ATELIER
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WORKSHOP
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Non linear oscillations and long-term evolution : application to planetary systems and spin-orbit problem

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We investigate the long-term evolution of planetary systems and the stability around the Cassini state in the spin-orbit problem via normal forms. In both problems, after some canonical transformations and averaging over the fast dynamics, the Hamiltonian turns out to have the form of a perturbed system of harmonic oscillators. The talk will be focused on three main applications : (I) the stability of the Solar System ; (II) the secular dynamics of the extrasolar planetary systems ; (III) the long-time stability around the Cassini state of the largest moon of Saturn, Titan.

1. (I) We study the stability of the planetary problem including Sun, Jupiter, Saturn (and Uranus) by extending the classical Lagrange–Laplace secular theory. We consider an approximation at order two in the masses for the Hamiltonian of the system and we study the long-time stability in the Nekhoroshev sense.

2. (II) We investigate the secular dynamics of explanatory systems consisting of two coplanar planets, considering a Hamiltonian at order two in the masses, to estimate the benefits of a second order model on the study of their long-term evolution. In addition we study the effects of the proximity to a mean motion resonance on the secular behavior of the planets.

3. (III) We investigate the long-time stability in the neighborhood of the Cassini state in the conservative spin-orbit problem. We explicitly apply our method to the rotation of Titan in order to obtain physical bounds of Titan latitudinal and longitudinal librations, finding a stability time greatly exceeding the estimated age of the Universe.

This work is part of a research project I'm carrying out in collaboration with A. Giorgilli (*Università degli Studi di Milano, Milano, Italy*), *& U. Locatelli* (*Università degli Studi di Roma “Tor Vergata”, Italy*), *A.-S. Libert* (*University of Namur, Belgium*) *and C. Lhotka* (*University of Namur, Belgium*) *& A. Lemaître* (*University of Namur, Belgium*).

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