The Hybrid Model and the A.I.K.E.F. Code

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The hybrid model is a semi-kinetic approach of the plasma description. Within this model the ions are described as individual particles, whereas the electrons are treated as a fluid. Based on this, the hybrid model is able to describe effects caused by the kinetic behaviour of the ions, such as the gyration of the ions in the magnetic field or the ring distribution of the cometary ions in the velocity phase space. Furthermore, the model can distinguish between the different ion species, namely the protons of the solar wind, the cometary water group ions and other cometary ions.

The presented simulations use the A.I.K.E.F. (Adaptive Ion Kinetic Electron Fluid) code as an implementation of the hybrid model. The details of the code, which has been developed at the University of Braunschweig, are described in detail by Müller et al. (2011). The predecessor of the A.I.K.E.F. code is a hybrid code developed by Bagdonat and Motschmann (2002b). This older version was successfully used by Bagdonat and Motschmann (2002a) and several other authors to investigate not only the interaction between a comet and the solar wind but also for other scenarios.

The A.I.K.E.F. code assumes massless electrons. Therefore the electron fluid is neutralising charges. This assumption prevents any investigation of structures or boundaries on scales smaller than the characteristic electron scales. The fluid is described by conservation laws and the pressure is assumed to be adiabatic. The momentum equation is used to calculate the electric field and the magnetic field is obtained by Faraday's law. The moments and the electromagnetic fields are calculated and stored at the nodes of an adaptive mesh, which allows a high resolution in regions of interest, e.g. the diamagnetic cavity. In contrast to the moments and the fields the particles move freely through the three dimensional simulation box. The dynamic behaviour is described by the Newtonian equation of motions with the Lorentz force and a collision force modelling interaction with the neutral gas.

Since the computational resources are limited, appropriate boundary conditions have to be used in order to describe the cometary environment in a correct way. Hence, a one-dimensional semi-kinetic model is used, which describes the plasma interaction from the undisturbed solar wind to the upstream boundary of the simulation box. This model, based on Galeev et al. (1985) is extended by a magnetic field, guarantees that the boundaries or structures do not move when the size of the simulation box is changed. A detailed description will be published in Koenders et al. (in prep.).

- C. Koenders et al., Revisiting Cometary Bow Shock Position, in preparation
- Müller, J., Simon, S., Motschmann, U., Schüle, J., Glassmeier, K., Pringle, G. J., 2011, A.I.K.E.F.: Adaptive hybrid model for space plasma simulations, Computer Physics Communications, 182, 946– 966
- Bagdonat, T., Motschmann, U., 2002, From a Weak to a Strong Comet - 3d Global Hybrid Simulation Studies, Earth Moon and Planets, 90, 305–321
- Bagdonat, T., Motschmann, U., 2002, 3D Hybrid Simulation Code Using Curvilinear Coordinates, Journal of Computational Physics, 183, 470–485

Rules of the Road:

The ICES website allows you to query data from hybrid simulations of the interaction between the comet and the solar wind. Based on the high level of complexity of the model as well as of the code and the vast amount of computational resources, which is gained from supercomputing facilities, the investigators are kindly requested to follow these rules when using data from the hybrid simulations:

- The treatment of the intentions of the work should be discussed with C. Koenders (c.koenders@tu-braunschweig.de) or U. Motschmann before the preparation of any presentation or publication. Maybe more suitable simulations can be performed.
- In case the data from the hybrid simulations is used as a main topic of the work, a co-authorship for C. Koenders and U. Motschmann and an acknowledgement for the computing facility are required. If only a minor reference is given to the hybrid simulations please quote the following references:
    1. C. Koenders et al., Revisiting Cometary Bow Shock Position, in preparation
    2. Müller, J., Simon, S., Motschmann, U., Schüle, J., Glassmeier, K., Pringle, G. J., 2011, A.I.K.E.F.: Adaptive hybrid model for space plasma simulations, Computer Physics Communications, 182, 946– 966