RevMexAA (Serie de Conferencias), **9**, 232–233 (2000)

Astrophysical Plasmas: Codes, Models, and Observations (Mexico City, 25-29 October 1999)
Editors: Jane Arthur, Nancy Brickhouse, & José Franco

THE EUV EMISSION-LINE SPECTRUM OF OY CARINAE IN SUPEROUTBURST: SCATTERING IN THE WIND

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RESUMEN

El satélite *Extreme Ultraviolet Explorer* observó la variable cataclísmica OY Carina en una erupción mayor durante 3 días en marzo de 1977. El espectro resultante a 80–180 Å, que contiene líneas anchas de emisión (FWHM $\sim$ 2000 km s^{-1}) de O V–O VI, Ne V–Ne VI, Mg V–Mg VI y Fe VI–Fe VIII, queda bien modelado por dispersión de la radiación de la capa límite en el viento del disco de acreción del sistema.

ABSTRACT

The *Extreme Ultraviolet Explorer* satellite observed the cataclysmic variable OY Carinae in superoutburst for 3 days in 1997 March. The resulting 80–180 Å spectrum, which contains broad (FWHM $\sim$ 2000 km s^{-1}) emission lines of O V–O VI, Ne V–Ne VI, Mg V–Mg VI and Fe VI–Fe VIII, is well modeled by scattering of boundary layer radiation in the system's accretion disk wind.

Key Words: **BINARIES: ECLIPSING — NOVAE, CATACLYSMIC VARIABLES — STARS: INDIVIDUAL (OY CARINAE) — STARS: WINDS, OUTFLOWS — ULTRAVIOLET: STARS**

Cataclysmic variables (CVs) are a diverse class of semidetached binaries composed typically of a mass-losing low-mass main-sequence secondary, an accreting white dwarf, and a luminous accretion disk. With a binary inclination of 83°, OY Carinae is one of only a handful of CVs in which the secondary eclipses the white dwarf. Details of OY Car's two stars, the accretion disk, and the boundary layer between the accretion disk and the surface of the white dwarf are determined from eclipse observations in the optical, UV, EUV, and X-ray (Wood et al. 1989; Bruch, Beele, & Baptista 1996; Horne et al. 1994; Naylor et al. 1988; Pratt et al. 1999).

One of the outstanding puzzles in the study of OY Car is the fact that in outburst the EUV flux is not eclipsed by the secondary (Naylor et al. 1988). The accretion disk wind is the most plausible source of this extended EUV emission, but it is not possible from the *EXOSAT* data to determine the *nature* of the emission. Possibilities include thermal emission and resonant scattering of boundary layer flux.

To determine the nature of the EUV emission of OY Car, we observed the source in superoutburst with the *Extreme Ultraviolet Explorer* (*EUVE*) satellite for 3 days in 1997 March. The resulting 80–180 Å spectrum, shown in Figure 1, contains broad (FWHM $\sim$ 2000 km s^{-1}) emission lines of O V–O VI, Ne V–Ne VI, Mg V–Mg VI and Fe VI–Fe VIII. The pattern of emission lines is inconsistent with that of a thermal plasma, but we show below that it is reasonably well modeled by resonant scattering of boundary layer flux.

For the scattering model, we assume that the boundary layer radiates like a blackbody with a temperature $T_{\rm bl} = 100{,}000$ K and a luminosity $L_{\rm bl} = 4\pi R_{\rm wd}^2 \sigma T_{\rm bl}^4 = 4.4 \times 10^{34}$ erg s^{-1} (where $R_{\rm wd} = 7.8 \times 10^8$ cm is the radius appropriate to a 0.7 $M_\odot$ white dwarf); the source is at a distance $d = 85$ pc; and the intrinsic flux suffers photoelectric absorption by a column density $N_{\rm H} = 3 \times 10^{19}$ cm^{-2}. For the scattering optical depth we assume $\tau_\lambda = (\pi e^2/m_{\rm e}c)\, nA\lambda_{\rm ij} f_{\rm ij}\, (g_{\rm i}/\Sigma g_{\rm i})\, (dv/dr)^{-1}$ where the wind velocity gradient $dv/dr = 3000$ km s^{-1}/10^{10} cm;

