EP 13: Exoplanets and Astrobiology

Time: Friday 10:00–12:30 Location: H-HS VIII

Invited Talk EP 13.1 Fri 10:00 H-HS VIII

Habitability of extrasolar planets and the impact of interior-atmosphere interactions under different stellar evolutions — •Mareike Godolt — Zentrum für Astronomie und Astrophysik, Technische Universität Berlin, Germany

Habitability of extrasolar planets is often defined by the potential availability of liquid water on the planetary surface. This depends on various factor, such as the water inventory of the planet as well as the atmospheric pressure and temperature at the planetary surface, which are the result of various processes and factors. Relevant factors include the size and mass of the planet via the gravitational acceleration, the atmospheric mass, as well as the atmospheric composition, which is a result of planetary formation and subsequent interactions with the interior and space as well as atmospheric chemistry. The atmospheric chemical composition and mass determine the impact of the stellar irradiation via radiative but also convective processes which dominate the heating and the cooling processes of the planet. In this talk I will review current knowledge of central factors for habitability and highlight the relevance of the common evolution of the planetary interior with the atmosphere and the host star. Furthermore, I will present studies evaluating the detectability of atmospheres of small, potentially habitable planets with near future instrumentation.

EP 13.2 Fri 10:30 H-HS VIII

The Size and Shape of Planetary Proto-Atmospheres — •Tobias Moldenhauer[1], Rolf Kuiper[1], Wilhelm Kley[1], and Chris Ormel[2] — [1]Universität Tübingen, Tübingen, Deutschland — [2]Tsinghua University, Beijing, China

Protoplanets formed by core accretion can become massive enough to accrete gas from the disk they are born in. If the planetary proto-atmosphere exceeds a critical mass, runaway gas accretion starts and the planet collapses into a gas giant. In recent years, many close-in super-Earths have been observed which raises the question on how they avoided becoming hot Jupiters. We use three-dimensional radiation-hydrodynamics to simulate the proto-atmosphere in the local frame around the planet. The simulations converge to a quasi-steady state where the velocity field of the gas does not change anymore. In post-processing we then use tracer particles to calculate the shape of the atmosphere and the recycling timescale. Recycling of the atmosphere counteracts the collaps by preventing the gas from cooling efficiently.

EP 13.3 Fri 10:45 H-HS VIII

Star-planet interaction: Alfvén wings and Stellar winds — •Christian Fischer and Joachim Saur — Institut für Geophysik und Meteorologie, Universität zu Köln

Star-planet interaction is the equivalent process of the well known moon-planet interaction in our solar system. The differences between both processes lie in the geometries of the background magnetic fields and the plasma flow relative to the magnetic field. In the case of star-planet interaction the resulting Alfvén wing and other wave structures of the exoplanet are controlled by structures in the stellar wind. Therefore we apply an MHD model to simulate how different stellar wind conditions affect Alfvén wings. In our presentation we show results of theses MHD simulations and discuss their implication on properties of star-planet interaction.

EP 13.4 Fri 11:00 H-HS VIII

Classifying Exoplanet Candidates with Convolutional Neural Networks: Application to the Next Generation Transit Survey — •Alexander Chaushev[1] and Liam Raynard[2] — [1]TU Berlin, Berlin, Germany — [2]University of Leicester, Leicester, UK

A key bottleneck in the discovery of transiting exoplanets is the large number of false positives produced by existing detection algorithms. Currently the solution to this problem is to vet the candidates by hand, however this is time consuming and can be inconsistent. Recently convolutional neural networks (CNNs), a type of 'Deep Learning' algorithm, have been shown to be effective at this task [Shallue+19].

Here I will present results from the on-going effort to automate the Next Generation Transit Survey (NGTS) candidate vetting process using a CNN. Currently we are able to exclude ~50% of false positives, while recovering ~90% of our manually identified candidates and all currently known planets in the NGTS dataset [Chaushev+19]. A key goal of the project is to understand and improve the network performance in the lowest signal to noise regimes. In this regard, NGTS provides a unique dataset as it has been continually pushing to find planets on the edge of detectability, leading to the discovery of NGTS-4b the shallowest transit discovered from the ground to date [West+19]. This makes NGTS an ideal testing ground for CNNs, and improvements made in the techniques here can readily be applied to space based data from K2 and TESS currently, and PLATO in the future.

EP 13.5 Fri 11:15 H-HS VIII

Machine learning inference of the interior structure of low-mass exoplanets — •Philipp Baumeister[1], Sebastiano Padovan[2], Nicola Tosi[1,2], Gregoire Montavon[3], Nadine Nettelmann[2], Jasmine MacKenzie[1], and Mareike Godolt[1] — [1]Centre of Astronomy and Astrophysics, Technische Universität Berlin — [2]Institute of Planetary Research, German Aerospace Center (DLR), Berlin — [3]Institute of Software Engineering and Theoretical Computer Science, Technische Universität Berlin

We explore the application of machine learning based on mixture density neural networks (MDNs) to the interior characterization of low-mass exoplanets up to 25 Earth masses constrained by mass, radius, and fluid Love number k_2. With a dataset of 900 000 synthetic planets, consisting of an iron-rich core, a silicate mantle, a high-pressure ice shell, and a gaseous H/He envelope, we train a MDN using planetary mass and radius as inputs to the network. We show that the MDN is able to infer the distribution of possible thicknesses of each planetary layer from mass and radius of the planet. This approach obviates the time-consuming task of calculating such distributions with a dedicated set of forward models for each individual planet. The fluid Love number k_2 bears constraints on the mass distribution in the planets' interior and will be measured for an increasing number of exoplanets in the future. Adding k_2 as an input to the MDN significantly decreases the degeneracy of possible interior structures.

