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ESO 207-61: A BROWN DWARF CANDIDATE IN THE HYADES MOVING GROUP

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ABSTRACT

ESO 207-61 has been discovered in a proper motion survey and selected by its proper motion $\mu = 0\farcs41$ yr^{-1} ($\theta = 358°$) as possible member of the Hyades moving group.

Spectrophotometry, *V*, *R*, *I* CCD photometry, and *J*, *H*, *K* IR photometry of the star are presented. Colors and spectral peculiarities are similar to those found in the "brown dwarf" LHS 2924.

Subject headings: photometry — spectrophotometry — stars: brown dwarfs — stars: individual (ESO 207-61) — stars: proper-motion

1. INTRODUCTION

In recent years, the question of the existence of very low mass stars, with masses below the hydrogen-burning limit ($M \lesssim 0.1\ M_\odot$), and their relative proportion to those brighter, more massive stars, have concentrated the attention of many astronomers working in the field. This somewhat renewed interest in the subject is due in part to the recent feasibility of obtaining relevant observations with modern detectors like CCDs and IR arrays (Fahlman et al. 1989; Stauffer et al. 1989; Leggett & Hawkins 1989). The detection and study of very low mass stars, or "brown dwarfs" (BDs), provide important constraints to the theories of structure and evolution of stars, near and below the hydrogen-burning limit, and the physics input involved (D'Antona and Mazzitelli 1985; Nelson, Rappaport, & Joss 1986; D'Antona 1987, 1989; Hubbard, Burrows, & Lunine 1990). The proportion of BDs to more massive stars is an important observational constraint to the theory of star formation (cloud fragmentation) and crucial in the determination of the mass-to-light ratio in our Galaxy.

The very low intrinsic luminosity of BDs makes them good candidates to account for the "missing mass" problem in the solar neighborhood (D'Antona & Mazzitelli 1986), that is the difference between the observed mass (0.1 $M_\odot$ pc^{-3}; Hill, Hilditch, & Barnes 1979 and Reid 1987) and the dynamical mass ($\sim$0.17 $M_\odot$ pc^{-3}; Oort 1960 and Bahcall 1986). Solving the "missing mass" problem in the solar vicinity might help understand the same type of mass discrepancies found at scales of galaxies and galaxy clusters.

In this *Letter* we present spectroscopy and photometry of a very low luminosity star ESO 207-61, which we believe is a "brown dwarf" belonging to the Hyades moving group.

2. DISCOVERY

A search program for faint proper motion stars was initiated in 1987, using red IIIa-F plates taken with the ESO Schmidt Camera at La Silla (Ruiz et al. 1988). The search was aimed at studying faint members of the Hyades and UMa moving groups (Eggen 1985, 1986). Stars belonging to each moving group were identified by the direction of their proper motions in the different areas considered.

Proper motion directions for members of the two streams, anywhere in the sky, were determined through the construction of the velocity ellipsoid for each group, using the bright stars that Eggen (1984, 1985, 1986) identified as group members and from which he obtained the convergent points of the streams (Méndez-Bussard & Ruiz 1990; Méndez-Bussard et al. 1990).

A spectroscopic follow-up of the stars with proper motions larger than $0\farcs3$ yr^{-1} (about 15 stars in each 5° by 5° plate) revealed that most of them are old population stars (cold white dwarfs and subdwarfs) and very few are nearby red dwarfs.

In order to avoid the well-known problem of confusion of proper motion directions of stars reflecting the solar motion (moving toward the Antapex) and the directions of Hyades stream members, we selected for our search Area ESO 207 centered at $\alpha = 07^h01^m$ and $\delta = -50°09'$, which is very close to the Antapex; therefore, one would not expect contamination of the Hyades stars by field stars reflecting the solar motion.

In Area ESO 207, the tangential projection of the total space velocity of the Hyades members (45 km s^{-1}) is expected to be 38 km s^{-1}.

