Combined LARES-LAGEOS Solutions

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Laser Relativity Satellite (LARES)
LARES is a new spherical geodetic satellite designed for SLR observations. It is made of solid tungsten alloy covered with 92 corner cubes (Fig. 1). Due to a very small area-to-mass ratio (Tab. 1), the sensitivity of LARES orbits to non-gravitational forces is greatly minimized. We process 82 weeks (Feb 12-Aug 13) of LARES observations from a global SLR network and we analyze the contribution of LARES data to the current SLR products (global scale, geocenter coordinates, station coordinates, Earth rotation and gravity field parameters). The quality of the combined LARES-LAGEOS-1/2 solutions is also addressed.

LARES orbits
Table 2 shows the perturbing accelerations of gravitatonal, non-gravitational, and general relativistic origin, acting on geodetic satellites. Comparing LARES and AJISAI (two satellites of similar altitudes), the impact of gravitational accelerations is nearly the same, whereas the impact of non-gravitational accelerations is about 22 times smaller for LARES than for AJISAI. Thus, LARES orbits are remarkably well suited for the recovery of the Earth’s gravity field or for the verification of the Lense-Thirring effect.

Figures 2-4 show the evolution of LARES mean orbital elements (eccentricity, inclination, semi-major axis, respectively). The secular drift of the LARES semi-major axis is mostly caused by the atmospheric drag, as opposed to the Yarkovsky effect for LAGEOS satellites. Nevertheless, the LARES’ drift is about 16 times smaller than the AJISAI’s drift. The residual LARES along-track acceleration is just -3E-12, i.e., 47 times less than the AJISAI’s along-track acceleration.

Correlations
Figure 5 shows the correlation matrices of LARES-only, LARES+LAGEOS-1/2, LAGEOS-only, and LARES+LAGEOS-1/2 weekly solutions. These matrices contain the core station coordinates, space orbits, Earth rotation parameters, geocenter coordinates, and gravity field parameters up to degree/order 6/6. All remaining parameters were pre-eliminated (range biases, pseudo-stochastic pulses, non-core station coordinates).

Combined multi-satellite solutions
The scale and origin (geocenter coordinates) of the inter-terrestrial reference frame (ITRF) are determined by the SLR observations. Thus, the highest quality of these parameters is crucial in the SLR solutions. Figure 6 shows the scale from the LARES, LAGEOS, and combined LARES+LAGEOS solutions with a corresponding spectral analysis. The LARES-only scale is noisy and shows some deficiencies in orbit modeling, namely in modeling of the non-gravitational forces which are reflected in the draconitic year of the LARES satellite (the time interval between two consecutive passes of the Sun through the orbital plane). The scale defined by LAGEOS-1/2 is stable, but also show the variations related to the draconitic year of LAGEOS-2. The orbit modeling deficiencies are substantially reduced in the combined LARES-LAGEOS-1/2 solutions, resulting in the most stable scale estimates.

Figure 7 shows that in the combined solutions the offset w.r.t. SLR2008 is smaller for the Y component, as compared to LAGEOS-LAGEOS-1/2 solutions. Moreover, the recovery of gravity field parameters can be greatly improved when including LARES data (Fig. 8, compare the Star+Ste+Aji solution with the LARES+Star+Ste+Aji), because of improved observation geometry and large LARES sensitivity to the gravity field.

Conclusions
In the combined LARES-LAGEOS solutions, the correlations between parameters are reduced and the global scale is less affected by the deficiencies in LAGEOS orbit modeling.

A very small impact of non-gravitational forces and high orbit stability of LARES will allow the recovery of the Earth’s gravity field and the validation of the effects of general relativity.

References

Figure 1: LARES before embedding the corner cube retro-reflectors (courtesy of ASI).