Experimental Spherical Retroreflector on Board of the Meteor-3M Satellite

V.D. Shargorodsky, V.P. Vasiliev, N.M. Soyuzova, V.B. Burmistrov,
I.S. Gashkin, M.S. Belov, T.I. Khorosheva, E. Nikolaev

Abstract

An experimental retroreflector (RR) based on the Optical Luneberg Lens concept will be tested on board of the Meteor-3M satellite planned for launching early next year. The ball lens is only 60 mm in diameter; but calculations show that it will be possible to obtain return signals from this RR by most of the existing SLR-stations, operating at λ = 532 nm.

In the Institute for Precision Instrument Engineering (IPIE) an experimental spherical retroreflector (SRR) has been developed. The SRR is based on the Optical Luneberg Lens principle first reported at the 11-th International Laser Raging Workshop in Deggendorf, Germany (Sept., 1998). The authors believe this principle may be used for implementation of SLR-satellites having a very small target error (less than 0.1 mm).

The experimental SRR is a small-size prototype of an autonomous SLR-satellite designed for a first space-based testing. Its diameter is only 60 mm, but nevertheless it may provide return signals strong enough for observation by most of the currently active SLR-stations.

It is planned to launch the SRR on board of the Meteor-3M satellite (circular orbit 1018 km high, with an inclination i = 99.6 deg.). The sun-synchronous orbit of the Meteor-3 is convenient for acquisition and tracking. The SRR is fastened in a holder allowing to observe it at any elevation angles more than 30 deg.

In case of a successful experiment, data may be collected on mechanical and thermal parameters which can help to design a larger autonomous satellite of this type.

In Figures 1 and 2, the SRR and its installation in a holder is shown.

