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Dust-formation episode of the long-period WC+O binary WR 137: direct imaging with HST-NICMOS2

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Abstract. We have resolved, for the first time in any WR+OB system, IR-emitting dust in the close environment of the long-period binary WR 137. The dust emission occurs in a few clumps within about 0.″5 of the star, as well as in a jet-like structure with total extension of about 0.″25.

1. Observations

Recent observations (Williams 1996 and these Proceedings) showed that the IR flux of one of the seven dust-forming WR+O systems (*cf.* Williams 1995), WR 137 (HD 192641, WC7+OB) was on the rise again, a dozen years after a spectacular culmination of dust formation in 1984.4 (Williams *et al.* 1985). We have used *HST*-NICMOS2 (0.″075/pixel scale) with the medium-band filters F165M (H', $\lambda_c = 1.65\,\mu$m) and F237M (K', $\lambda_c = 2.37\,\mu$m) to observe WR 137 and WR 138 (the latter as a point-spread-function reference star) for two orbits on 10 September 1997 (around the maximum of the IR K-band flux: Williams 1998, private communication), and for one orbit on 18 May 1998.

2. Results

The estimated H' magnitudes (6.74 in 1997 and 6.76 ± 0.03 in 1998) closely match the values obtained during the previous 1984.4 maximum (Williams *et al.* 1985), while the K' values (5.94 in 1997 and 6.06 ± 0.03 in 1998) slightly exceed the corresponding *broad-band* K fluxes, as expected for a system containing a copious amount of heated dust with $T_{\rm d} \leq 10^3$ K.

After maximum entropy (ME) image restoration (Cornwell & Evans 1985), we can see three distinct clumps in the 1997 K' image of WR 137: summed over all three clumps, $K'(1997) = 10.7 \pm 0.4$ mag. Two of the clumps disappeared about eight months later, while the persistent clump ($K' = 13.1$ mag) receeded away from the star (Fig. 1) at $i = 68° \pm 10°$ relative to the plane of the sky. The central source on the 1997 H' and, especially, K' ME-images, is elongated, with the major axis pointing to the ejected clumps. The 1998 K' ME-image shows a spectacular, bright jet with integrated flux of $K'(1998) = 7.6 \pm 0.3$ mag, moving at $i \approx 27°$ relative to the plane of the sky. Clearly seen in the 1998 H' image is a hot clump ($T_{\rm clump} \geq 2200$ K) positioned right at the jet's extremity.

Assuming the dust to be amorphous carbon (Williams *et al.* 1987; Zubko 1998) and adopting $T_* = 35\,000$ K, $R_* = 10\,{\rm R}_\odot$, and d = 1.82 kpc (van der Hucht *et al.* 1988), we find: *(a)* $M_{\rm d} \simeq 5.4\,10^{-9}\,{\rm M}_\odot$ for the two non-persistive clouds in

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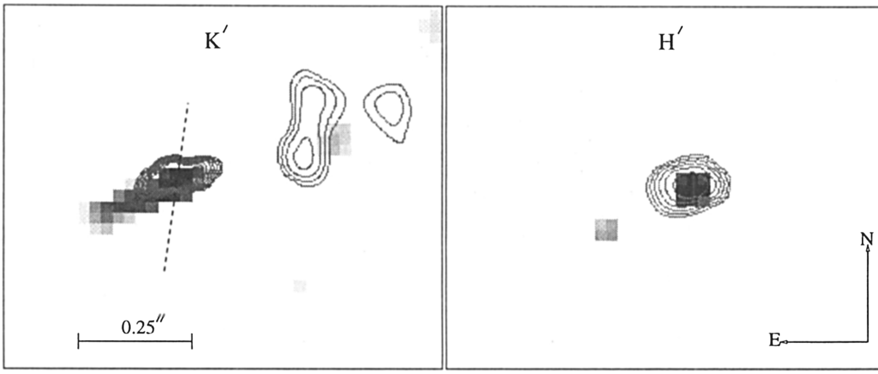

Figure 1. The *HST*-NICMOS2 ME-restored, factor-of-3 sub-sampled images of WR 137: gray-scales show the 1998 H' and K' log-scaled observations; the contours depict the 1997 H' and K' images. The dashed line indicates the probable orientation of the projected axis of symmetry of the flattened WR wind, based on spectro-polarimetry of the WR star.

1997; *(b)* $M_{\rm d} \simeq 2.3\,10^{-7}\,{\rm M}_{\odot}(1997) \simeq 2.2\,10^{-7}\,{\rm M}_{\odot}(1998)$ for the persistent cloud; and *(c)* $M_{\rm d} \simeq 1.7\,10^{-9}\,{\rm M}_{\odot}$ for the jet; all the masses are uncertain by a factor 3.

The dust formation and its spatial distribution in WR 137 are governed by four main factors: *(1)* by the changing orbital separation of the components around periastron; *(2)* by instabilities in the WR wind and/or instabilities in the wind-wind collision zone; *(3)* by instability-related shocks leading to strong temperature fluctuations; and *(4)* by an additional density enhancement from the flattened WR wind (Harries *et al.* 1998). All four factors combined together could lead to a $\frac{\rho}{\rho_0} \simeq 10^3$ gain in the gas density for clumps formed from gas compressed by the wind-wind collision, thus substantially facilitating the creation of dust.

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