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### **THE STATION “LVIV” OF SATELLITE LASER RANGING**

*The “Lviv-1831” station of satellite laser ranging (SLR) is a subdivision of Astronomical Observatory of Ivan Franko National University of Lviv. The station is carrying out regular observations of satellites since 1998, in 2002 the station was included into International Laser Ranging Service (ILRS) network.*

*The ranges to the number of geodetic satellites, namely LAGEOS-1, LAGEOS-2, Starlette, Ajisai were measured at the station.*

*The SLR contributes to the realization of ITRS (International Terrestrial Reference System), so that the “Lviv-1831” station is provided by International Earth Rotation Service with coordinates in current solutions (ITRF), presented in this paper.*

**Key words:** *satellite laser ranging, geodetic satellites, solutions, orbit*

**Introduction.** Satellite Laser Ranging (SLR) is a scientific technique used for exploration of near space. The observable to be measured is the round trip time of flight of ultrashort laser pulse from Earth-based station to a satellite equipped with retroreflectors. The general purpose of SLR is an accurate determination of orbits. It is implemented in the framework of global network of observational stations with centralized accumulation and processing of data, thus providing the data at the high level of precision and long-term stability. Currently SLR provides the most accurate determinations of geocentric position of an Earth satellite.

SLR is contributing to:

studies of gravity field of Earth (reference model and height of the geoid at long wavelengths), temporal variations due to mass redistribution in the system of solid Earth, oceans and atmosphere;

1. sea and ice level monitoring, support for the altimetry sensing measurements;
2. accurate determinations of tectonic motions;
3. ultrafine effects related to fundamental physics.

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### **SLR STATION ``LVIV-1831''**

The SLR station ``Lviv-1831'' is situated in Bryukhovychi village, about 10 km far from city of Lviv. It belongs to Astronomical Observatory of Ivan Franko National University of Lviv. The SLR station ``Lviv-1831'' involves the optical telescope TPL-1M, with 1.0\,m main mirror, the laser-pulse transmitter SL-212 with output power of 1 TW, and receiving/detection system able to yield the precision of picoseconds.

The station corresponds to the third generation of SLR according to the international classification. In 2002 the SLR station ``Lviv-1831'' was included into ILRS network~\cite{ILRS}. The data of observations are directed to the EUROLAS Data Center at DGFI and also to the Ukrainian Centre of determination of the Earth Orientation Parameters.

Also, the station co-operates with the national programme named ``Creation and development of governmental service of the unique time and standard frequencies''.

The station is identified with: name ``Lviv'', code ``LVIL'', CDP Pad ID ``1831'', IERS DOMES number ``12368S001'', SOD ``18318501'' [1].

### **GEODETTIC SATELLITES**

The number geodetic satellites are routinely observed by ``Lviv-1831'' SLR station, e.g. LAGEOS-1, LAGEOS-2, Starlette, Ajisai. The geodetic satellites are designed for such scientific purposes as determination the exact positions on the Earth's surface; the studies of shape and size of the Earth; exploration of the variations of the terrestrial gravity and magnetic fields. Most of geodetic satellites are passive and carry the retroreflectors as payload.

First LAGEOS, LAsER GEODynamics Satellite, was developed by NASA in 1976 and placed into a high inclination orbit. The second, LAGEOS-2, was a joint programme between NASA and the Italian space agency, designed to improve the coverage of seismically active areas and to find explanation for irregularities of the motion of LAGEOS-1. LAGEOS satellite is a 60-cm diameter sphere consisting of aluminum shell around the brass core, the surface is covered with 426 cube-corner retroreflectors.

Parameters of orbits: LAGEOS-1 -- 5858 x 5958 km with inclination = 109.8 deg., and LAGEOS-2 -- 5616 x 5950 km with inclination = 52.6 deg [2].

### **ITRF, SLRF**

Analysis Working Group (AWG) (ILRS) carries out the processing of the tracking data collected by ILRS. Its aim is to generate scientific data products. These products are solutions, based on these Satellite Laser Ranging (SLR) and Lunar Laser Ranging (LLR) observations. The most important results are the values of station coordinates and velocities, Earth Orientation Parameters (EOP), reference frame (RF) realizations.

The ILRS products are primarily used in the definition of the origin and absolute scale of the International Terrestrial Reference Frame (ITRF), a unique contribution of the laser ranging technique.

Most recent solutions of ITRF include ITRF2005 and ITRF2008. For ITRF2005 the AWG contributed a complete weekly series of SINEX files covering the period 1993 to 2005. During the current process for the establishment of ITRF2008, the effort was extended to include the historical LAGEOS data since 1983 on. It is planned that in the near future the AWG will generate additional products that can be used to establish new and improved versions of ITRF.

