Rev. Mexicana Astron. Astrof., **14**, 381-384 (1987)

DISCOVERY OF VERY LOW LUMINOSITY STARS

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RESUMEN. Durante el proceso de comparación de placas tomadas para un programa de búsqueda de supernovas se descubrió un cierto número de estrellas débiles ($m_{ph} \gtrsim 14$) las cuales mostraban un movimiento propio alto ($\mu \gtrsim 0.7$"/año).

Se presentan aquí observaciones espectrofotométricas y determinación de movimientos propios para tres de ellas, revelando que ER2 ($\mu = 1.04$"/año, $m_V \simeq 12.7$) y ER6 ($\mu = 0.78$"/año, $m_V \simeq 16.3$) son enanas rojas a distancias de 6 pc y 20 pc del Sol respectivamente. Mientras ER8 ($\mu = 2.127$"/año, $m_V = 17.06$) posee un espectro sin líneas el cual puede ser reproducido por un cuerpo negro a 3500 K, y en este caso se trataría de una estrella degenerada fría con una luminosidad $L \simeq 5\times10^{-5} L_\odot$ ($M_V \simeq 16.44$) y a una distancia de 13 pc del Sol.

ABSTRACT. During the blinking process of plates taken for a supernova search, a group of faint stars ($m_{ph} \gtrsim 14$) with high proper motions ($\mu \gtrsim 0.7$"/year) were discovered.

We present spectrophotometry and proper motion determinations for three of them, showing that ER2 ($\mu = 1.04$"/year, $m_V \simeq 12.7$) and ER6 ($\mu = 0.78$"/year, $m_V \simeq 16.3$) are red dwarfs at distances of 6 pc and 20 pc respectively. The featureless spectra of ER8 ($\mu = 2.127$"/year, $m_V = 17.06$) can be fitted by a black body at 3500 K and corresponds to a cold degenerate star with a luminosity $L \simeq 5\times10^{-5} L_\odot$ ($M_V \simeq 16.44$) at about 13 pc from us.

Key words: PROPER MOTIONS -- SPECTROPHOTOMETRY -- STARS-FAINT

I. INTRODUCTION

One of the main motivations that make searches for intrinsically faint stars worthwhile relates to the problem of the extent to which low luminosity stars, that is, red dwarfs, brown dwarfs and cold degenerates, contribute to the missing mass in the solar neighborhood (Bahcall 1985; D'Antona and Mazzitelli 1986). There is also the question of existence and number of cold degenerates, information that is needed for confrontation with available cooling theories (Bohm et al. 1977; Shaviv and Kovetz 1976) and theories of evolution of white dwarf progenitors (Iben and Tutukov 1984; Iben and Mac Donald 1985).

During the period 1979-1985 a supernova search program was carried out at our Department. The plate material consisted of IIaO plates taken with the 70/100/210 cm Maksutov Camera located at the Cerro El Roble Astronomical Station (Universidad de Chile).

In the process of blinking the monthly plate material, several faint ($m_{ph} \gtrsim 14$) stars were found having large proper motions ($\mu \gtrsim 0.7$"/year), that had not been previously catalogued. As they constitute a potentially interesting group of objects we observed them spectrophotometrically using the telescopes and equipment of Cerro Tololo Interamerican Observatory in Chile.

Here we present data for three of the stars found, two of them, ER2 and ER6 are nearby red dwarfs and the third one ER8 turned out to be a very low luminosity degenerate, probably the lowest luminosity degenerate known, for which preliminary parallax results indicate

that it may belong to the halo population.

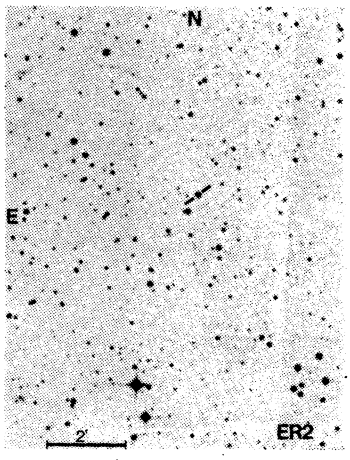
II. INDIVIDUAL OBJECTS

ER2: A μ = 1.04"/year with θ = 272° was found for this object For its determination two pairs of plates separated by 14 years (1970-1984) and 15 years (1969-1984) were used, the procedure is described in Ruiz et al. (1986). Figure 1 is a finding chart for the object.