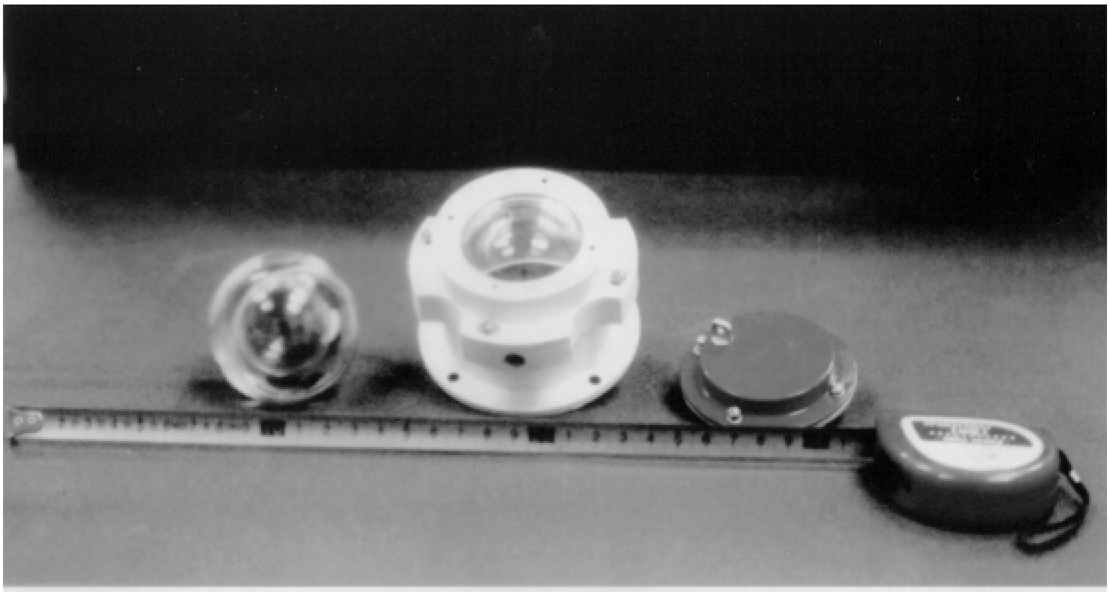

Fig.1. Spherical retroreflector in holder

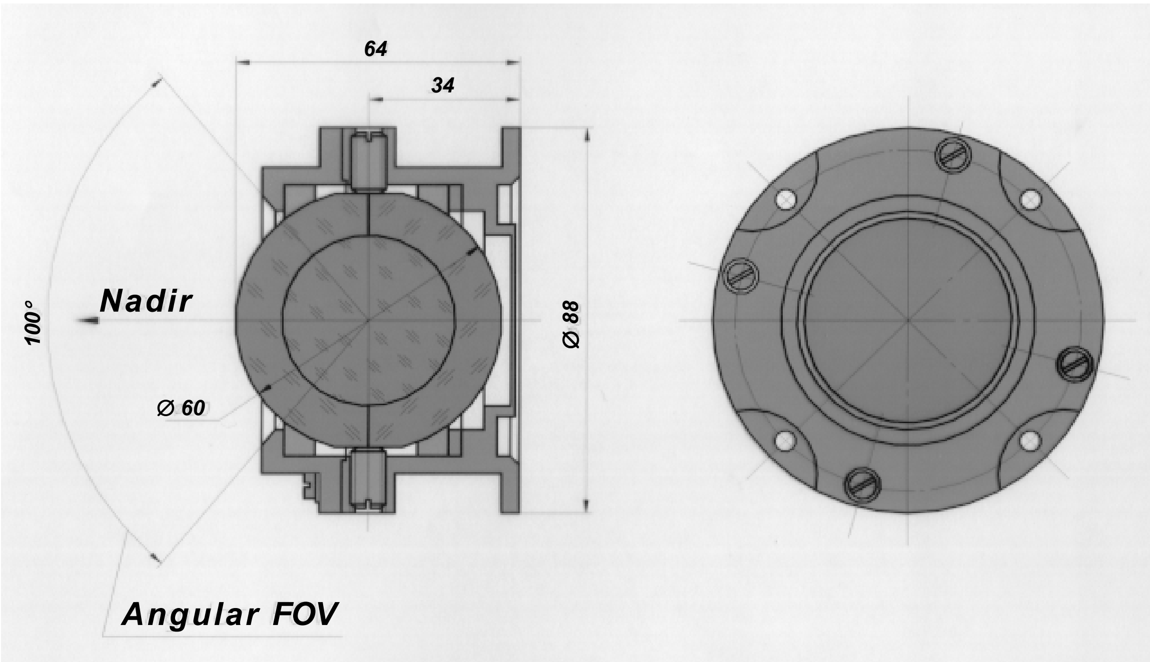

Fig.2. Spherical retroreflector in holder

In Figures 3 and 4, the SRR optical layout is shown for two slightly different implementations: with a glue layer between the inner ball and the external glass hemispheres, as well as with an air gap instead of the glue layer. The lab measurements show only a minor difference of reflection patterns for these two implementations.

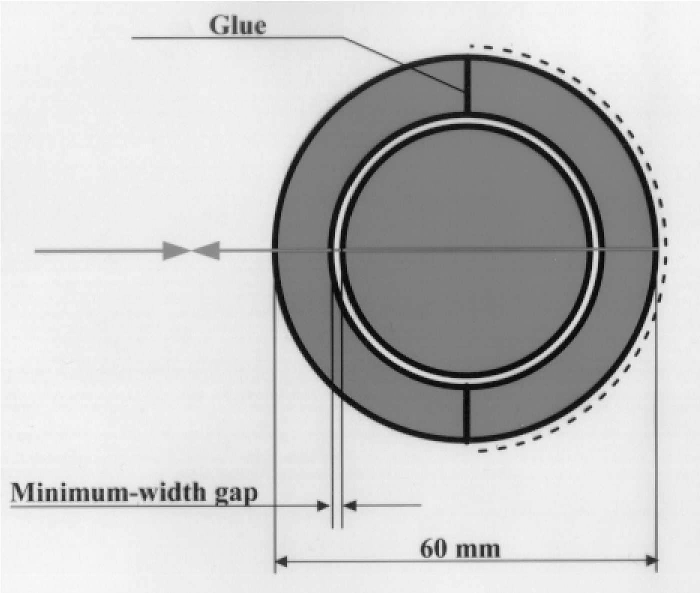

Fig.3. Spherical retroreflector: Optical layout

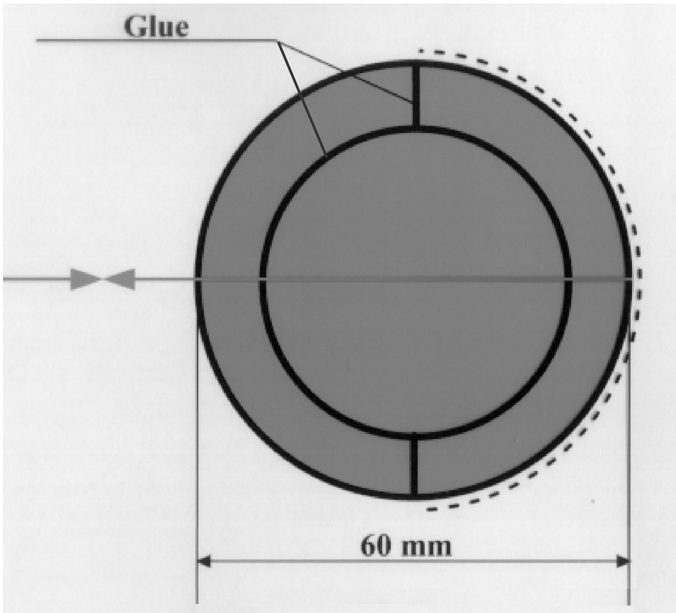

Fig.4. Spherical retroreflector: Optical layout

In Figures 5 and 6, you can see the measured reflection pattern of such an SRR (for convenience, velocity aberration limits for the Meteor-3M satellite observation are shown in Figure 6).

