RADIO OBSERVATIONS AND THE MASS FLOW RATE OF α CYG (A2Ia)

B. Wolf[1], O. Stahl
Remeis-Sternwarte Bamberg, Astronomisches Institut der Universität Erlangen-Nürnberg
W.J. Altenhoff
Max-Planck-Institut für Radioastronomie

I INTRODUCTION

From the free-free excess at 10μ Barlow and Cohen (1977) (hereafter referred to as BC) derived a mass loss rate of 6.9 10^{-7} $M_\odot$ yr^{-1} for α Cyg. They predicted a 10 GHz radio flux of 2.2 mJy. On the other hand Praderie et al. (1980) derived a considerable lower mass loss rate of 1.1 $10^{-8} \leq \dot{M} \leq 7\ 10^{-8}$ $M_\odot$ yr^{-1} from a curve of growth analysis of the envelope ultraviolet FeII-lines of α Cyg. Radio observations are desirable to make a decision about these discrepant results. Therefore we observed α Cyg at 15 GHz with the 100 m telescope of the MPIfR at Effelsberg. The observations are discussed together with recent VLA data of Abbott et al. (1980).

II OBSERVATIONS

We observed α Cyg on Sept. 21, 1979 with the 100 m telescope of the MPIfR in Effelsberg at a frequency of 15 GHz. The receiver was a cooled two channel parametric amplifier at the prime focus. An integration time of 3 hours was used. The flux was determined by direct comparison with the calibration source NGC 7027. No radio source was found at the position of α Cyg. The mean flux determined from 240 scans is S_ν (15 GHz) = - 0.63 ± 0.39 mJy. The negative flux value is caused by an extended confusing source in the beam situated about 3 to 5 arcmin north of α Cyg. A conservative upper limit of 1 mJy can be derived from our observations of α Cyg at 15 GHz.

Recently Abbott et al. (1980) observed α Cyg with the VLA and found an upper limit of 0.4 mJy at a frequency of 5 GHz and derived an upper limit for the mass loss rate of $\dot{M} \leq 2.5$ 10^{-7} $M_\odot$ yr^{-1}.

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III DISCUSSION

The observed upper limit of 1 mJy at 2 cm (0.4 mJy at 6 cm) is much lower than the predicted flux of α Cyg of 2.2 mJy at 3 cm, which was derived by BC using the velocity law of P Cyg. The upper limits at 15 GHz and 5 GHz (Abbott et al., 1980) and the observed infrared free-free flux of 2.59 Jy at 10μ (BC) yield a spectral index larger than 1.03 and 1.01 respectively, whereas BC predicted an index of 0.88 (cf. figure).

