Recent upgrades of the Metsähovi SLR telescope

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Introduction

Metsähovi satellite laser ranging station has been under renovation since 2005. In 2006 a new 2kHz laser was purchased and simultaneously upgrades for the telescope drive mechanism were planned. Faster and more accurate operation of the telescope will be achieved by upgrading the motors and by installing high accuracy absolute encoders. The telescope was fully disassembled in 2007 and vigorous work for the restoration and upgrading of the telescope was started. In 2008 it became evident that the old optical system coundn't operate with a 2 kHz laser due to outgoing and incoming beams using a single optical path. Hence a new optical scheme was planned. In the old system the separation of the beams was controlled with rotating mirrors. The old mechanism was only capable to approximately 100Hz repetition rate. In the new system the beams will travel through separate paths. Currently, the optical and mechanical updates are in implementation phase and in this poster we will give a short presentation of the recent work done and future plans at the Metsähovi SLR telescope.

New optical system

To enable 2 kHz observations a new optical design was necessary for separating parallel beams. In 2009 a new optical solution was designed in co-operation with the original designers of the telescope at the University of Latvia in Riga. In the new system the transmitted beam is guided outside of the main aperture to a separate beam expander (Fig. 1.). To make this possible the focus of the telescope had to be changed. This fundamental modification brings focal point from the Coudé-focus into Cassegrain-focus and reduces focal length to a quarter while also reducing slightly the effective aperture. Earlier the focus and the PMT-detector were in a separate room and the visual channel for the CCD was separated to the other side of the telescope with rotating mirrors. These mirrors were also used for guiding the beams to travel in parallel directions. With the new design the rotating mirrors will be discarded. Wavelength of 532nm will be guided to the new C-SPAD detector and other wavelengths will be separated with dichroic mirror to the CCD-camera. These will be now mounted inside the telescope into the Cassegrain-focus. The new custom made lenses are now being tested and the precision mounts are being manufactured in Riga. The new optical setup can be seen in the Fig. 1. It shows the transmitted beam on the right, outside the main aperture.

