Report of the Working Group on Natural Planetary satellites

J.E. Arlot, president

M. Assafin, C. Blanco, J. Camargo, N. Emelianov, R.A. Jacobson, D. Pascu, Q.Y. Peng, M. Soma, P.K. Seidelmann, D.B. Taylor, R. Viera-Martins, G. V. Williams, members

Introduction

IAU decided a complete renewal of Commission and Working group structures. So, it is time to report the activity of the working group on Natural Planetary satellites which was created in 1973 at the IAU GA in Sydney. At the beginning, the working group was affiliated only to commission 20 (positions ans motions of asteroids, comets and satellites). The aim of the working group was to encourage observations and modelization of the motion of the natural planetary satellites. The first task was to gather astrometric observations which were not easily available. A data base was proposed gathering almost all published astrometric observations. Ephemerides were also provided and the working group became associated to commission 4 (ephemerides), commission 8 (astrometry) and commission 7 (celestial mechanics). Later, it became affiliated to commission 16 (physics of planets and satellites), either the astrometric observations and the dynamical modeling being depending on some physical parameters of the satellites.
At the present time, the working group maintains a data base hosted by IMCCE (Paris observatory, France) and by Sternberg Astronomical Institute (Lomonosov University, Moscow, Russia).

The new goals of the Working Group

The WG decided to promote new goals:
-the increase in astrometric accuracy of satellite observations
-the use of physical parameters to improve the dynamics of natural satellites and photometric data for the identification of the center of mass on the images
-the use of the future Gaia reference catalogue for a new reduction of old observations allowing to have a global reference system for all data used for ephemerides purpose.

The database maintained by the Working Group

The WG maintained first a web site providing :
-links to ephemerides services (IMCCE, JPL, MPC)
-bibliographic database of papers related to Natural satellites
-tables of physical and dynamical parameters and links to NASA and USGS
-data on pole and rotation parameters
-sofwares and miscellaneous data.
Then, the WG proposed a database of near all published astrometric observations for each satellite system. The largest part of observations are positions either in RA and DEC or in relative positions to planet or satellites. For some main satellites, data on the observation of phenomena (eclipses by Jupiter, mutual events, occultations of stars) are provided.
The WG has the goal to upgrade the data base into standard format. Following a support by the European union, a new data base providing standard data is now proposed. The standard format elaborated by the commission 20 for small bodies will have to be modified in order to be used for the satellite data.
The data base gathers :
- 5000 observations of the Martian satellites

- 12641 observations of the Galilean satellites
- 1294 observations of the inner satellites of Jupiter
- 10820 observations of the irregular satellites (some of then gathered by the MPC)
- 1286 observations of the inner satellites of Saturn
- 51921 observations of the main satellites of Saturn
- 5505 observations of the irregular satellites of Saturn
- 5200 observations of the main satellites of Uranus
- 265 observations of the inner satellites of Uranus
- 790 observations of the irregular satellites of Uranus
- 4700 observations of Triton
- 900 observations of Nereid
- 312 observations of the other satellites of Neptune
- 78 observations of Charon
- 42 observations of the other satellites of Pluto

Note that all of these observations are published observations with all the needed metadata. Other observations are available, especially observations from space probes, which are not included in the data base because of the lack of metadata. The WG encourages the owners of observational data to publish them, making them available and useful for all.

The impact of Gaia on the Natural satellites knowledge

We are waiting for observations to be made by Gaia : about 50 observations of each satellite until magnitude 20 (except the Galileans too bright) and made on a 5-year period. These observations would be very accurate, as observations from space, but limited on a restricted interval of time (as for observations from space).
Besides the observation of the satellites themselves, Gaia will provide a reference star catalogue of one billion stars (until magnitude 20) with an accuracy better than one mas when the present catalogues (such as UCAC4) provide an accuracy around 50 mas. More, the Gaia catalogue will provide proper motions of stars with an accuracy of one mas after one century. So that :
- a new reduction of old data would be useful either to increase the accuracy of the positions and also to get all observations in the same reference frame that is essential for ephemerides purpose ;
- new reduction techniques should be proposed to have the benefit of a so accurate reference star catalogue
- studies should be made on the photometric aspect of the surface of the largest satellites in order to be able to quantify the shift between the observed center of light of the objects and the center of mass, useful for dynamical studies, which may be supposed to be at the center of the geometrical figure of the satellite.

Toward the past

The possibility of the reference star Gaia catalogue to reduce old observations will lead astronomers to search for old observations (photographic plates), to digitize them and to reduce them with nowadays methods. We encourage laboratories, institutes and observatories to work in that direction. However, the number of available plates is so large that we invite astronomers to cooperate in the choice of the best plates to be studied.
Note that an old observations worth to be re-reduced is an observation made before Gaia (photographic plates, CCD, space observations).

The giant planets

The giant planets are not easily observable for astrometric purpose. The atmosphere of Jupiter, the rings of Saturn make the center of mass difficult to identify. So that the only way to get their

positions is to observe satellites which are orbiting around the center of mass of the system. A large part of the database could be used for that purpose when the positions are provided in RA and DEC.

The ephemerides servers

Ephemerides of the Natural planetary satellites are provided by several web sites :
-the JPL server « Horizons » provides ephemerides for all satellites with all useful parameters derived from the ephemerides
-the IMCCE/SAI server « Multisat » provides ephemerides for all satellites for several ephemerides with parameters useful for observers together with plotted configurations. Observers may get easily residuals for their observations directly on the web page
-the MPC server provides ephemerides for irregular outer satellites of the planets which have been observed as asteroids by surveys dedicated mainly to small bodies.
The working group includes members involved in these ephemerides sites.

Conclusion

The working group wishes to continue its work, encouraging :
- regular campaigns of observations
- reduction of old data on the basis of usefulness for dynamical modeling
- publication of astrometric observations, especially those from space probes, with all necessary metadata.
The working group on Natural satellites would be affiliated first to the new commission « Ephemerides of solar system ».