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# ESO 439−162/163: A COMMON PROPER MOTION BINARY FORMED BY A MAGNETIC DQ AND A DC TYPE WHITE DWARF

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## ABSTRACT

In the course of a search for faint large proper motion stars, a common proper motion pair was identified having a $\mu = 0''.38 \pm 0''.03$ yr$^{-1}$ in the direction $\theta = 233°$. The stars are separated by 23″ and have apparent visual magnitudes 18.77 and 19.84, respectively. Spectrophotometry of the stars established that the fainter component is a cold (~4000 K) DC white dwarf, while the brighter one is a magnetic white dwarf with strong Swan bands of $C_2$ shifted and broadened by a $\sim 10^8$ G magnetic field.

*Subject headings:* spectrophotometry — stars: binaries — stars: magnetic — stars: white dwarfs

## I. INTRODUCTION

Since 1986, we have conducted a search for faint large proper motion stars in the ESO R Sky Survey plates (Ruiz *et al.* 1988). In ESO Area 439 with a time base of 7 yr we found about 250 stars with detectable motions, among which there are eight close common proper motion binaries, four of them not previously cataloged.

The pair 439−162/163 was particularly interesting due to its rather large proper motion $\mu = 0''.38 \pm 0''.03$ yr$^{-1}$ in the direction $\theta = 233°$. Figure 1 (Plate L1) is a finding chart for the binary; their 1986.1 coordinates for the equinox 1950.0 are

$$439-162: \quad \alpha = 11^h27^m24^s.0, \quad \delta = -31°06'19''$$

$$439-163: \quad \alpha = 11^h27^m25^s.8, \quad \delta = -31°06'15''.$$

## II. OBSERVATIONS

*BVRI* photometry obtained in 1988 March at Las Campanas Observatory (Carnegie) with the 1 m telescope using a TI (No. 1) CCD, indicate the following magnitudes for the stars:

$$439-162: \quad B = 19.59, \quad V = 18.77, \quad R = 18.24, \quad I = 17.93$$

$$439-163: \quad B = 20.98, \quad V = 19.84, \quad R = 19.04, \quad I = 18.91.$$

The measurements were made in *BV* of the Johnson system and *RI* of the Kron-Cousins system.

In 1988 March we obtained spectrophotometry of the stars using the 3.6 m telescope at La Silla equipped with EFOSC. The detector was an RCA CCD and the B300 grism was used which with a 2″ wide slit gave about 20 Å resolution. During the night three flux standards as well as several He-Ar lamps were observed in order to flux and wavelength calibrate the spectra. The calibrations were performed at the CTIO La Serena Computing Facilities using IRAF. The spectra thus obtained are shown in Figures 2 and 3.

## III. RESULTS AND DISCUSSION

The star 439−163 has a DC type spectrum (Fig. 3) with a spectral distribution corresponding to a blackbody at ~4000 K. Very weak Ca II (H+K) in absorption seems to be present, indicating that 439−163 could be considered a mild case of a metallic white dwarf (DZ). The broad shallow absorption near 6600 Å is real and might correspond to Hα. This broad absorption feature was also detected in good signal-to-noise ratio spectra, obtained with the same instrument and equipment, of other brighter cold DC stars like ER 8 and vB 3.

If we take the absolute visual magnitude of 439−163 to be $M_v \approx 17$, and considering that its $m_v = 19.8$, then its distance would be 35 pc. At 35 pc, the separation between the stars is $1.2 \times 10^{16}$ cm, suggesting that no strong interaction among them has taken place during their evolution.