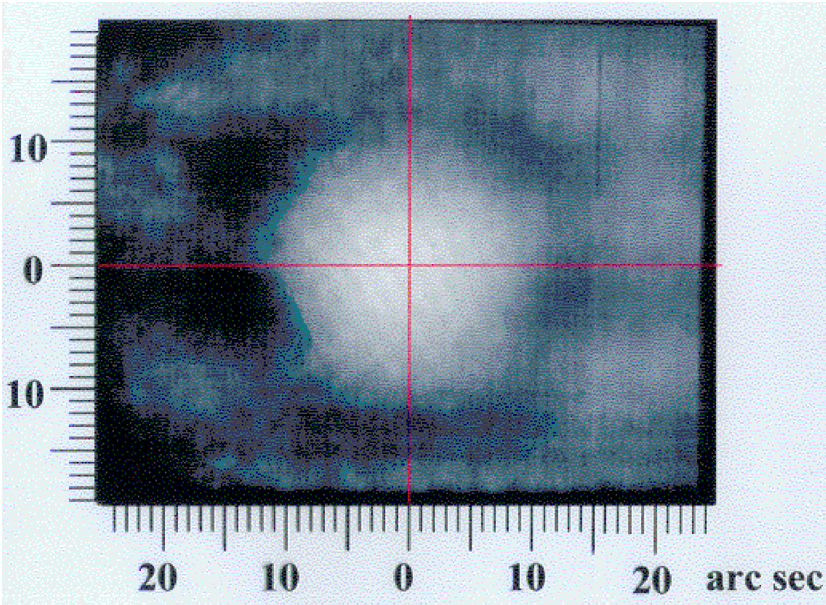

Fig.5. Reflection pattern

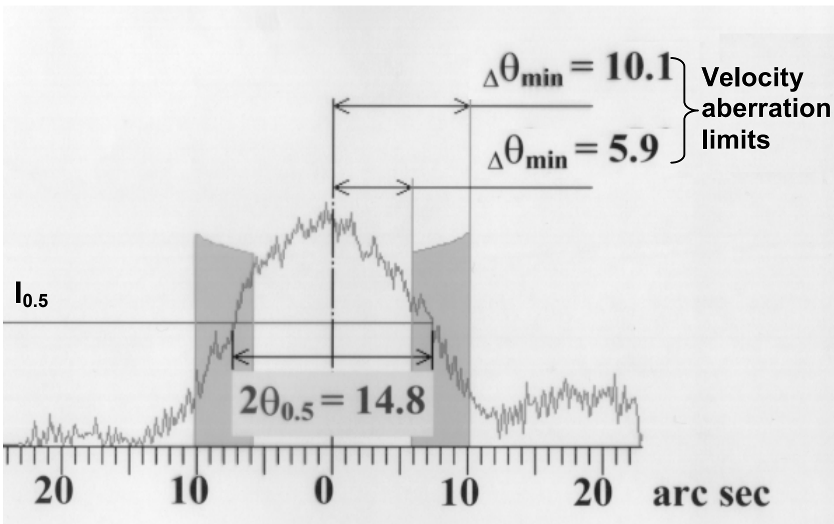

Fig.6. Cross-section of reflection pattern

In Figure 7, a table is presented showing calculated effective cross-section values for such an SRR for two possible cases:

- A classical velocity aberration
- Fizeau-effect compensation of the velocity aberration (if this really exists).

Elevation angle, deg.	**Compensated velocity aberration**	**Classical velocity aberration**	
		Near zenith pass	**Low-elevation pass**
90	12.57	0.68	0.68
80	13.15	1.95	1.95
70	12.96	2.82	2.0
60	12.76	3.51	2.24
50	11.21	1.95	1.85
40	13.06	5.46	3.41
30	11.21	6.23	3.21

Fig.7. Effective cross-section of spherical retroreflector, $m^2 x10^3$

Angular FOV	**0 to 50 deg**
SLR-station line-of-sight elevation angle	**30 to 90 deg**
Reflection pattern angular width (FWHM)	**$2\theta_{0.5}$=14.8 arc sec**

Fig.8. Basic parameters of the reflection pattern