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High-contrast imaging study on the candidate companions around the star AH Lep

Samantha B. Brown Sevilla,[1] Faustine Cantalloube,[1] Wolfgang Brandner,[1] Markus Feldt,[1] Thomas Henning,[1] Anne-Lise Maire,[2] Joshua Schlieder,[3] A. Boccaletti,[4] M. Bonnefoy,[5] G. Chauvin,[5,6] S. Desidera,[7] V. D'Orazi,[7] R. Gratton,[7] M. Keppler,[1] A-M. Lagrange,[5] M. Langlois,[8] D. Mesa,[7,9] M. Meyer,[10,11] M. Samland,[1] T. Schmidt,[4] and A. Vigan[12]

[1] *Max Planck Institute for Astronomy, Königstuhl 17, 69117, Heidelberg, Germany*
[2] *STAR Institute, Université de Liège, Allée du Six Août 19c, B-4000 Liège, Belgium*
[3] *NASA Exoplanet Science Institute, California Institute of Technology, CA 91125, Pasadena, USA*
[4] *LESIA, Observatoire de Paris, PSL Research University, CNRS, Sorbonne Unniversités, UPMC Univ. Paris 06, Univ. Paris Diderot, Sorbonne Paris Cité*
[5] *Univ. Grenoble Alpes, CNRS, IPAG, 38000, Grenoble, France*
[6] *Unidad Mixta Internacional Franco-Chilena de Astronoma, CNRS/INSU UMI 3386 and Departamento de Astronoma, Universidad de Chile, Casilla 36-D, Santiago, Chile*
[7] *INAF - Osservatorio Astronomico di Padova, Vicolo dell Osservatorio 5, 35122, Padova, Italy*
[8] *CRAL, UMR 5574, CNRS, Université de Lyon, Ecole Normale Supérieure de Lyon, 46 Allée d'Italie, F-69364 Lyon Cedex 07, France*
[9] *Instituto de Astronomía y Ciencias Planetarias de Atacama, Copayapu 485, Copiapó, Atacama, Chile*
[10] *Institute for Particle Physics and Astrophysics, ETH Zurich, Wolfgang-Pauli-Strasse 27, 8093 Zurich, Switzerland*
[11] *Department of Astronomy, University of Michigan, 1085 S. University Ave, Ann Arbor, MI 48109-1107, USA*
[12] *Aix Marseille Univ, CNRS, CNES, LAM, Marseille, France*

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AH Lep (R.A.(J2000) = 05 34 09.16, Dec.(J2000) = 15 17 03.18) is a young, nearby, solar-type star (G2V). Gaia DR2 and BANYAN Sigma provide a 99.9% probability of the star belonging to the Columba moving group (Zuckerman, B. et al. 2011), and therefore, it has an estimated age of 42^{+6}_{-4} Myr (Bell, C. P. M. 2015). It has a parallax of $p = 17.26$ mas, corresponding to a distance of $d = 57.9$ pc (Gaia Collaboration et al. 2018). The star has been reported to have variable photospheric and X-ray emission (e.g., Burleigh, M. R. et al. 1998; Cutispoto, G. et al. 2003).

AH Lep was first observed in high-contrast imaging as a part of the SEEDS survey by Brandt, T. D. et al. (2014), for which they obtained H-band data and used Angular Differential Imaging (ADI, Marois, C. et al. 2006) to look for candidate companions (CCs) around their targets. In the case of AH Lep, they do not report any CCs within 7.5" (∼400 au).

In this research note, we report AH Lep high-contrast imaging observations obtained using VLT/SPHERE (Spectro-Polarimetric High-contrast Exoplanet REsearch, Beuzit, J.-L. et al. 2019) in Paranal, Chile, within the SHINE (SpHere INfrared survey for Exoplanets, Chauvin, G. et al. 2017) survey. Observations took place on January 28th, 2018, using the IRDIFS_EXT mode, which simultaneously allows to obtain dual-band imaging with the IRDIS camera (Dohlen, K.

Corresponding author: Samantha B. Brown Sevilla
brown@mpia.de

et al. 2008; Vigan, A. et al. 2010) in K1/K2 filters, and Integral Field Spectroscopy (IFS, Claudi, R. U. et al. 2008) in the Y-H filter. The data, taken in pupil tracking mode, were reduced in the standard way, making use of the SPHERE Data Center pipeline (Delorme, P. et al. 2017).

For the data analysis, we used ADI technique to look for planetary signals around AH Lep. In particular, we used the ANgular Differential OptiMal Exoplanet Detection Algorithm (ANDROMEDA, Cantalloube, F. et al. (2015)), which utilizes an inverse problem approach to search for CCs. Two candidates were found at a projected separation of 421.05 ± 3.40 mas and 769.81 ± 3.57 mas, which correspond to 24.37 ± 0.19 au and 44.57 ± 0.20 au, respectively, and with H-band magnitudes being 12.2 mag and 12.6 mag fainter than AH Lep, corresponding to a contrast of $12.7\text{x}10^{-6}$ ± $1.54\text{x}10^{-6}$ and $8.62\text{x}10^{-6}$ ± $1.14\text{x}10^{-6}$, respectively (see Fig. 1, left).