The spectrum of 439−162 in Figure 2 corresponds to a magnetic white dwarf, dominated by very broad and deep absorption troughs (about 58% central depth at 5160 Å). Such peculiar spectrum is comparable to that of LP 790−29 (Liebert *et al.* 1978) which shows strong bands of $C_2$ distorted by a magnetic field $B > 10^8$ G. In the case of LP 790−29 the observed positions of the $C_2$ Swan bands were shifted to the blue by ~750 cm$^{-1}$; this shift, according to Liebert *et al.* (1978) was caused by a magnetic field $\gtrsim 10^8$ G. In 439−162 the centers of the Swan bands are observed at 4590 Å, 4992 Å, 5411 Å, and 5912 Å corresponding to the bands normally at 4700 Å, 5160 Å, 5585 Å, and 6100 Å, respectively, indicating a shift to the blue of 550 cm$^{-1}$ which would imply a magnetic field somewhat lower than that of LP 790−29 but close to $10^8$ G. The broad band redward of 6150 Å might correspond to Phillips system $C_2$ bands as suggested by Liebert *et al.* (1978).

The fitting of a blackbody to the spectrum of 439−162, in order to estimate a temperature, is very difficult; no clear continuum is observed. Visual photometry corroborates this; *B*, *V*, *R*, and *I* magnitudes are affected by the presence of strong absorption bands, obliterating the usual meaning of the different colors. If we take that the fluxes measured at 4200 Å, 5650 Å, and 6150 Å correspond to the continuum, then the spectrum can be fitted by a 6300 K blackbody. This temperature is close to the lower limit observed for carbon white dwarfs (Wegner 1983*a*, *b*; Wegner and Koester 1985; Fontaine *et al.* 1984); below 6000 K, the convective envelope of the star recedes, and the diffusion tail of the carbon core fades from the surface, and the star becomes a DC type white dwarf, which might be the case of the companion 439−163 at $T \sim 4000$ K.

At 35 pc the tangential velocity of 439−162/163 would be 63 km s$^{-1}$. This, combined with the fact that 439−163 is as cold as 4000 K, indicates that the system must be old, belonging to

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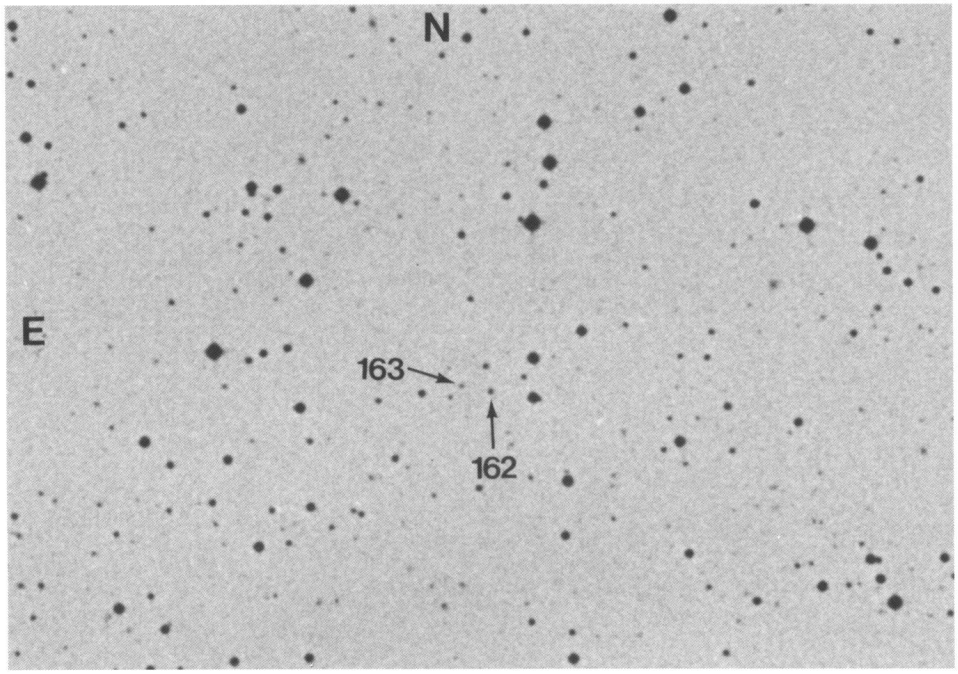


FIG. 1.—Reproduction of the ESO R Survey (area 439); the position of 439 – 162 and 439 – 163 is indicated. The separation between the stars is 23″.

