RevMexAA (Serie de Conferencias), **15**, 230–230 (2003)

Winds, Bubbles, & Explosions: A Conference to Honour John Dyson. Pátzcuaro, Michoacán, México, 9-13 September 2002. Editors: S. J. Arthur & W. J. Henney

NON-THERMAL RADIO EMISSION FROM SINGLE HOT STARS

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Many O stars are observable at radio wavelengths, due to thermal emission from the ionized gas in the stellar wind. The emergent radio spectrum has a characteristic spectral index ~ 0.6 (i.e., $F_\nu \propto \lambda^{-0.6}$). However, about 25% of the brightest O stars have a radio spectrum that differs from the thermal radio emission (Bieging, Abbott, & Churchwell 1989). This *non-thermal* radio emission is believed to be synchrotron radiation from relativistic particles accelerated in shocks (White 1985). Such shocks could come from colliding winds or from the instability of the driving mechanism of the wind. The magnetic field in hot stars needed to produce a synchrotron spectrum is below the current detection limits.

In the presence of shocks and a magnetic field, electrons are accelerated to relativistic energies (Bell 1978). The acceleration of the electrons results in a power-law distribution for the momentum p (with exponent n). For reasons of simplicity, we also assume a power law (with exponent δ) for the spatial dependence of the distribution: $N(r,p)\,dr\,dp \propto r^{-\delta} p^{-n}\,dr\,dp$.

Due to the very large free-free opacity of the wind, photons emitted below the characteristic radius R_ν (Wright & Barlow 1975) are absorbed. Thus, the synchrotron radiation must be formed outside R_ν. Further, it can be expected that beyond a certain position in the wind, shocks are too weak to produce synchrotron-emitting particles. Therefore, we introduce $R_{\max}$ as the outer boundary of the synchrotron emission region (Compton cooling prevents electrons from carrying their energy very far from a shock).

In the region where the synchrotron emission is emitted, the magnetic field can be expressed as: $B \sim 1/r$, assuming spherical symmetry. We take into account the Razin-effect, which causes synchrotron radiation to be suppressed at higher wavelengths.

We explored the parameter space of the model for a specific observation of Cyg OB2 No. 9. The most important result (see Figure 1) is that $R_{\max}$ is well constrained, although the model also depends on other parameters (n and δ). The outer boundary $R_{\max}$ of the synchrotron emitting region must lie between $785\,R_*$ and $875\,R_*$. It is unexpected that shocks can survive to such distances.

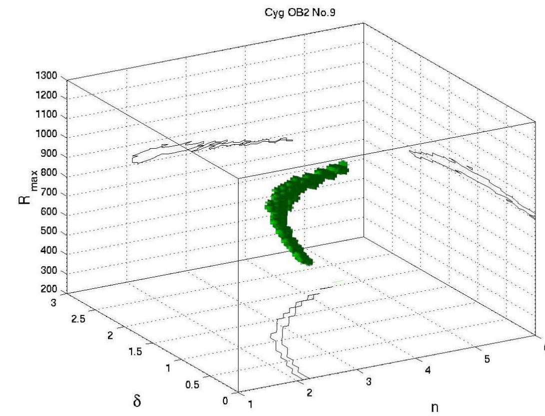

Fig. 1. All the combinations of n, δ and $R_{\max}$ that fit the VLA observations (1984 December 21) for Cyg OB2 No. 9 lie within the boomerang-shaped region. Different projections are plotted to situate the solutions in the parameter space. The following stellar parameters were used: $R_* = 22\,R_\odot$, $v_\infty = 2900\,\mathrm{km\,s^{-1}}$, $D = 1.82\,\mathrm{kpc}$, $B_* = 100\,\mathrm{Gauss}$, $T_{\rm wind} = 15,000$ K and $\dot{M} = 2\times10^{-5} M_\odot \mathrm{yr}^{-1}$. The flux densities: $5.7 \pm 0.1\,\mathrm{mJy}$ for 2 cm, $7.4 \pm 0.1\,\mathrm{mJy}$ for 6 cm and $4.9 \pm 0.1\,\mathrm{mJy}$ for 20 cm.

The present model assumes a wind with shocks, but without clumping. Yet, shocks in the wind compress the gas and form clumps. This has an effect on the formation region of the radio emission. It can be shown (e.g., from Abbott, Bieging, & Churchwell 1981) that the characteristic radius changes as: $R_\nu^{\rm clumped} = R_\nu^{\rm smooth}/f_{\rm cl}$. For a clumped wind, R_ν will be lower and $R_{\max}$ will follow.

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