Forces in magnetospheric launching of micro-ejections

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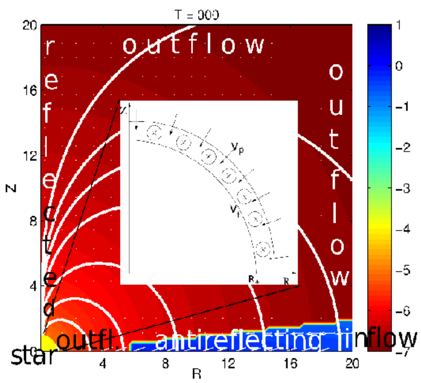
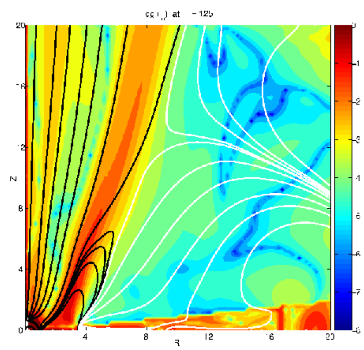
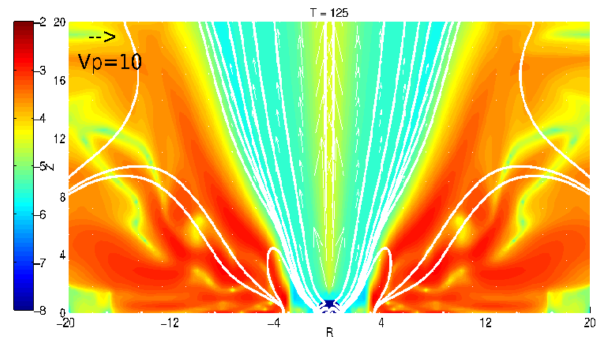
In 2D-axisymmetric simulations with our resistive MHD code Zeus-347 we show that micro-ejections, a quasi-stationary fast ejecta of matter of small mass and angular momentum fluxes, can be launched from a purely resistive magnetosphere above the disk gap. They are produced by a combination of pressure gradient and magnetic forces, in presence of ongoing magnetic reconnection along the boundary layer between the star and the disk, where a current sheet is formed. Mass flux of micro-ejections increases with increasing magnetic field strength and stellar rotation rate.



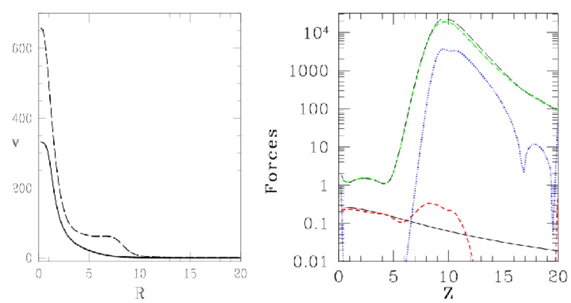
Simulations setup A star-disk-corona system, shown above, is set in the vicinity of central object in the computational box. In addition to disk and its halo, the magnetosphere in the closest vicinity of the star is included in simulations,with physical resistivity included in the whole box. The disk is initially slightly sub-Keplerian, and initial magnetic field is a stellar dipole. A star-shown in inserted panel in magnification-is set as a rotating, absorbing boundary, enclosing the origin.



We show the absolute value of the toroidal current, in logarithmic color grading, in code units. In solid lines are drawn poloidal magnetic field lines, with lines along which magnetic field vector points towards the star, painted in *black color*, and those where the field points in the opposite direction, in *white color*. Reconnection is ongoing along the boundary sheet between the opposite-directed magnetic fields. The quasi-stationary state is reached, with matter pushed out of the magnetosphere by pressure gradient and magnetic forces, helped by reconnection.



Mass flux is depicted in units of mass accretion rate at R=2.8 stellar radii, in logarithmic color grading, in simulation with stellar magnetic field of 200 G. The white solid line shows the poloidal magnetic field, and vectors represent velocity.



In the left panel is shown velocity in the above simulation, in units of Keplerian velocity at R=2.8 stellar radii, along the outer Z-boundary. Dashed line depicts magnetic field of B=200 G, and in solid line is the velocity with a weaker field of B=20 G. In the right panel are shown forces in code units, in a logarithmic scale, along a slice parallel to the axis of symmetry, at R=5. In blue dotted line is shown the magnetic force, and in solid, green dot-dashed, red short-dashed and black long-dashed lines are shown absolute value of the gravitational force, pressure gradient, centrifugal and total force, respectively. Ejection along the axis is artificial, produced by the steep gradient in magnetic pressure nearby the axis. At larger radial distance realistic, physical ejections occur, and they are mainly launched by pressure gradient and magnetic forces.

Conclusions:

Reconnection is a part of the launching mechanism of micro-ejections. It is similar to the reconnection in solar micro-flares, only that now launching occurs in the magnetosphere above the disk gap.