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0.0.1 Space plasma physics

Research Team Prof. Dr. Joachim Vogt, Dr. Bertalan Zieger, Dr. Matthias Hoeft (since August 2006)

The structure and dynamics of near-Earth space are controlled by the interaction of the geomagnetic field with the stream of solar particles called the solar wind. This interaction leads to the formation of a magnetic cavity in space that is commonly referred to as the Earth's magnetosphere. The highly variable solar wind causes magnetospheric dynamics on short timescales of hours to days which leads to space weather phenomena like geomagnetic storms, auroral emissions, failures of communication satellites, and electrical power disruptions on the ground. On geological timescales, variations of the geomagnetic core field are expected to have a strong effect on the magnetospheric structure and on the behaviour of energetic particles in near-Earth space. At IUB, magnetosphere formation and other space plasma processes are studied using large-scale magnetohydrodynamic (MHD) simulations, plasma theory, and data from spacecraft.

Highlights The DFG funded project *Studies of paleomagnetospheric processes* dealt with the magnetosphere during geomagnetic polarity transition periods. In a paper published in the Journal of Geophysical Research, MHD simulation results were compared with an empirical model for the size and the shape of the magnetospheric boundary layer (magnetopause). Very good agreement was found within the validity range of the empirical model. Outside this range our MHD simulations offer a more complete description of the magnetopause shape and size in terms of solar wind parameters and the geomagnetic dipole moment. The empirical model could be generalized beyond the former validity range. In a second study, the distribution of energetic particles in the paleomagnetosphere was investigated by analytical means. Since our collaborators at the universities in Bremen and Osnabrück use our results as input to model the chemistry of the middle atmosphere in response to solar energetic particle events, we were particularly interested in the polar cap region that is most affected by such particle events. Our results indicate that with decreasing dipole moment and increasing quadrupole contribution, this region can extend down to latitudes as low as 40 degrees. More complex magnetic field configurations are modelled using MHD simulation results and field line tracing schemes. Figure 1 illustrates how the open field line region may look like during a geomagnetic polarity transition with a highly non-axisymmetric core field. An invited paper on the results of this project and on the work of our collaborators within the DFG Priority Programme SPP 1097 was presented at a DFG Colloquium.

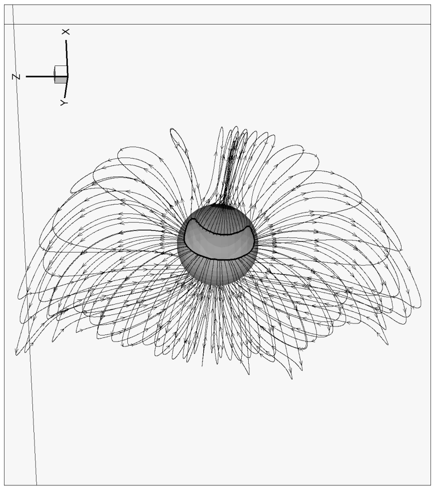

Abbildung 1: Closed magnetic field lines in a simulated paleomagnetosphere. The region in the center is penetrated by open field lines (not shown) and thus accessible by low-rigidity particles from solar energetic particle events. Figure produced by Bertalan Zieger.

In a second DFG funded space plasma project (jointly with Prof. Marcus Brüggen and Dr. Matthias Hoeft), we are planning to model radio emissions of coronal mass ejections which happen on time scales like hours or days, and lead to space weather phenomena like geomagnetic storms and substorms. The project started in August 2006.

Supervised jointly by faculty from marine geosciences (Prof. Laurenz Thomsen) and space physics (Prof. Joachim Vogt), the GeoAstro student team *Neptunas* participated in ESA's Student Parabolic Flight Campaign 2006. During two parabolic flights on the Zero-G Airbus A-300, four 3rd-year students Simona Balan, Matteo Kausch, Eva Steken, and Wilken-Jon von Appen studied the influence of microcravity on the photosynthetic yield of microalgae. The students received support also from industry (OHB System, Bluebiotech, Heinz Walz GmbH).

Organization

1. COSPAR Capacity Building Workshop to be held in June 2007, Sinaia, Romania (jointly organized with Prof. Peter Willmore, University of Birmingham, Prof. Thierry Dudok de Wit, CNRS Orleans, Dr. Octav Marghitu, MPE Garching and ISS Magurele, Dr. Marius Echim, BIRA Bruxelles and ISS Magurele). Sponsored by COSPAR, ROSA, and other space organisations. Acquired funding in 2006: 50 000 €.
2. Successful WAP proposal to renew the computational infrastructure of the CLAMV Teaching Lab (jointly with Prof. Martin Zacharias, Dr. Achim Gelessus, and Dr. Heinrich Stamerjohanns). Approved by the DFG: 230 000 €.

Collaborations

1. Technische Universität Braunschweig: Prof. Karl-Heinz Glassmeier.
2. University of Michigan, Ann Arbor, USA: Prof. Tamas Gombosi, Dr. Ward Manchester.
3. IUB: Prof. Marcus Brüggen, Prof. Laurenz Thomsen, Prof. Vikram Unnithan.
4. Universität Osnabrück: Prof. May-Britt Kallenrode.
5. Universität Bremen: Dr. Miriam Sinnhuber.
6. Ruhr-Universität Bochum: Prof. Reinhard Schlickeiser, Priv.-Doz. Dr. Horst Fichtner.
7. ASTRON, The Netherlands: Dr. Michiel van Haarlem.
8. OHB-System, Bremen: Dr. Klaus Slenzka.

Grants

1. DFG VO 855/1-3 (2004–2006, ~126 300 €), J. Vogt and K.-H. Glassmeier: *Studies of paleomagnetospheric processes*.
2. DFG VO 855/2 (2006-2007, ~79 500 €): J. Vogt and M. Brüggen: *The CME source region in LOFAR related simulations*.
3. Support from the European Space Agency (ESA) and from industry (OHB System, Bluebiotech, Heinz Walz GmbH) for the GeoAstro student team *Neptunas* to participate in the *ESA Student Parabolic Flight Campaign 2006*.

Publications

J. Vogt, B. Zieger, K.-H. Glassmeier, and A. Stadelmann. Scaling the magnetosphere in space and time. In *Terra Nostra*, pages 94–105. Alfred-Wegener-Stiftung, 2006.

B. Zieger, J. Vogt, and K.-H. Glassmeier. Scaling relations in the paleomagnetosphere derived from MHD simulations. *J. Geophys. Res.*, 111:A06203, June 2006a. doi: 10.1029/2005JA011531.

B. Zieger, J. Vogt, A. J. Ridley, and K.-H. Glassmeier. A parametric study of magnetosphere-ionosphere coupling in the paleomagnetosphere. *Adv. Space Res.*, 38:1707–1712, 2006b. doi: 10.1016/j.asr.2005.04.077.