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Habitability and dynamical perturbations

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Abstract

The search for an Exo-Earth is certainly a big challenge which needs maybe detections of planetary systems resembling our Solar system in order to find life like on Earth. Numerical investigations of Jupiter-Saturn like configurations indicate strong dynamical perturbations for the planetary motion in the habitable zone for certain systems. Therefore, we show the dynamical influence on the habitability of a planet.

1. Introduction

The search for planets outside the Solar system showed an unexpected diversity of planetary systems. Most of the planets indicate high eccentricity motion while the Solar system planets move in nearly circular orbits and nearly the same plane. Taking into account migration and other turbulent phases during the formation process, one could assume, that the instability phase in our planetary system was moderate and, therefore, advantageous for habitability of our Earth. From the numerous detected planets so far no terrestrial planet comparable to our planet has been discovered. However, even if we find Solar system analogues, it is not certain that a planet in Earth position will have similar circumstances as those of Earth. It is known, that small changes in the architecture of the giant planets can lead to orbital perturbations in the area of the terrestrial planets which could affect the habitability of a planet in the habitable zone.

2. Dynamical model

To study the dynamics of test-planets in the habitable zone we used the restricted problem which is commonly used for such investigations. In this model, the test-planets move in the gravitational field of the star and the giant planets without perturbing their orbits. As we study Solar system analogues, we use a G2 main sequence star like the Sun as host-star. From the four giant planets in the Solar system, we take only Jupiter and Saturn into account, as it was shown that Uranus and Neptune do not influence the area between Venus and Mars significantly [1]. To create Solar system-like configurations, we fix the orbit of Jupiter to its observed position one and vary Saturn's orbit. Planetary orbits are described by a set of orbital elements: semi-major axis, eccentricity, inclination, argument of perihelion, longitude of ascending node and mean anomaly. These parameter show variations due to gravitational perturbations as soon as more than two celestial bodies build a system. From studies of the Solar system it is known that resonant perturbations may influence the orbital motion significantly.

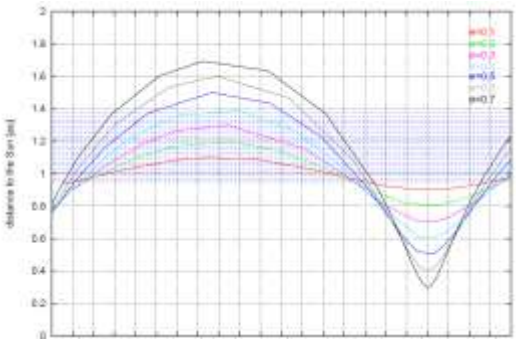

Figure 1: Variation of the distance to the Sun (y-axis) of a planet at 1au calculated for one orbital period. Different curves show the variation of the distance for various eccentricities of the planet.

3. Summary and Conclusions

Perturbations of the giant planets may increase the eccentricity of planets moving in the habitable zone. A higher eccentricity could influence the habitability of a planet significantly as such a planet would leave the habitable zone when orbiting its host-star more or

less frequently, depending on the eccentricity and its variation.

In a previous study, it was shown that Earth remains habitable even for an eccentricity of 0.7 [2]. On such a highly eccentric orbit, the peri-center of Earth will be closer to the Sun than Mercury's orbit (see Fig. 1 black curve)

In our presentation we discuss the question whether eccentric planetary motion in the habitable zone can be habitable taking into account the early evolution the Sun and the planetary system.

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