During the spectroscopic follow-up of the stars in Area ESO 207 with proper motions larger than $0\farcs3$ yr^{-1}, we found a star named ESO 207-61 with a proper motion $\mu = 0\farcs41$ yr^{-1} in the direction (P.A.) $\theta = 358°$ (Hyades member direction), which has a peculiar red spectrum with weak TiO bands, similar to the spectrum of the "brown dwarf" LHS 2924 reported by Probst & Liebert (1983) and Liebert, Boroson, & Giampapa (1984).

The 1989.0 coordinates of ESO 207-61 are $\alpha = 07^h06^m33^s.2$ and $\delta = -48°56'04''$, equinox 1950.0.

3. OBSERVATIONS

3.1. *Spectrophotometry*

The spectrum in Figure 1 was obtained in 1990 January at CTIO using the 1.5 m telescope equipped with a Cassegrain Spectrograph and a coated GEC CCD detector. The resolution was about 18 Å, and the slit oriented E-W was 3″ wide. Data reduction was performed at CTIO using IRAF. As

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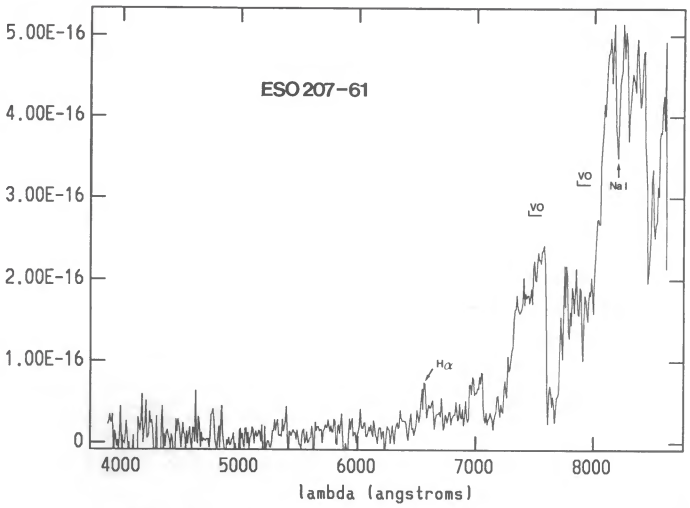

FIG. 1.—Spectrum of ESO 207-61 taken with the CTIO 1.5 m telescope. The integration time was 5400 s. Fluxes (F_λ) in ergs cm^{-2} s^{-1} Å^{-1}.

in LHS 2924 (Probst & Liebert 1983; Liebert et al. 1984), strong VO is present while TiO is weaker than in other low-luminosity red dwarfs like vB 10 and GL 569b (Henry & Kirkpatrick 1990).

3.2. *CCD Photometry*

V, *R*, *I* (Kron-Cousins) photometry was obtained in 1990 April at the CTIO 0.9 m telescope with a TI CCD chip. Magnitudes were obtained observing Graham's standards (Graham 1982) and have an average precision of 4%. Figure 2 is a copy of the *R* frame indicating the position of ESO 207-61, to be used as a finding chart.

3.3. *IR Photometry*

J, *H*, *K* photometry was obtained in 1990 March at the CTIO 4 m telescope equipped with an IR camera and a 62 by 58 InSb detector. The resulting magnitudes have a precision of the order of 3%. A summary of the CCD and IR photometry is given in Table 1.

4. RESULTS AND DISCUSSION

The spectra in Figure 1 as well as the colors in Table 1 suggest that ESO 207-61 is a very cold star similar to LHS 2924, which has been considered the only spectroscopically confirmed BD (Greenstein 1989). Given that a trigonometric parallax for this object is not available yet and based on the similarities with LHS 2924, one can assume ESO 207-61 has the same absolute visual magnitude as LHS 2924 which is $M_v = 19.5$, implying that ESO 207-61 is at a distance of 15 pc and has a tangential velocity $V_T = 29$ km s^{-1}. Taking into account the fact that small mass stream members like ESO 207-61 are expected to have a larger velocity dispersion than that of the more massive members, the derived $v_T = 29$ km s^{-1} is consistent with the star being a member of the Hyades

