Submission of a Proposal for a Commission: Letter of Intent

Proposed Commission

Name of the Commission: Solar System Ephemerides

Temporary Commission code: NC-26

Proposer details

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Commission Category

Cross-Division Commission

Parent Division 1: Division A Fundamental Astronomy

Parent Division 2: Division F Planetary Systems and Bioastronomy

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Co-Proposers

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Rationale

Commission replaces existing Commission: Division F Commission 20 Positions & Motions of Minor Planets, Comets & Satellites

Text:

1. Goal

The objectives of the SSE commission would be to support the development of high precision ephemerides, and the products and services that disseminate them, for all solar system bodies: planets, asteroids, comets, natural satellites (of planets and asteroids). The scope includes coordinating data archiving centers and supporting the need for global clearinghouses for observations of each type. An important aspect is proper statistical treatment of all the available observations, including possible standards for data communication, making this treatment possible. Ephemerides to be disseminated to non-astronomers need to be guaranteed, even when they are not a scientific goal for the astronomical community.

Ephemerides (aka positions and motions) of Solar System bodies are all connected, with interacting computations. This was not the case in the past, e.g., ephemerides of the major planets and of the small bodies were computed separately, with different algorithms and by different data centers. Now the perturbations from the more massive asteroids are significant terms in the error budget for planetary ephemerides. Conversely, the most demanding utilization of planetary ephemerides is in the computation of orbits of asteroids crossing the orbits of the planets, as needed to predict possible impacts. The center of mass of the planet-satellites systems depends on dynamics of all satellites.

Also the separation between the orbital and the rotational dynamics is not always possible, due to orbital effects (such as Yarkovsky) depending upon the obliquity between the spin axis and the orbital angular momentum. Tidal effects can result in the main accuracy problem for long term satellite ephemerides. In practice, the ephemerides problem is best solved by an iterative process including computations for each class of bodies: it might even include solutions for orbits of interplanetary spacecraft, which may be used to constrain the orbits of the natural bodies around which they orbit.

2. Definition of the scope of the proposed commission

The new commission we are proposing would therefore have a scope including the ones of the previous Commissions 20 and 4. As a consequence, we believe it should be "Cross division" with a double affiliation to Division F and Division A. However, it is our intention to discuss in detail, in the final proposal, specific competences of the SSE commission as well as specific boundaries with the scope of other commissions. These should not necessarily be based upon the traditional scopes of Commissions 4 and 20. Here we are giving a first order outline of these boundaries.

The scope of the SSE commission should include: the orbits of all the major planets (including Earth), of their natural satellites (including the Moon), of the asteroids, of the satellites of the asteroids (including cases better characterized as binary asteroids), of comets, of interplanetary S/C (only as necessary to derive orbits of the natural bodies they visit). Description (and evaluation for impact risk) of close approaches between any of the above mentioned bodies. Rotational elements for all the natural bodies of the Solar System (excluding Earth). Non-gravitational perturbations acting on asteroids and comets orbits and rotations. Harmonic expansions of the gravity field for all bodies (excluding Earth), and tidal effects and dissipation of energy acting between satellites and planets, when necessary for accurate ephemerides.

The interdisciplinary nature of ephemeris development implies that the scope of the SSE commission does extend to some activities historically led by other commissions, but we do not expect the SSE commission to have primary cognizance over these activities. Examples

include: pure celestial mechanics, such as theories of motion for solar system bodies; space-time reference systems and relativistic effects; gravity fields of solar system bodies; tides. These subjects are within the scope of the SSE Commision responsability only when specifically used to compute ephemerides. This point should be discussed in greater detail when the other proposed commissions are known.

3. Interfaces with other IAU scientific bodies

Commissions 20 and 4 used to have an especially large set of Working Groups (WG) and Centers connected with their activities. We propose that this rich structure is mostly maintained, possibly with better definitions of the interfaces.

