf.org:pathways2015:66818

Performance Expectations for the WFIRST AFTA Coronagraph Instrument

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Abstract

WFIRST AFTA is a built and qualified 2.4 meter space telescope, being fitted for a wide field instrument designated for dark energy research. For the past year an intensive study effort has been commissioned to add a powerful coronagraph instrument to this mission for the purpose of imaging and characterizing exoplanetary systems. A preliminary design is now in place and performance studies are under way. Since the telescope was not originally designed with coronagraphy in mind, it features an obscured pupil that is challenging for this application. Nevertheless, we have been able to produce coronagraph designs that achieve contrasts of 1e-9 or better for typical targets and expected observing conditions. In this presentation we describe the modeling approach for determining the performance of this highly capable instrument, our plans for validating the model, and recent performance estimates.

*Speaker

sciencesconf.org:pathways2015:66886

WFIRST-AFTA Coronagraph Overview and Technology Development Status

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Abstract

NASA's WFIRST-AFTA mission study includes the first high-contrast stellar coronagraph in space. This coronagraph will be capable of imaging and spectrally characterizing giant exoplanets similar to Neptune and Jupiter and possibly super-Earths, as well as circumstellar disks. The selected primary design called the Occulting Mask Coronagraph (OMC) combines two starlight suppression approaches, Shaped Pupil and Hybrid Lyot, in one instrument. The Phase-Induced Amplitude Apodization Complex Mask Coronagraph (PIACMC) was selected as the backup design. Substantial advances have been made since the technology development plan was formulated in February of 2014, including successful fabrication of starlight suppression masks for all 3 selected coronagraph types and the testbed demonstration of better than 10-8 contrast with the obscured AFTA pupil. We will present the coronagraph design overview, its engineering capabilities, and the recent technology development results.

*Speaker

sciencesconf.org:pathways2015:70023

cm/s relative stability of two laser frequency combs for routine operation on HARPS and FOCES

Ronald Holzwarth*[1,2], Gerardo Avila[3], Anna Brucalassi[4], Bruno Martins[5], Izan Leão[5], Gaspare Lo Curto[3], Frank Grupp[6], Theodor Hänsch[2], and Hanna Kellermann[7]

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Abstract

Astronomical spectrographs have been lacking calibration sources with sufficient precision for the detection of Earth analogues, which requires measuring radial velocity amplitudes of about 9 cm/s. Laser frequency combs (LFCs) promise to overcome this limitation by offering a regular pattern of spectral lines that is linked to an atomic clock. We report on the commissioning and test of an LFC at the two-channel fiber-fed spectrograph HARPS, located at ESO's La Silla Observatory in Chile. The test was conducted
in conjunction with a second LFC owned by the University Observatory Munich, which is foreseen for the FOCES spectrograph at the Wendelstein Observatory. Both LFCs covered the spectral range of HARPS to about 77 % from 450 to 690 nm.
After optimization of the light delivery in optical fibers to HARPS to suppress modal noise, a relative stability of the two LFCs of better than 2 cm/s was obtained. After the test, the LFC for FOCES was transported back to Germany, while the LFC for HARPS
stays on the site and will soon start operating routinely within its planned astronomical observation schedule. This will increase the sensitivity of HARPS to low-mass planets in the habitable zone of their host stars.

*Speaker

sciencesconf.org:pathways2015:74041

CRIRES+: the high-resolution, near-infrared spectrograph at the VLT

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Abstract

CRIRES+ at the ESO/VLT will be a unique, adaptive optics enabled, high-resolution (R=100000) instrument from 1 – 5m combined with the collecting power of an 8m aperture in 2017. The currently being upgraded instrument features cross-dispersion capabilities, spectro-polarimetry modes, a new detector mosaic, and newly developed precision wavelength calibration techniques. We present an overview of the ambitious instrument upgrade project, with particular emphasis on new developments regarding precision wavelength calibration in the near-infrared. The project is realized by a consortium of five European partners. CRIRES+ will help to answer major questions in many fields of astronomy, primarily in exoplanet detection and characterization, stellar magnetic fields, and the molecular universe.

*Speaker

sciencesconf.org:pathways2015:74737

Key Question 7 :

What future capacity is needed ?

Oral presentations

Missions and Technology in NASA's Exoplanet Exploration Program

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Abstract

The Exoplanet Exploration Program (ExEP) develops and manages NASA space science missions for detecting and characterizing exoplanets and searching for possible signatures of life. ExEP includes space missions, mission concept studies, technology investments, and ground-based science that directly support these objectives. Exoplanet science community engagement is very important, with the ExoPAG providing a key forum for input to NASA. In this paper, we provide an overview of the Program, highlighting the mission concepts and technology developments that enable future missions on the path to habitable planets.
ExEP missions and mission concepts include Kepler, K2, the probe-scale imaging mission concepts and WFIRST-AFTA. WFIRST represents a major investment that includes dark energy science, a wide-field infrared survey, a microlensing survey for outer-exoplanet demographics, and a coronagraph for direct imaging of planets around nearby stars. The Program supports follow-up observations using the Keck Observatory that contribute to the science yield of Kepler and K2, and mid-IR observations of exozodiacal dust by LBTI. NExScI develops and makes available archives, tools, and professional education for the exoplanet community. Program elements all contribute to the goal of detecting and characterizing exoplanets, helping to inform the science needs and the enabling technologies for the next generation of exoplanet instruments. The exoplanet field is rapidly evolving, and ExEP actively responds to changes in the scientific and programmatic landscape through the active involvement of the scientific and technical communities.

*Speaker

sciencesconf.org:pathways2015:64605

ARIEL

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Abstract

Nearly 2,000 exoplanets have been discovered and missions by ESA and NASA from space such as GAIA, Cheops, PLATO, K2 and TESS will increase this number to tens of thousands. Of all these exoplanets we know very little, i.e. their orbital data and, for some of these, their physical parameters such as their size and mass. Pioneering measurements using transit spectroscopy with Hubble, Spitzer and ground-based facilities have enabled the detection of a few of the most abundant ionic, atomic and molecular species and to constrain the thermal structure of a few planets. Future large, general purpose facilities will allow the acquisition of better exoplanet spectra than are currently available, especially from fainter targets. A few tens of planets will be observed with JWST and E-ELT in great detail. A breakthrough in our understanding of planet formation and evolution mechanisms will only happen through the observation of the planetary bulk and atmospheric composition of a statistically large sample of planets (~500). This requires conducting stable spectroscopic observations from a dedicated agile space mission, covering simultaneously a broad spectral region from the visible to the mid-IR, over 3.5 years. The ESA-M4 mission candidate ARIEL is designed to accomplish this goal and will provide a complete, statistically significant sample of gas-giants, Neptunes and super-Earths with temperatures hotter than 600K, as these types of planets will allow direct observation of their bulk properties, enabling us to constrain models of planet formation and evolution. The Ariel consortium currently includes academic institutes and industry from eleven countries in Europe; the consortium is open and invites new contributions and collaborations.

