MULTIWAVELENGTH STUDY OF THE WO STAR SAND 2

L. NORCI[1], V.F. POLCARO[2], C. ROSSI[3] and R. VIOTTI[2]
[1] *Max-Planck-Institut für Extraterrestrische Physik, Postfach 1603, D-85740 Garching, B.R. Deutschland*
[2] *Istituto di Astrofisica Spaziale, via Enrico Fermi 21, I-00044 Frascati, Italy*
[3] *Istituto Astronomico, Universitá di Roma La Sapienza, I-00161 Roma ,Italy*

Abstract. We present the results of a multifrequency observation of the WO star Sand 2 in the LMC. Two *ROSAT* PSPC observations, with exposure times of 8953 s and 4540 s, are used to investigate possible X-ray emission from Sand 2. The optical spectrum observed with the *ESO* 2.2m telescope close to the time of the *ROSAT* observations, shows strong emission lines of He II, C IV, O V and O VI. All lines have a velocity broadening of $4\,200 \pm 100$ km s^{-1}. The UV spectrum from the *IUE* archive shows a C IV resonance doublet at 155 nm with a P-Cygni absorption at $\sim -5\,000$ km s^{-1}, with wings extending to about $-8\,000$ km s^{-1}. A combination of two different BB temperatures (80 000 K and 25 000 K) are required to fit the UV-optical continuum, dereddened by $E_{B-V} = 0.25$.

Key words: stars: Wolf-Rayet – WO – LMC – individual: Sand 2

Sand 2 (Br 93, Sk-68°145, FD 73) belongs to a small subgroup (about four objects) of the Wolf-Rayet stars, the WO stars, characterized by the presence of extremely strong O VI 381.1-383.4 nm emission and of a very high velocity wind. Although the WR stars are known to be soft X-ray emitters from *Einstein Observatory* observations (see Pollock 1987) none of the four WO stars is so far known to be a pronounced X-ray source.

Sand 2 lies in the northern part of the LMC 30 Dor nebula, to which it is probably physically associated (Lortet & Testor 1991). It is embedded in a bright H II region, with a very complex [O III] structure (Pakull 1991), and a possible far-IR excess (Lozinskaya 1991). The low resolution spectrum of the star has been published by Torres & Massey (1988).

The optical spectrum of Sand 2 shows strong emission lines of He II, C IV, and O V, with a velocity broadening of $4\,200 \pm 100$ km s^{-1}. The very high ionization O VIII 606.4–6.8 nm doublet is present in narrow emission (FWHM of about 220 km s^{-1}), much weaker than that in the galactic WO star Sand 4 (Polcaro *et al.* 1992).

The ultraviolet spectrum is characterized by many emission lines very prominent over the continuum. The strongest is the C IV doublet at 155 nm which also presents a P-Cygni absorption violet shifted by about $-4\,800$ km s^{-1}. The UV-optical continuum energy distribution, corrected for $E_{B-V} = 0.25$, is fitted with a combination of two 80 000 K and 25 000 K black-body spectra.

In the 1.0–2.4 keV energy range a complex of two weak sources are present near the position of Sand 2 in both the *ROSAT* PSPC observations. No

K. A. van der Hucht and P. M. Williams (eds.), Wolf-Rayet Stars: Binaries, Colliding Winds, Evolution, 66–67.

source is visible in the intermediate (0.4–1.0 keV) and low (0.1–0.4 keV) energy bands. We have determined the position of the two sources by fitting the source photon distribution with a Gaussian profile, after correcting the two images for the boresight effect by means of field sources of known position. We have superposed the two contour maps by using as a reference point the bright source CAL 71. Sand 2 clearly lies at an intermediate position between the two X-ray sources. Considering the present uncertainty in the position of the two sources, because of the source weakness and our poor knowledge of the instrument response at so large off-axis angles, it is difficult at the moment to establish whether Sand 2 is the optical counterpart of one of the two sources. It should be noted that the SIMBAD map shows no other stars within a radius of 2′ centered on the sources. But we cannot rule out the possibility of other, much fainter optical counterparts.

The background subtracted count-rate for the weakest of the two X-ray sources is $(2.9 \pm 0.6) \times 10^{-3}$ s^{-1}. At the distance of LMC this corresponds to a luminosity in the 0.1–2.4 keV energy range of 9.5×10^{33} erg s^{-1}, assuming a spectrum with $\log N_H = 20$ and kT = 1 keV (see Pollock 1987). The strongest source is about a factor 2 more luminous.

Higher positioning accuracy (PSPC pointed on the source, HRI) and a better detailed study of the field in the visual is required to ascertain whether Sand 2 can be associated with one of the two detected soft X-ray sources.

References

Dopita, M. A, Lozinskaya, T., Mc Gregor, P.J., Rawling, S.J. 1990, *ApJ* 351, 563

Lortet, M.-C., Testor, G. 1991, *A&A Suppl.* 89, 185

Lozinskaya, T. 1991, in: K.A. van der Hucht & B. Hidayat B. (eds.), Wolf-Rayet Stars and Interrelations with Other Massive Stars in Galaxies, *Proc. IAU Symp. No. 143* (Dordrecht: Kluwer), p. 371

Pakull, M.W. 1991, in: K.A. van der Hucht & B. Hidayat B. (eds.), Wolf-Rayet Stars and Interrelations with Other Massive Stars in Galaxies, *Proc. IAU Symp. No. 143* (Dordrecht: Kluwer), p. 391

Polcaro, V.F., Viotti, R., Rossi, C., Norci, L. 1992, *A&A* 265, 563

Pollock, A.M.T. 1987, *A&A* 171, 135

Schmutz W. 1991, in: K.A. van der Hucht & B. Hidayat B. (eds.), Wolf-Rayet Stars and Interrelations with Other Massive Stars in Galaxies, *Proc. IAU Symp. No. 143* (Dordrecht: Kluwer), p. 39

Torres, A.V., Massey, P. 1988, *ApJ Suppl.* 65, 459