TABLE 1

PHOTOMETRY OF ESO 207-61

V	*V*−*R*	*R*−*I*	*J*	*J*−*H*	*H*−*K*	*V*−*K*
20.39.....	1.76	2.40	13.40	0.78	0.41	8.18

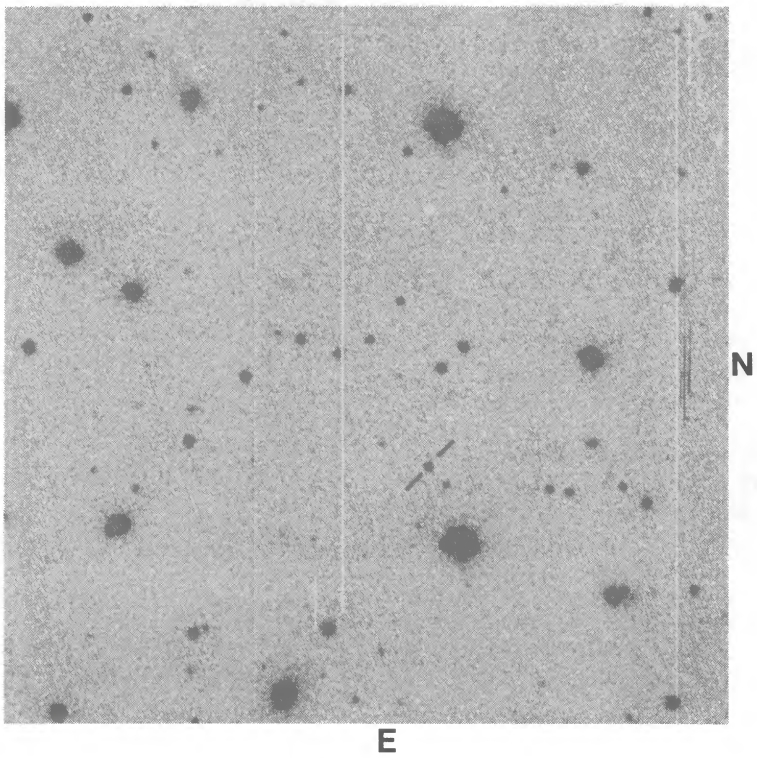

FIG. 2.—Copy of the *R* frame of ESO 207-61 taken with the CTIO 0.9 m telescope and a TI CCD. The position of the star is indicated. The frame is about 3′ in size.

stream with a mean tangential velocity in the area of 38 km s^{-1}.

The luminosity of ESO 207-61 is difficult to obtain from the available observations as there is no direct way to estimate its bolometric correction from the data. BD's model atmospheres constructed by Luinine, Hubbard, & Marley (1986) indicate that the blackbody approximation is not correct for these cold stars which suffer a strong blanketing effect due to water absorption in the L band. As a result the blackbody effective temperature obtained from J, H, K fluxes is systematically larger by about 300 K compared to the one computed from the models (Hubbard et al. 1990).

Bearing in mind the above limitations, one can still attempt to get a very rough approximation of the luminosity of ESO 207-61 using the Te versus various colors' calibration derived by Probst & Liebert (1983) for the coldest known red dwarfs. For ESO 207-61 we get a range of values of Te with a mean about 2200 K. If we consider a bolometric correction BC = -5, appropriate for a 2200 K blackbody (Allen 1983) we estimate for ESO 207-61 a $M_{\rm Bol} \approx 14.5$ and a $\log L/L_{\odot} \simeq -3.9$, which according to the theoretical luminosity function calculated by Hubbard et al. (1990), corresponds to the luminosity below which BDs in the Hyades should start to dominate in numbers over lower main-sequence stars. Another factor that favors the detection of Hyades BDs in Area ESO 207, also pointed out by Hubbard et al. (1990), is that unlike the search for BDs in the Hyades of Leggett & Hawkins (1988, 1989) which was limited to the central region of the cluster where low-mass stars might be undersampled, Area ESO 207 is far away from the Hyades cluster's center.

In the future, CCD trigonometric parallax measurements of ESO 207-61 should help decide in a more accurate way the exact nature of this peculiar star.

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