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New estimates on Super-Earths HD219134 b & c: Is planet b a magma ocean planet?

Roxanne Ligi (1), **Caroline Dorn** (2), and Aurélien Crida (3,4)
(1) INAF-Osservatorio Astronomico di Brera, Merate, ITALY (2) University of Zurich, Institut of Computational Sciences, University of Zurich, Zurich, SWITZERLAND (3) Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, Laboratoire Lagrange, 06304 Nice cedex 4, FRANCE, (4) Institut Universitaire de France, Paris, FRANCE

Abstract

We investigate the density difference between the two transiting super-Earths HD 219134 b and c and its possible origin, including significant melt fractions for planet b. The density difference between both planets is extremely well constrained. Our recent interferometric observations of HD 219134 allow for high precision estimates of the stellar radius, and hence planetary parameters. We present our new mass and radius estimates, and discuss the possible origins of the $\sim 10\%$ density difference between planet b and c. To first order, planet b's close proximity to the star may allow high tidal heating rates that can allow the mantle to be partially molten, while planet c can be solidified. A difference in melt fraction may explain the observed density difference [1]. However, we also show that the uncertainties on the individual bulk densities are not sufficiently accurate to exclude the absence of a density difference as well as differences in volatile layers.

1. Astrophysical observations

Planet parameters are never as accurate as those of their host stars. One of the best way to determine stellar parameters is to use interferometry, which provides a measure of the angular diameter (e.g.: [2, 3]). When the star has a transiting exoplanet, the stellar density can be deduced [4]. Then, the stellar mass can be obtained independently of any stellar evolution model, strongly correlated with the radius. This in turn provides a valuable constrain on the planetary mass, radius, and density. This method was developed in our previous work and applied to 55 Cnc [5, 6]. Here, we apply it to HD 29134, one of the few other stars with transiting exoplanet accessible with ground instruments to date.

2. Results

We observed HD 219134 from 2016 to 2018 using the VEGA/CHARA instrument at visible wavelengths. We find an angular diameter of $\theta_{\mathrm{UD}} = 0.980 \pm 0.020$ mas. Combined with the distance provided by Gaia, and the stellar density with derive from the transit parameters, this leads to a star 14% less massive than found in previous works which relied on Hipparcos distance and stellar evolution models.

In turn, the two planets are lighter than previously thought. We will present our new values of the planetary masses, radii and densities. These two super-Earths, despite belonging to the same system, have a significantly different density (with the more massive one being less dense). We will discuss the implications on their composition, internal structure, and evolution. In summary, planet b is a candidate planet to have a significantly high melt fraction and therefore to be a magma ocean planet.

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