2MASS 1315–2649: A HIGH PROPER-MOTION L DWARF WITH STRONG Hα EMISSION

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ABSTRACT

In a previous Letter, I reported that 2MASSI J1315309–264951 is an L dwarf with strong Hα emission. Two spectroscopic epochs appeared to show that the Hα was variable, decreasing from 121 to 25 A˚ EW, which I interpreted as a flare during the first observation. Gizis independently discovered this object, and his intermediate spectroscopic epoch shows Hα with 97 A˚ EW. A new fourth epoch of spectroscopy again shows a very large Hα EW (124 A˚), confirming this object to be a persistent, strong Hα emitter. Whether the Hα is steady (like 2MASS 1237+6526) or the result of continuous strong flaring (like PC 0025+0447) remains unclear. Imaging confirms that 2MASS 1315–2649 has a high proper motion (0.71 yr⁻¹), corresponding to a transverse velocity of ~76 km s⁻¹ at its distance of ~23 pc. Thus, 2MASS 1315–2649 is consistent with being ≥2 Gyr old and therefore relatively massive. If that is so, the correlation of Hα activity with mass found by Gizis et al. would seem to support the continuous strong flaring scenario, although it does not rule out a brown dwarf binary accretion scenario.

Subject headings: stars: activity — stars: individual (2MASSI J1237392+652615, 2MASSI J1315309–264951, PC 0025+0447) — stars: low-mass, brown dwarfs

1. INTRODUCTION

M dwarf stars often show Hα in emission, but the frequency of Hα emission peaks around type M7 and declines for later-type L and T dwarfs (Gizis et al. 2000). The only objects of type L5 or later seen to exhibit strong Hα are the persistent Hα-emitting T6.5 dwarf 2MASSI J1237392+652615 (Burgasser et al. 2002, hereafter B02), the flaring L5 dwarf 2MASSI J0144353–071614 (Liebert et al. 2002), and the L5 dwarf 2MASSI J1315309–264951 (Hall 2002, hereafter H02; Gizis 2002, hereafter G02). I report on a new spectrum and a proper-motion estimate of this latter object, hereafter 2MASS 1315–2649, which are of interest given the rarity of L and T dwarfs with strong Hα and the uncertain mechanism(s) driving such emission.

2. SPECTROSCOPY

Spectroscopy of 2MASS 1315–2649 was secured beginning at 00:15 on UT 2002 September 9 using the ESO Multi-Mode Instrument at the ESO 3.6 m New Technology Telescope (NTT). A 316 line mm⁻¹ grating blazed at 6200 A˚ was used to cover the wavelength range 4500–7000 A˚ at 1.575 A˚ pixel⁻¹ and resolution 4.6 A˚, given the 1” slit. Three 5 minute exposures were obtained at the parallactic angle. Despite cirrus and the high air mass, the unresolved Hα line is readily visible on the individual exposures. The sky-subtracted spectrum was extracted using an aperture 8 pixels (2’664) wide. CD −32°9927 (Hamuy et al. 1994) was used for flux calibration.

As in H02, the continuum was measured at 6400–6550 and 6575–6725 A˚, and the average used for the equivalent width calculation. I find an Hα EW = 124 ± 55 A˚ [log (L_Lα/L_Jα) = −4.01, following H02], compared with 121 ± 31 A˚ in 2001 March and 25 ± 10 A˚ in 2001 August (H02), and 97 A˚ in 2001 May (G02). Either the 2001 August measurement is a spurious outlier and the object has persistent, nonvariable Hα emission of EW = 100 A˚ [log (L_Lα/L_Jα) = −4], or the Hα emission is continuously flaring or slowly variable with that same EW. Smaller uncertainties on the Hα fluxes than the current 25%–40% are needed to distinguish between these scenarios.

Note that Hβ was not detected to a 3 σ limiting flux equal to 37% of the Hα flux. That is, the Balmer decrement is Hα/Hβ > 2.7 in this object. This is larger than the value of 2.3 measured for PC 0025+0447 by Mould et al. (1994) but is similar to the limit Hα/Hβ > 4.2 measured for 2MASS 1237+6526 by Burgasser et al. (2000); see § 4.

3. ASTROMETRY

An unfiltered CCD image was taken just prior to the NTT spectroscopy. The exposure time was 3 minutes, and the pixel scale was 0.333 ± 0.001. The image shows both 2MASS 1315–2649 and USNO J131531.230–264953.01, an optically brighter star slightly south of east. The separation between the objects (epoch 2002.685) is 7.14 ± 0.05, including the systematic uncertainty due to differential refraction, at a position angle (P.A.) of 96°2 east of north. This is significantly different from the Two Mass All Sky Survey (2MASS)–US Naval Observatory (USNO) coordinate separation of 4°23 ± 0.32 at P.A. = 114°5, where uncertainties of 0.25 and 0.2 have been assumed for the USNO (mean epoch 1977.792) and 2MASS (epoch 1998.411) positions, respectively. Systematic errors between USNO and 2MASS are possible, but an R = 12.6 star located only 38” distant has coordinates that differ by only 0.23”. Thus, it appears that the objects’ separation has increased significantly since the 2MASS observations, as suggested by H02.