*Speaker

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sciencesconf.org:pathways2015:66546

Robustly searching for Earth-like biosignatures

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Abstract

How common are exoplanets with Earth-like biosignatures (i.e. Earths and super-Earths in their HZ showing biosignatures in their spectra)? We present a strategy to robustly answer this question. Using our existing knowledge of the frequency of Earths and super-Earths and a census of the stars in the solar neighbourhood we construct a sample of ~100 targets which we quantify in terms of contrast, angular separation and apparent magnitude. We then calculate the technical requirements for a dedicated space telescope to find these targets and obtain their spectra with a mission timescale of ~5 years. Finally, a novel design concept which can be launched on an Ariane V will be presented.

*Speaker
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sciencesconf.org:pathways2015:66545

Recognizing and characterizing terrestrial planets

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Abstract

In order to image and characterize the reflected light from terrestrial planets in the habitable zones of solar-type stars, it will be necessary to not only separate the planet from instrumental artifacts such as speckles, but also to recognize the planet against a host of background sources. We discuss strategies that may mitigate these concerns and both enhance our ability to detect and recognize planets, while simultaneously offering characterization. To reach the brightness levels of Earth-like planets at modest distances from our Solar System, 10 pc and beyond, it will be necessary to reach depths equivalent to the deepest of the "deep fields" currently observed by HST, or fainter. With such magnitude limits, there are not only distant Galactic stars to contend with, but also a myriad extragalactic sources. The scope of this problem is outlined and ways to deal with it. The use of an integral field spectrograph offers exceptional post-processing versatility that may be used to aid in the identification of planets, while also, for some observing configurations, enhanced capabilities for speckle discrimination. With the addition of polarimetry, the ability to recognize planets shining purely by reflected light is improved, and a new suite of useful diagnostics become available, including potential recognition of the presence of liquid water. Effective characterization in a reasonable amount of time, governed by the astrophysical constraints of planets' orbits, requires substantial numbers of photons, which drives mission concepts towards larger apertures, and the need for stability, towards space. The instrumentation choice can profoundly influence the architecture of the mission as a whole.

*Speaker

sciencesconf.org:pathways2015:66440

Developing an integrated analysis approach to explanetary spectroscopy

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Abstract

Analysing the atmospheres of Earth and SuperEarth type planets for possible biomarkers will push us to the limits of current and future instrumentation. As the field matures, we must also upgrade our data analysis and interpretation techniques from their "ad-hoc" beginnings to a solid statistical foundation. This is particularly important for the optimal exploitation of future instruments, such as JWST and E-ELT.
At the limits of low signal-to-noise, we are prone to two sources of biases: 1) Prior selection in the data reduction; 2) Prior constraints on the spectral retrieval. A unified set of tools addressing both points is required.
To de-trend low S/N, correlated data, we demonstrated blind-source-separation (BSS) machine learning techniques to be a significant step forward. Both in photometry and spectroscopy. BSS finds applications in fields as diverse as medical imaging to cosmology. Applied to exoplanets, it allows us to resolve de-trending biases and demonstrate consistency between data sets that were previously found to be highly discrepant and subject to much debate.

For the interpretation of the data, we developed a novel atmospheric retrieval suite, Tau-REx. Tau-REx implements an unbiased prior selections via a custom built pattern recognition software. A full subsequent mapping of the likelihood space (using cluster computing) allows us, for the first time, to fully study degeneracies and biases in emission and transmission spectroscopy.
The development of a coherent end-to-end infrastructure is paramount to the characterisation of ever smaller and fainter foreign worlds. In this conference, I will discuss what we have learned for current observations and the need for unified statistical frameworks in the era of JWST, E-ELT.

*Speaker

sciencesconf.org:pathways2015:66595

Direct exoplanet imaging with small-angle Vortex coronagraphs

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Abstract

Vortex coronagraphs are among the most promising solutions to perform high contrast imaging at small angular separations from bright stars. They enhance the dynamic range at very small inner working angle (down to the diffraction limit of the telescope) and provide a clear 360 degree discovery space for high-contrast direct imaging of exoplanets. In this talk, we will report on the first scientific results obtained with Vortex coronagraphs installed on 10-m class telescopes (i.e., the VLT and the LBT) and on the recent installation of one Vortex at Keck. We will describe the in-lab and on-sky performance of the Vortex, and describe the lessons learned after a few years of operation. Finally, we will discuss the prospects of our vortices for future extremely large telescopes and space missions.

*Speaker

sciencesconf.org:pathways2015:66607

Exo-Earth Discovery and Characterization with Large UV-Optical-IR Observatories

Avi Mandell*[1], Christopher Stark[2], Aki Roberge[1], Shawn Domagal-Goldman[1], Karl Stapelfeldt[3], Tyler Robinson[4,5], Mark Clampin[6], Marc Postman[2], and Harley Thronson[1]

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Abstract

A Large UV-Optical-InfraRed (LUVOIR) telescope was recommended by the recent AURA Beyond JWST report [1] and our study team is developing the concept further for consideration by the US National Research Council 2020 Decadal Survey. A critical metric for constraining requirements of this mission is the discovery and characterization of Earth-like planets around Sun-like stars using high-contrast imaging, and we have focused on using exo-Earth yield to provide constraints on technical requirements early in the design process. An estimate of the detection yield for Earth-like planets can be calculated using a Monte Carlo simulation of a design reference mission (DRM), allowing the exploration of a variety of mission design and astrophysical parameters. We have developed a new strategy called altruistic yield optimazation (AYO) that optimizes the target list, exposure times, and number of revisits to maximize mission yield for a specific set of mission parameters [2]. In this presentation we discuss the various physical and technological parameters that go into the DRM simulations, and the associated uncertainties based on the current state of research. We will also discuss the potential follow-up science capabilities for spectroscopic characterization facilitated by a large aperture. For example, a telescope of aperture 10 meters would be able to measure integrated exo-Earth fluxes with multi-hour integration times, providing a map of albedo variations as the planet rotates. A large aperture would also provide reasonable inner working angles for coronographic observations beyond the visible wavelength range, enabling detections of important atmospheric molecules such as CH4 and CO2.

