IAA Transactions, No. 8, "Celestial Mechanics", 2002

# The projects of IMCCE concerning the natural planetary satellites

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Astronomers of IMCCE are involved in the study of the natural planetary satellites in constructing theoretical models as well as in producing observations in order to validate and fit the theories. The goal of the present paper is to present our current works and our plans for the next years.

**Inner satellites of Jupiter**

We are making numerical integration for Amalthea (J5), Thebe (J14), Metis (J15) and Adrastea (J16) (Vachier et al., 2001) and also we are building an analytical theory of their motions. We are continuing observations in the visible wavelengths for J5 and J14 using a coronograph and in the infrared wavelengths for J15 and J16 because of the brightness of Jupiter. We gathered observations from 1995 to 2001 made at Pic du Midi (France), Flagstaff (Arizona, USA) and Itajuba (Brazil).

**Galilean satellites of Jupiter**

The present theory of the motion of the Galilean satellites is based upon the Sampson-Lieske theory built in 1921 and revitalized in 1977. This theory appears unable to be sufficiently accurate for the modern studies. So, we are building a semi-analytical theory thanks to a frequency analysis of the results of a numerical integration of the motion of the satellites. We continue to make and gather observations for the fit of the initial conditions. At the present time, we have about 2000 photographic observations for each satellite made from 1890 to 1991 and 1000 observations of mutual events made from 1973 to 1997 (see for example the catalogue published by Arlot et al. in 1997). Observations of classical eclipses and observations of positions made using a micrometer at the end of the XIXth century are available but are not used. Our goal is to put into evidence the influence of the energy loss due to the tides created by Jupiter on the satellites by measuring the acceleration in the motion of the satellites. The implication of such a measure will help us to understand the interior of the satellites, Europa

for example, which is suspected to have a deep ocean under an iced crust. Only high precision observations may allow such a challenge. Aksnes and Franklin (2001) published some values for these accelerations. That is why we will start a campaign of observations of the mutual events of the Galilean satellites next October. Note that about 500 events will occur from October, 2002, to September, 2003. The list and some information concerning the observation of these events are available at the web address: http://www.bdl.fr/phemu03_eng.html and have been published (Arlot, 2002). Observers are encouraged to join this campaign which will be only 6 months long. Afterwards, we will continue the observations through classic CCD observations. In the past, observations of the occultations of Io in the 3.8 micrometers infrared wavelength, allowed us to measure the flux emitted by the volcanoes on this satellite (Arlot et al., 1997).

**Outer satellites of Jupiter**

The ephemerides of these objects are built using numerical integrations. Unfortunately, the observations are rare and of poor accuracy, mainly because of the use of unadapted star catalogues. We are observing these objects and performing a new reduction procedure, attempting to avoid the zonal errors of the star catalogues used. Our program concerns J6 to J13 and the newly discovered satellite S/1999 J1. Note that these objects are not a goal for space probes and need more ground based observations. At the present time, we are continuing CCD observations using a 1.2 meter telescope at Observatoire de Haute Provence. We made 244 observations of J6 to J13 in 1998, 406 in 1999, 186 observations in 2000 and 453 in 2001–2002. We made 53 observations of J17 in 2000 and 36 in 2001–2002. Some of these observations are available and we are interested to get more observations.

**Major satellites of Saturn**

These objects have their motions modelized through a semi-analytical theory TASS built a few years ago. This theory deals with the global system of the major satellites of Saturn for the first time, but was fitted on several series of old observations, the reduction of which requires to be done again with an improved procedure. Our plans are to fit this theory on much more new and accurate observations such as new CCD observations and mutual events observations that we made during the 1995 occurrence of (Thuillot et al., 2001). CCD direct observations were made together with these mutual events observations (Vienne et al., 2001).

**Outer satellites of Saturn**

We are observing these objects and plan to build new ephemerides from numerical integration for Phoebe (S9) and the newly discovered satellite S/2000 S3. We made 135 observations of S9 in 1998, 39 in 1999, 78 in 2000 and 175 in 2001–2002. We made 50 observations of S/2000 S3 in 2001–2002. These observations are available (Fienga et al., 2002) and we also are interested to get the observations made in other observatories.

**Satellites of Uranus and Neptune**

We performed numerical integration for the satellites of Neptune (Veiga et al., 1999). Tests were made by fitting the initial conditions on JPL ephemerides and we plan now to fit it on new observations in order to get more accurate ephemerides and to observe and modelize the motion of several small satellites such as Puck (Descamps et al., 2002) thanks to the use of adaptive optics.

As a conclusion, I would like to present the data base of astrometric observations of the natural planetary satellites which is available on the Web site of IMCCE, the NSDB/NSDC providing raw data as published by the observers, bibliographic data on observations and theoretical works on natural satellites and an interactive software allowing to know what data are included as standard data in the data base. The data base is available at http://www.bdl.fr/nsdc.html on Internet and has been made thanks to the collaboration of the Sternberg Institute in Moscow. We thank in advance the observers for sending their data to the NSDC data base. The observations of natural planetary satellites demand only small telescopes as it was shown in (Arlot et Colas, 1997).

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