

Dynamics of the Extra-solar Planetary Systems

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With the discovery of the first planets orbiting other stars, PSR 1257+12 (Wolszczan and Frail 1992) and 51 Peg (Mayor and Queloz 1995), we now continuously improve our basic concepts on planetary dynamics. The discovered worlds challenge our imagination by their unusual orbital configurations and raise new questions in our understanding of their formation and dynamical evolution. For centuries paradigm, with clock-working revolution of the low-eccentricity and low-inclination planets, our own Solar System emerges now as an atypical structure in the current sample of the 21 known multi-planetary extra-solar systems.

In the light of new discoveries, the understanding of the planetary dynamics is receiving particular attention for several reasons. These include:

1. Detection of the extra-solar planets and determination of their orbits. Almost all the extra-solar planets have been detected indirectly by so-called radial-velocity measurements. This technique explores the dynamical effects that the planets produce in their parent star's motion. The determination of the planetary orbits from the observational data involves the basic concepts of Celestial Mechanics. To obtain good fits, the understanding of the planetary dynamics is indispensable.
2. Long-term evolution and stability of the extra-solar systems. The extra-solar planets exhibit an astonishing variety of physical and orbital patterns, such as large masses, very small distances to the central star and high eccentricities. Also, planets have been detected in binary and triple stars systems and around pulsars. Several multi-planet systems exhibit the resonant dynamical states that are very unusual among the planets of our Solar System.
3. The theories of formation/migration and dynamical evolution of the planet systems. All available theories were designed to explain the planets orbiting our Sun. Nowadays, the striking contrasts between extra-solar and the Solar systems activate the substantial revision of the old models and the appearance of alternative theories. The extension of the classical perturbation theories to the larger domains of orbital parameters is required to explain the orbital characteristics of the extra-solar systems.
4. Planetary habitability studies, search for life. Which conditions are necessary to make a planet habitable and for life to survive? The answer of this question includes an extended list of requirements and, no doubt, some of them will be related to the dynamical stability of planets inside the habitable zones