CPD −71° 172, a New Binary with a Hot Subdwarf

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The Very Wide Field Camera (VWFC) is an experiment developed with, as a major aim, the detection in a range of faint magnitudes of the stellar objects showing a strong ultraviolet excess. It consists of an all reflection F/1.9 Schmidt camera which refocuses the image of the sky given by a hyperbolic mirror onto the photocathode of an image intensifier. It provides a useful field of about 66° in diameter with a resolution of about 5 arcminutes. Three UV interference filters centred at 168, 195 and 254 nm can be placed alternatively in the incident beam. The images are recorded on classical KODAK IIa-0 emulsion. The VWFC was flown aboard Spacelab-1 in December 1983 and 66 frames were obtained; because of orbital constraints, only twenty per cent of the celestial sphere could be covered by the deepest survey. Thanks to an adequate image data processing particularly well adapted to correct the images from straylight background, limiting magnitudes as faint as m (195 nm) = 9.3 were reached.

In the course of identifying stars around the Small Magellanic Cloud, a well-defined star-like object was found (Fig. 1) with no other counterpart than a cool star; according to the data provided by the Centre de Données Stellaires in Strasbourg and to the ESO/SRC Sky Atlas prints, the only possible candidate was CPD −71° 172, an F0 star with magnitudes $m_v \sim 10.5$ and $m_B \sim 10.9$. From these values, the expected 195 nm magnitude was normally expected at about 12.3 whereas it was estimated to be close to 8. A so large UV excess led us to suspect a hot subluminous companion to the cool primary. We confirmed soon the spectral type of the latter by help of a spectrogram obtained at ESO La Silla. At the same time, a first low resolution UV spectrum provided by the IUE satellite confirmed the existence of a very hot subdwarf companion. The binary association of both stars seems evident after their angular distance, which is likely less than 1 arcsecond (the pair is optically still unresolved), and after the distance inferred from the cool star (700 pc). The absolute magnitude deduced for the blue star, $M_v \sim 3$, is a common value for this kind of objects. We recall their great interest as they provide a direct means of testing the ability of models to reproduce the last stages of stellar evolution towards the white dwarf degenerates. In this connection and from a practical point of view, the interest of binary systems similar to CPD −71° 172 lies in the opportunity they offer to determine unambiguously the absolute magnitudes of hot subdwarfs, so long they belong to loose systems in which no significant mass exchange has occurred when the original primary was near the red giant tip.

Visible spectrography was performed on IIIa-J hypersensitized plates using the Boller and Chivens spectrograph attached to the ESO 1.52-m telescope, with a dispersion of 39 Å mm^{-1}. We classified the star as F 2.5 IV with an uncertainty of 1 subclass; no He I or He II lines were visible.

UV spectra at low resolution have been obtained in the range 120 to 320 nm with the IUE satellite; they are fully dominated, especially in the shorter wavelength region, by the flux of the hot component, showing a UV gradient similar to that of BD 75° 325, a well-studied sdO star.

Johnson, Cousins and Strömgren photometries were carried out at ESO and SAAO, with the aim of a photometric deconvolution between the components. The fitting of intrinsic colours of both components to so many colours was a puzzling task which required an iterative method. We found that a colour excess E (B−V) = 0.014 was necessary to reproduce the observed colours. The deconvolution implied a fit of the Kurucz (1979) model atmospheres normalized at V to the flux distribution in the IUE

