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PhD abstract for the New Graduates Forum

Aspects of the magnetosphere–stellar wind interaction of close-in extrasolar planets

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1. Background

Since 1995, more than 200 extrasolar planets were detected,¹ of which a considerable fraction orbit their host star at very close distances. Two distinct classes of planets are discussed: (a) Gas giants with orbital distances below 0.1 AU (“Hot Jupiters”), and (b) Close-in Earth-like exoplanets (which are not yet detected, but which are expected to exist).

For close-in extrasolar planets, the interaction between the stellar wind and the planetary magnetosphere is expected to be very different from the situation known from the solar system. Important differences arising from the close sub-stellar distances include a low stellar wind velocity, a high stellar wind density and strong tidal interaction between the planet and the star. This interaction is shown to lead, for example, to a synchronization of the planetary rotation with its orbit (“tidal locking”).

2. Magnetic moments and magnetospheres

The low rotation rates of tidally locked planets are expected to lead to small planetary magnetic dipole moments (Farrell et al., 1999; Grießmeier et al., 2004). Taking tidal interaction into account, planetary magnetic

moments are estimated and sizes of planetary magnetospheres are derived. Two different effects resulting from the magnetospheric interaction are studied in detail: planetary radio emission, and shielding of terrestrial planets against galactic cosmic rays.

3. Planetary radio emission

The magnetospheres of all strongly magnetized planets in the solar system are known to be sources of nonthermal radio emission. For “Hot Jupiters”, much stronger radio emission is expected than for the solar system planets. This planetary decametric radio emission can be expected to exceed the emission of the planetary host star (Zarka et al., 1997; Grießmeier et al., 2005a). Characteristics of radio emission triggered by stellar winds of stars with different ages (Grießmeier et al., 2005a) or by coronal mass ejections (Grießmeier et al., 2006b) are discussed. It is shown that the frequency range and the sensitivity of current radio detectors are not yet sufficient to detect exoplanetary radio emission. With planned improvements of the existing instrumentation and with the construction of new radio arrays, the detection of exoplanetary radio emission will be possible in the near future (Zarka, 2004; Grießmeier et al., 2006a).

4. Shielding against galactic cosmic rays

As a second application, the flux of galactic cosmic rays to the atmospheres of terrestrial exoplanets in close orbits

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¹The current state can be found e.g. at the Extrasolar Planets Encyclopaedia: <http://exoplanet.eu>.

around M stars is studied. The weak magnetic field of different types of close-in terrestrial exoplanets leads to a weak protection against cosmic rays (Grießmeier et al., 2005b). This is likely to have implications for planetary habitability. This should be taken into account when selecting targets for the search for biosignatures in the spectra of terrestrial exoplanets.

5. Conclusion

Within this PhD thesis, different aspects of the magnetosphere–stellar wind interaction of close-in extrasolar planets were studied. Two applications were discussed in detail, namely planetary radio emission and the shielding of terrestrial exoplanets against galactic cosmic rays.

References

- Farrell, W.M., Desch, M.D., Zarka, P., 1999. On the possibility of coherent cyclotron emission from extrasolar planets. *J. Geophys. Res.* 104 (E6), 14025–14032.
- Grießmeier, J.-M., Stadelmann, A., Penz, T., Lammer, H., Selsis, F., Ribas, I., Guinan, E.F., Mutschmann, U., Biernat, H.K., Weiss, W.W., 2004. The effect of tidal locking on the magnetospheric and atmospheric evolution of “Hot Jupiters”. *Astron. Astrophys.* 425, 753–762.
- Grießmeier, J.-M., Mutschmann, U., Mann, G., Rucker, H.O., 2005a. The influence of stellar wind conditions on the detectability of planetary radio emissions. *Astron. Astrophys.* 437, 717–726.
- Grießmeier, J.-M., Stadelmann, A., Mutschmann, U., Belisheva, N.K., Lammer, H., Biernat, H.K., 2005b. Cosmic ray impact on extrasolar Earth-like planets in close-in habitable zones. *Astrobiology* 5 (5), 587–603.
- Grießmeier, J.-M., Mutschmann, U., Glassmeier, K.-H., Mann, G., Rucker, H.O., 2006a. The potential of exoplanetary radio emissions as an observation method. In: Arnold, L., Bouchy, F., Moutou, C. (Eds.), Tenth Anniversary of 51 Peg-b: Status of and Prospects for Hot Jupiter Studies. Platypus Press, pp. 259–266 URL: (<http://www.obs-hp.fr/www/pubs/Coll51Peg/proceedings.html>).
- Grießmeier, J.-M., Mutschmann, U., Khodachenko, M., Rucker, H.O., 2006b. The influence of stellar coronal mass ejections on exoplanetary radio emission. In: Rucker, H.O., Kurth, W.S., Mann, G. (Eds.), Planetary Radio Emissions VI. Austrian Academy of Sciences Press, Vienna, pp. 571–579.
- Zarka, P., 2004. Non-thermal radio emissions from extrasolar planets. In: Beaulieu, J.-P., Lecavelier des Etangs, A., Terquem, C. (Eds.), Extrasolar Planets: Today and Tomorrow, ASP Conference Series, vol. 321, pp. 160–169.
- Zarka, P., Queinnee, J., Ryabov, B.P., Ryabov, V.B., Shevchenko, V.A., Arkhipov, A.V., Rucker, H.O., Denis, L., Gerbault, A., Dierich, P., Rosolen, C., 1997. Ground-based high sensitivity radio astronomy at decameter wavelengths. In: Rucker, H.O., Bauer, S.J., Lecacheux, A. (Eds.), Planetary Radio Emissions IV. Austrian Academy of Sciences Press, Vienna, pp. 101–127.