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Understanding the Puzzling Nature of the Ultracool Brown Dwarf HD4113C

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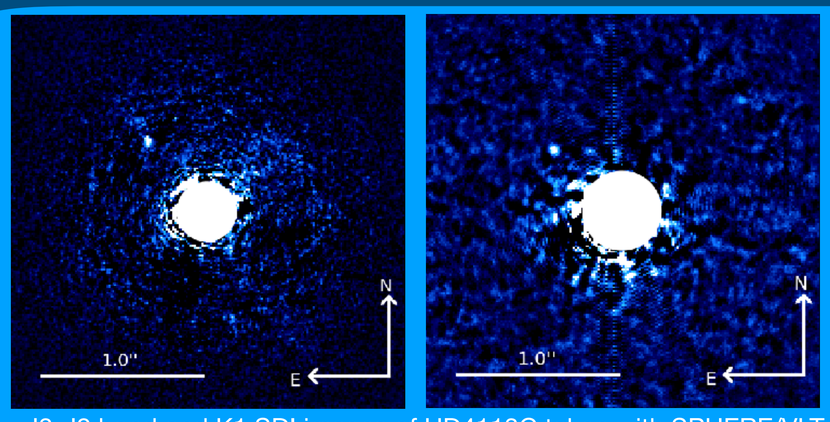
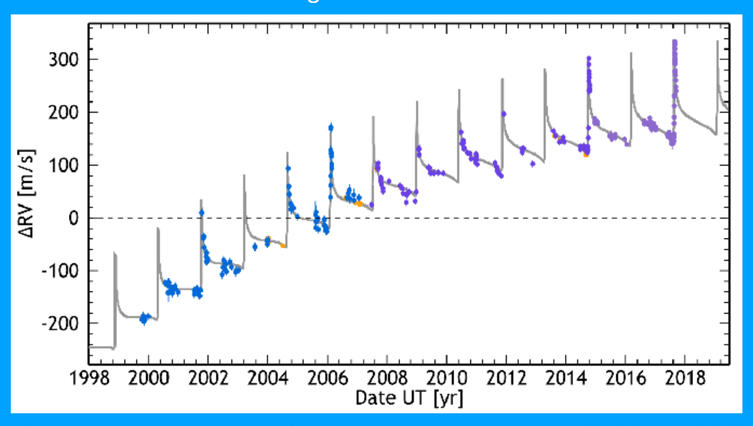


J3-J2 band and K1 SDI images of HD4113C taken with SPHERE/VLT



Radial velocity measurements of HD4113A taken with CORALIE/EULER. The RV time series shows the eccentric orbital model of the inner giant planet, HD4113Ab as well as the long term drift corresponding to HD4113C.

Introduction

The Background

HD4113C is an ultra cool brown dwarf, discovered by Cheetham et al. 2017, originally detected through a long period radial velocity curve, observed with CORALIE/EULER. The companion candidate was then imaged with SPHERE/VLT and one of the coldest brown dwarfs ever imaged was detected with an effective temperature of ~500-600K. However, this ultra cool substellar companion appears to be too cold for its mass and age, presenting a challenge to brown dwarf cooling models. The dynamical mass derived from radial velocities suggest that the companion is 36±5 M_{Jup} whereas the derived isochronal mass suggests that the brown dwarf is 66±5 M_{Jup} .

