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ULTRAVIOLET SPECTROSCOPY OF THE "MUÑECA"

G.B. Baratta
Osservatorio Astronomico di Roma, Via del Parco Mellini 84, 00136 Roma
and
A. Cassatella and R. Viotti
Istituto di Astrofisica Spaziale, CNR, Via E. Fermi 21, 00044 Frascati, Italy

RESUMEN

Se describe el espectro UV de algunas regiones de la pequeña nebulosa que rodea a η Car (la *Muñeca*) obtenido con el *IUE*. En alta resolución la *cabeza* NO muestra un espectro de baja excitación con líneas de emisión más anchas que las estelares, ligeramente corridas al rojo (+50 a +120 km s^{-1}), lo que sugiere una contribución de luz estelar dispersada por polvo en la nebulosa. Se encuentra una velocidad de expansión de más de $\geq$ 1000 km s^{-1}, similar a la del viento estelar. Están presentes líneas de emisión de Fe II delgadas, excitadas por fluorescencia. También se identificaron líneas de fluorescencia de Fe I excitadas por la línea *k* del Mg II. En baja resolución, las regiones más densas presentan líneas de emisión de Fe II y Mg II. La región exterior que emite en rayos X muestra un rico espectro de líneas de alta temperatura de He II, N III], N IV, y N V. También se ha identificado el multiplete del Fe III $\lambda\lambda$ 1895–1926, y las líneas de recombinación dielectrónica de Fe II $\lambda\lambda$ 1785–88. Se encuentran ausentes el C IV y el C III], mientras que aparece débilmente C II λ1350. Se sugiere que la anomalía química de C/N puede originarse, al menos en parte, en la condensación de granos de polvo. La componente *interestelar* verdadera de la extinción i.s. hacia η Car ha sido medida a partir de la banda de 2200 A. El valor derivado, $E_{B-V} \simeq$ 0.35–0.6, está en buena concordancia con los derivados para las estrellas vecinas.

ABSTRACT

We describe the UV spectrum of some regions of the small nebula around η Car (the *Muñeca*) obtained with *IUE*. At high resolution, the NW *head* displays a low excitation spectrum with slightly redshifted (+50 to +120 km s^{-1}) emission lines broader than the stellar ones, suggesting a contribution from stellar light scattered by dust in the nebula. An expansion velocity of up to $\geq$ 1000 km s^{-1} is found, similar to that of the stellar wind. Narrow, fluorescence excited Fe II emission lines are present. We also identified Fe I fluorescence lines excited by the Mg II *k*–line. At low resolution, the denser regions present emission lines of Fe II and Mg II. The outer X-ray emitting region displays a spectrum rich of high temperature lines of He II, N III], N IV, and N V. We also have identified the Fe III $\lambda\lambda$1895–1926 multiplet, and the dielectronic recombination Fe II $\lambda\lambda$1785–88 lines. C IV and C III] are absent, while C II λ 1350 is weakly present. We suggest that the C/N chemical anomaly could originate at least partly from the condensation of dust grains. The true *interstellar* component of the i.s. extinction towards η Car has been measured from the 2200 A band. The derived value of $E_{B-V} \simeq$ 0.35–0.6 is in good agreement with that of the nearby stars.

Key words: **CIRCUMSTELLAR MATTER — DUST EXTINCTION — STARS: INDIVIDUAL: (η CAR) — STARS: MASS-LOSS — ULTRAVIOLET: STARS**

η Car is surrounded by a small nebulosity resembling, according to the Argentinian astronomers, a *Muñeca* (i.e., a baby doll, *lat.*: homunculus), which has been formed during the last 100–200 years from the matter ejected by the central star. The spectroscopic study of the Muñeca could therefore give important information on the past history of the star, on the chemical composition of its atmosphere, and on the interaction with the ambient medium. The UV spectrum of the Muñeca was first observed in December 1980 (Viotti et al. 1981), and repetitively observed in the following years (e.g., Davidson, Walborn, & Gull 1982; Davidson et al. 1986). These observations were made also following the high resolution X-ray imagery of η Car by the *Einstein* Observatory which revealed the presence of a diffuse source at the position of the S condensation (or *shell*), a few arcsec west of the Muñeca (Seward et al. 1979; Chlebowski et al. 1984). A marked peculiarity was also the strong point source coincident with the stellar core, and the absence of X-ray emission from the bright NW part of the Muñeca , the "head" of the Muñeca .

