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WISE J064336.71-022315.4:
A THICK DISK L8 GAIA DR2-DISCOVERED BROWN DWARF AT 13.9 PARSECS

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While spectroscopically characterizing nearby ultracool dwarfs discovered in the Gaia Second Data Release (GDR2 Gaia Collaboration et al. 2018) with the TripleSpec spectrograph on the Palomar 200" telescope, we encountered a particularly cool, nearby, new member of the solar neighborhood: Gaia DR2 3106548406384807680 = WISE J064336.71-022315.4 = 2MASS J06433670-0223130 (hereafter W0643).

Astrometry: Gaia Collaboration et al. (2018) reports an epoch 2015.5 ICRS position for W0643 of $\alpha, \delta = 100^{\circ}90303036652 (\pm 1.3 \text{ mas}), -2^{\circ}38793881136 (\pm 1.2 \text{ mas})$ and proper motion $\mu_{\alpha}, \mu_{\delta} = 28.3 \pm 2.3, -221.2 \pm 2.5 \text{ mas yr}^{-1}$. The Gaia Collaboration et al. (2018) parallax $\varpi = 71.9 \pm 1.4 \text{ mas}$ corresponds to a distance of $13.9 \pm 0.3 \text{ pc}$. Combined, these yield a tangential velocity $V_{tan} = 14.7 \pm 0.4 \text{ km s}^{-1}$.

Photometry: W0643 has 2MASS photometry (Skrutskie et al. 2006) of $J = 15.48 \pm 0.05, H = 14.38 \pm 0.05, K_s = 13.62 \pm 0.05$ ($J - K_s = 1.86 \pm 0.07$), and AllWISE photometry (Wright et al. 2010) of $W1 = 12.85 \pm 0.03, W2 = 12.50 \pm 0.03, W3 = 11.54 \pm 0.26$, and $W4 < 8.74$. Gaia DR2 reports $G = 20.680 \pm 0.014$. Pan-STARRS PS1 (Chambers et al. 2016) reports $i = 21.071 \pm 0.007, z = 18.505 \pm 0.013$, and $y = 17.474 \pm 0.013$. Combined with the Gaia DR2 parallax, we estimate absolute magnitudes $M_G = 19.96 \pm 0.04$, and $M_{K_s} = 12.91 \pm 0.06$. The colors and magnitudes are typical for late-L dwarfs (Wang et al. 2018).

Spectroscopy: W0643 was observed 12:47 UT 17 October 2018 with TripleSpec on the Palomar 200" (Herter et al. 2008), with a $1'' \times 30''$ slit, and the spectrum covering $1.0\text{-}2.4 \mu\text{m}$ at resolution $R \simeq 2600$. W0643 was observed at airmass 1.26 and conditions were clear with $\sim 1''.5$ seeing. We obtained 8 frames of 240s each in an ABBA nodding pattern with the slit aligned with the parallactic angle. The A0V star HD 54601 was observed afterwards to provide telluric absorption correction and flux calibration (Vacca et al. 2003). Data were reduced with a modified version of SpeXtool (Cushing et al. 2004).

Analysis: In Fig. 1, we compare W0643's TripleSpec spectrum to SpeX Prism Spectral Library standards using SPLAT (Burgasser 2014; Burgasser & Splat Development Team 2017). We classify W0643 as L8, with a "plateau-shaped" H -band spectrum typical for field Ls (Allers & Liu 2013). We measured a heliocentric radial velocity of $142 \pm 12 \text{ km s}^{-1}$. When combined with Gaia astrometry, we determine a Galactic velocity (heliocentric; U towards Galactic center) of $U, V, W = -109, -91, -12 (\pm 10, 5, 3) \text{ km s}^{-1}$. We estimate that W0643 passed within $\sim 1.4 \text{ pc}$ away from the Sun $\sim 100,000$ years ago. Using the kinematic criteria of Bensby et al. (2003), we estimate a 96% probability that W0643 is a thick disk star, which implies an age of 9-13 Gyr (Haywood et al. 2018).