*Speaker

sciencesconf.org:pathways2015:66430

SPICA mission

Hiroshi Shibai*[1]

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Abstract

SPICA (Space Infrared Telescope for Cosmology and Astrophysics) is a space mission optimized for mid- and far-infrared astronomy with a cryogenically cooled (

*Speaker

sciencesconf.org:pathways2015:71689

Scientific Opportunities for a Starshade Working with a 2.4 m Telescope at L2

Aki Roberge*[1], Sara Seager[2], Mark Thomson[3], Margaret Turnbull[4], William Sparks[5], Stuart Shaklan[3], Marc Kuchner[1], N. Jeremy Kasdin[6], Shawn Domagal-Goldman[1], and Webster Cash[7]

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Abstract

A starshade paired with an existing 2.4 m telescope offers scientific opportunities for high-contrast direct exoplanet observations that are complementary to those offered by internal coronagraphs. Most excitingly, since the inner working angle is decoupled from the telescope aperture, a starshade can provide access to the habitable zones of some nearby stars even with relatively small telescopes. This capability may allow direct imaging and low-resolution spectroscopy of Earth-analog exoplanets. Here, I will summarize a potential starshade design for a 2.4 m telescope, briefly discuss the modest changes to the WFIRST mission that would be needed for it to be "starshade-ready", and give preliminary estimates of the scientific capabilities. This possible enhancement to the WFIRST mission would provide valuable technology development for someday flying a starshade with a larger telescope aimed at characterization of large numbers of habitable exoplanets.

*Speaker

sciencesconf.org:pathways2015:63836

Measuring the masses of the habitable planets around the 50 closest solar-type stars with Theia.

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[3]INAF - Osservatorio Astrofisico di Torino – Italy

Abstract

A major goal of exoplanetary science is the search for possible biosignatures on planets where life similar to ours would have emerged and modified the atmosphere. These planets can be detected by remote sensing using spectroscopic observation of O2, O3, H2O, CO2, and CH4 gases, but in the present context of funding, only missions in the range B$1-2 are seen as feasible for the next decades. This cost cap imposes serious constraints on the number of accessible targets limiting the exploration to the - 20 nearest systems with space coronagraphy in the visible wavelength range and - 40 systems with space interferometers working in thermal IR. It is thus imperative that promising target be identified ahead of time, to minimize several classes of risks intrinsic to the 'blind search' approach. Furthermore, the masses and the three-dimensional orbits of such habitable planets are key elements for deriving exobiological statements in the future, even the most basic ones. The mission called Theia has been submitted to the ESA call for M4 mission in 2015. Theia is a space observatory able to carry out high precision differential astrometry at the sub-microarcsecond level that allows mass determination of Earth-mass habitable planets around the 50 closest Solar-type stars using 15 - 20 % of the time of a three years mission. Theia is a single telescope designed to perform high accuracy astrometry using interferometric calibration and operating in L2. We will present the mission and its capability to measure the mass and orbit characteristics of the 50 closest planetary systems down to the Earth mass in the habitable zone of solar-type stars.

*Speaker
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sciencesconf.org:pathways2015:66495

Respective capabilities of affordable Coronagraphs and Interferometers searching for Biosignatures

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Abstract

We describe an analytic model to estimate the capabilities of space missions dedicated to the search for biosignatures in the atmosphere of rocky planets located in the Habitable Zone of nearby stars. Relations between performance and parameters such as mirror diameter, distance to targets..., are obtained.
Two types of instruments are considered: Coronagraphs observing in the visible, and Nulling Interferometers observing in the thermal infrared. Missions considered are single-pupil coronagraphs with a 2.4 m primary mirror, and formation flying interferometers with 4 x 0.75 m collecting mirrors and baselines ranging from a few decametres to a few hectometres.

The numbers of accessible planets are calculated as a function of eta_earth, the mean number of Earth analogues and super-Earths in stellar Habitable Zones.

Based on current estimations, eta_earth=10% around FGK stars and 50% around M stars, the built-in (starshade) coronagraph could study in spectroscopy only ~ 1.5 (2.0) relevant planets, and the interferometer ~ 14 ones. These numbers are obtained under the major hypothesis that the exozodiacal light around the target stars is not an issue.
For the long-term future, building both types of spectroscopic instruments, and using them on the same targets, will be the optimal solution because they provide complementary information. But as a first affordable space mission, the interferometer looks the more promising in term of biosignature harvest.

*Speaker

sciencesconf.org:pathways2015:63583

How to Directly Image a Habitable Planet Around Alpha Centauri with a ~30-45cm Space Telescope

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Abstract

Several mission concepts are being studied to directly image planets around nearby stars. It is commonly thought that directly imaging a potentially habitable exoplanet around a Sun-like star requires space telescopes with apertures of at least 1m. A notable exception to this is Alpha Centauri (A and B), which is an extreme outlier among FGKM stars in terms of apparent habitable zone size: the habitable zones are ~3x wider in apparent size than around any other FGKM star. This enables a ~30-45cm visible light space telescope equipped with a modern high performance coronagraph or starshade to resolve the habitable zone at high contrast and directly image any potentially habitable planet that may exist in the system. The raw contrast requirements for such an instrument can be relaxed to 1e-8 if the mission spends 2 years collecting tens of thousands of images on the same target, enabling a factor of 500-1000 speckle suppression in post processing using a new technique called Orbital Difference Imaging (ODI). The raw light leak from both stars is controllable with a special wavefront control algorithm known as Multi-Star Wavefront Control (MSWC), which independently suppresses diffraction and aberrations from both stars using independent modes on the deformable mirror. This paper will present an analysis of the challenges involved with direct imaging of Alpha Centauri with a small telescope and how the above technologies are used together to solve them. We also show an example of a small coronagraphic mission concepts to take advantage of this opportunity called "ACESat: Alpha Centauri Exoplanet Sattellite" submitted to NASA's small Explorer (SMEX) program in December of 2014.

*Speaker
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sciencesconf.org:pathways2015:66590

Key Question 7 :

What future capacity
is needed ?

Posters

Modeling Spectroastrometric Detections of Exomoons

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Abstract

Direct imaging of extrasolar planets with future space-based coronagraphic missions may provide a means of detecting companion moons for exoplanets with bands of strong atmospheric absorption. Although currently proposed telescopes will not have the angular resolution necessary to spatially resolve a planet and its moon, the angular shift of a point spread function centroid can be measured to precisions better than the angular resolution of the telescope yielding information at angular scales nearer to that of exoplanet-exomoon separation. At wavelengths of light where an exomoon outshines its host due to absorption in the planet's atmosphere, the centroid will shift towards the exomoon. We thus propose a detection strategy based on the variation of the center of light with wavelength, "spectroastrometry," which can both yield a detection of an exomoon and allow for characterization of the moon's orbit and mass of the exoplanet. To explore this detection method, we consider two model systems: an earth moon analogue and a warm Jupiter with earth as its moon. We discuss the instrumentation requirements for detection of these model systems around nearby stars, as well as characterization of the moon-planet systems that may be identified with this approach. The presence of an exomoon could create interesting possibilities for extrasolar habitability and cause inaccurate planetary characterization if it went undetected.

