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Bulletin of the AAS

Mapping Exoplanet Atmospheres with Direct Ground-based Observations

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Published on: Apr 03, 2024

URL: https://baas.aas.org/pub/2024n4i626p05

Planetary rotation and atmospheric features, such as giant storms and hurricanes, give rise to variability in exoplanet atmospheres as they rotate in and out of view. By monitoring this variability, we can construct maps that detail their physical appearance. Ground-based observatories have the resolution and photon collecting power to reach the high contrasts and small inner working angles needed to monitor these faint companions over their rotation timescales. But, bright host stars and a lack of reference stars accessible to the typically narrow field of view of ground-based coronagraphic imagers makes this difficult. Here, I present a new approach with results from our differential spectrophotometric monitoring campaign of a young, widely-separated substellar companion using NALES/LBT, an integral field spectrograph (R = 40) in combination with a vector Apodising Phase Plate (vAPP) coronagraph. Unlike focal-plane coronagraphs, the vAPP is insensitive to telescope vibrations and reaches deep speckle suppression while simultaneously providing an unsaturated PSF of the star for use as a reference to remove variations due to Earth's atmosphere. By adopting techniques traditionally used for exoplanet transmission spectroscopy, we create light curves of the companion directly to search for inhomogeneities in its atmosphere. I will show the ~4-5% differential precision we already achieve with just one night of monitoring and an analysis of the astrophysical features we find in the light curve. Through this method, we can achieve high-precision differential spectrophotometry for directly imaged exoplanets inaccessible to space-based telescopes. This work is a path-finder for further studies with VLT/ERIS and exoplanet mapping with ELT/METIS.