Dynamical Simulations of Magnetically Channeled Line-Driven Stellar Winds: III. Angular Momentum Loss and Rotational Spindown

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We examine the angular momentum loss and associated rotational spindown for magnetic hot stars with a line-driven stellar wind and a rotation-aligned dipole magnetic field. Our analysis here is based on our previous 2-D numerical MHD simulation study that examines the interplay among wind, field, and rotation as a function of two dimensionless parameters, one characterizing the wind magnetic confinement ($eta_{ast} equiv B_{eq}^{2} R_{ast}^{2}/{dot M} v_{infty}$), and the other the ratio ($W equiv V_{rot}/V_{orb}$) of stellar rotation to critical (orbital) speed. We compare and contrast the 2-D, time variable angular momentum loss of this dipole model of a hot-star wind with the classical 1-D steady-state analysis by Weber and Davis (WD), who used an idealized monopole field to model the angular momentum loss in the solar wind. Despite the differences, we find that the total angular momentum loss ${dot J}$ averaged over both solid angle and time follows closely the general WD scaling ${dot J} = (2/3) {dot M} Omega R_{A}^{2}$, where ${dot M}$ is the mass loss rate, $Omega$ is the stellar angular velocity, and R_{A} is a characteristic Alfv'{e}n radius. However, a key distinction here is that for a dipole field, this Alfv'{e}n radius has a strong-field scaling $R_{A}/R_{ast} approx eta_{ast}^{1/4}$, instead of the scaling $R_{A}/R_{ast} sim sqrt{eta_{ast}}$ for a monopole field. This leads to a slower stellar spindown time that in the dipole case scales as $tau_{spin} = tau_{mass} 1.5k/sqrt{eta_{ast}}$, where $tau_{mass} equiv M/{dot M}$ is the characteristic mass loss time, and k is the dimensionless factor for stellar moment of inertia. The full numerical scaling relation we cite gives typical spindown times of order 1 Myr for several known magnetic massive stars.

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Weblink: http://arxiv.org/pdf/0810.4247v1; http://www.morrisville.edu/~uddoula/public/data/spindown_final.pdf

Comments:

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