*Speaker

sciencesconf.org:pathways2015:64198

New photonic technologies for the Habitable-zone Planet Finder instrument

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[3]The Pennsylvania State University (PSU) – United States

Abstract

The Habitable-zone Planet Finder (HPF) is a stabilized, near-infrared (NIR) Doppler velocimeter being developed at Penn State to discover terrestrial-mass planets around cool M dwarfs. HPF consists of a fiber-fed high resolution spectrograph operating in the z/Y/J NIR bands (0.8 - 1.3 microns), where mid-late M-dwarfs are most luminous. I will present an overview of the current state of high precision radial velocity (RV) measurements in the NIR, and discuss the unique design traits of the HPF spectrograph. In particular, I will focus on recent 'astro-photonic' systems developed by the Penn State Optical/Infrared instrumentation group which solve or simplify many issues currently limiting the achievable RV measurement precision of existing Doppler instruments. These issues include precision wavelength calibration, image scrambling in optical fibers, and speckle noise in multi-mode astronomical fibers. Technologies presented here will enable 1 m/s measurements in the NIR, opening an entirely new discovery space for terrestrial-mass planet discovery.

*Speaker

sciencesconf.org:pathways2015:66159

The Search for Life: Large UV-Optical-IR Observatory Concept

Mark Clampin*[1]

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Abstract

A Large UV-Optical-InfraRed (LUVOIR) telescope was recommended by the NASA 30 Year Roadmap [1], and by the AURA Report [2], as the approach required to detect Earth-like planets and search for life. An architecture for a LUVOIR observatory has been studied by a our consortium (GSFC, JPL, MSFC and STScI) over the last five years.
In this presentation we will discuss the science goals for the LUVOIR observatory which are to conduct a survey for earth-like planets in the Habitable zones of nearby stars to identify candidate earth-like planets, followed by a spectroscopic survey of these candidates to identify those that exhibit spectroscopic biosignatures and merit further characterization and surface variability studies. A LUVOIR telescope also presents new, ground-breaking opportunities for general astrophysics including star and planet system formation studies, which we will also discuss.

Studies of exoplanet yield vs. aperture (Stark et al. 2014; Mandell et al. 2015) point to a desired aperture size of 12 meter for this observatory. We will discuss an observatory architecture (Fig. 1) that would enable this class of aperture, leveraging the technology and infrastructure of legacy of NASA's current and future optical and infrared observatories. We will discuss the observatory science requirements to enable the search for life on earth-like planets and conduct a general astrophysics program.
In order to detect earth-like planets at contrasts of -10-10, the observatory must function as an integrated system with a coronagraph implementation that integrates seamlessly with the telescope architecture. We will review options for coronagraph designs and discuss the performance challenges required to achieve the desired system performance.

*Speaker

sciencesconf.org:pathways2015:66441

Exo-C: A Modest-aperture Space Telescope for Imaging Exoplanetary Systems with an Internal Coronagraph

Karl Stapelfeldt*[1], John Trauger[2], Stephen Unwin[2], Ruslan Belikov[3], Geoffrey Bryden[2], Kerri Cahoy[4], Supriya Chakrabarti[5], Mark Marley[3], Michael Mcelwain[1], Victoria Meadows[6], and Eugene Serabyn[2]

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Abstract

"Exo-C" is NASA's first community study of a modest aperture space telescope optimized for high contrast observations of exoplanetary systems. The mission will be capable of taking optical spectra of nearby exoplanets in reflected light, discovering previously undetected planets, and imaging structure in a large sample of circumstellar disks. It will obtain unique science results on planets down to super-Earth sizes and serve as a technology pathfinder toward an eventual flagship-class mission to find and characterize habitable Earth-like exoplanets. We present the mission/payload design and its science yield, highlighting steps to reduce mission cost/risk relative to previous mission concepts. Key elements are an 1.4 m unobscured telescope aperture, an internal coronagraph with deformable mirrors for precise wavefront control, and an orbit and observatory design chosen for high thermal stability. Exo-C has a similar telescope aperture, orbit, lifetime, and spacecraft bus requirements to the highly successful Kepler mission (which is our cost reference). The needed technology development is on-course to support a mission start in 2017, should NASA decide to proceed. This paper summarizes the study final report completed in March 2015. Key accomplishments include excellent modeled telescope stability, a telescope and instrument design that is optimal for dual polarization throughput, and fitting the mission into the prescibed cost cap.

*Speaker

sciencesconf.org:pathways2015:66451

The Detector Interferometric Calibration Experiment: a demonstration of sub-μas astrometry for nearby exo-Earth detection

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Abstract

Astrometry offers a unique potential for discovering nearby exo-Earths around Sun-like stars. Contrary to radial velocities, this technique is hardly sensitive to astrophysical noise from the host star. For astrometry the difficulty lies in the control of instrumental systematics down to the extreme accuracy required for the detection, which is 0.3 μas for an Earth twin located around a Sun at 10 pc. Although no instrument is capable of such accuracy today, special mission concepts have been proposed to ESA like NEAT and Theia, which address the instrumental challenge. In this context, instrumental developments are being pursued at IPAG (Grenoble) with the Detector Interferometric Calibration Experiment (DICE), which aims to demonstrate the feasibility of sub-μas astrometric measurements. In the detector plane, the astrometric requirement is equivalent to estimating the distance between two Nyquist sampled centroids with an accuracy of 5e-6 pixel. To reach this objective it is necessary to calibrate the pixels of the detector with special techniques, to measure not only the relative pixel QEs (flat-field), but also the pixel true locations. DICE uses a special metrology system which projects phase modulated Young fringes in coherent light to retrieve the pixel locations.

