Spherical Retroreflector with an Exstremely Small Target Error

International Experiment in Spase

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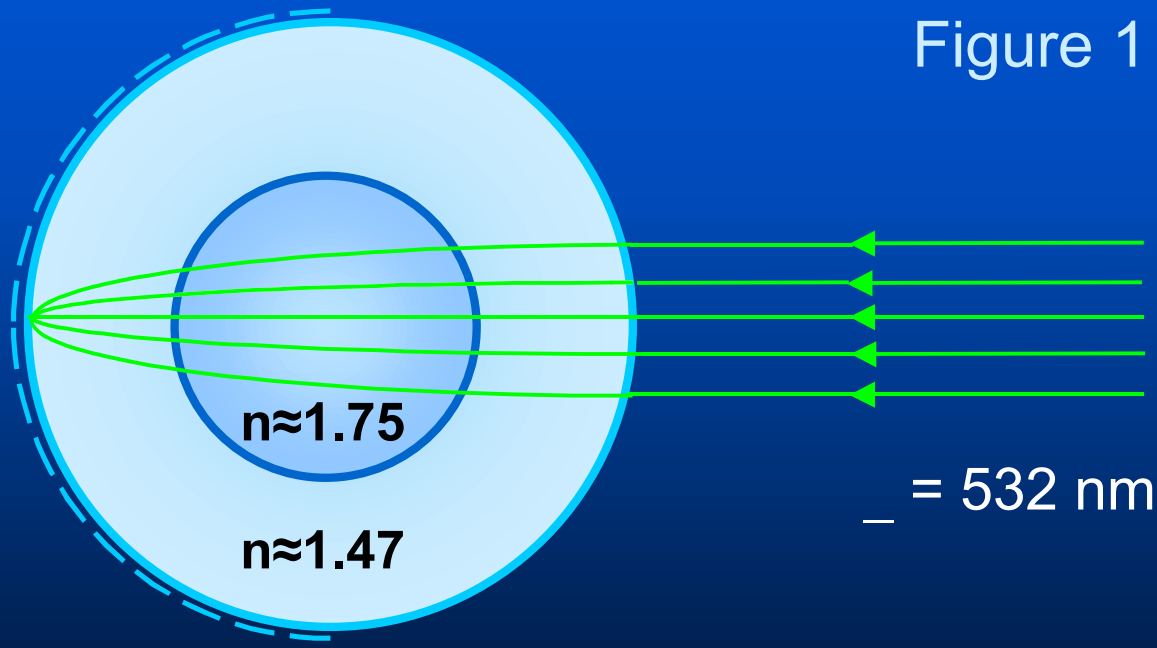
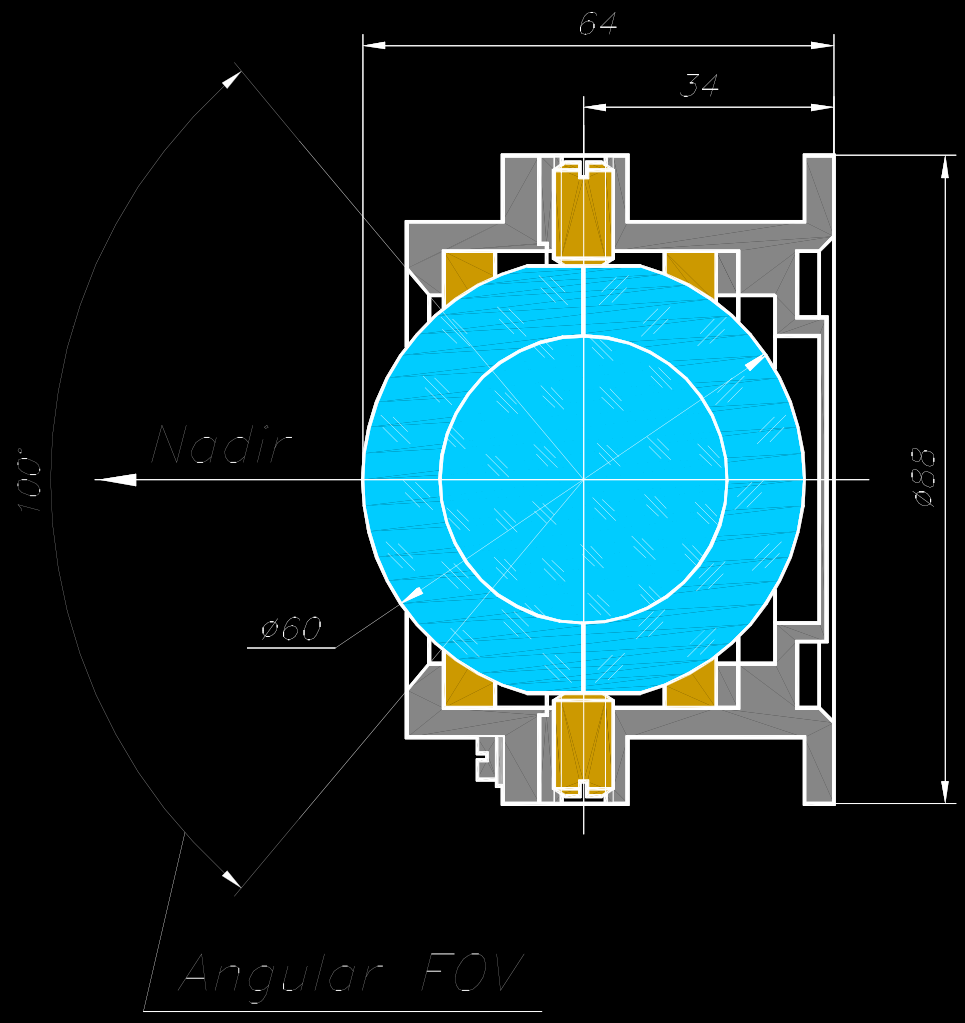
- The novel-type spherical retroreflector (first reported at the 11-th International Workshop on Laser Ranging in Deggendorf, Germany, 1998) is a ball lens made of several (at least two) layers of glass having different refraction index values.

