Centrifugal Breakout of Magnetically Confined Line-Driven Stellar Winds

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Abstract

We present 2D MHD simulations of the radiatively driven outflow from a rotating hot star with a dipole magnetic field aligned with the star's rotation axis. We focus primarily on a model with moderately rapid rotation (half the critical value), and also a large magnetic confinement parameter, $\eta_* \equiv B_*^2 R_*^2 / \dot{M} V_\infty = 600$. The magnetic field channels and torques the wind outflow into an equatorial, rigidly rotating disk extending from near the Kepler corotation radius outwards. Even with fine-tuning at lower magnetic confinement, none of the MHD models produce a stable Keplerian disk. Instead, material below the Kepler radius falls back on to the stellar surface, while the strong centrifugal force on material beyond the corotation escape radius stretches the magnetic loops outwards, leading to episodic breakout of mass when the field reconnects. The associated dissipation of magnetic energy heats material to temperatures of nearly 10^8 K, high enough to emit hard (several keV) X-rays. Such *centrifugal mass ejection* represents a novel mechanism for driving magnetic reconnection, and seems a very promising basis for modeling X-ray flares recently observed in rotating magnetic Bp stars like σ Ori E.