EP 13.6 Fri 11:30 H-HS VIII

In-situ permittivity measurements for characterising amorphic snow and ice for Enceladus Explorer — •Alexander Kyriacou, Pia Friend, Uwe Naumann, and Klaus Helbing — Gaußstr. 20 42119 Wuppertal

The detection of organic rich salt-water geysers on Saturn's ice-moon Enceladus by Cassini is evidence of a subsurface ocean, a possible habitat for extra-terrestrial life. A robotic space mission, Enceladus Explorer (EnEx) from the DLR space administration, has been proposed to land in safe proximity to a geyser and deploy a melting probe to search a near-surface aquifer for microbes. Forward ice-penetrating radar, from orbit and the surface will be crucial to locate the target reservoir, a safe landing position, and identify and localise obstacles for any given path of the IceMole. A tracking radar may also be used to track the IceMole's trajectory through the ice using antennae on the surface and from orbit.

Given the uncertain density and composition of the surface ice and geyser deposit layer, accurate and high resolution localisation would be aided by in-situ measurement of the dielectric depth profile. The concept for a near-field permittivity sensor, utilising mutual impedance between electrodes placed on the hull of a melting probe is presented. Alternative methods, utilising in-ice active transponders and target focusing are also discussed. The performance of these methods are tested using laboratory tests, simulations and field measurements in the Alps. The enhancement of radio-imaging and profiling with the use of the probe is examined with radio propagation simulations.

EP 13.7 Fri 11:45 H-HS VIII

On the interior of exoplanets with the Love number h_2 — •Hugo Hellard and Szilárd Csizmadia — DLR Berlin, Germany

The characterization of the interior of exoplanets will unveil precious information on their formation, structure, and evolution. The Love numbers h_2 and k_2, which describe the planet's response to external perturbations, contain information beyond the planetary mean density (e.g., radial density profile, rheological properties). Their knowledge will decrease the intrinsic degeneracy of the mass-radius diagram. While Love numbers are known for several Solar System bodies, they remain unmeasured for exoplanets. First, we introduce both

Love numbers and summarize how h_2 can be directly measured from (exo)planetary transit light curves. Second, we present the capability of the Hubble Space Telescope to measure h_2 of the hot-Jupiter WASP-121b before the high-quality data to be returned by the James Webb Telescope and the PLATO telescope in the next decade.

EP 13.8 Fri 12:00 H-HS VIII

Atmospheric Characterization via Broadband Color Filters on the PLAnetary Transits and Oscillations of stars (PLATO) Mission — •John Lee Grenfell[1], Mareike Godolt[2], Juan Cabrera[1], Ludmila Carone[3], Antonio Garcia Munoz[2], Daniel Kitzmann[4], Alexis M. S. Smith[1], and Heike Rauer[1,2,5] — [1]DLR-EPA, Berlin — [2]ZAA, TU Berlin — [3]MPIA, Heidelberg — [4]CSH, Bern — [5]PRS, FU Berlin

We assess broadband color filters for the two fast cameras on the PLAnetary Transits and Oscillations (PLATO) of stars space mission with respect to exoplanetary atmospheric characterization. We focus on Ultra Hot Jupiters and Hot Jupiters placed 25pc and 100pc away from the Earth and low mass low density planets placed 10pc and 25pc away. Our analysis takes as input literature values for the difference in transit depth between the broadband lower (500-675nm) wavelength interval (hereafter referred to as *blue*) and the upper (675-1125nm) broadband wavelength interval (hereafter referred to as *red*) for transmission, occultation and phase curve analyses. Planets orbiting main sequence central stars with stellar classes F, G, K and M are investigated.

EP 13.9 Fri 12:15 H-HS VIII

Planet Earth in spectropolarimetry — •Mihail Manev[1], Claudia Emde[2], Michael Sterzik[3], and Stefano Bagnulo[4] — [1]Meteorological Institute, Ludwig-Maximilians-University, Theresienstr. 37, D-80333 Munich, Germany — [2]Meteorological Institute, Ludwig-Maximilians-University, Theresienstr. 37, D-80333 Munich, Germany — [3]European Southern Observatory, Karl-Schwarzschild-Str. 2, D-85748 Garching, Germany — [4]Armagh Observatory and Planetarium, College Hill, Armagh BT61 9DG, UK

In the next ten years several new powerful telescopes are expected to see first light and bring many exciting discoveries of terrestrial exoplanets. Knowledge of Earth as an exoplanet is vital in order to be able to interpret these future measurements.

We analyzed spectropolarimertic observations of Earthshine, carried out at the VLT (Sterzik et al., Spectral and Temporal Variability of Earth Observed in Polarization, A&A, Vol. 622, A41, 2019), utilizing the state-of-the art Monte Carlo radiative transfer model MYSTIC (Emde et al., Influence of aerosols, clouds, and sunglint on polarization spectra of Earthshine, A&A, Vol. 605, A2, 2017).

The results reveal, which characteristics of Earth can be infered from spectropolarimetry and what signatures are expected from Earth-like exoplanets.