An Alternative Dynamical Approach to the Algebraic Method for Estimating the Figure Parameters for the Solar System Planets

Gonzalo Barderas and Pilar Romero

Instituto de Matemática Interdisciplinar. Astronomía y Geodesia, Facultad de Matemáticas, Universidad Complutense de Madrid, E-28040 Madrid, Spain

Recent advances in modeling rotational theories for the Planets of the Solar System are extending rotational symmetric models to include the effects of triaxiality, (see e.g. [1], [2] and [3] for the Earth; [4] for Mars; and by [5] for Venus). This requires to determine the orientation of the principal inertia axis from gravitational models. The current Solar System exploration offers this possibility.

The orientations of the principal inertia axes are usually derived solving an eigenvalue/eigen-vector problem, as for instance, by [1] and [6] for the Earth, using the EGM2008 Earth potential. Here we present an alternative approach using a qualitative analysis made in the embedded space phase that describes the effects of the gravitational perturbations on the longitudinal position at the synchronous orbit [7].

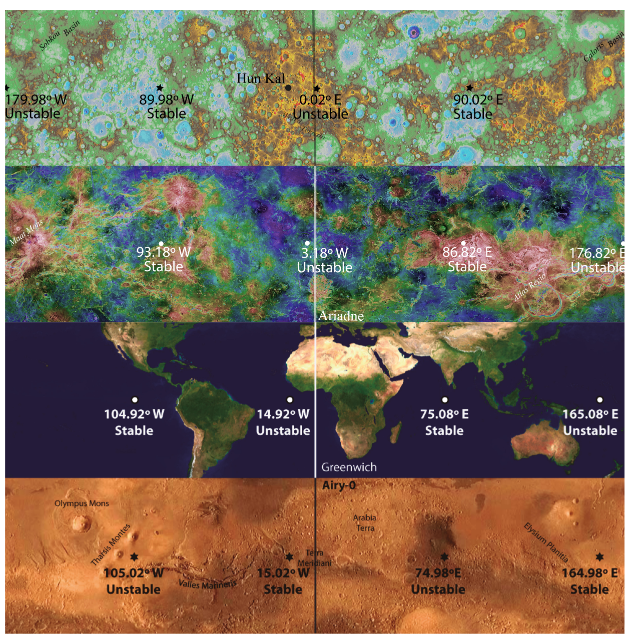

Figure 1: Equilibrium Points for the inner Solar System Planets. Background maps from *www.usgs.gov*

First, using variational principles, we show that the equilibrium positions in a rotating second degree and order gravity field are located at the synchronous orbit in the equatorial plane and in the directions of the planetary principal inertia axes. Then, from the equations that describe the gravitational perturbations on a longitudinal synchronous position we make a qualitative analysis to locate equilibrium positions (see Figure 1) that allows to readily place planetary principal inertia axes with respect to planetary conventional prime meridians.

We utilise this characterization to determine the orientation of the planetary principal inertia axes for the Solar System inner planets with respect to their Prime Meridians and with respect to the International Celestial Reference Frame.

Moreover, we evaluate the non-linear effects on the equilibrium point localization. The differences are explained in terms of the tangential accelerations derived for gravity field harmonic developments of order 2 and 5 at the stationary orbit. We also analyze the correlation of the planetary gravity field with the equilibrium point location. The results show the geographic locations of the stable points are tied to the greatest gravity anomalies, and the unstable points to the lowest gravity anomalies.

References

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