Understanding clouds as a necessary ingredient in the search for life: The case study of the exoplanet Kepler-7b

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An international team, with participation from the University of Bern, has produced the first map of clouds on an exoplanet using the Kepler Space Telescope. Studying the atmospheres of exoplanets is the path towards ultimately identifying life elsewhere in the Universe. Understanding the role of clouds in exoplanet atmospheres is a necessary ingredient in the cosmic hunt for life.

Discovered three years ago by astronomers using the Kepler Space Telescope, the exoplanet Kepler-7b orbits a Sun-like star outside of our Solar System. An unusual property of Kepler-7b is that it is unusually reflective to starlight: it reflects about 50% of the visible light incident upon its atmosphere. This motivated a detailed investigation by an international team of astronomers, including participation from the Center for Space and Habitability (CSH) at the University of Bern. The team measured reflected starlight for the entire orbit of Kepler-7b around its star, much like how one would measure the different phases of the Moon orbiting Earth, producing a "phase curve", which can be directly transformed into a crude map (with only east-west information). The unexpected structure present in the map, together with the unusually high reflectivity of the atmosphere, implied the existence of clouds. An analysis of the map structure also set constraints on the size of the cloud particles. This first measurement of a map of clouds was published in the *Astrophysical Journal Letters* (Demory et al. 2013). Another paper demonstrating the unusual reflectivity of Kepler-7b, compared to its

peers, was published in the *Astrophysical Journal* (Heng & Demory 2013).

Together with the "blue planet" study (of the exoplanet HD 189733b) by Evans et al. (2013), these studies are the first to empirically investigate the details of clouds in the atmospheres of exoplanets. Kevin Heng from the CSH was involved in all three studies. "Clouds are a nuisance, because they hinder us from performing a unique interpretation of an exoplanet atmosphere," explains Heng. When clouds are present in an atmosphere, there may be hundreds of ways of interpreting its chemical abundances. This is especially acute in the search for life elsewhere in the Universe, which must proceed through the characterization of the atmospheres of exoplanets. "The fear is that clouds will confuse our ability to clearly identify the signatures of life from scrutinizing the spectrum of an exoplanetary atmosphere, which is why we are investing time and energy to understand the effects of clouds," said Heng.

The Exoplanets and Exoclimes Group (EEG) of Kevin Heng is based at the University of Bern and specializes in the theory and simulation of exoplanet science. The EEG works closely with a network of astronomers, including Geneva Observatory, the Massachussetts Institute of Technology (MIT) and Oxford University, seeking advice on designing their theoretical studies to interpret the astronomical data, while also assisting the astronomers in formulating new ideas for their research.

More information: Brice-Olivier Demory, Julien de Wit, Nikole Lewis, Jonathan Fortney, Andras Zsom, Sara Seager, Heather Knutson, Kevin Heng, Nikku Madhusudhan, Michael Gillon, Thomas Barclay, Jean-Michel Desert, Vivien Parmentier, Nicolas B. Cowan: Inference of Inhomogeneous Clouds in an Exoplanet Atmosphere, *Astrophysical Journal Letters*, 2013, in press

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