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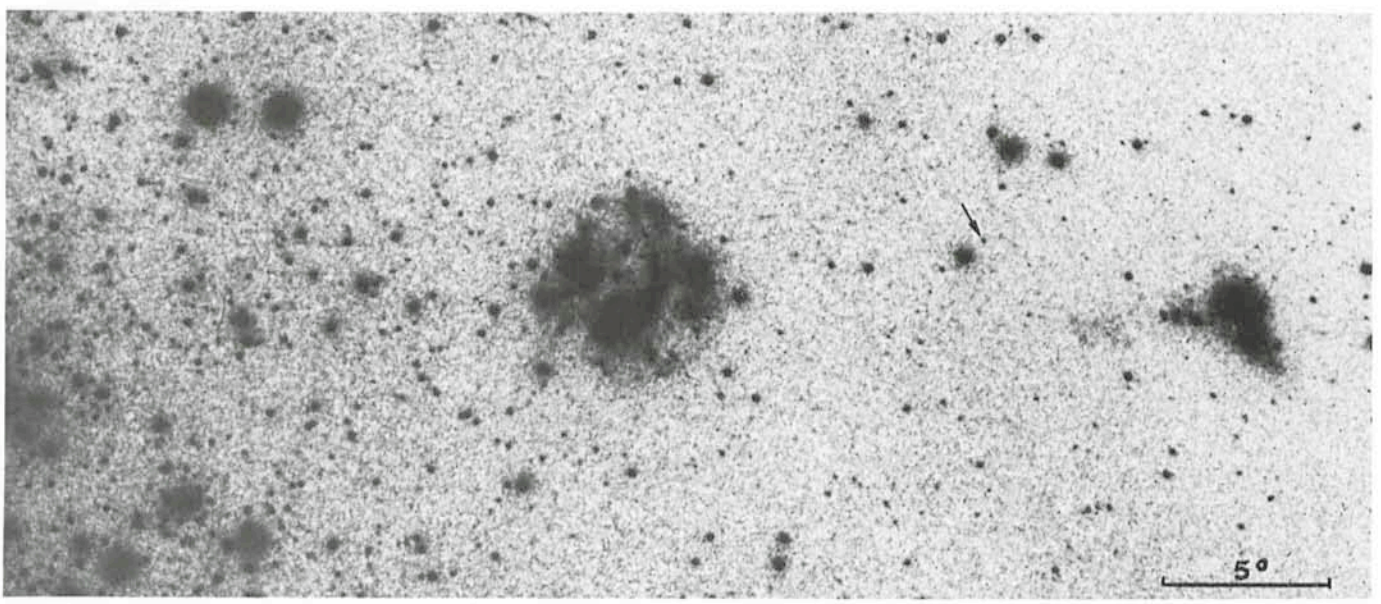

Figure 1: *Negative enlargement of part of a deep frame (195 nm filter, exposure time 304 s) of the VWFC in the region of the Magellanic Clouds: the LMC is at the centre, the SMC to the right (North is roughly up, East to the left). Four other newly identified objects showing UV excess have been found in this field.*

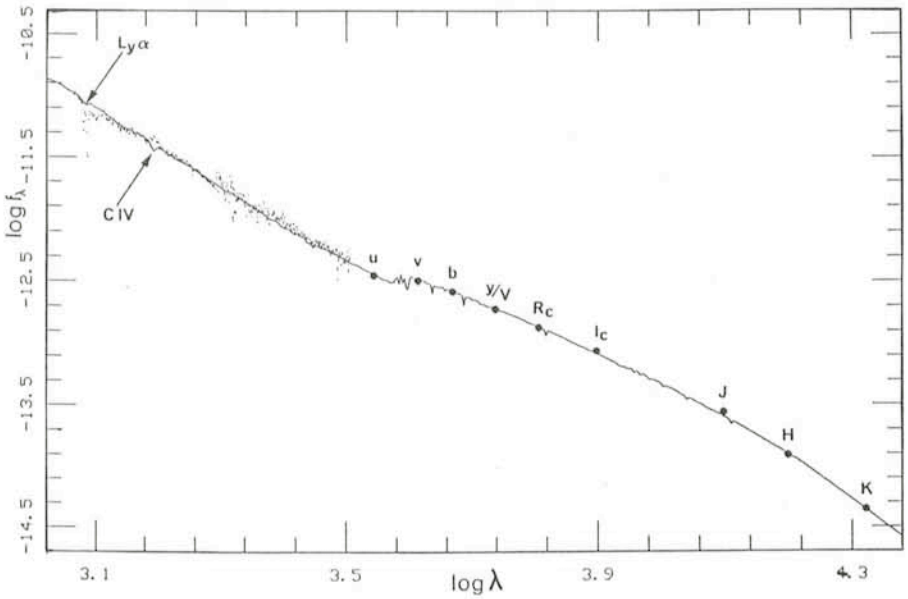

Figure 2: *Absolute flux distribution of CPD – 71°172AB from Lyman alpha to the Johnson K band (2.2 μm) expressed in erg (cm² s Å)⁻¹ versus the wavelength in Å units. Strömgren uvby, Cousins $R_c I_c$ and Johnson JHK fluxes are displayed by large filled dots. Small dots in the UV range represent the observations with IUE.*

range, following the method of Heber et al. (1984) and Heber (1986) though presently only LTE models were available. It provided a low estimate of the effective temperature $T_{eff} \sim 50{,}000°$ K for the hot star, from which were derived its intrinsic optical colours; some iterations were necessary to adjust the V magnitudes and the reddening so that all colours of the primary would be those of an early F star. The adopted solution was the following:

