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MASER EFFECTS IN THE RECOMBINATION LINES OF ETA CARINAE[1]

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Eta Car is a variable star surrounded by a cloud of gas and dust that absorbs a large part of its optical emission and that showed, in the past two hundred years, several events of mass ejection. It presents a 5.52 year period in the high excitation Heλ10830 line intensity (Damineli 1996), as well as in the radio continuum and recombination lines, from 5 to 230 GHz (Cox et al. 1995a, 1995b; Abraham & Damineli 1997, 1999). Changes in the central velocity of optical lines, with the same periodicity, suggest the presence of a companion star, in a highly eccentric binary orbit (Damineli et al. 2000). High resolution observations at 3 and 6 cm show an elongated structure surrounding the star, extending for several arc seconds, its actual size varying with epoch (Duncan et al. 1997).

We interpret this variable structure as an optically thick, edge on disk, ionized by a variable amount of ultraviolet photons, originating in both stars of the binary pair. When the secondary star, in its highly eccentric orbit approaches η Car, wind-wind collision increases the dust density, blocking the UV radiation. The external parts of the disk recombine and cool down, and this phenomena propagates to the inner parts of the disk, as the amount of radiation further decreases.

We used our continuum observations at 99, 147 and 230 GHz and the hydrogen recombination lines H30α, H35α and H40α, obtained with SEST in October 1999, near the maximum in the η Car light curve, to obtain the physical conditions in the emitting region. The continuum flux densities at 99, 147 and 230 GHz were 17.8, 20.7 and 23.5 Jy respectively, indicating that the region was optically thick to free-free radiation. The peak flux densities of the H40α, H35α and H30α recombination lines were 13, 23.9 and 43.9 Jy respectively, much higher than what is expected under LTE conditions. The velocity of the peak was about -56 km s^{-1} for the three lines, indicating an expansion velocity, when compared with the star velocity of about -8 km s^{-1}. The line widths at half intensity were 25, 30 and 40 km s^{-1} respectively, with an asymmetry towards positive velocities, specially in the lines with lower quantum numbers.

We modeled the region as a thin edge on disk, of high h and radius R, expanding with velocity $v(r) = v_0 + br$ and constant turbulent velocity $v_{\rm tur}$. Based on previous VLBI observations, we fixed the radius in 2", corresponding to 0.024 pc at the distance of 2.5 kpc. We assumed constant temperature and an electron density distribution of the form $N(r) = N_0(r_{\rm in}/r)^a$, where $r_{\rm in}$ is the internal radius of the disk. We found that the continuum free-free emission spectrum can be fitted by $N_0 = 8.8 \times 10^6$ cm^{-3}, $a = 1$ and $h = 0.36$". The NLTE recombination lines were very well fitted, both in peak intensity and shape, with a gas temperature of 8800 K, central expansion velocity $v_0 = -41$ km s^{-1}, $b = -10^3$ km s^{-1} pc^{-1} and $v_{\rm tur} = 20$ km s^{-1}. The maser amplification factor was about 10 at the center of the lines.

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