Using the VOSA SED analyzer (Bayo et al. 2008)¹ with the Pan-STARRS/2MASS/WISE photometry, we find a best fit BT-Settl CIFIST spectrum with $T_{\text{eff}} = 1400 \text{ K}$, $\log(g) = 4.5$, with solar metallicity, with luminosity $\log(L/L_{\odot}) = -4.61 \pm 0.02 \text{ dex}$. Combining these values, the age constraint, and the Sonora 2018 evolutionary models (Marley et al. 2018), we predict W0643's mass to be $\sim 0.070 M_{\odot}$ (i.e. a brown dwarf).

Part of this research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with NASA. This work has made use of data from the European Space Agency (ESA) Gaia mission (<https://www.cosmos.esa.int/gaia>), processed by the Gaia Data Processing and Analysis Consortium (DPAC, <https://www.cosmos.esa.int/web/gaia/dpac/consortium>). This research has benefitted from the SpeX Prism Spectral Libraries, maintained by Adam Burgasser at <http://pono.ucsd.edu/~adam/browndwarfs/spexprism>.

Facilities: Gaia, Hale, WISE, 2MASS, PS1, IRTF

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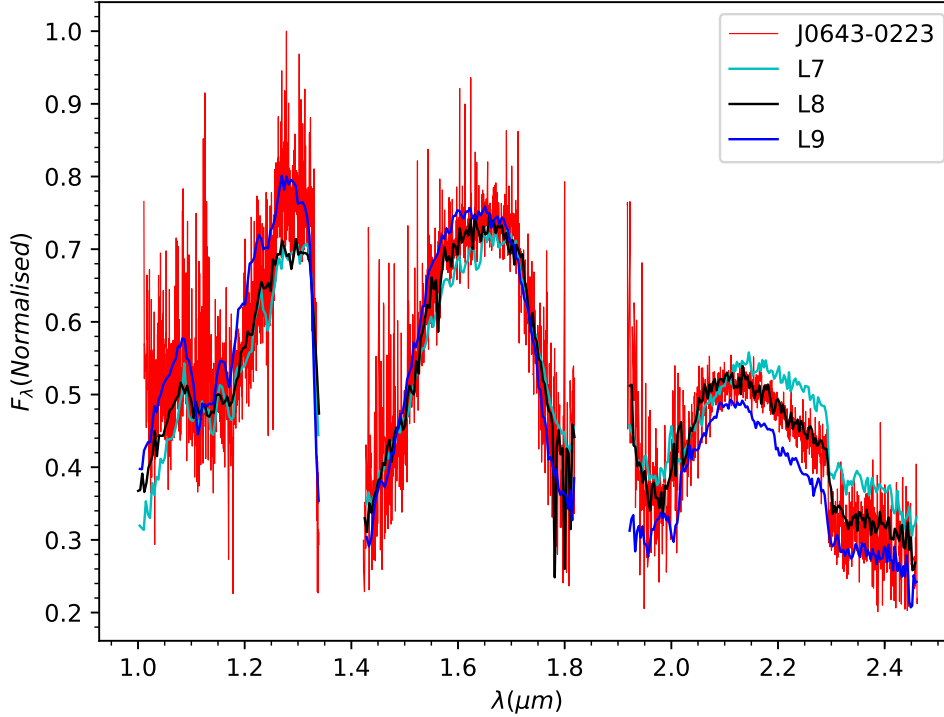


Figure 1. TripleSpec *JHK*-band spectrum of WISE J064336.71-022315.4 (red line) compared to those of the L dwarf standards 2MASS J0103+1935 (L7, in teal; Cruz et al. 2004), 2MASS J1632+1904 (L8, in black; Burgasser 2007) and DENIS J0255-4700 (L9, in blue; Burgasser et al. 2006).

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