Star	CPD −71° 172A	CPD −71° 172B
Spectral type	F 3–4 IV	SdOB
y or V	10.99	12.05
b–y	0.265	− 0.155
m_1	0.161	0.060
C_1	0.643	− 0.210
U–B	0.019	− 1.210
B–V	0.403	− 0.327
$V–R_c$	0.240	− 0.16
$V–I_c$	0.481	− 0.32
V–J	0.77	− 0.74
V–H	0.96	− 0.91
V–K	1.01	− 0.97

The visual absolute magnitudes of both stars were derived from the adopted spectral type and colours of the F component, using the Tables of Crawford (1975) and of FitzGerald (1970) to estimate its degree of evolution; the inferred intrinsic parameters were checked by means of the Barnes-Evans (1978) relation. We determined in that way:

Star	M_v	T_{eff}	BC	Log ($L/L_\odot$)	$R/R_\odot$	log g
CPD −71° 172A	1.80	6,700	−0.10	1.15	2.80	3.7
CPD −71° 172B	2.86	55,000	−4.80	2.70	0.24	5.4

Figure 2 shows the fit of the sum of the Kurucz models adopted for each component to the IUE and visible observed composite colours. As it can be seen, the overall agreement between models and observations is quite satisfactory. A subsequent check using the R index of Schonberner and Drilling (1984) yielded $T_{eff} \sim 50{,}000$ to $60{,}000°$ K.

We have compared CPD −71° 172 B to two well-known subdwarfs:

(1) BD 75° 325 is a field sdO with $T_{eff} \sim 50{,}000°$ K, log g ~ 5.3, helium rich after Kudritzki et al. (1980). The short wavelength IUE spectra of both stars have revealed comparable ionization and excitation temperatures; the He II line at 164 nm is much stronger in the spectrum of BD 75° 325, suggesting that helium is moderately to fairly depleted in CPD −71° 172 B. The abundance of nitrogen is roughly normal while silicon and carbon are depleted like helium.

(2) The ultraviolet spectrum of LS II + 18° 9, which is a helium normal star with $T_{eff} \sim 60{,}000°$ K, confirms both the normal abundance of nitrogen and the slight depletion of helium in the photosphere of CPD −71° 172 B. In case where these results would be confirmed by the analysis of IUE high resolution observations, this newly discovered subdwarf would be one of the first helium poor sdO's with $T_{eff} > 40{,}000°$K.

So far, 14 other potential candidates have been identified and spectrographic observations recently performed at ESO have revealed seven objects of various natures, for which a long-term general survey including multicolour photometry, radial velocity measurements and IUE observations is in progress.

Tentative Time-table of Council Sessions and Committee Meetings in 1987

October 6	Council in Paris
November 17	Scientific Technical Committee
November 19–20	Finance Committee
Nov. 30–Dec. 1	Observing Programmes Committee
December 7	Committee of Council
December 8	Council

All meetings will take place in Garching unless stated otherwise.

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List of ESO Preprints

506. V. Castellani and M.L. Quarta: The Oosterhoff Dichotomy Revisited. I. The Ranking of RR Lyrae Periods Versus Metallicity. *Astronomy and Astrophysics.* June 1987.
507. L.B. Lucy and M. Perinotto: Models for the Wind of the Central Star of NGC 6543. *Astronomy and Astrophysics.* June 1987.
508. A.F.M. Moorwood: IRSPEC: Design, Performance and First Scientific Results. Invited paper presented at the Workshop on "Ground-Based Astronomical Observations with Infrared Array Detectors", University of Hawaii at Hilo, March 1987. June 1987.
509. A. Renzini: Some Embarrassments in Current Treatments of Convective Overshooting. *Astronomy and Astrophysics.* June 1987.
510. P. Crane, A. Stockton and W.C. Saslaw: The Optical Spectral Index in the South Radio Lobe of 3C 33. *Astronomy and Astrophysics.* June 1987.