*Speaker

sciencesconf.org:pathways2015:66469

Speckle Area Nulling (SAN) for dark-hole adaptive optics control

Masahito Oya*[1,2], Jun Nishikawa[2,3], Masaaki Horie[1], Naoshi Murakami[4], Takayuki Kotani[2], Shiomi Kumagai[5], Motohide Tamura[2,6], Yosuke Tanaka[7], and Takashi Kurokawa[2,7]

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Abstract

In high-contrast imaging optical systems for direct observation of planets outside our solar system, adaptive optics with an accuracy of /10000 root mean square is required to reduce the speckle noise down to ten orders of magnitude in comparison with a star in addition to the nulling coronagraph which eliminate the diffracted light. We developed the speckle area nulling (SAN) method as a new dark-hole control algorithm. The SAN method is capable of controlling speckle electric field in a wide area quickly, in spite of an extension of the speckle nulling, and robust not relying upon an optical model. We conducted a validation experiment for the SAN method with a monochromatic light (=671nm), a MEMS deformable mirror of 140 dimensions and an achromatic vector vortex coronagraph. The SAN method applied to all of the pixels of the final focal plane camera closer than 1 /D in the control region. We succeeded in reducing the intensity of areal speckles by 4.4E-2. The region was 0.97 to 4.4/D from optical axis. Since there was only one DM and only the phase of the wavefront was being controlled, the control region was only on the half side of optical axis. The contrast ratio between the speckle intensity and the intensity of off-axis light was reduced by 8.8E-8 in the part of the control region.

*Speaker

sciencesconf.org:pathways2015:66594

Small Space telescope and mission design to image earth-like planets HZ of Alpha Centauri

Eduardo Bendek*[1], Ruslan Belikov[2], Sandrine Thomas[3], Julien Lozi[4], and Jared Males[5]

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[5]Steward Observatory (SO) – United States

Abstract

The increasing scientific interest on finding an earth-like planet in the HZ of Alpha Cen A&B system is based on a consistent increase of such planets frequency estimation. These stars are relatively bright stars (G2 and K1) driving the inner edge of the HZ to large angular separations of 0.7" and 0.4" respectively. This configuration is optimal for direct imaging detection of earth-like planets utilizing a specialized small (30-45cm) space telescope. In this paper we describe a mission concept and instrument to directly image and characterize Earth-like planets within the habitable zone around our nearest star system, Alpha Centauri (A and B stars). The mission will be capable of achieving contrasts ratios in the order of 1010 that are needed to image earth-brightness planets and obtain low-resolution (5-band) spectra of all planets. This date will constrain the presence and amount of an atmosphere. The instrument design is based on an off-axis telescope, which has a PIAA coronagraph embedded on the secondary and tertiary mirrors of the telescope. The Multi-Star Wave Front algorithm drives a Deformable Mirror controlling simultaneously diffracted light from the on-axis and binary companion star. The instrument rejects the stralight into the Low Order Wavefront Sensor that delivers high-precision pointing control, and allows the planet light reaching an EMCCD photon counting detector. Finally we utilize the ODI post-processing method that takes advantage of a highly stable environment (Earth-trailing orbit) and a continuous sequence of images spanning 2 years, to reduce the final noise floor in post processing to ~1e-11 levels, enabling high confidence and at least 90% completeness detections of Earth-like planets.

*Speaker

sciencesconf.org:pathways2015:66625

The balloon-borne exoplanet spectroscopy experiment - BETSE

Enzo Pascale*[1]

[1]Cardiff University – United Kingdom

Abstract

The balloon-borne exoplanet spectroscopy experiment (BETSE) is a proposed balloon spectrometer operating in the 1-5 micron band with spectral resolution of R = 100. Using a 50 cm diameter telescope, BETSE is desgnied to have sufficient sensitivity and control of systematics to measure the atmospheric spectra of representative sample of known hot Jupiters, few warm Neptunes, and some of the exoplanets TESS will soon begin to discover. This would for the first time allow us to place strict observational constraints on the nature of exo-atmospheres and on models of planetary formation. In a LDB flight from Antarctica, BETSE would be able to characterize the atmospheres of ~20 planets. If a ULDB flight is available, the combination of a longer flight and night time operations would enable BETSE to ground-breakingly characterize the atmospheres of more than 40 planets. Prior to an LDB or ULDB flight, BETSE would be tested in a 24 hr flight from Fort Sumner, NM, in order to test all subsystems, also observing more than 4 planets with SNR greater than 5.

*Speaker

sciencesconf.org:pathways2015:73816

SATELLITE MEETINGS

- SatMeet1 :
  - Laboratory Analogues of Exoplanetary Environments
  - Convenor : Emmanuele Pace, Arcetri (pace<at>arcetri.astro.it)
  - *Monday, Tuesday, and Wednesday 2:00-4:30PM in meeting room 115*
- SatMeet2 :
  - Mission concepts and measurement requirements for a future far-infrared space mission
  - Convenor : Dave Leisawitz, NASA Goddard (david.t.leisawitz<at>nasa.gov)
  - *Monday 2:00-4:30PM in meeting room 105*
- SatMeet3 :
  - Pathways Towards Exomoons
  - Convenor : David Kipping, CfA (kippingdavid<at>gmail.com)
  - *Wednesday 2:00-4:30PM in lecture room 106*
- SatMeet4 :
  - Habitable planets, M dwarfs and NIR spectrographs
  - Convenor : José A. Caballero, CAB (caballero<at>cab.inta-csic.es)
  - *Tuesday and Wednesday 2:00-4:30PM in lecture room 205*

- SatMeet5 :
  - Validation and Compilation of Kepler Habitable Zone Candidates
  - Convenor : Nader Haghighipour, IfA/Kepler HZ WG (nader<at>ifa.hawaii.edu)
  - *Monday 2:00-4:30PM in lecture room 205*
- SatMeet6 :
  - Prevalence of exozodiacal dust
  - Convenor : Denis Defrère, U. of A. (ddefrere<at>email.arizona.edu)
  - *Wednesday 2:00-4:30PM in lecture room 206*
- ~~SatMeet7 -- Cancelled :~~
  - A Bridge for a Pathway: Reconnaissance Missions and Instruments to Connect Explanet Discovery to Characterization
  - ~~Convenor : Eric Gaidos, U. Hawaii (~~gaidos<at>hawaii.edu~~)~~
  - *Tuesday 2:00-4:30PM in meeting room 214*
- SatMeet8 :
  - Connecting Stellar Abundances and Planet Habitability
  - Convenor : Natalie Hinkel, Arizona State University (natalie.hinkel<at>gmail.com)
  - *Monday 2:00-4:30PM in lecture room 206*
    and Tuesday 2:00-4:30PM in meeting room 105
- SatMeet9 :
  - Mapping Other Worlds: Spatial Studies of Exoplanets and Ultracool Atmospheres
  - Convenors : Daniel Apai, Steward Observatory (apai<at>arizona.edu) and Nicolas Cowan, Amherst (ncowan<at>amherst.edu)
  - *Tuesday 2:00-4:30PM in lecture room 206*
- SatMeet10 :
  - Future Plans and Potential Collaborations for Ground- and Space-Based Imaging of Exo-Earths
  - Convenor : Avi Mandell (avi.mandell<at>nasa.gov)
  - *Monday 2:00-4:30PM in lecture room 106*