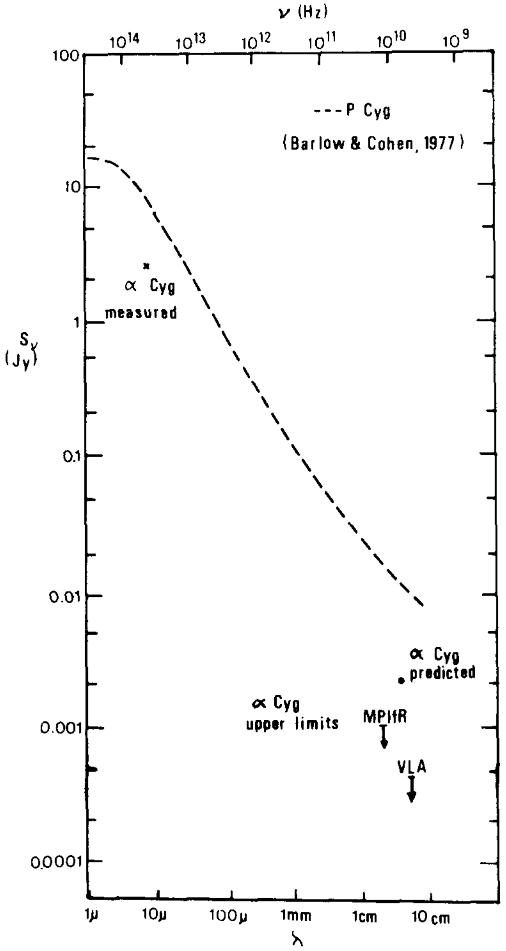

Figure.
The dotted line shows the flux density S_ν(Jy) versus frequency and wavelength for P Cyg as calculated by Barlow and Cohen (1977). The cross denotes the observed flux of α Cyg at 10μ . The predicted radio flux of α Cyg of 2.2 mJy at the frequency of 10 GHz is denoted by a point. The upper limits of 1 mJy at 15 GHz and 0.4 mJy at 5 GHz derived for α Cyg from our observations with the 100 m telescope and with the VLA (Abbott et al., 1980) respectively are indicated by arrows in the figure

This difference between the predicted and observed radio flux is presumably due to the velocity law used for their computations; i.e. one has to argue that the velocity law for the mass outflow from α Cyg should be quite different from that derived for P Cyg.
Wright and Barlow (1975) and Panagia and Felli (1975) find that a density distribution $n_e \sim r^{-\beta}$ gives rise to a spectrum

$S_\nu \sim \nu^{(4\beta-6.2)/(2\beta-1)}$ (valid for $\beta \geq 1.5$). Assuming spherical symmetry and taking into account the equation of continuity ($n_e v r^2$ =const.), one finds that a more rapid acceleration between the regions emitting the 10 μ and the radio radiation can produce a spectral index $\alpha \gtrsim 1.03$ (1.01) with $\beta \geq 2.66$ (2.62). In addition we can derive a lower limit for the velocity power law $v \sim r^{\beta-2} = r^\gamma$ with $\gamma \geq 0.66$ (0.62). If the formula for uniform velocity mass outflow which correlates the radio flux with the mass loss rate (cf.equation 7 of Wright and Barlow (1975)) is applied to the upper limit of 1 mJy at 15 GHz (0.4 mJy at 5 GHz) of α Cyg an upper limit of $\dot{M}$ is derived to $\dot{M} \leq 3.1\ 10^{-7}\ M_\odot\ yr^{-1}$ ($2.5\ 10^{-7}\ M_\odot\ yr^{-1}$). (We used: v_∞ =250 km s^{-1} (Lamers et al., 1978), the distance D = 0.61 kpc, the Gaunt factor g=4.4 (5.0) (from Spitzer (1962) with T_{eff} =9170 K (Groth, (1961)); the mean ionic charge and the mean number of electrons per ion were assumed to be equal to one.) This upper limit of $\dot{M}$ is by more than a factor of two below the value derived by BC but is compatible with the limits derived by Praderie et al. (1980).

IV CONCLUSION

The upper limit of 1 mJy (0.4 mJy) at the wavelength of 2 cm (6 cm) is below the predicted value for α Cyg (BC) by about a factor of three. This provides strong evidence that the velocity law derived by BC for the mass outflow of P Cyg is not applicable for A2Ia supergiants. The mass loss rates derived by BC from infrared data for a number of OBA supergiants are all based on the P Cyg velocity law. From the radio observations of α Cyg it seems rather probable that the velocity law is different for later type supergiants. Hence the mass loss rates derived for these stars from 10μ observations may be generally overestimated by more than a factor of two.

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[1] Permanent address: Landessternwarte Königstuhl,Heidelberg

DISCUSSION

VAN DER LINDEN: In your statement that material lost through the L2, L3 points is not subject to gravitational forces; you should be careful because the L2, L3 point are defined only for synchronous rotation (material bound to a star).

WOLF: In the L2 and L3 points the force exerted on the gas vanishes. According to the sketched flow pattern, material escapes through point L2. By radiation pressure it is supposed to be finally accelerated to the observed high velocities.

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