Figure 1 shows our low resolution observations of different regions of the Muñeca , and of the stellar core. The long wavelength range is characterized by the presence of strong Fe II and Mg II emission lines. The underlying continuum resembles that of a hot reddened source, with a deep 2200 A interstellar band. The short wavelength spectrum largely varies from one region to another. Fig. 1e shows the spectral order of the *IUE* Large Aperture (LA) close to the X-ray emitting S shell region. These observations reveal the presence of a rich emission spectrum with prominent lines of N V, Si IV, N IV], Si II, He II, N III], Si III], and Fe III. The high excitation Fe II 1785–88 A lines are also present. They are well probably produced by dielectronic recombination of Fe^{++}. C IV and C III are absent, while C II λ1350 is weakly present. The comparison with the UV spectrum of other nebular objects strongly suggests that this shell region should be nitrogen enriched

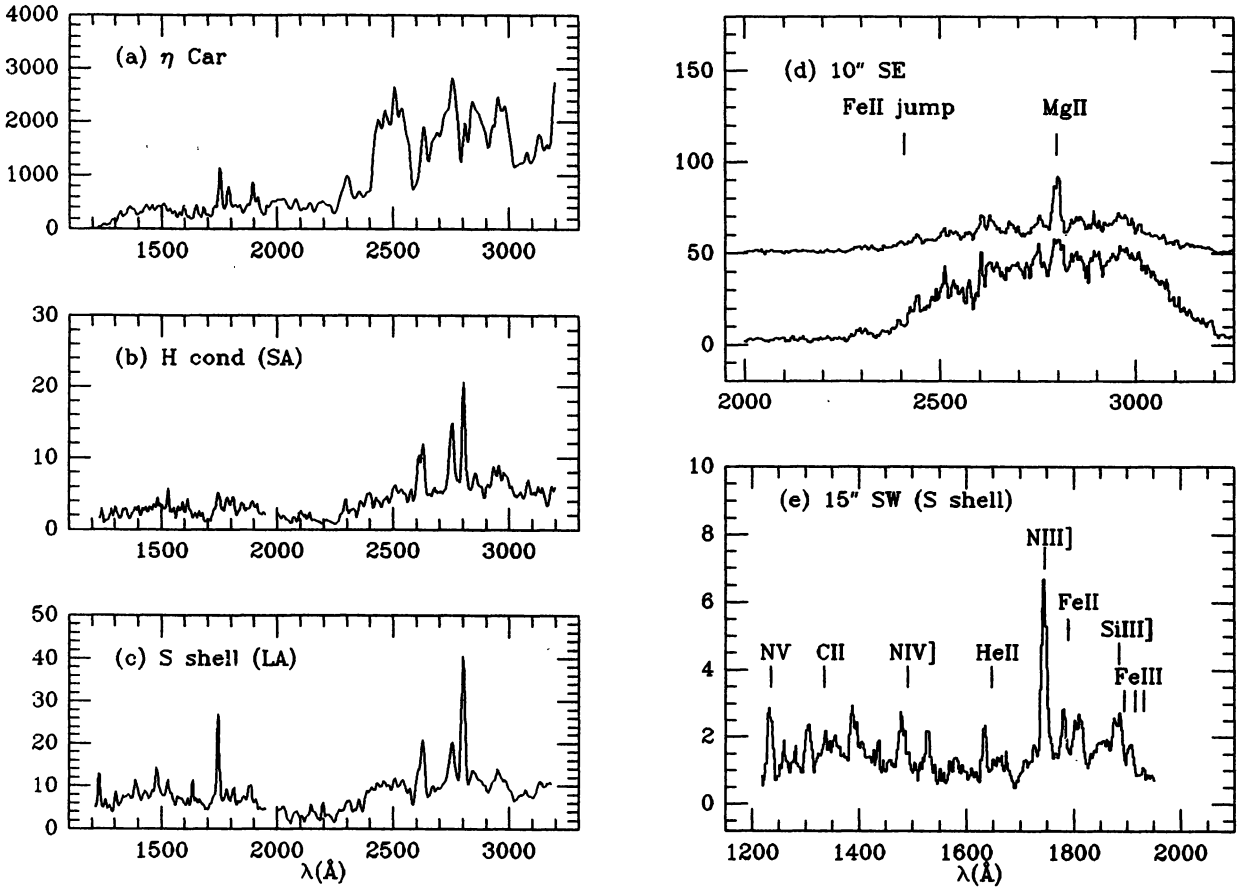

Fig. 1. *Left.* The low resolution *IUE* spectrum of η Car and of the Muñeca. *Right.* Spatially resolved views of the Large Aperture *IUE* spectra 10″ SE (LA orders No. 23 and 24), and 15″ SW (LA order No. 29) of η Car.

