Numerical modeling of MHD hypersonic flow over a large body in planetary magnetic field

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The interaction of magnetic field and plasma structures is of an essential interest in astrophysics and geophysics. In particular the attention is paid to the MHD phenomena occurring when a meteoroid (body of a space origin, i.e. asteroid or comet fragment) enters an atmosphere of a planet possessing own magnetic field.

This work is devoted to numerical study of the MHD phenomena arising in a hypersonic flow over a body in a magnetic field under conditions taking place at the collision of comet Shoemaker-Levy 9 with the Jupiter.

Numerical modeling has been carried out in 2D and 3D formulations. In 2D formulations the intensity of MHD interaction determined by the magnetic pressure number R_H varies when the Jupiter atmosphere altitude, at which the MHD process is considered, is chosen as $H = 100$, 280, 360 km. The analysis of influence of orientation of magnetic field with respect to the axis of the body and direction of its movement on the MHD effects is made.

It has been shown that at parallel orientation of an external magnetic field and an axis of a body amplification of a magnetic field mainly occurs in a skin-layer before a shock wave and is approximately equal to the ratio of velocities at the shock wave. The maximum factor of amplification of a magnetic field with respect to a field of the planet amounts to $\sim$10. At the perpendicular orientation of the magnetic field relative to the axis of the body and the direction of movement the high amplification of a field occurs in compressed layer in front of the body and in large area behind a body. At $R_H \ll 1$ maximal amplification of a magnetic field in compressed layer is proportional to $R_{em}^{1/2}$ and at the used initial data achieves $\sim 10^3$. At $R_H \geq 1$ MHD interaction leads to suppression of the gazdynamical vortices behind of a body, generation of a MHD jet in a distant tail behind the body.

3D modeling has been carried out with the data for 280 km altitude of Jovial atmosphere. Amplification of a magnetic field in a shock layer is approximately $\sim 10^2$. The configuration of gasdynamic and field and current structures is changed comparing to 2D solutions.