EP 5: Exoplanets and Astrobiology I

Time: Wednesday 16:30–18:00 Location: H9

Invited Talk EP 5.1 Wed 16:30 H9

Planets are Places: Characterization of Other Worlds in the 2020s and Beyond — •Laura Kreidberg — Max Planck Institute for Astronomy, Königstuhl 17, 69117 Heidelberg

The past 25 years have revealed a diversity of exoplanets far beyond what was imagined from the limited sample in the Solar System. With new and upcoming observing facilities and a rapidly growing number of nearby planets, we are poised to bring this diversity into focus, with detailed follow-up characterization of the planets' atmospheres. In this talk, I will discuss frontier questions in exoplanet atmosphere characterization, including: what can we learn about a planet's formation conditions from its present-day atmosphere composition? Where is the dividing line between rocky and gaseous worlds? How are climate, atmospheric circulation, and cloud properties affected by the planet's irradiation environment? And finally, under what conditions do terrestrial planets maintain their atmospheres? Finally, I will conclude with my outlook on the search for biosignatures in the atmospheres of inhabited worlds.

EP 5.2 Wed 17:00 H9

Spectral signature of atmospheric winds in high resolution transit observations — •Engin Keles — Leibniz-Institut für Astrophysik Potsdam (AIP)

Exoplanet atmospheres show large diversity and especially Jupiter type exoplanets, the so-called hot and ultra-hot Jupiters which orbit their host star in close orbits, have been studied in detail. As those planets are tidally locked, atmospheric winds, such as zonal jet streams, become triggered due to the temperature difference between the day- and nightside. Spatially resolved absorption lines, for instance the NaD-lines, from high-resolution transit observations, could be a good tracer for such winds, giving insights into the dynamics of the planetary atmosphere. Comparing Na-lines detected on gas giants from different high-resolution transit observations, the findings suggest that the Na-line broadening is tendentially stronger for planets with lower equilibrium temperatures. If caused by zonal winds, this would hint that zonal winds become stronger on cooler planets introducing stronger line broadening within the investigated temperature range, being in agreement with theoretical expectations.

EP 5.3 Wed 17:15 H9

The LIFE initiative - developing a space mission to search for life outside the Solar System — •Sascha P. Quanz[1] and LIFE Initiative[2] — [1]Institute for Particle Physics and Astrophysics, ETH Zurich — [2]www.life-space-mission.com

In the context of its Voyage 2050 process the European Space Agency has recently identified the detection and characterization of rocky, temperate exoplanets as a potential science theme for a future L-class mission. Since its official kick-off in 2018, the LIFE initiative (LIFE=Large Interferometer For Exoplanets) has been working towards exactly that goal: to develop the science, the technology and a roadmap for an ambitious mid-infrared space mission that will allow humankind to detect and characterize the atmospheres of hundreds of nearby extrasolar planets including dozens that are similar to Earth. In this talk I will summarize the current status of the LIFE initiative, highlight the unprecedented scientific potential of the LIFE mission, discuss synergies with other ground- and space-based exoplanet instruments and missions, and elaborate on remaining technological challenges.

EP 5.4 Wed 17:30 H9

Redox hysteresis of super-Earth exoplanets from magma ocean circulation — •Tim Lichtenberg — Atmospheric, Oceanic and Planetary Physics, University of Oxford, Oxford, United Kingdom

From an astronomical perspective, planets that formed under similar conditions should exhibit comparable compositional trends, such as volatile inventory, which can be compared to hypothetical M-R relations. However, internal redox reactions may irreversibly alter the mantle composition and volatile inventory of terrestrial and super-Earth exoplanets, which can affect their outgassed atmospheres and decouple the initial accreted composition from long-term climate. The global efficacy of these mechanisms hinges on the transfer of reduced iron from the molten silicate mantle to the metal core. Using scaling analysis I demonstrate that turbulent diffusion in the internal magma oceans of sub-Neptune exoplanets can kinetically entrain liquid iron droplets and quench core formation. This suggests that the chemical equilibration between core, mantle, and atmosphere may be energetically limited by convective overturn in the magma flow. Hence, molten super-Earths possibly retain a compositional memory of their accretion path. Redox control by magma ocean circulation positively correlates with planetary heat flow, internal gravity, and planet size. The presence and speciation of remanent atmospheres, surface mineralogy, and core-mass fraction of atmosphere-stripped exoplanets may thus constrain magma ocean dynamics and can be probed by upcoming observational facilities.

EP 5.5 Wed 17:45 H9

INCREASE - An updated model suite to study the INfluecence of Cosmic Rays on Exoplanetary AtmoSpherEs — •Konstantin Herbst[1], John Lee Grenfell[2], Miriam Sinnhuber[3], and Fabian Wunderlich[2] — [1]IEAP, Christian-Albrechts-Universität zu Kiel, 24108 Kiel, Germany — [2]PF, Deutsches Zentrum fuer Luft- und Raumfahrt (DLR), 12489 Berlin, Germany — [3]Institut fuer Meteorologie und Klimaforschung, Karlsruher Institut fuer Technologie (KIT), 76344 Eggenstein-Leopoldshafen, Germany

The first opportunity to detect indications for life outside of the Solar System may be provided already within this decade. However, the harsh stellar radiation and particle environment of planets in the habitable zone of their host stars could lead to photochemical loss of atmospheric biosignatures. A self-consistent model suite of combined state-of-the-art tools has been developed by Herbst et al. (2019) to study the impact of the radiation and particle environment on atmospheric particle interactions, composition, and climate interactions. Here we present our updated model suite to study a wide range of possible exoplanetary atmospheres and stellar environments tackling the following questions: (1) What processes determine whether (rocky) worlds around cooler stars can retain their atmospheres? (2) How do different atmospheres evolve for cool star systems?, and (3) How do results from our studies compare with observations? Thereby, we will focus on the impact of stellar activity on planetary climate, atmospheric escape, density and composition, surface radiation dose, and the impact on potential observables.