

**XXVII IAU GENERAL ASSEMBLY  
Rio de Janeiro**

**Joint Discussion 6  
TIME AND ASTRONOMY**

**Thursday 6 & Friday 7 - August 2009**

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**Participating Commissions:**

31 : Time  
4 : Ephemerides  
7 : Celestial Mechanics and  
Dynamical Astronomy  
8: Astrometry  
19 : Rotation of the Earth  
52 : Relativity in Fundamental  
Astronomy  
40 : Radio Astronomy

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**Coordinating IAU divisions :**

I : Fundamental Astronomy  
X : Radio Astronomy

**Scientific Organizing Committee**

Pascale Defraigne (Belgium, Chair)  
Aleksander Brzezinski (Poland, Co-chair)  
Richard Manchester (Australia)  
Sergei Klioner (Germany)  
Daniel Gambis (France)  
Rendong Nan (China)  
Demetrios Matsakis (US)  
Michael Kramer (UK)  
Yury Ilyasov (Russia)  
Gerard Petit (BIPM)

**Preliminary scientific program summary:**

The objective of this JD is to introduce the astronomical community to the state of the art in the aspects of time, its use for astronomy, and the contributions from astronomy. The JD will provide a forum for discussion of recent work on these topics, and will be organized in three sessions:

**Earth Rotation and Time:** an overview of UT1 determination as well as UT1 modeling and prediction.

**Atomic Time Scales:** the present realizations and performance of atomic time scales and time transfer techniques.

**Pulsar Timing and its Applications:** recent developments in precision pulsar timing and its application to time scales, planetary ephemerides, detection of gravitational waves and tests of gravitational theories.

**URL:** <http://www.astro.oma.be/IAU/COM31/jd6.php>

## DRAFT PROGRAM

### Earth Rotation and Time

- UT1/LOD realization and accuracy
- Geophysical impact on UT1
- Short- and long-term variations of UT1
- Use of UT1 for astro-geodetic studies
- UT1 prediction

### Atomic Time scales

- Stability of TAI, TT(BIPM)
- Impact of new frequency standards on SI time scales
- GNSS time scales
- Time transfer
- Recent Developments with Leap Seconds

### Pulsar Timing and its Applications

- Techniques of precision pulsar timing
- Pulsar time scales
- Pulsar tests of gravitational theories
- Pulsar Timing Arrays and detection of gravitational waves
- Improving solar-system ephemerides
- Pulsar Timing Noise

### **Abstract submission:**

The abstracts must be submitted **before March 1st, 2009**,  
via the website of the IAU General Assembly: <http://www.astronomy2009.com.br/>  
sub-menu “Instructions for Presenters”

## Detailed scientific rationale

Responsibility for the definition of time scales left the astronomical community some 40 years ago when, in 1967, the second became defined by an atomic transition in the International System of units SI and when TAI was defined as the primary international time scale in 1971. Atomic time is now  $10^7$  times more stable than the Earth rotation and some  $10^4$  times more stable than the planetary orbital motions that were used to define time until 1967.

But time still interacts with astronomy in many ways: as the independent variable for the description of all dynamical systems, its stability allows one to study these systems and their perturbations. Time is therefore of major importance for astronomers, with time scales based on the SI second for practical applications and coordinate time scales for theoretical developments. Precise timing of the rotational and orbital periods of pulsars has the potential to contribute to the long-term stability of International Atomic Time (TAI), thereby returning some aspects of time keeping to astronomy. Furthermore, since observational techniques rely on the measurement of the time of propagation of electromagnetic signals, astronomy provides an important testing ground for relativity.

Although universal time is not used any more to provide the official time, it still reflects the Earth rotation and dictates the leap seconds and hence UTC, the international reference for time and frequency. The future of leap seconds is presently still a subject of debate led by the ITU-R Special Rapporteur Group. In parallel, the knowledge of UT1 is needed for any coordinate transformation between terrestrial and celestial reference systems. Together with the atomic time, UT1 serves precise orbit determination for both space research and Earth studies. The recent measurements of multiple space geodetic techniques, individually or in combination, provide high precision monitoring of LOD and UT1, and allow predictions as needed for real time applications. This improved accuracy on the UT1/LOD measurements also brings a new set of constraints for geophysical models.

The present realizations of the Terrestrial Time TT are the International Atomic Time TAI provided by the BIPM on a monthly basis, and TT(BIPM) based on the reprocessing using all primary frequency standard measurements. TT(BIPM) is presently the best reference to estimate the long-term stability of any other time scale, and in particular the long-term stability of pulsars. Thanks to the recent development of new frequency standards, and to the parallel progress in time scale algorithms and in time transfer techniques, the present atomic time scale stabilities and accuracies has been significantly improved.

Pulsars are incredibly stable clocks with a stability that rivals the best atomic clocks. Many pulsars are members of a binary system, enabling very precise measurement of the gravitational interactions between massive bodies and tests of gravitational theories. Such measurements have already given the most precise verification of Einstein's general relativity in the strong-field case. Future observations will reveal higher-order gravitational perturbations, providing even more stringent tests of gravitational theories.

Recent developments of “pulsar timing arrays”, in which a large sample of millisecond pulsars are regularly timed, have the potential to establish a time scale which is more stable than the best atomic timescales over long time intervals and hence to investigate the stability of these time scales. They also are sensitive to errors or omissions in the planetary ephemerides used to model the Earth’s motion and hence to improve those ephemerides. Finally, they have the potential to make a direct detection of gravitational waves from astronomical sources. Such measurements would open up a new window on the Universe and provide important constraints on models for the early Universe and galaxy evolution.