PhD proposal in the framework of Time-Frequency metrology and time transfer technology for T2L2 and ACES/Pharao

Subject: Scientific applications of space optical time transfer
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Localization: Institut UTINAM/Observatoire de Besançon – Frequent missions to the site of "plateau de Calern" (Observatoire de la Côte d'Azur)
Financial partners: LabEx First-TF, Regional Council of Franche-Comté
Profile of applicant: Applied statistics, signal processing, time and frequency metrology
Application deadline: 2013, June 15th
Gross salary: ~1650 € /month (1350 € net)
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DESCRIPTION

Context: The system time transfer by laser link T2L2 was launched by CNES on Jason2 in 2008. It is the only space physics experiment currently in flight.

The technique is based on laser ranging, whose performance in terms of precision and accuracy are respectively less than 10 ps and 50 ps. The treatment of optical links obtained from the international network of laser stations (in support of satellite orbit determination) has produced a very large data base in OCA. This is the first network of ground clocks including hydrogen-maser, interconnected by space links. Several campaigns of time transfer by laser were conducted to determine the performance of the time transfer by laser: the stability of each ground-satellite link was estimated to be 6 ps @ 60 seconds, the accuracy stood at 120 ps. In addition, interoperability of time transfer systems by GNSS and by laser was developed to better understand the differences and behavior (noise) between the techniques. Ultimately, we plan to extend this interoperability to ELT data with the German group (Technical University of Munich (UTM) and laser station Wettzell).

More and more exchanges are growing between OCA, Paris Observatory (on clocks, ground calibration experiments, fundamental physics), Besançon Observatory (behavior of clocks, simulation and characterization of noise) and UTM (in synergy with ELT).

All this leads us to propose a thesis on scientific applications T2L2, based partly on the conclusive results of the analyzes, available data, future campaigns, comparisons laser-GPS and secondly on future perspectives in physics and geodesy including the ELT system (laser-based) in connection with the ACES / Pharao space system.

Scientific Objectives: The scientific objectives of space optical time transfer applications concern directly the mission Jason 2 (space geodesy) as well as, more generally, the possible probe of physics domain, such as the optical propagation in the atmosphere, gravitational aspects and the creation / maintenance of time scales.

Ground-space time transfer with the Jason2 clock from a network equipped with ground clocks laser stations, are used to estimate the behavior of the on-board oscillator (which is the basis of the DORIS system radio-positioning) concerning the fine changes of its frequency.

At first, the student will propose an approach for the construction of an on-board time scale (in the presence of deterministic and stochastic signatures) with the aim to reconstruct a single time scale for all stations / ground clocks without common visibility. The aim is to reach 10^{-13} Hz with DORIS in order to retrieve a time scale with uncertainty about 1 ns per Jason2 revolution and to improve modeling of embedded oscillator (DORIS), including its accuracy.

From on-board clock monitoring established over thousands of seconds, it is possible to estimate distances (called "1-way") by comparing the synchronized ground clocks and the space clock. Distances are absolutely essential to demonstrate the capabilities of the "1-way" technique in support of the orbit determination, and more generally to navigation. In addition, being based on a much smaller optical block (the T2L2) than the Jason2 reflector used in space geodesy, it is also possible to "read" the visual effects created by the reflector (itself composed of six headlamps assembled into a single opto-mechanical system) on the laser distance measurement. In a second time, the student will study the 1-way measurement function and its performances compared to the laser ranging (which works with round-trips); furthermore, propagation problems in the atmosphere will also be studied, since laser time transfer is not limited by shots of small elevation above the horizon.

Finally, in a third time, the student will examine all the opportunities of introducing gravitation in the database for the analysis of T2L2 data: the aim is to understand how to measure phenomena and to assess its relevance, given the precision / accuracy obtained. For example: mapping configurations to study the Lorentz invariance, inter-comparing estimates of frequency laser for stations at different altitudes, so with geopotential effects.

OCA team will also widely involved by this thesis, in laser telemetry and time transfer technology (distribution, measurement systems, optical links, with Etienne Samain and Myrtille Laas-Bourez particular). Indeed, the expected accuracy for time scales and gravitational aspects can only be achieved with the calibration ground operations carried out in France (OCA and OP) and Europe. The T2L2 project was accepted for a period of two additional years of life until the end of 2014 and beyond for analysis.

Expected Results: Collaboration has started between OCA, Observatories of Paris and Besançon and the group at University of Munich in charge of ELT link on ACES / Pharao. It will allow two-way to enhance the TF aspects (including transfer of space-time) between the communities of time-frequency and space geodesy.

The results of scientific applications of space optical time transfer are expected, first, for short-term stability of on-board time scale (10^{-13} Hz) and, secondly, for the timing accuracy of the laser system: 50 ps in common-view and 1 ns in non-common view (currently the synchronization network stations is 250 ns on average). The implications of this work will then deal directly with the space geodesy mission itself, in terms of orbit determination by laser (more accurate distances, more controlled spread). Finally, in the medium term the concept of establishing a single on-board time scale must consider gravitational aspects and eventually lead to synergy (scientific cooperation) with the French and German colleagues (in charge of the ELT system).