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A numerical method to study the interaction between stellar wind and the upper atmospheres of the exoplanets

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Abstract

We present a numerical method for modeling of the interaction in the exoplanetary systems [1, 2].

1. Introduction

The code can be applied to the Solar system planets as well. The aim of the study is to model the high energetic and thermal particles coronae around the planets and to investigate their interaction with the incoming stellar wind.

2. Method

The particle code is based on Direct Simulation Monte Carlo (DSMC) method and includes stellar wind protons and atmospheric neutrals presented by metaparticles. We include also radiation pressure, gravitational effects (gravity, Coriolis, centrifugal, tidal forces), charge-exchange between protons and neutrals and elastic collisions between neutrals. The code allows to study the interaction processes in the exosphere under different conditions (distance from exoplanet to its host star, different exobase conditions etc.) for magnetized and non-magnetized bodies. As a result the distribution of neutral corona and ions around the planet is obtained. We present also post-processing programs developed to estimate non-thermal ion pickup from the exoplanets and briefly summarize how one can estimate the Ly-alpha attenuation produced by neutral cloud around an exoplanet.

3. Figures

As an example of the simulation result we shown a slice of a 3D simulated hydrogen cloud around Kepler-11d "Super-Earth". The star is on the right. The red and blue dots correspond to H^+ ions and neutral hydrogen atoms, respectively. The black dot represents the planet. The white empty area around the planet is the lower atmosphere which is not considered in the present study.

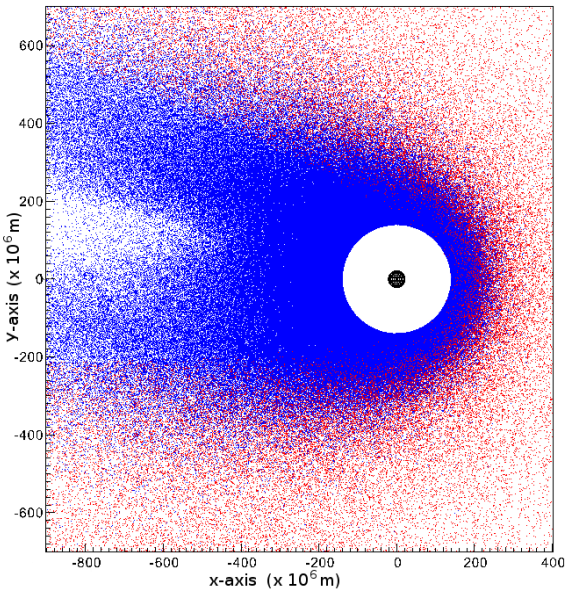

Figure 1: An example of modelled neutral hydrogen cloud around Kepler-11d [3].

4. Summary and Conclusions

The method can be used to estimate the ion pickup escape rate, to make some conclusions about stellar wind plasma environment in the vicinity of the planet and about planetary magnetic moment. The details about the code and application result can be found in [1, 2, 3].

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References

[1] Holmström, M., Ekenbäck, A., Selsis, F., Penz, T., Lammer, H., Wurz, P.: Energetic neutral atoms as the explanation for the high-velocity hydrogen around HD 209458b, Nature, Vol. 451, pp. 970-972, 2008.

[2] Kislyakova, K.G., Lammer, H, Holmström, M., Panchenko, M, Odert, P., Erkaev, N.V., Leitzinger, M., Khodachenko, M.L., Kulikov, Y.N., Güdel, M., and Hanslmeier, A.: XUV-Exposed, Non-Hydrostatic Hydrogen-Rich Upper Atmospheres of Terrestrial Planets. Part II: Hydrogen Coronae and Ion Escape, Astrobiology, Vol. 13, 1030-1048, 2013.

[3] Kislyakova, K.G., Johnstone, C.P., Odert, P., Erkaev, N.V., Lammer, H, Lüftinger, T., Holmström, M., Khodachenko, M.L., and Güdel, M.: Stellar wind interaction and pick-up ion escape of the Kepler-11 "super-Earths", Astronomy & Astrophysics, Vol. 562, A116, 2014.