The spectra in Figure 2 was obtained with the CTIO 1.5m telescope equipped with a Cassegrain Spectrograph and a SIT Vidicon detector. The slit was open as to include all the light from the star.

Using the depth of the TiO band head at λ5448 Å as a luminosity diagnostic (Pettersen et al. 1985) an absolute visual magnitude $M_V \simeq 13.9$ is obtained; on the other hand from the spectra one can estimate the apparent visual magnitude to be $m_V \simeq 12.7$ implying a distance $d \simeq 5.8$ pc and thus a tangential velocity v_T = 29 km s^{-1}.

The proper motion and distance of this object indicate that ER2 could be a member of the Hyades Supercluster (Eggen 1984).



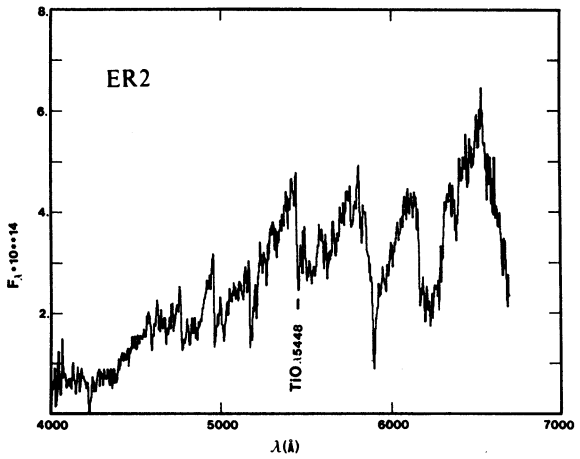


Fig. 1. The position of ER2 is indicated on a reproduction of the ESO (B) survey.

Fig. 2. Spectrogram of ER2 obtained with the Cassegrain spectrograph and a SIT Vidicon, a detector using the 1.5-m telescope of CTIO.

ER6: This star has a proper motion μ = 0.78"/year with θ = 215°.5. In this case also, two pairs of plates separated by 14 years were used for its determination. Figure 3 is a finding chart for it.

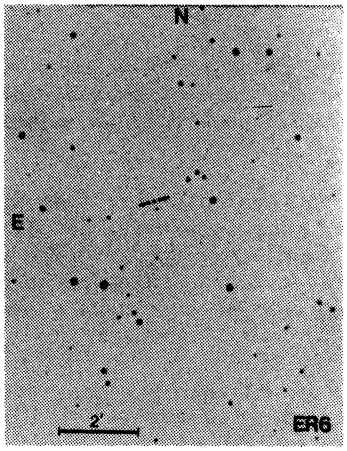
Figure 4 shows the blue and red spectra of ER6, obtained with the same telescope and equipment as described for ER2. The depth of the TiO band head at λ5448 Å give an absolute magnitude $M_V \simeq 14.8$, while the visual apparent magnitude estimated from the spectra is $m_V \simeq 16.3$ implying a distance d = 20 pc and a tangential velocity v_T = 76 km s^{-1}.

It would be very interesting to measure the radial velocity of ER6 because given its large v_T it might belong to the halo population.

ER8: The determination of a proper motion μ = 2.127"/year with θ = 268°.4 has been done in the same way as for ER2 and ER6 and is described in detail by Ruiz et al. (1986). Figure 5 is a finding chart for it.

The featureless spectra of Figure 6 was obtained at CTIO with the 4m telescope equipped with an R-C Spectrograph and a 2D Frutti detector.

