Geophysical Research Abstracts
Vol. 13, EGU2011-2547-1, 2011
EGU General Assembly 2011

Modeled instabilities at the magnetic cavity boundary of comet 67P/Churyumov-Gerasimenko

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In case of a high enough production rate ($\sim 10^{27}$ s^{-1}) the dynamics of cometary plasma in the vicinity of a comet is governed by its interaction with the neutral gas. Abundant collisions force the plasma to follow the neutral gas that originates from the comet. Once the density of the expanding neutral gas becomes small enough the neutral and the plasma components decouple. Furthermore the outflowing plasma also interacts with the cometary pick-up ions originating outside this region as well as the solar wind. This interaction heats up the plasma, which in turn increases the value of the local sound speed and therefore decreases the local Mach number. The inner shock then forms where the supersonic plasma transitions to subsonic speeds (Mach number < 1). This shock prevents the plasma originating upstream from reaching the close proximity of the comet and is therefore responsible for the cavity, the magnetic field-free region close to the nucleus. This effect has been observed at comet 1P/Halley by the European Space Agency's (ESA) Giotto spacecraft during the flyby on March 14, 1986.
We use our magnetohydrodynamics model BATSRUS (Block-Adaptive-Tree-Solarwind-Roe-Upwind-Scheme) to simulate the solar wind - comet interaction. The model includes photoionization, ion-electron recombination, as well as charge exchange and was already successful in reproducing the above-mentioned measurements of the plasma environment at comet 1P/Halley by ESA's Giotto spacecraft [see e.g. Gombosi et al., J. Geophys. Res., 101 (1996) and Rubin et al., Icarus, 199 (2009)]. In this work we are interested in the plasma environment of comet 67P/Churyumov-Gerasimenko, the target comet of ESA's Rosetta mission. Rosetta will rendezvous with 67P/Churyumov-Gerasimenko in Spring 2014 and immediately start to observe the comet to ascertain a safe deployment of the Philae landing module. We will focus on the early phase after the lander delivery at roughly 2.7 AU and present conditions where the plasma flow outside the inner shock can become unstable. We will show that this phenomenon is governed by a tight interplay of the magnetic field draped around the magnetic cavity and the neutral gas production as well as its distribution around the comet. We will also discuss the involved time-scales and compare these to the comet's rotation and/or the formation of jets.
This work has been supported by JPL subcontract 1266313 under NASA grant NMO710889 and NSF grant AST 0707283.