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VVV J165507.19−421755.5: A Nearby T Dwarf Hidden in the Galactic Plane

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ABSTRACT

We present the discovery of VVV J165507.19−421755.5, a mid-T dwarf found through ongoing unWISE-based proper motion searches. A near-infrared spectrum of this object obtained with the NIRES instrument on the Keck II telescope indicates a spectral classification of T5. Using data from the VISTA Variables in the Via Lactea (VVV) catalog with a 9 year baseline, we measure a proper motion of $(\mu_\alpha \cos(\delta),\ \mu_\delta) = (-631.0 \pm 1.3, -315.0 \pm 1.4)$ mas yr^{-1} and a trigonometric parallax of $\pi_{abs} = 66.0 \pm 4.8$ mas, corresponding to a distance of 15.2 ± 1.1 pc. The trigonometric parallax agrees well with our photometric distance estimate ($16.1^{+5.1}_{-3.9}$ pc) assuming that VVV J165507.19−421755.5 is a single T5 dwarf. VVV J165507.19−421755.5 is a new member of the 20 parsec census.

Keywords: T dwarfs (1679), Brown dwarfs (185), Infrared spectroscopy (2285), Spectroscopy (1558)

1. DISCOVERY OF J1655−4217

VVV J165507.19−421755.5 (J1655−4217) was initially discovered through "SMDET" machine learning analysis (Caselden et al. 2020) of unWISE coadds (Meisner et al. 2018). Although not immediately visible to the human eye in these coadds, J1655−4217 was visually confirmed to be a moving point source in imaging data from the Vista Variables in the Via Lactea survey (VVV; Minniti et al. 2010) over a 5.3 year baseline (Figure 1). Once its status as a candidate nearby source was confirmed, its spectrum was obtained using the Near-Infrared Echellette Spectrometer (NIRES; Wilson et al. 2004) on the Keck II 10 m Telescope.

2. ANALYZING J1655−4217

We obtained Keck/NIRES spectroscopy of J1655−4217 on the night of 2022 June 11 (UT) in clear and dry conditions with 0″.5 seeing. NIRES is a cross-dispersed spectrometer, providing 1–2.4 μm spectroscopy at an average resolution of $\lambda/\Delta\lambda \approx 2700$ for its 0″.55 slit (Wilson et al. 2004). Four exposures of 250 s each were obtained, followed by an observation of the A0 V HD 154409 for flux and telluric calibration. Data were reduced using a modified version of the Spextool package (Cushing et al. 2004) using standard settings.

We analyzed a smoothed (30 pixels) and normalized version of the reduced NIRES spectrum using tools in the SPLAT Python library (Burgasser & Splat Development Team 2017). We compared the spectrum of J1655−4217 to T dwarf spectral standards (Burgasser et al. 2006; Theissen et al. 2022), and found a best overall fit (minimum χ^2) to the T5 standard (Figure 1). This is also a good visual match, with no spectral peculiarities indicative of low surface gravity or unresolved multiplicity.

