Global simulations of accretion onto magnetized stars: results of 3D MHD simulations and 3D radiative transfer

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Spectro-polarimetric observations of several young classical T Tauri stars (CTTSs) show that the magnetic field of stars may be complex, and can be represented as a superposition of different multipoles \cite{1}. We use a “Cubed Sphere” code to perform global 3D MHD simulations of disk accretion onto stars with complex magnetic fields, and investigate matter flow around these stars \cite{2, 3}. We observe that at large distances from the star, the dipole component often dominates and determines the disk-magnetosphere interaction. However, closer to the star, the higher-order multipoles dominate and determine the shapes of hot spots at the surface of the star. The model has been applied to a young star V 2129 Oph. To compare the results of our simulations with observation, we calculate hydrogen spectral lines from the magnetospheric flow, using the three-dimensional radiative transfer code TORUS \cite{4}. The results of 3D MHD and 3D radiative transfer models are in good agreement with the observations \cite{5}. In another set of 3D MHD simulations and 3D radiative transfer analysis, we investigate accretion onto a star with a dipole field in either stable or unstable regimes. We investigate the boundary between these two regimes \cite{6}, and calculate the photometric and spectral properties of modeled stars \cite{7}. We found that in the stable regime, the light-curves and spectral lines vary orderly in time with one or two peaks per period, while in the unstable regime, a stochastic light curve and stochastic spectral variability are observed, with several peaks per period.

Figure 1: An example of accretion onto a star with a predominantly octupolar field. Magnetic field lines and a slice of the density distribution are shown (from \cite{8}).

\cite{5} S.H.P. Alencar et al., Astron. & Astrophys., 541, 1 (2012).
\cite{6} A.A. Blinova, M.M. Romanova, R.V.E. Lovelace, in prep. (2013).