

First Circular – Workshop of the International Space Science Institute (ISSI)

20 May 2015

**High Performance Clocks, with special emphasis on
Geodesy and Geophysics and applications to other bodies of
the Solar System**

November 30 – December 4, 2015

Conveners:

Veronique Dehant (Royal Observatory of Belgium),
Leonid Gurvits (Joint Institute for VLBI in Europe and Delft University of Technology),
Michael Kramer (Max Planck, Bonn),
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Context:

Following a Forum on “Understanding Gravity”, which was held in December 2013 at ISSI, with the participation of 20 of the leading experts in this field, proposals were made to hold Workshops in ISSI to review the status of key aspects of research in the field. The Forum was organised and sponsored by ISSI in Bern, Switzerland, together with the ESA High-level Science Policy Advisory Committee (HISPAC). The Forum report can be found at http://www.issibern.ch/program/pdf/hispac_forum_report.pdf.

The first workshop on *High Performance Clocks, with special emphasis on Geodesy and Geophysics and applications to other bodies of the Solar System* is organised and sponsored by ISSI in Bern, Switzerland, together with the ESA High-level Science Policy Advisory Committee (HISPAC).

Objective of the Workshop:

The main objective is to discuss a possible technology transfer across disciplines. The idea is to bring together scientists from space research and ground development, from time transfer techniques and radio-science missions; from the time/frequency community, as well as from the Earth sciences, fundamental physics and solar system exploration communities, in order to study, e.g., by extensive numerical simulation,

possible improvements in applications when including local clock measurements at 10^{-18} (1 cm level in geopotential height difference). The outcome would be proposals for improvements (if any) in a number of research fields. For example, in Earth sciences, improvements could concern global and regional gravity field models, with specific geophysical applications when using in combination different satellite data (GOCE, GRACE, etc.), ground gravimetry and levelling, precise positioning, etc. New proposals for solar-system exploration and for fundamental physics are also expected outcomes of this workshop.

The topics covered in the Workshop:

I. Clocks, Time Transfer and Technology

Key words: general introduction to high precision clocks and comparison techniques; certain clocks and techniques (e.g. neutral atom clocks, optical fiber comparisons, space techniques); technology developed for high precision clocks in Earth Sciences and Solar System Exploration.

I.1 Clocks technology on the ground

I.2 High-precision clocks in space

I.3 Time transfer – clock comparison

II. Applications in Earth sciences

Key words: applications of clocks with $1e-18$ stability and accuracy in geodesy and geosciences, in particular to gravity field determination, positioning, and reference frames.

II.1 Using clocks for gravity field determination

II.2 Using clocks for positioning

II.3 Using clocks for reference frames

III. Applications in fundamental physics

Key words: High precision clocks and time transfer for fundamental physics questions in general relativity or other tests of theories.

III.1 Radioscience and other objectives to be done with high precision clocks

III.2 Applications of high precision/accuracy clocks in fundamental physics, and related space projects.

IV. Applications in Solar System science

Key words: High precision clocks and time transfer for one-way, two-way or three-way links, or Same Beam Interferometry (SBI), or Phase referencing technique, for improving precise orbit determination (or flybys) of spacecraft and precise positioning of lander or rover and therewith increasing science output (gravity field determination, rotation, and interior properties); improving corrections to the data such as relativistic corrections; exploration involving long-distance active laser and/or radiolinks involving high precision clocks.

IV.1 Terrestrial planets and the Moon

IV.2 Giant planets, moons and small bodies

IV.3 Future technology for Solar System

V. Astrophysics and cosmology

Key words: Using pulsar for detection of gravitational waves; exploiting the data, for any proper motion study, there are new ways of precise astrometry and also in spectroscopy and requiring time connection; comparison of spectral lines in maser sources and redshift; implication for future spectroscopy and ground base astronomy.

V.1 Pulsar timing in astrophysics and cosmology

V.2 Pulsar timing in aerospace navigation

V.3 Timing in high precision astrometry

V.4 Clocks and frequency standards in VLBI

V.5. Spectroscopy and fundamental constants

A final program will be included in the Second Circular.

Product of the Workshop

A printed volume will be published after the workshop in the *Space Sciences Series of ISSI* by Springer Verlag (see www.issibern.ch/publications). The volume will be issued both as a hardcover book in our series and also as an issue of the journal *Space Science Reviews*. We expect that papers will be due about 3 to 6 months after the workshop so they can reflect the discussions during the workshop. This volume is NOT intended to be the proceedings of the Workshop, but a collection of in-depth papers inspired by contributions and discussions at the Workshop, with emphasis on interdisciplinarity (a total of about 15 to 20 high-quality topical review papers is expected). All papers will be peer reviewed, and the volume is expected to appear about 12 months after the workshop.

Location: The Workshop will be held at the International Space Science Institute, Hallerstrasse 6, 3012 Bern, Switzerland.

Attendance: by invitation only, ~ 40-45 participants maximum.

Young scientists: Under its special programme of supporting young scientists, ISSI will invite (in addition) 4 to 6 early career scientists, within 2 years of their PhD, to take a full part in the Workshop.

Funding: ISSI will provide the subsistence costs (hotel and a per diem to cover meals) to all participants, but not the travel costs. There will be no registration charge for the Workshop.

Schedule:

Formal invitations and First Circular:	15 April 2015
Registration deadline:	15 September 2015
Second Circular and final program:	30 September 2015
Hotel deadline:	30 October 2015
Workshop:	Nov 30 – Dec 4 2015