Figure 1



- The “target error” of such a retroreflector depends primarily on the uncertainly of its operating temperature, causing a corresponding uncertainty of the optical path length inside the ball lens.

- An experimental 60-mm-diameter spherical retroreflector, after being tested in laboratory conditions, has been 10 December 2001 launched into space on board of the METEOR-3M(1) satellite having a 1018.5-km-high circular orbit.



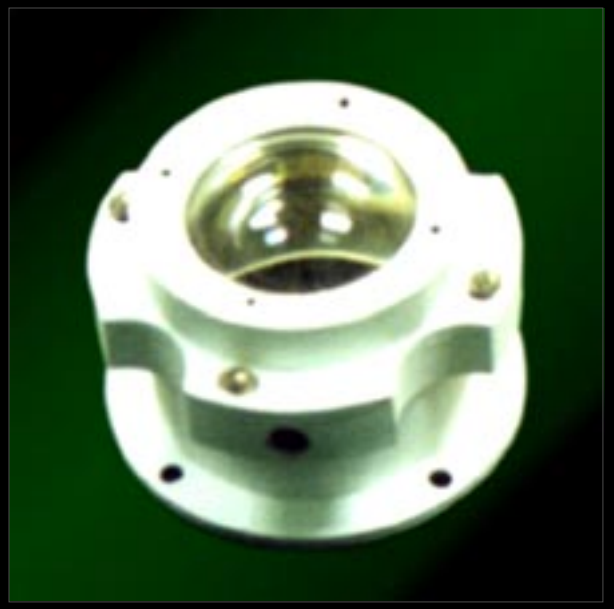


Figure 2

- Many stations of the International Laser Tracking Network provided systematical observations of the METEOR-3M(1) retroreflector.

