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Lyman alpha observations of the HD 219134 system: deuterium-to-hydrogen ratio of the local ISM and the exosphere of the super-Earth HD 219134b

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Abstract

In July 2015, we announced the discovery of the super-Earth HD 219134b, orbiting a V = 5.57 star 6.5-pc away from us Motalebi et al. 2015. It was the brightest and closest transiting system known so far. The density of HD 219134b is compatible with a rocky planet, possibly containing a large amount of volatile species. The planet receives high stellar irradiation, which could significantly erode its atmosphere. Estimates indicate that this 4.5 Earth-mass object should nonetheless retain a substantial atmosphere. HD 219134b lies sufficiently far from its star to allow the formation of a hydrogen cloud with a detectable coma. We observed it at three different epochs in the far ultraviolet (FUV) using the HST/STIS allowing us to detect, for the first time, a possible atmospheric escape from a super-Earth. The detection of escaping hydrogen is revealed by a redshifted absorption in the Lyman alpha line. Those observations also show that HD 219134 has, by far, the brightest Lyman alpha emission among all measured transiting exoplanet host stars, which make it possible to observe it at high resolution with the STIS/E140H grating.

The high-resolution observations allow us to reconstruct the intrinsic Lyman alpha line of the star with unprecedented constrains for a planetary system. The stellar flux in this region is used as a proxy to assess the entire energy deposit of the star in the atmosphere of the planet, which is controlling the atmospheric escape mechanism. As the intrinsic line is absorbed by the deuterium and hydrogen of the interstellar medium (ISM), it also allows us to probe the deuterium-to-hydrogen ratio of the local ISM. As deuterium is only produced during the big bang and destroyed in the stars (astration process), this ratio is a key ingredient for cosmological simulations and in understanding the evolution of galaxies by evaluation of the birth/death rates of stars.

References

[1] Motalebi, F. et al.: The HARPS-N Rocky Planet Search: I. HD 219134 b: A transiting rocky planet in a multi-planet system at 6.5 pc from the Sun, Astronomy \& Astrophysics, Vol. 584, pp. A72, 2015