(cf., Davidson et al. 1986). This chemical anomaly could orginate from processed material brought out by the stellar wind, and therefore give a hint to the nature of the central star. Alternatively, it could be associated with the condensation of dust grains in the stellar wind which could selectively reduce the amount of carbon and oxygen. The high temperature region which is very close to the outher parts of the shell, probably arises from a shocked region.

Our low resolution *IUE* observations near the "right foot of the doll" are largely affected by scattered light (partly instrumental). The less affected southern parts of the *IUE* aperture shown in Fig. 1d display a low energy emission line spectrum, with strong Mg II, and many Fe II lines over a hot reddened continuum. The "Fe II jump" at 2400 A typical of the stellar core spectrum (Fig. 1a) is also marginally present, indicating a small contribution from the stellar light scattered by dust grains in the nebula. The spectrum of the 10.72 mag O star # 64 of the Trumpler 16 association (Feinstein, Marraco, & Muzzio 1973) is visible in the northern part of the *IUE* image.

The "head of the doll" (the H condensation) was observed with *IUE* at high resolution in the 2300–3200 A range. The UV spectrum of the H condensation displays a low excitation spectrum with slightly redshifted (+50 to +120 km s^{-1}) emission lines broader than the stellar ones, suggesting a prominent contribution from stellar light scattered by dust in the nebula. Some line profiles are shown in Figure 2. From the P Cygni profiles an expansion velocity of up to $\geq$ 1000 km s^{-1} is derived similar to that of the stellar core's wind (Damineli et al. 1993; Viotti et al. 1989). Narrow, slightly blueshifted ($-$ 34 km s^{-1}) high excitation Fe II emission lines are present. We also identified Fe I emission lines at $\lambda\lambda$2823, 2844 fluorescence excited by the Mg II *k*–line (Fig. 2).

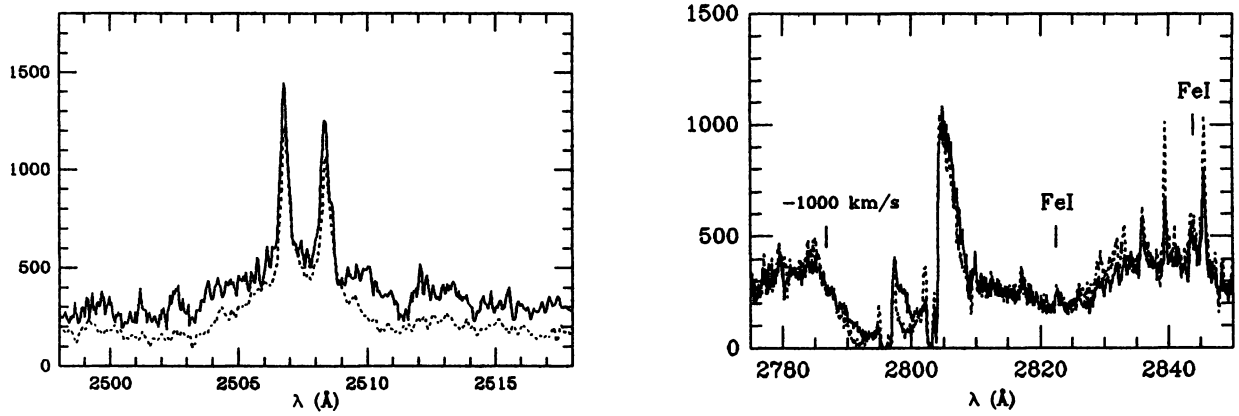

Fig. 2. The high resolution spectrum of H condensation near the fluorescent Fe II $\lambda\lambda$2506–8 lines, and the Mg II doublet (full line), compared with that of the stellar core (dotted line).

The interstellar extinction towards η Car has been in the past matter of many investigations based on its optical spectrum (e.g., Pagel 1969; Viotti 1969). The huge IR excess implies that the optical and UV radiation from the central star is largely absorbed by the circumstellar matter, which contributes to the *local* extinction and could be as large as $E_{B-V} = 0.7$ (e.g., Andriesse, Donn, & Viotti 1978). The very peculiar UV spectrum of η Car is not of great help in this matter, since the depth of the interstellar 2200 A band cannot be measured being largely affected by the Fe III and Fe II line absorption at the blue and red edges of the band. The 2200 A band is however clearly visible in the low resolution *IUE* spectra of the nebula a few arcsec from η Car (see Fig. 1). Our E_{B-V} determination of 0.35 to 0.6 from three regions are in good agreement with those measured in the Trumpler 16 stars (Feinstein et al. 1973; Tapia et al. 1988), and can be taken as the true *interstellar* extinction towards η Car.

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