Number of METEOR-3M(1) passes observed by stations of the International Laser Tracking Network till September 21, 2002

Station name	Station number	Number of passes
NASA stations		
Greenbelt	7105	13
Haleakala	7510	6
Hartebeesthoek	7501	14
McDonald	7080	4
Monument Peak	7110	52
Yarragadee	7090	60
Total		*149*

Station name	Station number	Number of passes
Other stations		
Beijing	7249	1
Changchun	7237	16
Grasse	7835	15
Graz	7839	31
Herstmonceux	7840	51
Matera (MLRO)	7941	2
Mount Stromlo	7849	2
Potsdam	7836	5
Riga	1884	2
Riyadh	7832	29
San Fernando	7824	28
Shanghai	7837	6
Simosato	7838	4
Wettzell	8834	1
Total		*193*
Grand Total		*342*

- A considerable amount of tracking has been done also by the new Russian SLR station near Moscow.

Number of METEOR-3M(1) passes observed by the new Russian SLR station near Moscow

Month 2002	Number of passes
January	
February	1
March	6
April	10
May	16
June	13
July	12
August	9
September	3
Total	***70***

The new-generation OLS

SAZHEN-T OLS telescope

has been put in operation
in 2000 near Moscow

SAZHEN – T OLS shelter

- Precision orbit determination (POD) has been provided by the Mission Control Center (MCC, Russia) as well as by Honeywell Technology Solutions, Inc (HTSI, USA). The same POD accuracy has been achieved in both organizations.

- The POD results are used for support of the SAGE-III mission (NASA, USA); the corresponding instrument operates successfully on boards of the METEOR-3M(1) satellite.

- The SAGE-III POD requirement is to provide an error in the METEOR-3M(1) position prediction no more than 500 m along the orbit.

The MCC provides daily POD data based on SLR, and IRVS distribution for stations. The maximum prediction error along the orbit is less than 100 m, with mean values 20…30 m along the orbit and <10 m in directions normal to the orbit.

• Figure 3 shows the results of orbit determination and prediction, based on SLR and RF measurements. As a base (zero line), the orbit computed from SLR network data during September 20, 2002 to September 26, 2002 has been used. The plots show deviations from the basic solution for various particular solutions. The red line shows deviations of an orbit obtained September 23, 2002, using a standard procedure of RF measurements processing; the blue line shows the result of a week-long prediction obtained from the standard solution for September 16, 2002, from RF measurements. The black line shows orbit deviations obtained from SLR measurements (regular operation of the MCC-M Laser Center using data from September 18, 2002 to September 23, 2002).