The computation of SLRF2008 was fulfilled by the ILRS/AWG to fill the lacuna of a complete reference for all the SLR sites ever having tracked the LAGEOS and other satellites.

**RESULTS**

For the larger time interval, 2000-2012 observations of LAGEOSes are represented in the Figure 1.

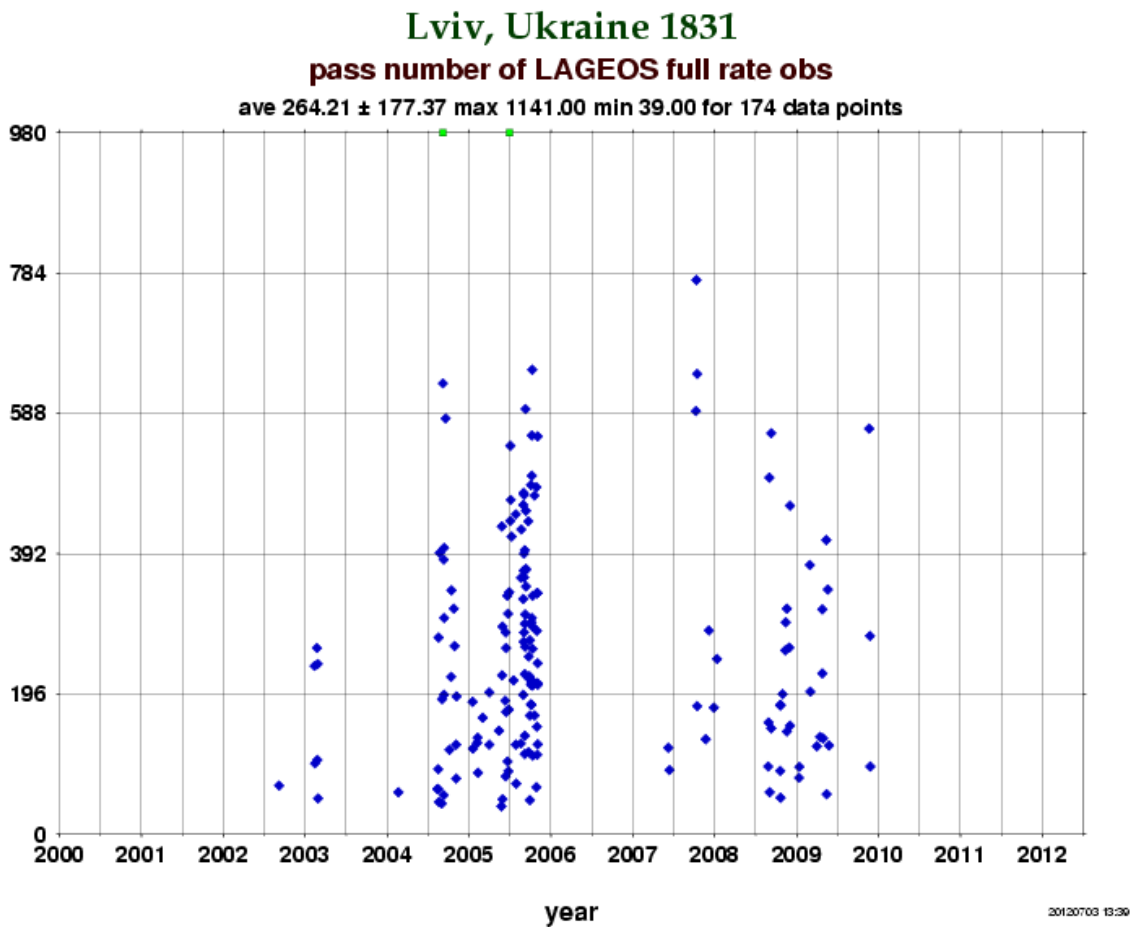


Figure 1.Lageos Observations at Lviv-1831 [1]

Due to the results of our observations of LAGEOS-1 and LAGEOS-2, the solution of ITRF2005 and the new solution of ITRF2008 has provided the refined coordinates of our station, see Table. according to the site ITRF and ILRS.

Table 1.

**ITRF2005 station position at epoch 2000.0 and velocities rescaled**

SITE NAME	TECH. ID.	X, m	Y, m	Z, m	Sigmas
BRJUHO VYCHI	SLR 1831	3760674.582	1670776.412	4857165.262	0.076 0.068 0.062
		Vx, m/y	Vy, m/y	Vz, m/y	
		0.0309	0.0042	0.0344	.0142 .0129 .0114

Table 2.