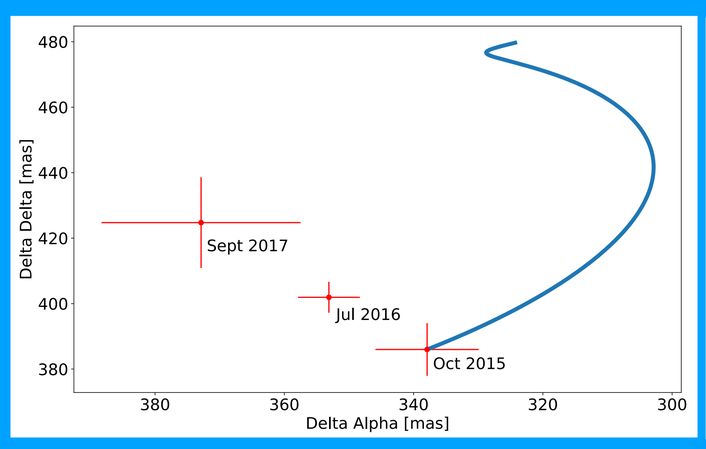
The Big Question

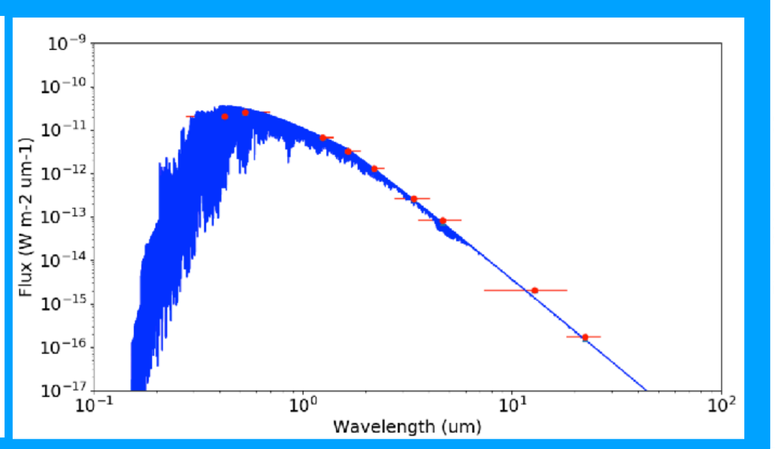
There are two scenarios that could answer this. Is the brown dwarf really that cold? Or is there another object in this system to account for the observed flux?

The Next Steps

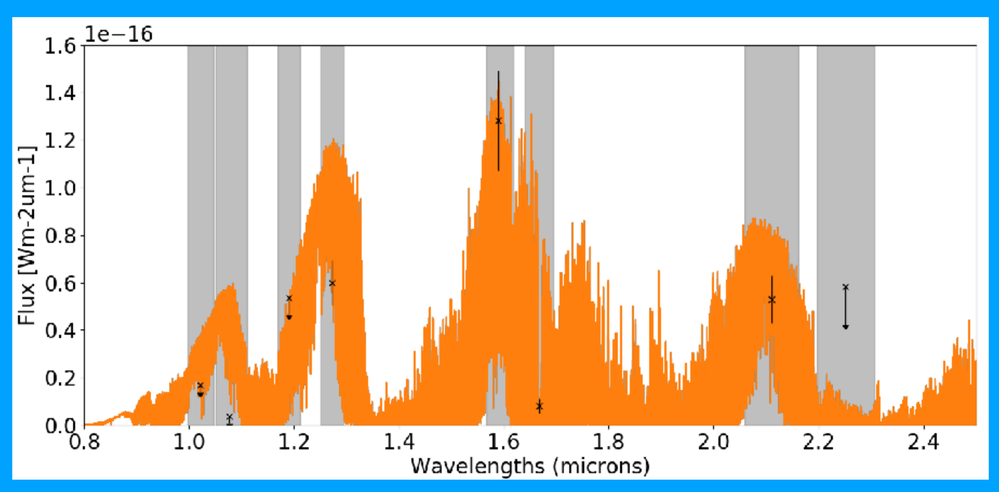
We present the follow-up observations taken with SPHERE with updated parameters for the position angle, contrast and separation, allowing us to provide further constraints on the orbital and physical parameters of HD4113C.

Observations and Analysis





Left: Calculated proper motion of HD4113 shown by the curve with the points showing the position of HD4113C over time, showing that the companion must not be a background star. **Right:** Fitted SED from the BT-Settl models (Allard 2015) for HD4113A, in order to calculate the flux for HD4113C



Fitted spectrum for T_eff = 550 K (Morley et al. 2012). The grey bands show the FWHM of the IRDIS filters are shown with gray bars (YJHK), where the H band data is taken from Cheetham et al. 2017.

