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Dynamics of the Saturnian system with regard to high precision observations

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The acquisition of high precision astrometric observations of Solar System objects can be applied to the improvement of the dynamical models and to explore some specific problems of celestial mechanics. In particular, in the Saturnian system, the next investigation of the CASSINI space probe and the interpretation of these data will require the use of an improved dynamical model. This is why campaigns of observations have been recently organized. We present here new precise observations of the major satellites in relation with the celestial mechanics problems we study in this system. The study of the interplay of tides and resonances in the Mimas-Tethys system, for example, requires to know the magnitude of the secondary resonance that is the value of the eccentricity of Tethys, and to know the magnitudes of tides that is the secular acceleration in the longitude of Mimas. Others studies require also to know constraints: theory of motion of the eight major satellites, tidal effects in the other satellites, motion of the co–orbital satellites. New recent observations of the major satellites have then been obtained and will allow us to measure the magnitudes of the parameters of the theoretical studies. Some of these observations are already reduced. We present them and the method applied to obtain the high precision required.

Several years ago, a theory of motion of the eight major satellites of Saturn has been built in a dynamically consistent way, in which the satellites are considered all together; its only parameters are explicitly the initials conditions, the masses of the satellites and the oblateness coefficients of Saturn. Its internal precision is a few tens of kilometers (TASS, Vienne & Duriez, 1995).

This study has shown some new terms in the mean longitude of Mimas which depend of the Tethys eccentricity. Because of this eccentricity and tidal effects due to dissipation in Saturn, the system can enter in one or several secondary resonances. Champenois and Vienne (1999) have shown that the system may have been trapped in a secondary resonance or may have behaved in a chaotic way on capture in the present main resonance. The probability of capture into the present resonance may be much higher (up to 1) than 0.04 found previously. The evolution, under tidal effects, of the dynamics of this system extremely depends upon the value of the eccentricity of Tethys which is not well known at present.

Since 1990, the observations of Saturn satellites are mainly CCD ones and often published in pixels. So no astrometry is really done upon them. The problem is that generally there is no reference stars which would allow to do an astrometric reduction. But we succeed in extracting the astrometric data from these kind of observations. Our recent reductions (Vienne et al., 2001 and Peng et al., 2002) lead to 6919 observations for which the precision reachs $0.''064$ ($0.''075$ for the 270 positions of Mimas). All others available CCD observations of others authors (3350 positions) are given in pixels only. Their precision is estimated to $0.''086$ ($0.''141$ for the 15 positions of Mimas). These observations had led to a new estimation of the eccentricity of Tethys: $e' = 0.00021 \pm 0.00008$. More investigations are necessary to reduce the uncertainty.

In 1995, mutual occultations and eclipses of the satellites occurred. Many observers then planned to observe these events. Sixty–six such observations of events were successfully performed in several countries (Thuillot et al., 2001). The analysis of these sixty-six observations are in progress. We expect that the precision on the relative position will reach about $0.''01$.

Some others studies are also in progress such as the tidal effects in the other satellites or the motion of the co–orbital satellites. In all cases we show that high precision observations are necessary to well studying the dynamics of the saturnian system, and in particular to understand the evolution of this planetary system.

References

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