On the spatial distribution of Main Belt Asteroids.

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1. INTRODUCTION

Since about two centuries, the dynamical and physical aspects of minor planets and asteroids have been extensively investigated. Several dynamical groupings have been identified and explained. Groupings in proper elements (a, e, i) define asteroid families. Recently, Carvunis et al. (2013) investigated these groupings in the multi-dimensional space defined by proper elements, the geometric albedos from Wide- field Infrared Survey Explorer (WISE) mission, as well as the Sloan Digital Sky Survey-Moving Object Catalog data, fourth release (SDSS-MOC4) multi-band photometry data. Here we present the analysis of a not so common distribution, the Main Belt Asteroid (MBA) populations in the osculatory, mean, and proper elements. We investigate the distribution of main belt asteroids in the (inclination, longitude of the ascending node) space with respect to the ecliptic-equinox J2000. We identify and confirm a sinusoidal behaviour of this distribution, which disappears when the inclination is given with respect to Jupiter's orbital plane, or with respect to the invariable plane (IP). We show that this behaviour can be explained by planetary secular effects, mainly due to Jupiter. Furthermore, we identify three different orbital behaviours that explain the density distribution in this space.

Key words: Secular perturbations – Minor planets, asteroids: general – Celestials mechanics.

2. MODEL AND ARGUMENTS

The solution to the secular problem induced by the effects of both Jupiter and Saturn, is given by the following equations:

\[ p(t) = l + \varphi(t) = \varphi_0 + \varphi_0 \sin \left( \alpha t + \varphi_0 \right) + \varphi_1 \sin \left( \alpha t + \varphi_1 \right), \]

where \( \varphi_0 \) and \( \varphi_1 \) are the components of the inclination vector \( \alpha \) and \( \ell \) of the eccentricity vector.

The indices \( i = 1 \) and \( i = 2 \) are used for Jupiter and Saturn, respectively. The coefficients \( \varphi_0 \) and \( \varphi_1 \) as well as the Laplace coefficients are given by their classical expressions in the literature (Murray & Dermott (1999) for example).

The three identified dynamics are:
- libration for small free values, i.e. the case of (24) Themis for example (Fig.3(a)).
- homogenous or regular circulation, i.e. the case of (19) Fortuna for example (Fig.3(b)).
- heterogenous circulation, i.e. the case of (44) Nyx for example (Fig.3(c)).

What we recall here by heterogeneous circulation is a circulation for which the body spends most of his time in a forced region.

3. CONCLUSIONS

- We have explained with a simple secular model the observed distribution of minor planets in the (i, \( \Omega \)) plane, with respect to the ecliptic-equinox J2000.0.
- This distribution is mainly due to secular effects of Jupiter.
- The results are the same when considering a more complete model, with all the other planets of the solar system which we have integrated using a Gauss-Radau integrator (Eggl & Dvorak, 2010).
- We were able to distinguish three different dynamical behaviours that depend on the initial inclination.
- The superposition of the three dynamics explains the observed distribution, though one question remains open: what are the initial conditions that would lead to the observed distribution?

4. REFERENCES