Stellar Rotation
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Differential Rotation and the $v \sin i$ Parameter

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Abstract.
We study the effects of a differential rotation upon the determination of the $v \sin i$ parameter. The effects are studied for several values of the ratio t = kinetic energy/gravitational potential energy, which include energy ratios higher than permitted for critical rigid rotation and using an internal conservative rotation law that allows for a latitudinal differential rotation in the stellar surface. Two effects are outstanding: when differential rotation is dependent on the stellar latitude the $v \sin i$ parameter does not necessarily correspond to the equatorial rotation velocity; the line width is a double valued function of $v \sin i$ and it is dependent on t and the aspect angle i.

1. Results

In this work we adopt a cylindrically symmetric angular momentum distribution law given by (Mark 1968, ApJ, 154, 627): $j(m) = (J/M)a(b)m(1 + bm)$ with $a(b) = b^2/[b - \ln(1 + b)]$; where J is the total angular momentum, M is the stellar mass, b is a constant, and m is the mass fraction inside a cylinder of radius ϖ. This law implies $\Omega_{\text{pole}} > \Omega_{\text{equator}}$ and allows for a latitudinal differential rotation in the stellar surface. For these cylindrical rotation laws it is possible to build dynamically stable models up to energy ratios t $\simeq 0.26$, where t is the ratio between the kinetic energy and the gravitational potential energy. Moreover, for these laws the maximal radial velocity ($v_M \sin i$) does not necessarily correspond to the equatorial rotation velocity. At high t values (t > 0.03) the stars present strong geometrical deformations which may affect, in particular, the determination of the $v \sin i$ parameter (Fig. 1).

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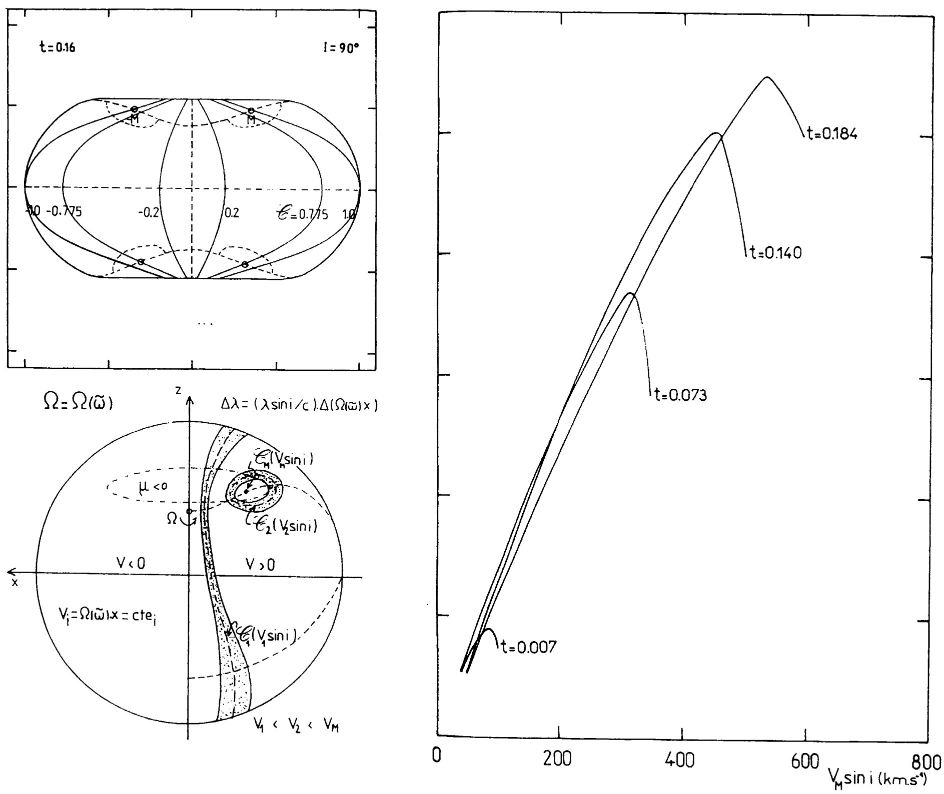

Figure 1. *Top left:* shows that the visible curves of equal radial velocity C depends on the stellar geometrical deformation, and consequently on the stellar inclination. This figure corresponds to a differentially rotating star with $i = 90°$ and t = 0.16 (t was chosen high to show more clearly the geometrical deformation effect). Note that the curves $C > 1$ (closed curves around the points ±M) are partially hidden by the geometrical depression in the polar regions. *Bottom left:* Contribution of the local profile for two values of $\Delta\lambda$; they follow the regions of equal projected rotation velocity ($v = \Omega(\varpi)x = cte$). By considering the stellar geometrical deformation the region inside the dot-dashed curve ($\mu < 0$) are not seen by the observer and thus do not contribute to the total rotationally broadened line profile. *Right:* Full width at half intensity (FWHI, named $\Delta\lambda\,{}^1/_2$) of the HeI14471 line as a function of $v_M \sin i$ for the adopted cylindrical rotation law with $b = -0.454$ and several values of t. We note that for this cylindrical rotation law two values of the $v \sin i$ parameters may exist for the same FWHI. The first value does not depend strongly on the rotation law, even for uniform rotation. The second value appears only if the differential rotation is cylindrical. At high inclinations the curves C contributing to the strongest $\Delta\lambda$ Doppler shift ($C > 1$) are hidden in the polar hole. For a given rotation law the second value of the $v \sin i$ parameter is a function of both t and the stellar mass.