According to the IAU web site, the following are the groups affiliated to Comm. 20 and/or 4, or to Div. A and F with a connection to Comm. 20 and/or 4:

Minor Planet Centre is a Centre, affiliated with Div. F

Near Earth Asteroids is a WG affiliated with Div. F

Cartographic Coordinates and Rotational Elements is a WG affiliated with Div. A and F

Natural Planetary Satellites is a WG affiliated with Comm. 4-7-8-16-20

Small Bodies Nomenclature is a WG affiliated with Div. F

Standardizing Access to Ephemerides is a WG affiliated with Comm. 4

It is not possible to propose at this stage the exact definitions and the new affiliations. Whatever the affiliation, all these groups need to have an interface, a direct communication channel with the new SSE Commission.

We are convinced that the first five of the above IAU scientific bodies have functions which are permanent. Indeed, they are in charge of updating information which evolves continuously with new discoveries and with better knowledge about already discovered objects.

The "Standardizing Access to Ephemerides" WG had a very specific goal of standardization between the national ephemerides services, which appears to have mostly been achieved for planetary ephemerides.

We believe it is necessary to have a permanent forum for the people in charge of the national ephemerides offices and for the main users, taking care in general of the problems of documentation, availability and dissemination of ephemerides to a wider public. Thus we plan to discuss, at the right step in the procedure, a possible proposal of a new WG on "Disemination of Ephemerides".

4. Activities of the proposed SSE Commission

Without trying to cover all the possible activities, we list some important initiatives we see as characteristic of the goals of the SSE commission.

4.1: standards, with the goal of data openness and prompt dissemination of available scientific data. The "old" Commission 20 has already started working on a Data Exchange Standard specifically for asteroid, comet and TNO astrometric observations (including radar) and ephemerides data. We expect that the first step of this proposed standard will be presented by Commission 20, the SSE Commission should continue and complete the work.

Similar work could be proposed for natural satellite astrometry, and for planetary orbital data. The situations are more complex, because there are more different types of observations, and also because of the lack of a global data repository. However, this only emphasizes

the need to start some effort.

Other standards, such as the Virtual Observatory ones, should be discussed.

4.2: There are new and rapidly evolving fields of astronomical research on Solar System bodies, such as: Asteroid satellites and asteroid couples (possible split satellites), asteroid rotation and shapes, non-gravitational perturbations on asteroids and comets. To date there are neither standards nor official repositories (for both raw observational and processed data); nevertheless, large data set are beginning to appear, and they are available through informal repositories, e.g.:

Informal repository for asteroid satellites:
http://www.johnstonsarchive.net/astro/asteroidmoons.html

Informal repository for asteroid spin states, shapes, etc.
http://astro.troja.mff.cuni.cz/projects/asteroids3D/

Non-gravitational perturbations: so far only tables in papers such as Farnocchia et al 2013, Nugent et al. 2013.

While not all informal repositories should become "official", some standardization and support to an open data policy is advisable.

4.3: It is essential not to confuse the cultural scope of the proposed Commission with the scientific competences of the commission members. Interdisciplinary competences, by far exceeding the scope of a single Commission, are a requirement to produce good results, such as reliable ephemerides. Thus one essential activity is the organization of opportunities for cultural exchange, among which the joint meetings under IAU sponsorship.

As an example of a proposal which could put together most of the community interested in this commision: if there was an initiative for an IAU symposium, to be held if possible as early as 2017, on top accuracy ephemerides for all the Solar System bodies, we think the SSE Commission should support it. Then we could seek support from the future commissions of Division A which will be in charge for Celestial Mechanics, Relativity, Astrometry, Time and Reference Systems.

Additional interactions have to be negotiated, in particular taking into account of the following well understood interfaces with other (presumed) commissions: in Div. A, Celestial Mechanics (theoretical and educational), Relativity (theoretical, standards), Space-Time Reference Systems (standards), Astrometry (star catalogs, debiasing); in Div. F Physical properties of minor bodies (standards, photometry incidental with astrometry), Planets (gravity fields, tides).

5. Procedure

This LoI has been written by 3 representatives of the sub-communities working on ephemerides of asteroids, satellites, and planets; they have consulted with the outgoing presidents (of Comm. 4, Comm. 20, Div. F, Div. A).