

OBSERVATIONS OF THE SATELLITES OF JUPITER AND SATURN

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ABSTRACT

The planets Jupiter and Saturn are surrounded by several families of satellites. The dynamics of these satellites are not well-known for a lot of them because of the small number of observations available regarding the needed astrometric accuracy. However, it would be interesting to know the evolution of these objects and especially the stability of the systems of satellites. We are making astrometric ground based observations at the present time in order to improve our knowledge of the dynamics of these satellites. However, the accuracy of the observations is not sufficient to be able to extrapolate ephemerides or to know more about the dynamics of the systems and the observations by Gaia should answer some questions concerning these satellites.

Key words: Gaia; Astrometry; Satellites; Planets; Dynamics.

1. INTRODUCTION

The natural satellites of the planets will be observed by Gaia (Tanga & Mignard 2005) and the observations will be of great interest:

- first: astrometric data of high accuracy will lead to dynamical models of their motion with high quality for the far faint satellites. The study of the stability of such systems may be performed. Concerning the Galilean satellites, a good modelling of their motion will help to detect and measure tidal effects.

- second: knowledge of the motion of these satellites will allow the improvement of the planets positions themselves – the centre of mass of the system – difficult to observe. This will improve the ephemerides of the giant planets thanks to the observation of their satellites.

Note that the satellites of different giant planets present similarities and the interest of the observations made by Gaia will be the same for all the systems (mainly Jupiter and Saturn).

2. THE SATELLITES OF JUPITER

2.1. The Inner Satellites

These satellites are orbiting inside the orbit of Io, the first Galilean satellite and outside the main ring. Because of the closeness of the planet, they are very difficult to observe from the ground.

At the present time, our knowledge of the dynamics of the inner satellites of the giant planets is very limited. This is mainly due to the too few number of observations available: only the observations made by the space probes have a sufficient accuracy and further observations made either in the infrared wavelengths, or using coronagraphs do not provide sufficient accuracy to build a dynamical model of the motion of these objects. Gaia will be able to provide several observations spread over several years which will be possible to link with past observations. Then, dynamical evolution (precession of the orbits) will be reachable.

2.2. The Galilean Satellites

These satellites are bright, similar to inner planets, and easily observable even in a small telescope. They could be seen with the naked eye if the bright planet Jupiter was not so close to them. Their observations are easy to make and they present phenomena due to the closeness and the size of the planet Jupiter. The large size of these objects may present some difficulties in their observations but they are an important goal for Gaia.

The motion of the Galilean satellites is very complex due to numerous gravitational perturbations. Thanks to recent work (Lainey et al. 2004a,b), we have dynamical models needing to be fitted on the best astrometric data. Many ground-based observations have been made in the past, providing very accurate data (Vasundhara et al. 2003) over a long period of time. New accurate data from Gaia will allow the completion of a better dynamical model. In particular, it will be possible to quantify the tidal effects and to deduce models of the interiors of the satellites.

2.3. The Outer Satellites

These satellites are orbiting outside the orbit of Callisto, the farthest Galilean satellite. They are very faint due to their small sizes and their orbits are neither circular, nor in the equatorial plane of Jupiter as the inner and the Galilean satellites. They are observable as asteroids, independently of the planet Jupiter far from them. Only their faintness is a difficulty for their observation. Gaia will easily observe the satellites the magnitude of these being less than 20. Gaia will probably discover new satellites, mainly the closest to the planets difficult to detect from ground-based observatories. Our knowledge of these satellites will be improved as follows, based on the objects observable by Gaia:

- The stability of the system of the outer satellites will be studied thanks to very accurate ephemerides allowing the detection in the past or in the future of close approaches of satellites large enough (J-6, J-7, J-8) to enhance gravitational effects on the others. A quantification of such effects will be made in order to know the stability of the system.
- No accurate astrometry is possible without taking into account the sizes and shapes of the observed objects. The outer satellites of the giant planets look like small asteroids with unknown shapes since they were not goals of the space probes (except Phoebe S-9). We have very little information about the photometry of these objects. The information provided by Gaia will help to rebuild the shapes of these satellites thanks to the models made for the asteroids and will lead to better astrometric positions (Kaasalainen et al. 2005).

3. THE EPHEMERIDES OF THE GIANT PLANETS

Gaia will not be able to observe Jupiter and Saturn. In fact, the observations of the astrometric positions of the giant planets are very difficult to make either from space or from the ground because of the thick atmosphere which does not allow the location of the centre of mass to be determined. However, we know that the satellites are orbiting around the centre of mass of the system and the knowledge of accurate ephemerides of the satellites of the planets will allow to provide, through the observation of the satellites, accurate positions of the centre of mass of these planets.

4. CONCLUSION

The observations provided by Gaia may bring valuable information for the knowledge of the natural satellites of the planets either for the main satellites (Galilean satellites and similar of the other giant planets) or the faint satellites (inner and outer). The dynamical models should be strongly improved thanks to very accurate data – astrometric and photometric – and then studies of the long

term evolution and of the tidal effects will be easier. Moreover, the dynamics of the giant planets themselves will be improved too.

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