In order to verify whether these two companions are bound, we performed an astrometric analysis combining the SPHERE data with archival H-band data from the Gemini Planet Imager (GPI, Macintosh, B. et al. 2014) at the Gemini South telescope in Cerro Pachon, Chile, obtained on December 17th, 2016. The data were reduced with the public pipeline (Perrin, M. D. et al. 2014, 2016), and afterwards we applied ANDROMEDA to look for companions. Two CCs were found in this data set, and their parameters are consistent with the ones found for the SPHERE data. Our results of the astrometric analysis are shown in Fig. 1, right, where we used the GPI epoch for both sources as a reference and where the difference between epochs show the combined uncertainties of GPI+SPHERE data, this is limited by the systematic uncertainty between GPI and SPHERE astrometry, and not by the measurement procedure. We found that the CCs are most likely background sources as they appear to follow the stationary background track. The astrometric values used to perform the astrometric analysis were calibrated following the procedures in Maire, A. L. et al. (2016) for the SPHERE data, and following Konopacky, Q. M. et al. (2014) for the GPI data.

Additionally, we extracted the spectra of the two point sources from the SPHERE/IFS data, where we found no significant evidence of methane (CH_4) absorption, ruling out that the point sources are T dwarfs, notwithstanding, the absence of CH_4 may be due to several reasons, e.g. clouds in their atmospheres. A more detailed analysis of the spectra of the point sources might help to clarify their nature, however, this is beyond the scope of this research note and will be left for a future work.

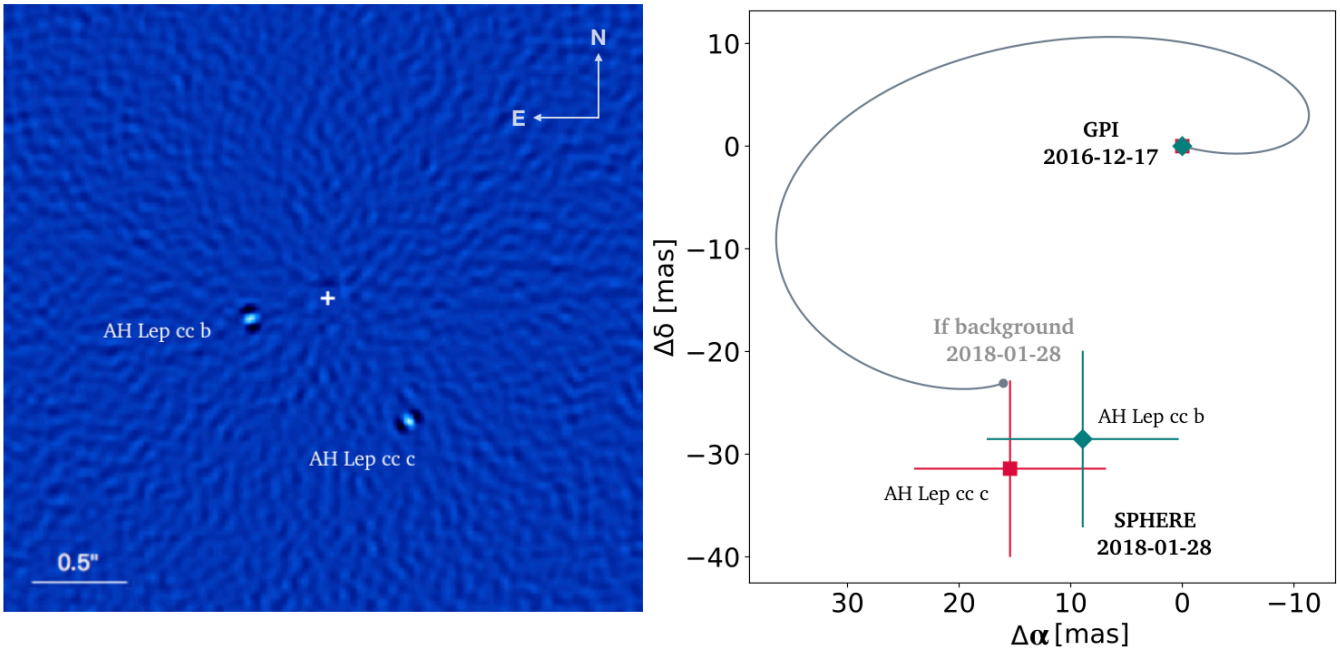

Figure 1. Left: SPHERE/IRDIS ANDROMEDA image of AH Lep obtained in the H-band. The white cross indicates the position of the star. Right: Relative astrometry of the CCs of AH Lep. The markers show the measurements of the relative positions of the CCs, at both the initial GPI epoch, and further in time at the SPHERE epoch. The gray line traces the path a stationary background object would have followed with respect to AH Lep between the two epochs.

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