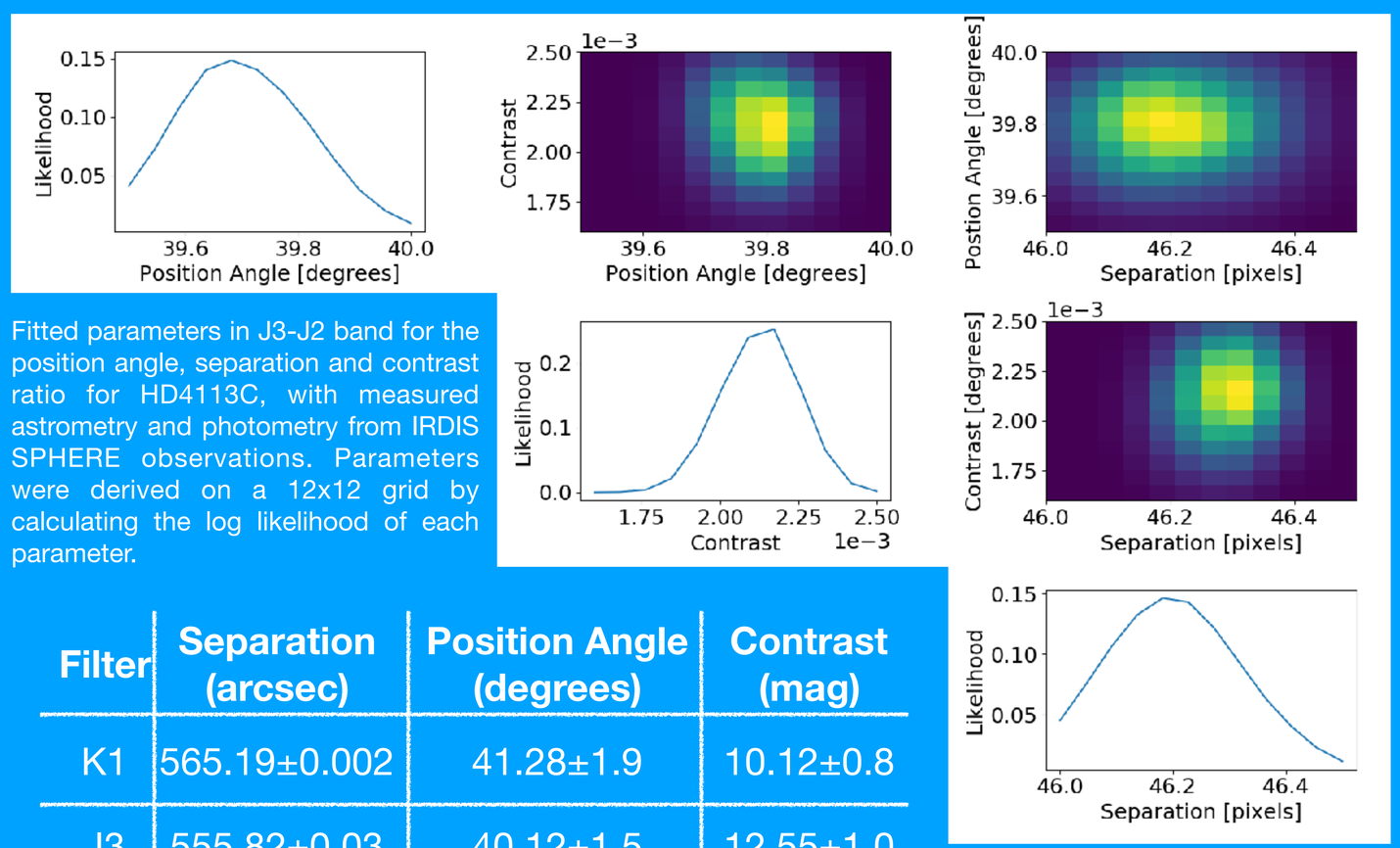
Follow-up observations of HD4113C were taken using IRDIS (J23, Y23 and K12 bands) and IFS on SPHERE simultaneously over 3 nights in 2017. These observations provide us with new photometric points on the spectrum, in wavelengths that we previously did not observe. We see a clear detection of HD4113C in J3, J3-J2, K1 and K1-K2 bands, reduced using SDI+ADI techniques. We analysed the images to derive the position angle, separation and contrast of HD4113C, and adding additional photometric points to HD4113C's spectrum and astrometric points to help us further constrain its orbit.

Conclusions

Here we present the first analysis of the follow-up observations of HD4113C to help us understand the discrepancy in the dynamical mass and the derived isochronal mass.

These updated parameters are the first step to further understanding whether this discrepancy is due to two unresolved brown dwarfs closely orbiting one another in the system.

Additional photometry (YJK bands), as well as previous photometric points (H23 band) and a new astrometric point has been derived which will allow us to further constrain HD4113C which in turn will help us understand the orbit and calculate whether or not there is an additional companion present.



Fitted parameters in J3-J2 band for the position angle, separation and contrast ratio for HD4113C, with measured astrometry and photometry from IRDIS SPHERE observations. Parameters were derived on a 12x12 grid by calculating the log likelihood of each parameter.

Filter	Separation (arcsec)	Position Angle (degrees)	Contrast (mag)
K1	565.19±0.002	41.28±1.9	10.12±0.8
J3	555.82±0.03	40.12±1.5	12.55±1.0

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References
Cheetham et al., 2017, Direct imaging of an ultracool Substellar companion to the exoplanet host star HD 4113 A
Allard, F., 2015, The BT-Settl Model Atmospheres for Stars, Brown Dwarfs and Planets
Morley et al. 2012, Neglected Clouds in T and Y Dwarf Atmospheres

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