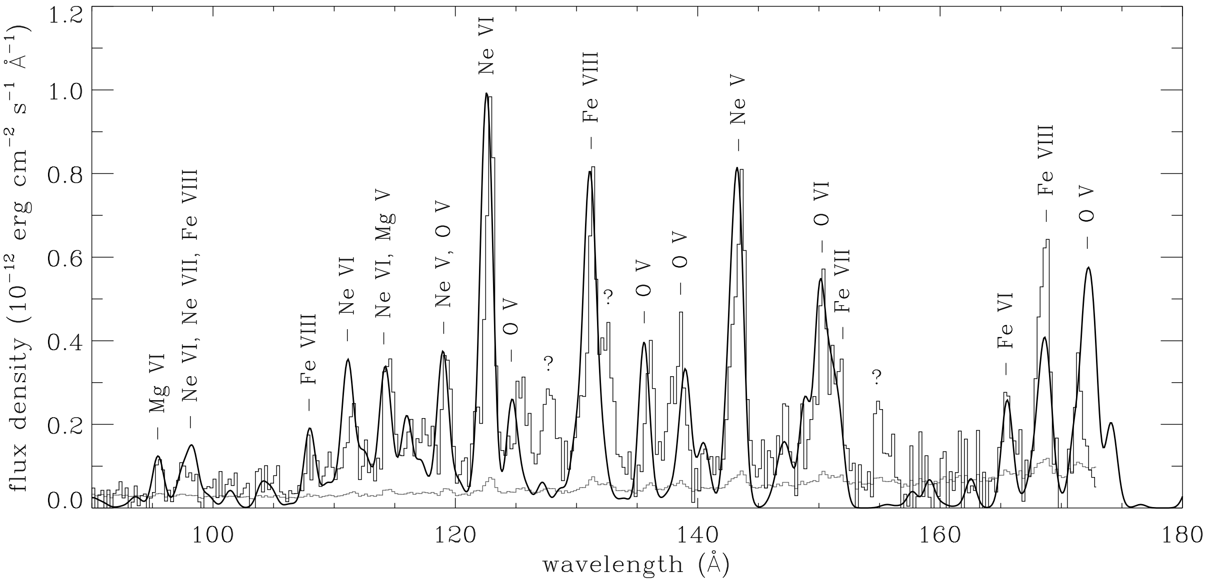

Fig. 1. Mean *EUVE* spectrum of OY Car. The spectrum is shown by the black histogram, the error by the grey histogram, the scattering model spectrum by the thick line. Line identifications are based on the model.

the density $n = 10^{10}$ cm^{-3} at a distance $r = 10^{10}$ cm; the optical depth is distributed as a Gaussian with FWHM = 0.9 Å; the abundances A are as given by Allen (1973); and the wavelengths $\lambda_{\rm ij}$, oscillator strengths $f_{\rm ij}$, and statistical weights $g_{\rm i}$ are as given by Verner, Verner, & Ferland (1996). The resulting model shown in Figure 1 required only modest (factor of two) modifications of the abundances/ionization fractions to produce the match to the data.

Given the success of this model, it is natural to ask if radiation pressure alone is capable of driving the inferred mass-loss rate of $\dot{M}_{\rm wind} = 4\pi r^2 \mu m_{\rm H} n v = 8\times 10^{15}$ g s^{-1}. It is not: for reasonable parameters, the total radiative force is ~ 200 times that of the O VI $\lambda150$ line of $L_{\rm O\,VI}/c = 3\times 10^{20}$ dynes; the resulting mass-loss rate is $\dot{M}_{\rm wind} = L_{\rm total}/vc \sim 2\times 10^{14}$ g s^{-1}, an order of magnitude short of the value required.

C. W. M.'s contribution to this work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

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