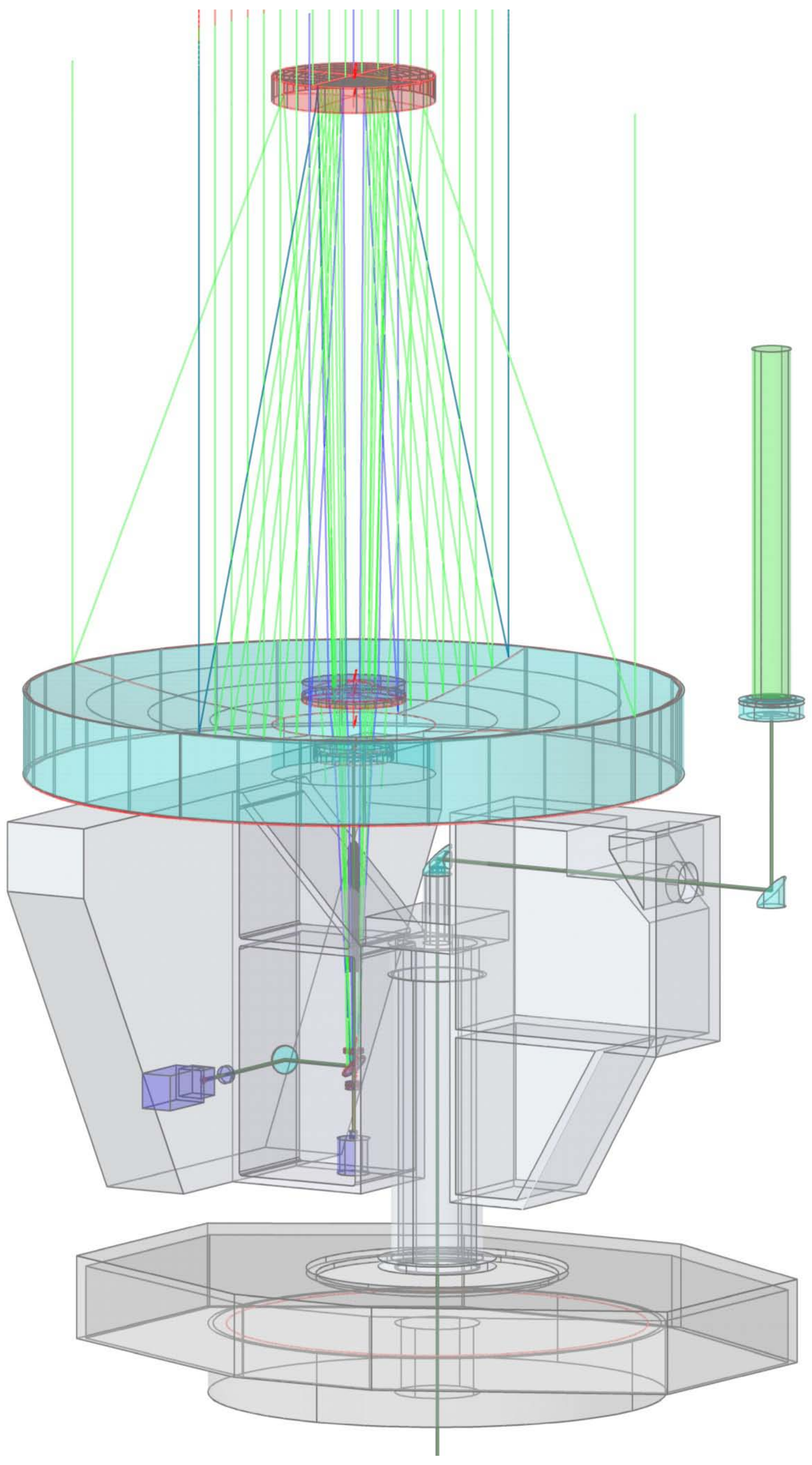

Figure 1. CAD-drawing of the telescope mount and the new optical setup. The green color shows the laser beam; magenta iillustrates the detectors and red and turquoise shows the optics. The three new custom lenses are mounted to the hole in the middle of the main mirror.

Drive mechanics

Updating of the telescope drive system is ongoing. The old stepper motors and optical encoder rings will be replaced by servo motors and electronic absolute encoders, respectively. In summer 2010 Heidenhein ERA8480C encoder was installed on the azimuth mount (Figure 2.). The new encoder provides ~3" accuracy on the azimuth axis. In summer 2011, the encoder will be calibrated. On the elevation axis a Heidenhein ERA4481C encoder will be installed. Resulting from a different design it will give even more precise pointing data for the elevation axis.

The old motors will be replaced with Maxon servo motors. These will enhance the speed of the telescope as well as give additional pointing data. Adapters will be made to install them on the old gear system.

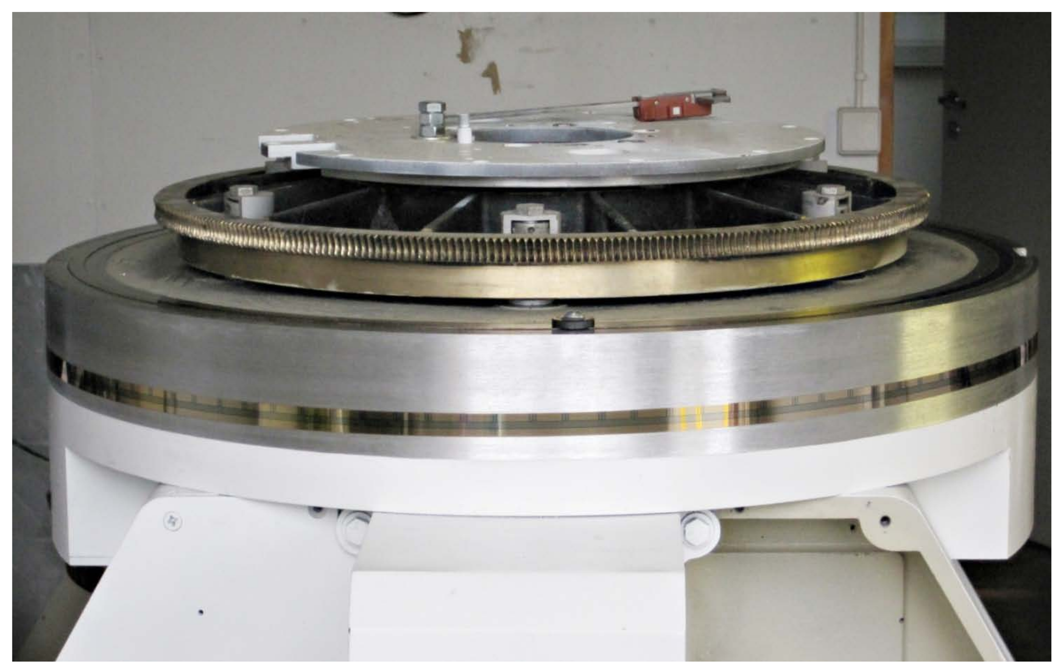

Figure 2. The gold plated scale of the azimuth encoder mounted on the telescope mount.