The magnitude V = 17.06 and color (b-y) = 0.94 were recently measured by Barbara



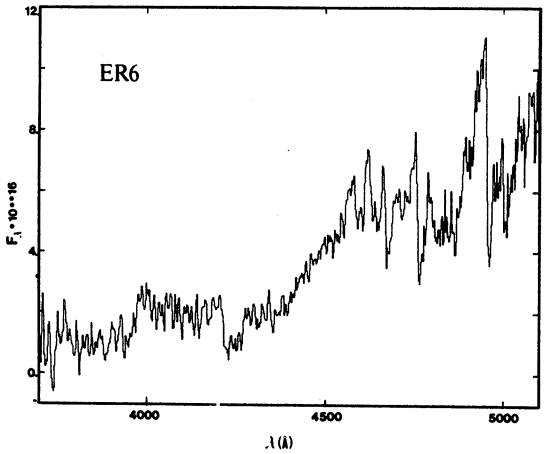


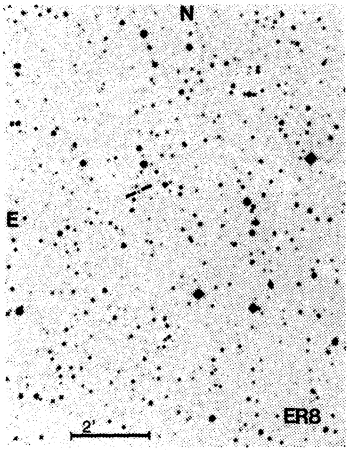
Fig. 3. The position of ER6 is indicated on a reproduction of the ESO (B) survey.

Fig. 4. Spectrogram of ER6 obtained with the same telescope and equipment as for ER2 in Figure 2.

Twarog using the PF CCD at the 4m Telescope of CTIO.

With this information available it was suggested (Ruiz et al. 1986; Eggen 1985) that ER8 was a member of the Hyades Supercluster at a distance d $\sim$ 4.5pc with a luminosity L $\simeq$ 6.4 x 10^{-6} $L_\odot$, thus being the lowest luminosity degenerate star known to date and posing some questions upon current cooling theories for white dwarfs that predict such faint and cold degenerates to be the oldest stars in the galaxy while membership to the Hyades Supercluster suggests an age no larger than about 3 x 10^9 years.

Very preliminary determination of the trigonometric parallax of ER8, obtained using a CCD detector at the 1.5m of CTIO (Anguita and Ruiz 1986), give a distance d $\simeq$ 13.3 pc. At this distance ER8 will still be the lowest luminosity degenerate known L $\simeq$ 5 x 10^{-5} $L_\odot$ (M_V=16.44) with a tangential velocity v_T = 134 km s^{-1} and thus be a member of the halo population, and therefore its age of about 10^{10} years will not be in conflict with current cooling theories (Shaviv and Kovetz 1976).



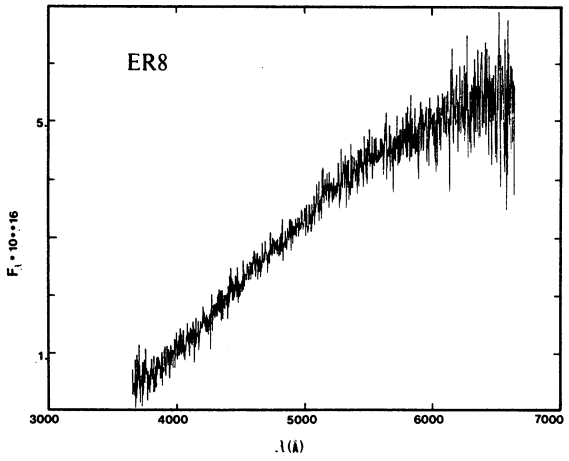


Fig. 5. The position of ER8 is indicated on a reproduction of the ESO (B) survey.

Fig. 6. Spectrogram of ER8 obtained with the 4-m telescope at CTIO equipped with an RC spectrograph and a 2D-Frutti system as detected.

III. CONCLUSIONS

From this rather limited sample of faint large proper motion stars we have found at least one very unusual object (ER8), and as we continue studying the rest of the objects we expect to have a group of faint red dwarfs that will be of great importance for the calibration of the luminosity function (Wielen et al. 1983).

Unfortunately the objects that form this list were not searched for, they were just found and thus we cannot make statistics with them, there is also the fact that the plates were blue (IIaO) while most of the low luminosity stars are red. Presently we are involved in a systematic search for faint large proper motion stars using the red (IIIaF) plates taken by ESO at La Silla (Chile) for their red survey, and in the near future we expect to have a statistically more meaningful sample of faint stars.

We would like to thank O. Eggen and C. Anguita for constant encouragement and many interesting discussions. We also thank B. Twarog for doing photometry of ER8 and M. Wischnjewsky for measuring the plates used for proper motion determinations.

This research was partially supported by grants from DIB (E 2455-8614; E 1936-8634) and FONDECYT.

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