SatMeet2 - Mission Concepts and Measurement Requirements for a Future Far-Infrared Space Mission

David Leisawitz*[1]

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Abstract

The quest to understand how habitable conditions arise during the process of planet formation is expected to be a major science driver for a future far-IR mission, such as the "Far-IR Surveyor Mission" in NASA's Astrophysics Roadmap. This satellite meeting was intended to serve as an opportunity for the participants to learn about concepts for the Far-IR Surveyor, and to learn what is technically feasible and affordable in a mission that could begin in the 2020s; and it also served as an opportunity for the participants to discuss measurement requirements for the mission, including angular resolution, spectral resolution, and sensitivity. Imaging and learning the spatial distribution of gaseous and frozen water in nascent planetary systems is a key objective.

*Speaker

sciencesconf.org:pathways2015:73999

SatMeet3 - Pathways Towards Exomoons

Kipping David*[1]

[1]Harvard University – United States

Abstract

I will summarize some of the important results and discussions from the Pathways Towards Exomoons satellite meeting.

*Speaker

sciencesconf.org:pathways2015:74137

SatMeet4 - Habitable planets, M dwarfs and NIR spectrographs

José Caballero*†1, Mahadevan Suvrath[2], and Ravi Kopparapu[3]

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[3]Pennsylvania State University – United States

Abstract

Our three-day satellite meeting matches the main objective of the conference, which is "phasing" astrophysicists, planetary scientists and instrument scientists (and biologist) for the search and characterisation of habitable planets. Our satellite meeting on "habitable planets, M dwarfs and near-infrared spectrographs" will cover all the topics that go from tidal locking and atmosphere circulation models, through M-dwarf activity, planet atmosphere chemistry and biosignatures, to a comprehensive review of all big precise radial-velocity projects in the near-infrared. For these reviews, we will count with some of the major experts in their respective topics. The first half of the three-day satellite meeting will focus on the scientific areas, while the second half will do on the technological ones. Special emphasis will also be given to the latest developments in wavelength calibration in the near-infrared. Our meeting will be held on the first day in conjunction with the complementary satellite meeting "Validation and compilation of Keplerhabitable zone candidates".

*Speaker

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sciencesconf.org:pathways2015:74149

SatMeet5 - Validation and Compilation of Kepler Habitable Zone Candidates

Nader Haghighipour*[1], Stephen Kane[2], and Ravi Kopparapu[3]

[1]Institute for Astronomy, University of Hawaii – United States
[2]San Francisco State University – United States
[3]Penn State – United States

Abstract

The significance of a terrestrial-planet-rich universe is fully realized in the study of habitability. The Kepler mission has a primary science goal of determining the frequency of terrestrial planets in the Habitable Zone (HZ). Commonly referred to as -Earth, the frequency of HZ terrestrial planets has become a major focus of interpreting Kepler results. The process of determining -Earth requires a reliable list of HZ candidates whose properties have been adequately vetted to produce robust planetary and stellar properties. The latter constitutes the main task of the Kepler HZ Working Group. Our group is working towards a more complete understanding of false-positives in the Kepler candidate list with a particular focus on terrestrial-size planets. This includes the use of follow-up data to better characterize the stellar properties to constrain both the size of the planet and the extent of the HZ. We present a summary of the topics discussed in the satellite meeting 5, and highlight the findings of the Kepler HZ working group.

*Speaker

sciencesconf.org:pathways2015:73882

SatMeet6 - Prevalence of exozodiacal dust

Defrère Denis*†[1], Steve Ertel[2], Olivier Absil[3], William Danchi[4], Carlos Eiroa[5], Jane Greaves[6], Phil Hinz[1], Grant Kennedy[7], Alain Léger[8], Aki Roberge[4], Karl Stapelfeldt[4], and Sebastian Wolf[9]

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Abstract

When observing an extrasolar planetary system, the most luminous component after the star itself is generally the light scattered and/or thermally emitted by a population of micron-sized dust grains. These grains are expected to be continuously replenished by the collisions and evaporation of larger bodies just as in our solar zodiacal cloud. Exozodiacal clouds ("exozodis") must therefore be seriously taken into account when attempting to directly image exoEarths. With this satellite meeting, we propose to discuss the progress made in the field since Pathways I (2009) and review the pathways to improve our knowledge on exozodis in regard of new observational results (completed near- and mid-infrared interferometric surveys, WISE, and Herschel) and new analyses on the impact of exozodis on the direct detection of exoEarths.

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sciencesconf.org:pathways2015:73879

SatMeet8 - Connecting Stellar Abundances and Planet Habitability

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Abstract

When considering whether a planet is habitable, there are a number of factors that must be taken into account. To date, the most prevalent discussion has centered around the physical location of the planet orbiting the star, specifically the habitable zone and temperatures on the planet. However, the chemical make-up of the planet, including the atmosphere, is equally important in determining whether a planet can support life. The presence of particular bioessential elements within the planet profoundly affects not only interior processes, but also surface (continents, oceans) and atmospheric conditions. All of these environmental influences ultimately determine the habitability of the planet. Therefore, to better understand the structure and formation of habitable extrasolar planets, we need to investigate the composition of the stellar host and how it affects orbiting planet(s).

Currently, the only confirmed connection between stellar host abundances and their planets is the presence of giant planets around stars with an enriched [Fe/H] -content. The purpose of this satellite meeting is to more closely examine other elements in stars that have both giant and/or terrestrial planets and discuss their implications for planet evolution. We will explore how stellar abundances impact and are impacted by the presence of exoplanets. We also would like to address how to define meaningful, chemical biomarkers within the star-planet system. The connection between planetary structure and element abundances within the host star is important, yet not well understood. As a result of the talks and discussion within this satellite meeting, we hope to make progress down the pathway towards habitable planets.

*Speaker

sciencesconf.org:pathways2015:74056

SatMeet9 - Mapping Other Worlds

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Abstract

Spatial information provides powerful and unique constraints on the physics and chemistry of planetary atmospheres and surfaces, including cloud formation, structure, and evolution; atmospheric dynamics; compositional variations in gas, solid, and liquid phases; as well as inferring surface spectra — including biosignatures — and surface coverage. Recent years have seen exciting progress in this new field, including numerical methods to interpret time-resolved exoplanet data, the first maps of brown dwarfs and transiting exoplanets, and exciting ideas and technique to map habitable zone exo-earths.
In our "Mapping Other Worlds" session we will explore:
1) state-of-the-art observations of spatially resolved ultracool atmospheres;
2) methods to obtain spatially resolved exoplanet data in the future;
3) approaches to deduce spatial information from time-resolved data;
4) science goals that can be achieved through spatially resolved data.
In this talk we will summarize the key results presented in the Mapping Other Worlds satellite session.