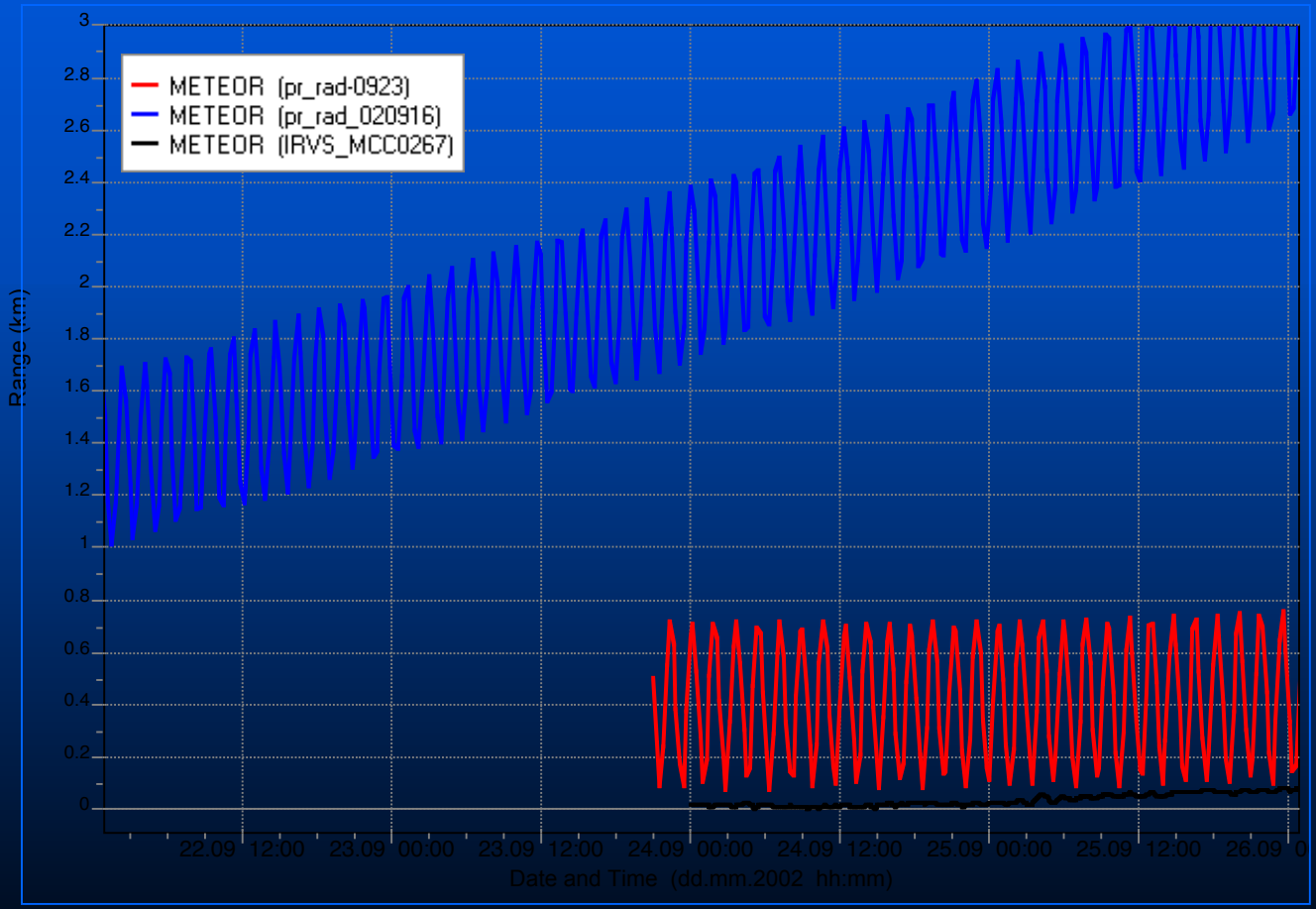


Figure 3. Orbit deviations for solutions based on SLR and RF measurement data

- Measurements of relative return signal strength for METEOR-3M(1), LAGEOS-1,2 and ETALON-1,2 provided data for calculation of the experimental retroreflector cross-section. The estimated value is about 10,000 sq. m.

The data have been collected from measurements of the Russian SLR-station near Moscow.

- Based on the currently obtained results, we propose to start the development of a full-scale autonomous satellite-retroreflector of this type, that could be launched into an orbit suitable for solving scientific problems requiring the highest grade of measurement precision.

- Simple determination of the satellite spin rate may be provided. The spin rate slowdown will be much less than for existing quasi-spherical satellites carrying retroreflector arrays.

•As an example, the satellite may have the following parameters:

Ball lens external diameter	214 mm
Satellite mass	14.5 kg
Retroreflector cross-section	>100.000 sq. m.
Target error	<0.1 mm

•The required orbit parameters should be determined in accordance with the mission goals. The development, manufacturing, and organization of launching may be accomplished by the Institute of Precision Instrument Engineering (IPIE, Moscow, Russia), if the necessary funding will be provided by interested organizations.