Levelling of the telescope

The telescope mount was levelled with a digital level to discover any possible tilt due to accidental movements of the mount during the disassembling. The flatness of the azimuth rail (Figure 3.) was also checked. It was found out that there were bumbs with maximum amplitude of ~0.1 millimeter on the rail and a tilt of ~0.2mm on the North-South axis. The tilt is easily removed but individual bumps need to be included in the telescope pointing model. In the Fig. 4 the coarse model of the anomalies on the rail can be seen. Measurements were taken in 10 degree steps on the rail i.e. every 6cm as seen on the Figure 3. Three separate measurements were taken in every point with the rod in place. The whole measurement was repeated three times, hence we got nine measurements for every point. We examined only the height differences, not absolute heights. The measurements will be repeated with greater accuracy when the telescope is assembled.

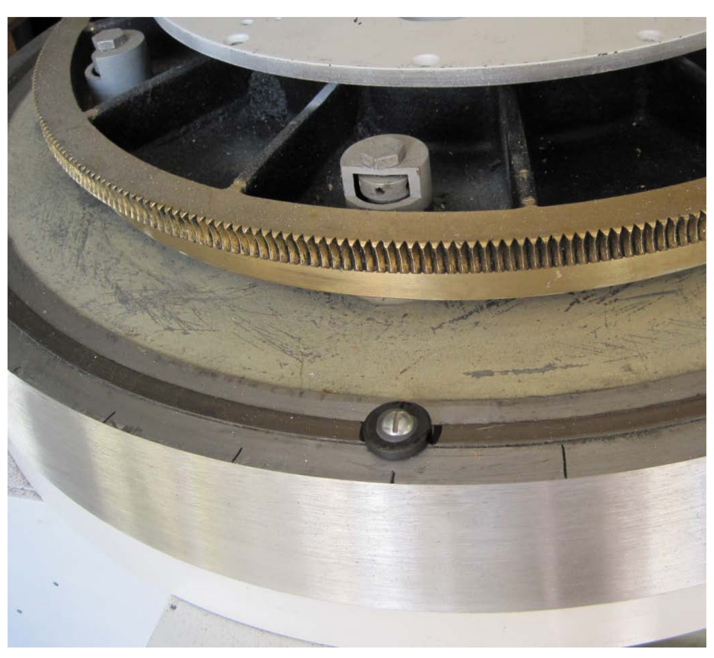

Figure 3. The azimuth rail. Black marks show the levelled points. The rod was placed on the magnet to reduce error due to placing of the rod on the rail.

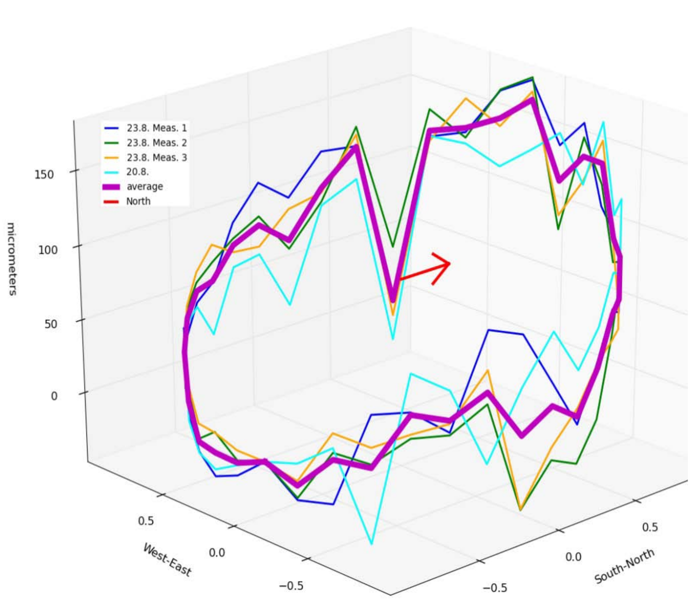

Figure 4. Plot showing levelled height differences. The starting point is set to zero. Magenta is the total average, other colors are the averaged separate measurements.

Future plans

After installing the new optics, motors and encoders we will start to build the telescope control software. The motors and encoders need to be calibrated and new calibration targets for the telescope has to be made. For precise pointing a pointing model will be done. Metsähovi is a fundamental station, hence new local tie measurements are important and will be made when the telescope is assembled. Ongoing research is done for the local tie measurements of the Metsähovi VLBI antenna. This research will help us pursuing towards the 1 mm level on the local ties of the SLR telescope as well.

Parallel to this work we are seeking funding for a new telescope for the kHz laser. This system would use smaller and faster telescope for LEO observations. The old telescope could be used with a slower but more powerful laser to observe MEO satellites e.g. GNSS satellites.

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