*Speaker

sciencesconf.org:pathways2015:74342

SatMeet10 - Ground- and Space-Based Imaging of Exo-Earths: Opportunities for Synergy and Collaboration over the Coming Two Decades

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Abstract

Over the next two decades, a generation of ambitious, highly-capable ground- and space-based observatories, instruments, and analysis tools will become available that will, by means of direct detection and characterization of exoplanets, answer the most exciting questions in the study of exoplanets: Where are the nearby habitable planets? What do observations of their atmospheres and surfaces reveal? And, of course, are there signs that they host life? We can address how planetary systems of all kinds form and evolve, and what the key relationships are that link stellar properties and the diverse types of planets found. This "satellite meeting " is intended to be a forum where the major facilities expected to be in operation by the end of the next twenty years (ELTs, ALMA, future space-based imaging missions) will be summarized and discussed within the context of synergies among them, and with other facilities and instruments. Opportunities for international participation will be explicitly discussed and a short list of recommended actions to achieve effective collaboration will be produced. We estimate five to ten major missions, facilities, or concepts will be briefly presented, allowing adequate time for discussion of "next steps" towards a roadmap for discovering and characterizing Earth-like worlds.

*Speaker

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sciencesconf.org:pathways2015:64353

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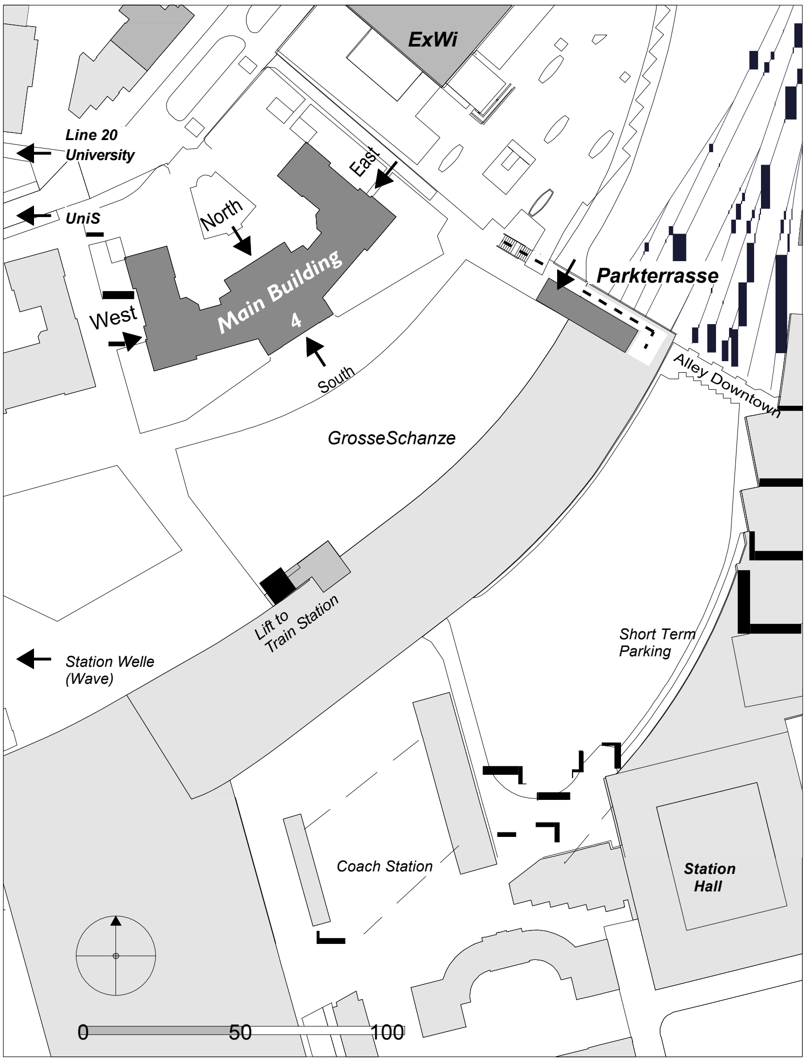
Situation



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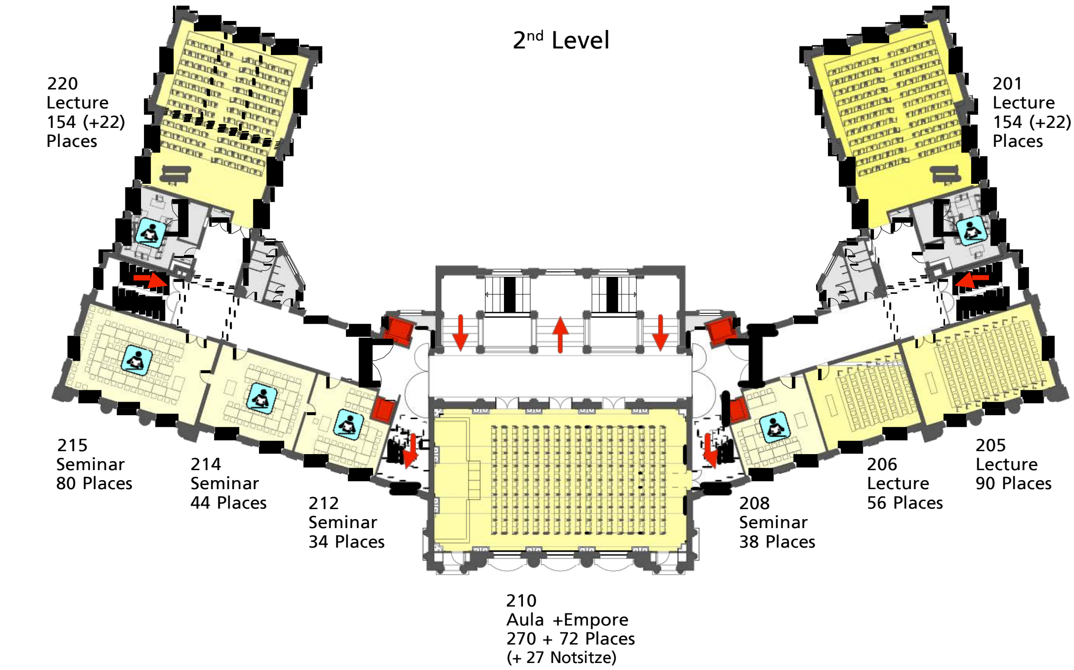

