NUMERICAL STANDARDS OF FUNDAMENTAL ASTRONOMY WORKING GROUP UPDATE

B. LUZUM, U.S. Naval Observatory, USA, N. CAPITAINE, Observatoire de Paris, France, A. FIENGA, Observatoire de Besançon, France, W. FOLKNER, Jet Propulsion Laboratory, USA, T. FUKUSHIMA, National Astronomical Observatory, Japan, J. HILTON, U.S. Naval Observatory, USA, C. HOHENKERK, HM Nautical Almanac Office, UK, G. KRASINSKY, Institute of Applied Astronomy RAS, Russia, G. PETIT, Bureau International des Poids et Mesures, France, E. PITJEVA, Institute of Applied Astronomy RAS, Russia, M. SOFFEL, Dresden Technical University, Germany, P. WALLACE, Rutherford Appleton Laboratory, UK

ABSTRACT. The Working Group (WG) for Numerical Standards of Fundamental Astronomy was initiated at the 2006 International Astronomical Union (IAU) General Assembly (GA). At the 2009 IAU GA, Resolution B2 adopted the Current Best Estimates (CBEs) assembled by the NSFA WG as the IAU (2009) System of Astronomical Constants. With the initial task completed, the WG turned its attention to other tasks of importance to its long-term success. These tasks include identifying the best methods for maintaining an IAU list of CBEs as well as setting up an archival system for past values of CBEs. Addressing these issues will standardize the maintenance of a documented list of CBEs, allowing this task to be provided as an IAU service. An update on these activities is provided. In addition, unresolved questions regarding the Gaussian gravitation constant and the use of the astronomical unit and the mass of the Sun will be discussed.

1. INTRODUCTION

The International Astronomical Union (IAU) Working Group (WG) on Numerical Standards for Fundamental Astronomy (NSFA) was tasked with updating the IAU Current Best Estimates (CBEs), conforming with the IAU Resolutions, International Earth Rotation and Reference Systems Service (IERS) Conventions and Système International d'Unités whenever possible. As part of its effort to achieve this, the WG is working in close cooperation with IAU Commissions 4 and 52, the IERS, and the Bureau International des Poids et Mesures (BIPM) Consultative Committee for Units. For a brief review of the WG, see Luzum *et al.* (2008) and Luzum *et al.* (2009).

A significant milestone was achieved at the 2009 IAU General Assembly when Resolution B2 adopted the CBEs assembled by the NSFA WG as the IAU (2009) System of Astronomical Constants. In addition to adopting a new System of Constants, the resolution also recommended:

- keeping CBEs as an electronic document;
- developing a procedure for adopting CBEs;
- that IAU Division I establish a permanent body to maintain CBEs for fundamental astronomy.

The NSFA WG is now concentrating on the first two items, namely setting up the electronic document and establishing the procedure for adopting the CBEs. The following provides the status of this work.

2. FEATURES OF THE IAU (2009) SYSTEM OF ASTRONOMICAL CONSTANTS

The IAU (2009) System of Astronomical Constants has several significant changes with respect to the IAU (1976) System of Astronomical Constants. The WG believed that the previous categories of "Defining constant," "Primary constant," "Derived constant," and "System of planetary masses" did not properly capture the structure of the new system. As a result, in addition to "Defining Constant," which was retained, more descriptive category names have been introduced to help the classification and grouping of the constants. "Natural Measurable Constant" was used to describe the constant of gravitation. The category "Body constants" contains the physical constants associated with solar system

bodies. The obliquity of the ecliptic at J2000.0 was placed in the category "Initial values at J2000.0" and "Other Constants" was used for the astronomical unit and the average value of $1 - d(TCG)/d(TCB)$.

In addition,

- eight new constants have been added to the list (L_B, TDB_0, θ_0, $\dot{\theta}$, M_S/M_{Eris}, M_{Ceres}/M_S, M_{Pallas}/M_S, and M_{Vesta}/M_S);
- two constants have been removed (τ and p);
- twelve values have been replaced by more current, accurate values (G, au, L_C, M_M/M_E, M_S/M_V, M_S/M_{Ma}, M_S/M_J, M_S/M_{Sa}, M_S/M_P, GM_S, GM_E, and ϵ_0).

The full report of the WG on the new System of Constants is expected to be finished soon (Luzum *et al.*, 2011).

3. SCIENTIFIC CONCERNS

While the establishment of the new System of Constants represents a significant milestone, it does not end the scientific efforts of the WG. As before, the WG will need to stay abreast of the improvements in the scientific community. As new values are determined by improved measurements, space missions, *etc.*, the WG will need to determine whether they should become CBEs. It will also be necessary for the WG to be cognizant of changes in other scientific areas (*e.g.* geodesy) that could be relevant to updating the CBEs.

As an example, a new value for the mass of Mercury has become available based on recently reduced MESSENGER data (Smith *et al.*, 2010). This new estimate will be used to test the procedures being established for adopting new values for CBEs.

The other long-standing concern regards the status of the Gaussian gravitation constant k and the astronomical unit au. There is a proposal being made (see Capitaine *et al.*, this volume) to redefine au, but concerns regarding these proposals have also been raised. It is expected that a resolution will be drafted to resolve this issue before the next IAU General Assembly.

4. FUNCTIONALITY CONCERNS

Two significant issues that are being addressed by the WG involve questions regarding the procedure for adopting future CBEs and the design of the CBE electronic document. Significant progress is being made in both of these areas.

What is the procedure for adopting future CBEs?

A draft procedure is being discussed within the working group that defines the procedure by which future CBEs will be adopted. The current draft calls for future CBEs to be initiated by an official proposal followed by a discussion of the merits of the proposal. Some of the points to be considered in the discussion include whether the new value is an improvement over an existing value, the length of time until a new CBE is likely to become available, and whether the new value is presented in a refereed journal article. After the discussion has concluded, a vote will take place to determine the outcome.

In addition to the formal procedure for considering new CBEs, several "bookkeeping" tasks will also need to be adopted to ensure that appropriate documentation is provided. This documentation includes providing each "version" of the constants with a unique identifier, such as a date. Old versions of the CBEs will need to be archived so that past CBE versions remain available in the future. Also, providing records or notes about significant topics of debate should be provided so that decisions of the WG can be put into the appropriate context.

What is the design of the CBE electronic document?

Initial work on designing the CBE electronic document has begun. As noted above, the document will need, in addition to the CBEs themselves, information regarding the version of CBE, archives of past values and informational notes for the values.

On a related note, the location of the home page is still a subject of discussion. It is expected that the final document will be hosted on a computer associated with an IAU-related page such as the IAU Division I page or the IAU Commission 4 page.

5. FUTURE OF NSFA WG

In order to maintain a list of CBEs into the future, the efforts of the WG will need to continue past the next IAU General Assembly, when the WG is scheduled to be dissolved. However, the current IAU bylaws do not allow for an ongoing WG. This issue is being addressed by IAU Division I which is proposing that the IAU bylaws be changed to allow for a standing working group. If this change was to be adopted and the NSFA WG becomes a standing working group, then the efforts to maintain CBEs would seamlessly be continued into the future.

6. REFERENCES

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