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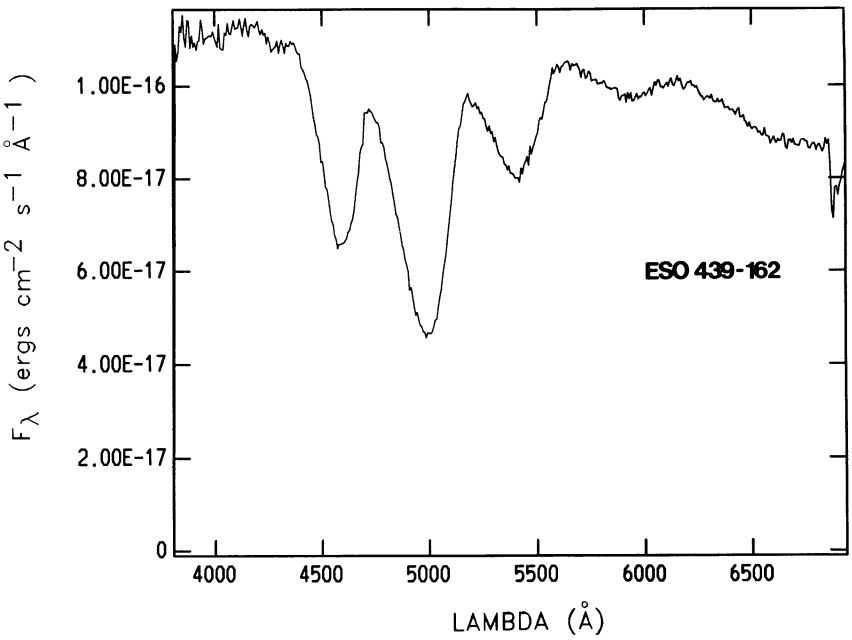


FIG. 2.—Spectrum of ESO 439 – 162 obtained with the 3.6 m telescope + EFOSC at La Silla. The total integration time is 3 hr.

the old disk or halo population, consistent with the suggestions by Sion *et al.* (1988), which found that DQ stars have higher than average space motions with more halo members than other WD spectroscopic subgroups.

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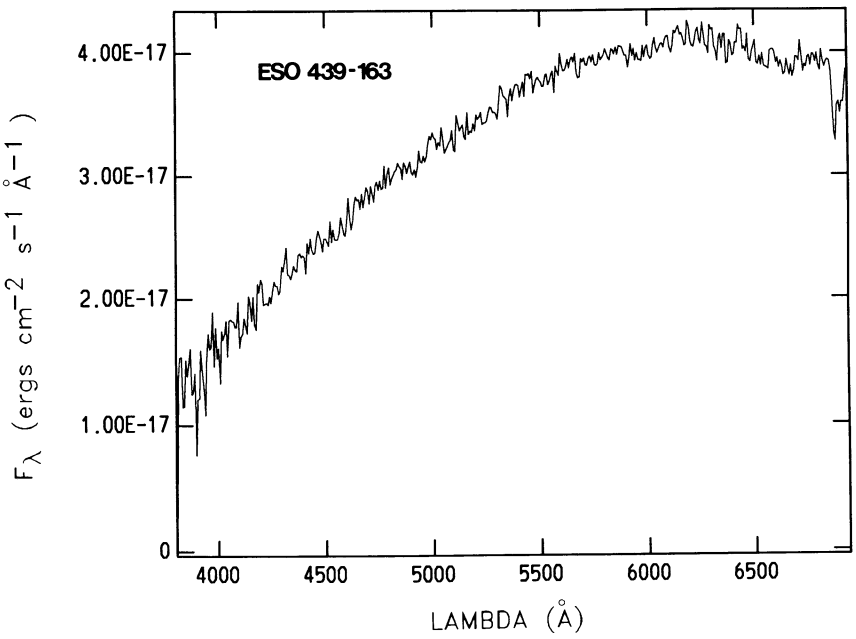


FIG. 3.—Spectrum of ESO 439 – 163, obtained with the same instrumentation and integration time as Fig. 2.

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