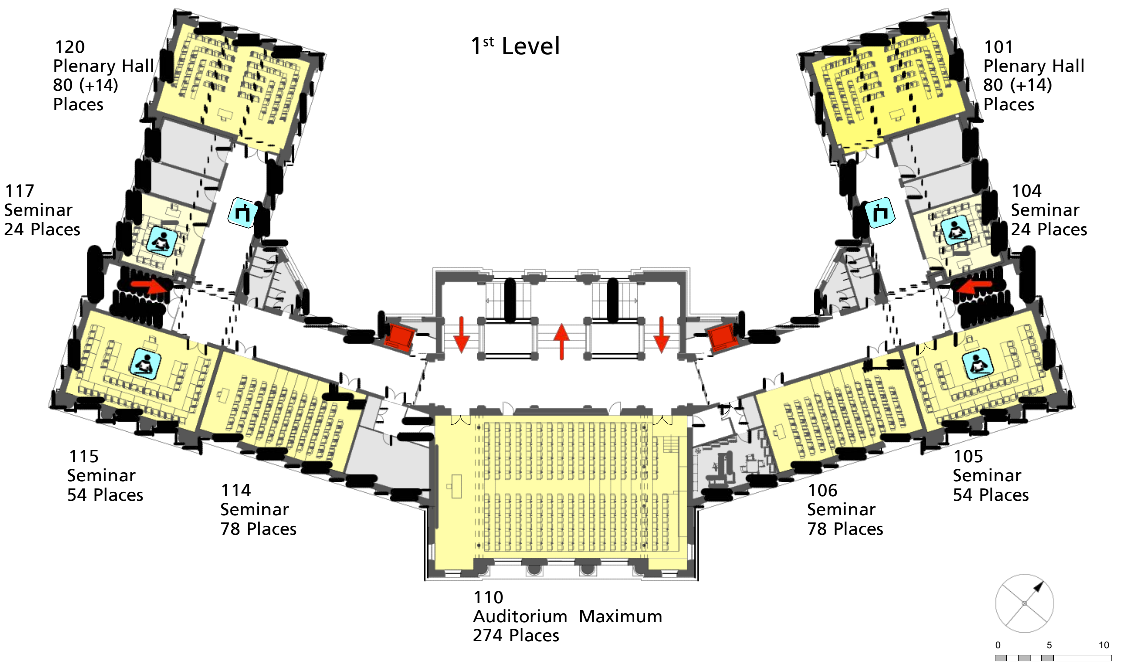

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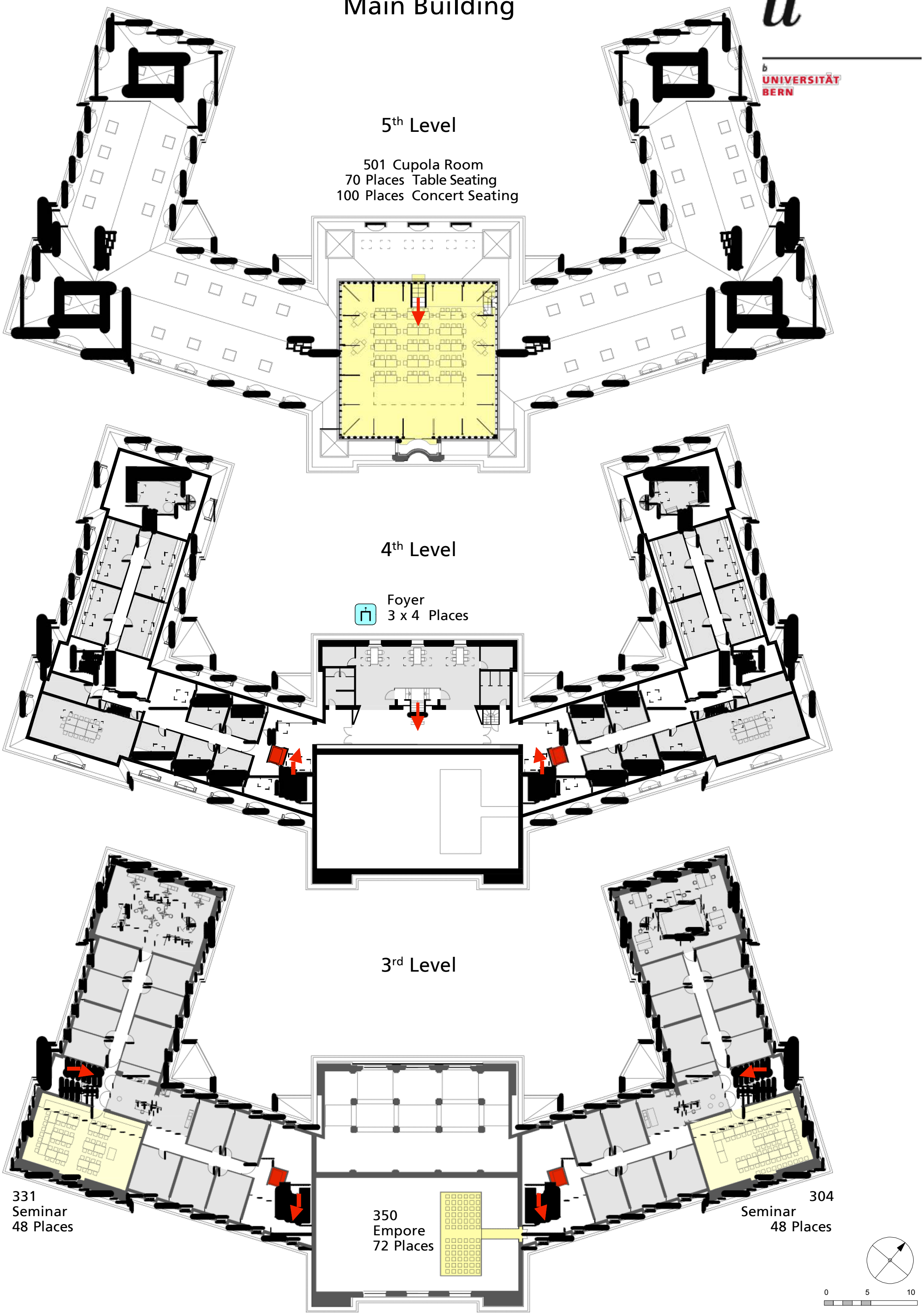

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