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Editores: Juan José Clariá, Diego García Lambas, y Hugo Levato

DISK FORMATION IN BE-STARS DUE TO LINE DRIVEN STELLAR WIND AND ROTATION

M. Curé[1]

Departamento de Física y Meteorología, Universidad de Valparaíso, Casilla 5030, Valparaíso, Chile

The theory of radiation driven wind has been very successful in describing the observed terminal velocities and mass loss rates from hot stars. After the pioneering work of Castor, Abbott and Klein (1975, hereafter CAK), who realized that the force due to line absorption in a rapidly expanding envelope can be calculated using the Sobolev approximation, they developed a simple parameterization of the line force and were able to construct an analytical wind model. The influence of star's rotation was investigated by Castor (1979) and Marlborough and Zamir (1984). Both studies concluded that the effect of adding a centrifugal force term in the CAK equation results in a lower terminal velocity wind, but the mass loss rate is not substantially affected.

Concerning Be–Stars, the modified-CAK theory (Friend & Abbott 1986; Kudritzki et al. 1986) gives a good description of the polar wind, but it cannot account for a slowly accelerating flow like the observed in the equator of Be–Stars. Therefore, several additional mechanisms based on radiatively driven wind theory have been proposed to explain the equatorial flow of these objects, e.g., magnetic fields and rotation; viscous force; sound waves. Despite all these efforts, the most important problem with all these models, is that they produce too strong equatorial expansion. Not only the terminal velocity is too high ($\sim$ 1000 km s^{-1}) but also there is a too rapid increase in the velocity. Contrary to this result, the fitting of $H\alpha$ line profile, requires terminal velocities of about 200 km s^{-1} or less (Poeckert & Marlborough 1978).

Therefore we performed a re-analysis of the modified CAK theory including the rotational centrifugal force term in the radiatively driven wind theory. After a suitable change of variables, an equation for the mass loss rate is derived analytically, that gives an accuracy within 1% confidence compared with numerical calculations. Furthermore a non-linear equation for the position of the critical (singular) point is obtained. This equation predicts the existence of two other critical points, besides the standard modified-CAK critical point. When the stellar rotation velocity is about (or greater than) 0.8 $V_{breakup}$, there is again only one critical point located far away in the wind. Numerical solutions from this new critical point are attained, having very low terminal velocities (see below). As Be–Stars are rapid rotators, the centrifugal force increases from the pole to the equator and, at certain critical angle, the standard modified–CAK solution ceases to exist and the only solution is this 'new' slow solution. Thus, between the pole and this critical angle the wind is described by the standard modified–CAK (fast) wind and from this critical angle up to the equator by a slow wind with higher density than the polar low density wind. Numerical calculations for a typical $B1\ V$ Star are attained. The stellar parameters are: $T_{eff} = 25000K$, $\log g = 4.03$ and $R/R_{\odot} = 5.3$ and line force parameters: $k = 0.3$, $\alpha = 0.5$ and $\delta = 0.07$. When $v_{rotation} = 0.9 \times v_{breakup}$, the critical point is located at $r = 1.014R_{*}$ for the polar direction and $r = 23.63R_{*}$ for the equatorial direction. Terminal velocities and mass loss rates are: $v_{\infty} = 2025$ km s^{-1}, $\dot{M} = 3.178 \times 10^{-9}\ M_{\odot}$ y^{-1} for the polar direction and $v_{\infty} = 443$ km s^{-1}, $\dot{M} = 6.854 \times 10^{-9}\ M_{\odot}$ y^{-1} for the equatorial direction. The critical angle for this case is approximately 40 degrees. Therefore we conclude, that line driven stellar wind theory can explain disk formation in rapid rotational stars.

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[1]michel.cure@uv.cl