**ITRF2005 station position at epoch of minimum variance and velocities rescaled**

SITE NAME	TECH. ID.	X, m	Y, m	Z, m	Sigmas
BRJUHOVYCHI	SLR 1831	3760674.746	1670776.434	4857165.445	0.009 0.009 0.007
		Vx, m/y	Vy, m/y	Vz, m/y	
		0.0309	0.0042	0.0344	.0142 .0129 .011

Table 3.

**Results according to SLRF2005 [3]**

X, m	0.376067459042917E+07	.109387E+00
Y, m	0.167077641349530E+07	.982053E-01
Z, m	0.485716525388868E+07	.900784E-01
Vx, m/y	0.289737175221634E-01	.205258E-01
Vy, m/y	0.392959139115047E-02	.187355E-01
Vz, m/y	0.363274798553268E-01	.165189E-01

(ftp://cddis.gsfc.nasa.gov/pub/slr/products/resource/reanalysis\_2007/SLRF2005\_POS+VEL.snx.txt)

Table 4.

**ITRF2008 station position at epoch 2000.0 and velocities rescaled [4]**

SITE NAME	TECH. ID.	X, m	Y, m	Z, m	Sigmas
BRJUHOVYCHI	SLR 1831	0.376067473563698E+07	0.167077643037227E+07	0.485716543779447E+07	0.32330E-02 0.36276E-02 0.26569E-02
		Vx, m/y	Vy, m/y	Vz, m/y	
		- .228163272262724E-02	0.175681714423597E-0	0.408218739007309E-01	0.28320E-02 0.34733E-02 0.24574E-02

```

ITRF-2008
+SITE/ID
CODE PT__DOMES__T_STAT DESCRIPT__
APPROX_LON_APPROX_LAT_APP_H_
1831 A 12368S001 1831 23 57 15.8 49 55 03.2 359.2
+SOLUTION/EPOCHS
*Code PT SOLN T Data_start__ Data_end_____ Mean_epoch__
1831 A 1 C 02:169:32156 08:328:00000 05:247:70322
    
```

Table 5.

**Results according to SLRF2008 [5]**

([ftp://cddis.gsfc.nasa.gov/pub/slr/products/resource/SLRF2008\\_110913.txt](ftp://cddis.gsfc.nasa.gov/pub/slr/products/resource/SLRF2008_110913.txt))

X, m	0.376067473563698E+07	0.32330E-02
Y, m	0.167077643037227E+07	0.36276E-02
Z, m	0.485716543779447E+07	0.26569E-02
Vx, m/y	-.228163272262724E-02	0.28320E-02
Vy, m/y	0.175681714423597E-01	0.34733E-02
Vz, m/y	0.408218739007309E-01	0.24574E-02

SLRF2008

```

Code PT__DOMES__T_STAT DESCRIPT__ APPROX_LON_
APPROX_LAT__APP_H_ CDP-SOD_
1831 A 12368S001 L Lviv LVIV 23 57 15.8 49 55 3.2 359.8 18318501
SOLUTION/EPOCHS
*Code PT SOLN T Data_start__ Data_end_____ Mean_epoch__
1831 A 1 C 02:169:32156 08:328:00000 05:247:70322
    
```

**Література**

- [1] [http://ilrs.gsfc.nasa.gov/stations/sitelist/LVIL\\_sitelog.html](http://ilrs.gsfc.nasa.gov/stations/sitelist/LVIL_sitelog.html)
- [2] [http://www.mao.kiev.ua/EOP/ENGLISH/slr/lviv/slr\\_lviv\\_location.html](http://www.mao.kiev.ua/EOP/ENGLISH/slr/lviv/slr_lviv_location.html)
- [3] [http://itrf.ensg.ign.fr/ITRF\\_solutions/2005/ITRF2005\\_SLR.php](http://itrf.ensg.ign.fr/ITRF_solutions/2005/ITRF2005_SLR.php)
- [4] [http://itrf.ensg.ign.fr/ITRF\\_solutions/2008/ITRF2008\\_files.php](http://itrf.ensg.ign.fr/ITRF_solutions/2008/ITRF2008_files.php)
- [5] [ftp://cddis.gsfc.nasa.gov/pub/slr/products/resource/SLRF2008\\_110913.txt](ftp://cddis.gsfc.nasa.gov/pub/slr/products/resource/SLRF2008_110913.txt)