Dynamical Simulations of Magnetically Channeled Line-Driven Stellar Winds: II. The Effects of Field-Aligned Rotation

Asif ud-Doula^{1,2}, Stanley P. Owocki^1 and Richard H.D. Townsend^1

1.Bartol Research Institute,
University of Delaware,
Newark, DE 19716
2. Department of Physics and Astronomy,
Swarthmore College,
Swarthmore, PA 19081

Building upon our previous MHD simulation study of magnetic channeling in radiatively driven stellar winds, we examine here the additional dynamical effects of stellar {em rotation} in the (still) 2-D axisymmetric case of an aligned dipole surface field.
In addition to the magnetic confinement parameter eta_{ast} introduced in Paper I, we characterize the stellar rotation in terms of a parameter $W equiv V_{rm{rot}}/V_{rm{orb}}$ (the ratio of the equatorial surface rotation speed to orbital speed), examining specifically models with moderately strong rotation $W =$~0.25 and 0.5, and comparing these to analogous non-rotating cases.
Defining the associated Alfv'{e}n radius $R_{rm{A}} approx eta_{ast}^{1/4} Rstar$ and Kepler corotation radius $R_{rm{K}} approx W^{-2/3} Rstar$, we find rotation effects are weak for models with $R_{rm{A}} < R_{rm{K}}$, but can be substantial and even dominant for models with $R_{rm{A}} gtwig R_{rm{K}}$.
In particular, by extending our simulations to magnetic confinement parameters (up to $eta_{ast} = 1000$) that are well above those ($eta_{ast} = 10$) considered in Paper I, we are able to study cases with $R_{rm{A}} gg R_{rm{K}}$;
we find that these do indeed show clear formation of the {em rigid-body} disk predicted in previous analytic models, with however a rather complex, dynamic behavior characterized by both episodes of downward infall and outward breakout that limit the buildup of disk mass.
Overall, the results provide an intriguing glimpse into the complex interplay between rotation and magnetic confinement, and form the basis for a full MHD description of the rigid-body disks expected in strongly magnetic Bp stars like $sigma$~Ori~E.

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Comments:

Email: asif@bartol.udel.edu