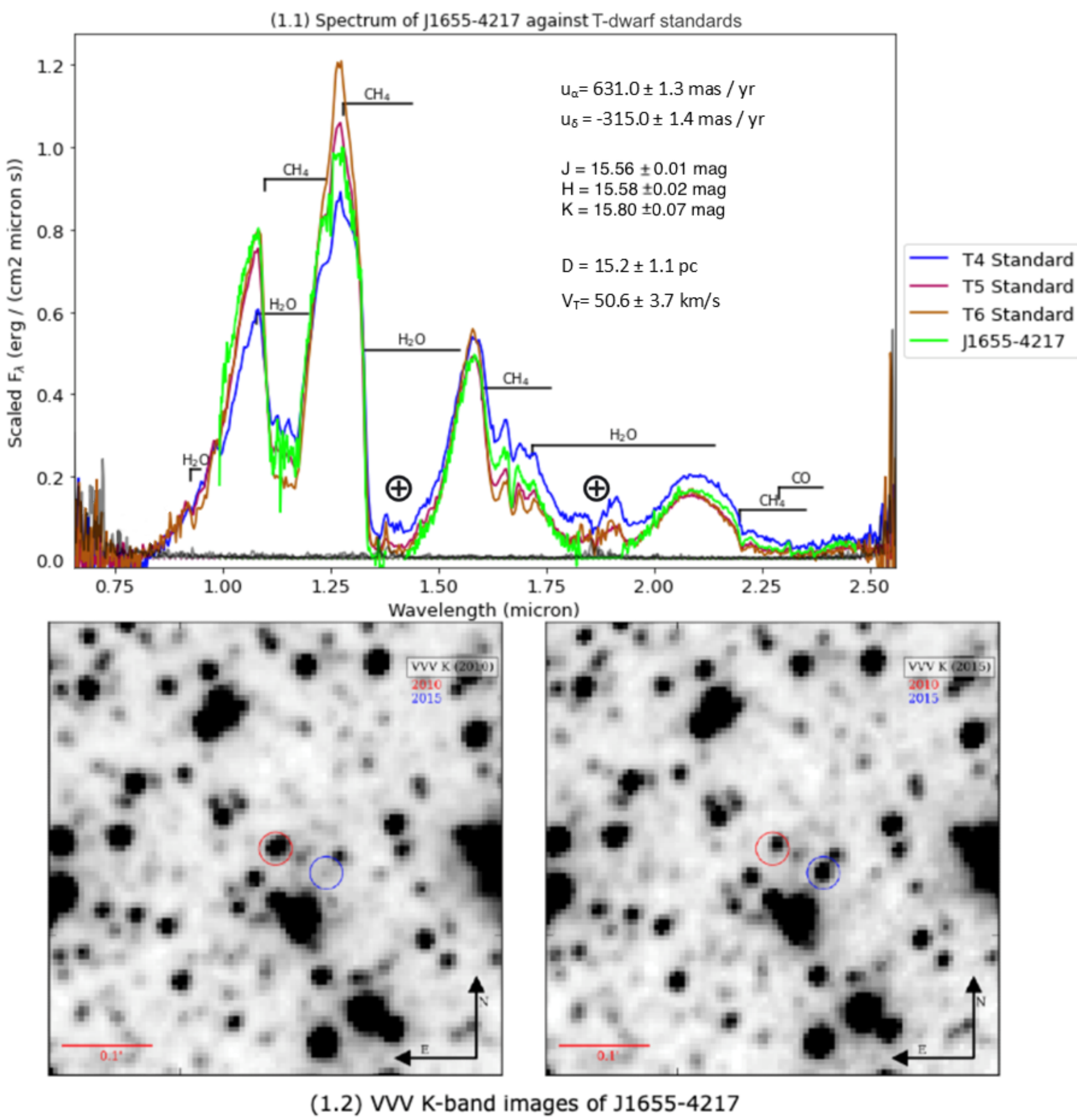

Figure 1. Figure 1.1: Smoothed NIRES spectrum of J1655−4217 (green line), compared to low-resolution T4, T5 and T6 spectral standards (blue, purple, and brown lines, respectively; data from Burgasser et al. 2004). T5 provides the best match. Measured and inferred properties of this object are summarized in the upper right. Figure 1.2: VVV K-band images of J1655−4217 in 2010 and 2015. The red circle highlights the 2010 position (left) and the blue circle highlights the 2015 position (right).

We obtained preliminary proper motion and parallax measurements from 'VIRAC2', version 2 of the VVV Infrared Astrometric Catalogue (VIRAC; Smith et al. 2018). A total of 126 VVV epochal detections spanning a 9 year time baseline were used for the astrometric fit. The VIRAC2 proper motion is $(\mu_\alpha \cos(\delta), \mu_\delta) = (-631.0 \pm 1.3, -315.0 \pm 1.4)$ mas yr^{-1} and the corresponding trigonometric parallax measurement is $\pi_{abs} = 66.0 \pm 4.8$ mas, corresponding to 15.2±1.1 pc. The total proper motion is 705.3 ± 1.3 mas yr^{-1} and the tangential velocity is 50.6±3.7 km s^{-1}.

Using the individual VVV detections, we determined an average apparent K-band magnitude of 15.80 ± 0.07 mag (Vega). We then used the proper motion trajectory to identify J-band and H-band counterparts in the VVV data, and from these determined an average J-band (H-band) Vega apparent magnitude of 15.56 ± 0.01 (15.58 ± 0.02) mag. The implied J-band, H-band, and K-band absolute magnitudes (using the VIRAC2 trigonometric parallax) are all consistent with those of other field T5 dwarfs within 1σ (Dupuy & Liu 2012; Kirkpatrick et al. 2021). Note that the region surrounding J1655−4217 is too crowded in WISE (FWHM $\approx 6''$; Wright et al. 2010) to extract accurate $W1$ or $W2$ flux information. This area was also imaged by Spitzer/GLIMPSE360 (Churchwell et al. 2009) in 2004, but J1655−4217 is badly contaminated by a similarly bright background source at that epoch.

3. DISCUSSION

We conclude that J1655−4217 is a new T5 brown dwarf member of the 20 pc solar neighborhood census (Kirkpatrick et al. 2021). Future studies can expand upon our measurements, including determination of its radial velocity for full kinematic analysis. J1655−4217 was likely overlooked in previous VVV astrometric surveys due to blending in several epochs. While its absolute magnitudes are consistent with a single source, J1655−4217's location in a crowded stellar field makes it an excellent adaptive optics target to search for fainter and cooler companions. Furthermore, the crowded field surrounding J1655−4217 and its accurately measured proper motion make this object a promising target for a future microlensing-based determination of its mass. The discovery of J1655−4217 reinforces the continued incompleteness of the brown dwarf census in the Galactic plane.

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Software: SMDET (Caselden et al. 2020), Spextool (Cushing et al. 2004), SPLAT (Burgasser & Splat Development Team 2017), WiseView (Caselden et al. 2018)

Facilities: Keck(NIRES), NEOWISE, Spitzer(IRAC), VISTA(VIRCAM), WISE

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