# CSH Symposium 2024

UNIVERSITÄT BERN

CSH

CENTER FOR SPACE AND HABITABILITY

The CSH Fellowship is the flagship program for the CSH to attract excellent postdoctoral researchers to carry out their independent research programs at the University of Bern.

On behalf of the CSH Fellowship Panel, co-directors Prof. Susanne Wampfler and Prof. Yann Alibert are pleased to invite you for the public presentations of the candidates in the form of the annual CSH Symposium.

The CSH Symposium will take place on February 14th, 2024, in room -108 at Gesellschaftsstrasse 6, 3012 Bern (and online on Zoom).

| **Time (CET))** | **Speaker** | **Research topic(s)** |
|---|---|---|
| 09:00 – 09:30 | *Welcome coffee/tea* | |
| 09:30 – 09:45 | Prof. Susanne Wampfler/ Prof. Yann Alibert (CSH) | Introduction to the CSH |
| 09:45 – 10:15 | Dr. Solène Ulmer-Moll (Geneva/Bern) | Exoplanets |
| 10:15 – 10:45 | Marrick Braam (Edinburgh/Leuven) | Exoplanets |
| 10:45 – 11:15 | *Coffee break* | |
| 11:15 – 11:45 | Beatriz Campos Estrada (Copenhagen/Graz) | Exoplanets |
| 11:45 – 12:15 | Dr. Valentin Bickel (CSH) | Planetary geomorphology |
| 12:30 – 13:30 | *Lunch at Restaurant Grosse Schanze* | |
| 14:00 – 14:30 | Dr. Sacha Gavino (Copenhagen) | Astrochemistry/Disks |
| 14:30 – 15:00 | Caroline Piaulet-Ghorayeb (Montréal) | Exoplanets |
| 15:00 – 15:45 | *Coffee break* | |
| 15:45 – 16:15 | Wenhan Zhou (OCA Nice) | Small bodies |
| 16:30 – 17:00 (setup from 16:20) | Dr. Anna Gülcher (JPL) - *remote* | Geophysics |

Zoom Link for remote participants:

https://unibe-ch.zoom.us/j/67018085793?pwd=bnc3NGdkTy8yOHZSTTJuMmNPbHpxdz09

Meeting-ID: 670 1808 5793

Password: 277610

**Dr. Solène Ulmer-Moll (University of Geneva/University of Bern)**

*Exploring the interior and dynamics of temperate exoplanets*

Understanding the origin and evolution of planetary systems, in particular those akin to our Solar System, is one of the major quests driving exoplanetary research. High precision photometry missions are at the forefront of discovering transiting planets of all sizes, giving us access to their radius and inclination. Yet the majority of detected transiting planets have orbits which would fit within Mercury's orbit. Characterising transiting temperate gas and ice giants is a key missing piece in the exoplanet puzzle. I propose a project based on the detailed interior modelling and dynamical study of newly detected temperate planets. This work will reveal the nature and origin of these planets and will assess their impact on the habitability of planetary systems.

**Marrick Braam (University of Edinburgh/KU Leuven)**

*The 3-D environmental potential for the origin of life on exoplanets*

The diversity of confirmed exoplanets offers opportunities to test theories on the origin of life and look for biosignatures. Previous work has shown that photochemistry can drive prebiotic processes in exoplanet atmospheres. However, these studies rely on 1-D atmospheric models, overlooking the inherent 3-D nature of planetary atmospheres. In this talk, I will outline my proposal to determine the 3-D environmental potential for the origin of life on exoplanets and the observability of prebiotic compounds in their atmospheres. The proposed project will deliver a comprehensive 3-D model of exoplanet atmospheres with, for the first time, interactive formation of prebiotic compounds like hydrogen cyanide and formaldehyde. For exoplanets in diverse orbits around M, K, G, and F stars, we will quantify the 3-D spatial distributions of these compounds and their temporal variations to determine the potential for prebiotic chemistry. We will use the distributions to assess the observability of 3-D prebiotic chemistry with the Large Interferometer For Exoplanets, a Swiss-led mission concept. I will discuss foreseen collaborations for this interdisciplinary project intended to advance our quest for life in the Universe.

**Beatriz Campos Estrada (Niels Bohr Institute, University of Copenhagen/Space Research Institute, Graz)**

*Challenging cloud microphysics with observations of planetary mass companions and hot Jupiters*

Planetary atmospheres hold fingerprints of the still uncertain planet formation processes. Clouds present a challenge to atmospheric characterisation as they can often hide spectral features of the gaseous components of atmospheres. However, clouds are present in all Solar System bodies with atmospheres, and they are likely present in almost every extrasolar planet with an atmosphere. Silicate clouds have been detected for the first time in observations of a planetary mass companion and a hot Jupiter with JWST. The resolution of JWST allows us to test our understanding of cloud microphysics in exoplanet atmospheres for the first time. If holding a CSH fellowship, I will test the microphysics of cloud formation against existing and incoming observations of planetary mass companions and hot Jupiters. I will do this by using a state-of-the-art self-consistent atmospheric model of cloudy substellar atmospheres. The model considers both cloud microphysics and cloud radiative feedback and is the first model capable of reproducing the absorption feature of silicate clouds in the mid-infrared spectra of planetary mass companions.