Assuming the USNO star has negligible proper motion, 2MASS 1315–2649 has a proper motion of 0.71 ± 0.07 yr⁻¹ at P.A. = 253°8. This is approximately 10 times larger than expected if 2MASS 1315–2649 is a member of the TW Hya association of young stars (it was selected for observation by

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1 Based on observations collected at the European Southern Observatory (ESO), Chile, for proposal 69.A-0068.
G02 as a candidate member). At the distance of ~23 ± 2 pc estimated (using Fig. 7.21 of Burgasser 2002) from its apparent magnitude and spectral type (L5, from the high-quality spectrum of G02), the proper motion corresponds to a transverse velocity of ~76 ± 10 km s⁻¹. This rather large velocity suggests that 2MASS 1315–2649 is relatively old and massive, as discussed in the next section.

4. DISCUSSION

Four epochs of spectroscopy now exist for 2MASS 1315–2649, three of which show log (L_Hα/L_{bol}) = -4. Thus, this object is a persistent, strong Hα emitter, of which only a few other examples are known among the M, L, and T dwarfs: the M9.5 dwarf PC 0025+0447 (Martín, Basri, & Zapatero Osorio 1999, hereafter MBZ99), the T6.5 dwarf 2MASS 1237+6526 (§ 1), and possibly the M9 dwarf LP 412-31 (Gizis et al. 2000, § 6.2), which has just two spectral epochs and is not discussed further.

The M dwarf PC 0025+0447 has always been observed to have strong Hα emission [log (L_Hα/L_{bol}) = -3.4], yet it also shows classic signatures of flaring. MBZ99 show that the Hα strength varies on timescales of days to years by up to a factor of 4 (from EW 390 ± 45 to 110 ± 15 Å), that Hα emission is sometimes seen, and that the optical spectrum is veiled by an additional blue continuum when the emission lines are stronger. A T Tauri interpretation is disfavored by the lack of an obvious near-infrared excess and by line profiles dissimilar to those of T Tauri stars. Thus, MBZ99 conclude that PC 0025+0447 has a highly active chromosphere and/or corona; it very likely has continuous strong flares. Continuous weak flaring occurs in many late-type dwarfs (Tsikoudi, Kellett, & Schmitt 2000), but typically with Hα equivalent widths 10–100 times smaller.

The T dwarf 2MASS 1237+6526 has Hα emission of log (L_Hα/L_{bol}) = -4.3 (B02) that is constant to within 10% over three epochs spanning 2 yr. Thus, it is unlikely to have continuous strong flares. B02 suggest that it could be a young, very low mass brown dwarf still accreting material from a surrounding disk, similar to the weak-lined T Tauri stars. However, they cannot completely rule out a close brown dwarf binary accretion hypothesis.

Existing observations of 2MASS 1315–2649 are insufficient to determine to which of the above two objects it is most similar. Three of four spectra taken over 1.5 yr are consistent with a constant Hα flux (to within ~30%). The discrepant observation is of the lowest quality, but other than that there is no a priori reason to discard it. However, the proper motion and Balmer decrement of 2MASS 1315–2649 may be clues to the origin of its Hα.

Since the velocity dispersion of disk stars increases with age, the large transverse velocity inferred for 2MASS 1315–2649 from its proper motion suggests that it is ~2 Gyr old (Dahn et al. 2002) and therefore relatively massive for its spectral type. This is consistent with the correlation noted for weaker Hα emitters by Gizis et al. (2000), namely, that “active L dwarfs are drawn from an older, more massive population.” Unless the incidence of close brown dwarf binaries is a strong function of mass, strong magnetic fields appear to be the only plausible explanation for this trend. The inferred high mass of 2MASS 1315–2649 thus suggests that it is a continuously flaring object with an unusually strong magnetic field.

Gas that is optically thin in the Balmer lines will have Hα/Hβ ∼ 3.3 for all 2500 K < T < 2 × 10⁴ K (Ferland 1980; Martin 1988), whereas Balmer decrements as high as ~5 are seen in T Tauri stars, produced in optically thick, low-ionization gas at T ~ 6500 K (Lamzin et al. 1996). These observations appear nicely consistent with PC 0025+0447 having Hα/Hβ ~ 2.3 due to flares and 2MASS 1237+6526 having Hα/Hβ > 4.2 due to disk (or close binary) accretion, but this is misleading. Flares are complex processes arising in chromospheric gas with n_e ~ 10^{12} cm⁻³, sufficient to be optically thick in lower order Balmer lines (Houdebine et al. 1991), and so a chromospheric origin for emission with Hα/Hβ > 3.3 cannot be ruled out. In fact, dwarfs later than M4 often have Hα/Hβ > 3.3, and values up to 15 have been seen (Gizis, Reid, & Hawley 2002). Given this large range of Hα/Hβ seen in normal dwarf star chromospheres, 2MASS 1315–2649 could have continuous strong flares like PC 0025+0447 despite having a larger Balmer decrement (Hα/Hβ > 2.7 at 3σ).

5. CONCLUSION

The origin of the persistent, strong Hα emission of 2MASS 1315–2649 remains unclear. Its inferred old age makes it unlikely to be a brown dwarf T Tauri analog, and its inferred high mass suggests that it has continuous strong flares, but existing observations cannot rule out an accreting brown dwarf binary scenario. As with the other two known persistent, strong Hα-emitting dwarf stars, determining the origin of the emission will require high-quality spectroscopic or photometric monitoring.

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