Report on LLR and the Transponder Standing Committee 2020

Ulrich Schreiber, Jean-Marie Torre

The year 2020 with the growing pandemic threat of COVID-19 has been severely hampering some of the activities in the community and we believe this statement holds true for about any activity of the ILRS. Nevertheless a few things have been accomplished that we are reporting here.

1. Hayabusa 2 tracking:
The Japanese space probe Hayabusa 2 is returning from an asteriod rendevous in the solar system. The probe is equipped with a lidar system, so a transponder ranging experiment for December 5 – 23, 2020 is scheduled as a target of opportunity for testing optical ranging in space applications. The challenge is the low repetition rate of the laser of 0.5 Hz and the large uncertainty for the space probe internal delay. The stations Koganei, Mt. Stromlo, Grasse and Wettzell (WLRS) are scheduled for this purpose. The distance to the target is between 20 and 80 million km. Due to the high background light level, chances are slim that ranging succeeds.

2. Time Transfer: ACES
After a long fight with the ESA/NASA safety panel, we have come to the point that laser ranging to the ISS for the ACES time transfer experiment is accepted, provided that the stations proof that they remain below the maximum permissible energy for the laser radiation and on 532 nm only. The restriction in optical wavelength comes from the fact that irritations of autonomous docking visiting vehicles have to be avoided. These systems use the infrared for the docking procedure. For that matter the CCR array of ACES is particularly coated with a bandpass coatin,g specifically for the second harmonic of Nd:YAG. The standing committee is working with the interested stations to sort out laser safety requirements for the ISS tracking. The launch of ACES on Space X has been rescheduled for the second half of 2021.

3. Common view time transfer over space debris
We have developed a new analysis model for a highly accurate time transfer. It involves diffuse reflections from space debris and links the clocks of the Wettzell station (WLRS) to the clock of the Graz station. In these measurements returns from laser pulses from Wettzell hitting a burnt out rocket stage were timed both in Wettzell and Graz. A clock offset of about 2 µs could be established with an error margin of 3 ns. The whole process has still a lot of room for improvement and there are all reasons to expect that accurate optical time transfer can be done with a remaining error of well below 1 ns, which would even exceed the error magin of microwave time transfer techniques. From this activity two papers emerged, which are currently under review at Acta Astronautica and Metrologia.

Accurate Ground to Ground Laser Time Transfer by diffuse Reflections from Tumbling Space Debris Objects: T Liu, JJ Eckl, M Steindorfer, P Wang, KU Schreiber; submitted to Metrologia

Photometric Space Object Classification via Deep Learning Algorithms; T Liu, KU Schreiber; submitted to Acta Astronautica

4. Lunar Laser Ranging
In this year we had planned and organized a novel type of community meeting in order to reorganize the LLR activities more coherently and close the loop between the observation and

the analysis side. While a lot of different groups have their stakes in LLR, there is no common agenda and the goals differ a lot from one group to the other. In order to find more synergy and common interest, this meeting should also recognize and redistribute some of the responsibilities. Due to the COVID-19 threat, the meeting was put on hold and we expect to host it at the earliest convenience, hopefully in 2021. Due to the organizational and partly controversial matters to handle, it is definitively not suitable for a virtual meeting.