**Dr. Valentin Bickel (CSH)**

*Martian Slope Streaks - a Smoking (Water) Gun?*

Slope streaks are geologic features that form on martian slopes and fade within a few decades. Most controversially, their occurrence has been linked to the presence of near-surface water/brines, with major implications on the present-day habitability of Mars. I am using a novel, deep learning-driven approach to shed new light on a decade-old discussion**.**

**Dr. Sacha Gavino (Niels Bohr Institute, University of Copenhagen)**

*Chemistry evolution in protoplanetary disks - A link to exoplanet elementary composition*

The chemical elemental composition of an exoplanet is directly inherited from the content of the accreted material in the protoplanetary disk. The C/O ratio, among other chemical tracers, is expected to be a good tool to probe the chemical history of planet formation. However, to address these questions, a sophisticated type of models that couples dust dynamics and chemical evolution in disks is required. These models are inherently complex and numerically very challenging. Based on recent improvements of a gas-grain code, the proposed work will consist in carrying on with the development of a state-of-the-art dynamo-chemical modeling framework in order to simulate the chemical evolution in protoplanetary disks. In particular, the proposed work aims to constrain the radial dependence of the C/O ratio and other chemical tracers to help solve the chemical puzzle between the elemental composition of planetary atmospheres and their formation pathway. Additionally, these results will be analyzed in light of multi-wavelength observations.

**Caroline Piaulet-Ghorayeb (Trottier Institute, University of Montréal)**

*SEEING THE UNSEEABLE*
*Opening new windows into exoplanet atmospheres and compositions*

Over the past few years, leaps in the number of planets with precise masses and radii, and in spectroscopic studies of exoplanetary atmospheres using space-based telescopes have revolutionized our understanding of their nature, formation, evolution and atmospheric chemistry. Recent years have seen tantalizing evidence for small volatile-rich planets, or "water worlds", but they have yet to be confirmed by atmosphere observations. JWST's high-precision and near-infrared coverage also started yielding insights into the exotic chemistry of the hottest giant exoplanets - but we still do not grasp how much of their emission is driven by these massive planets' internal heat reservoirs. At the other end of the temperature range, the chemical transition from hot carbon-monoxide-rich to colder methane-rich giant planet atmospheres has yet to be understood from both observational and theoretical modeling perspectives. I will present how I propose to contribute new insights into these questions at the frontier of exoplanetary science and foster new interdisciplinary collaborations with CSH researchers.

**Wenhan Zhou (Observatoire de la Côte d'Azur, Nice)**

*Rotational and Orbital Evolution of Asteroids*

The main belt asteroids, remnants of the primordial planetesimals, have undergone extensive collisional fragmentation over billions of years. To understand primordial planetesimals, we need to identify those asteroids formed initially and those resulting from subsequent collisions, known as asteroid families. Currently, the identification method is to examine the orbital dispersion of collisional fragments under the Yarkovsky effect—a radiative force modifying asteroid orbits. However, the Yarkovsky effect depends on the rotational evolution that is far from well understood. To solve this problem, I developed an advanced rotational evolution model, accounting for collisions, radiative torques and tumbling states, effectively reproducing the observed spin distributions of asteroids. This model will be applied to study the long-term orbital evolution of asteroids, thereby enhancing the precision in identifying and categorizing asteroid families. In addition, the upcoming observation missions, such as Gaia, TESS and LSST, will open a golden era to test these models.

**Dr. Anna Gülcher (NASA Jet Propulsion Laboratory/California Institute of Technology) - remote**

*Venus as a case study for the (in)habitability of Earth-like (exo)planets*

No other planet that we know of resembles Earth as much as our neighbour Venus in terms of size, mass, and chemical makeup. The two planets once formed under very comparable conditions, but their environments today could not be more different. Whereas Earth environment is habitable and allows for liquid water, Venus has a crushingly thick atmosphere over a hellish, hot surface. My dedication lies in understanding the different evolutionary paths of Earth and Venus, and what that means for the diversity of Earth-like (and thus, Venus-like) exoplanets. In particular, I believe that the focus of the inhabitability of Venus is key for understanding the habitability of our own planet. This presentation will argue for Venus as a natural laboratory to explore the evolution and (in)habitability of Earth-like (exo)planets. I will present my research plans for the CSH fellowship, starting with how I plan to establish geodynamic models as a pivotal role in the preparation of several upcoming Venus missions like VERITAS and EnVision. I will also address how I aim to explore how the water content in the mantle of rocky Earth- and Venus-like planets affects mantle convection and surface tectonics/volcanism (i.e., ingassing/outgassing), and how I plan to develop coupled tectonic-climate scenarios to address the co-evolution of the interior, surface, and atmospheric conditions of Venus and rocky planets. Ultimately, the coupling of endogenic processes with exogenic processes of Earth and Venus will shed light on the building blocks for an (in)habitable planet. Finally, in connection with several upcoming Venus missions, I will highlight the expected  impact of this research to the broader (scientific and public) community, hoping to foster excitement for the 'Decade(s) of Venus' that awaits us.