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# THE OPERATION OF THE JOINT ASTRONOMICAL, GEODETIC AND GEOPHYSICAL OBSERVATION STATION NEAR POLTAVA

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### Problem in General Terms

Decision of many important problems of geodynamics (the study of the evolution of the Earth's figure, the research of various phenomena and processes occurring inside the planet and on its surface) requires a complex approach. It can be ensured by carrying out joint astronomical, geodetic and geophysical observations (JAGGO) in the same place. In particular, all combinations of Love's numbers characterizing the elastic properties of the Earth can be determined on the basis of such observations. The data of these JAGGO of point spatial position changes can be used for creating coordinate networks of different purpose, for establishing zero-points of terrestrial coordinate systems, for high-precision navigation.

### Analysis of Recent Research and Publications

The importance of joint use of different type observations is shown in the works [1-5]. The expediency of creation of individual stations of JAGGO and their networks in Ukraine, Eurasia and the world is substantiated in the articles [2, 3, 5-8].

Of course, there are research institutions in the world that perform complex geodynamic observations [9, 10]. Poltava Gravimetrical Observatory (PGO) is one of them [11]. But their points of different type observations are usually at considerable distances and interconnected only by local coordinate network (LCN) in the best case.

Real jointing of different type observations is realized in the PGO at the experimental station created near Poltava at the observation basis of URAN-2 radio-telescope in Stepanivka villiage [12, 13]. Its observation points are very close together, in the same building. The peculiarity of this station is also that the results of different observations at its points in different epochs can be reduced to the same geometrical centre. A corresponding technique of reduction measurements and calculations should be applied for such reducing [13-15].

### Formulation of the Problem

The purpose of this paper is a brief overview of the current situation at the station of JAGGO in Stepanivka, types of the performed observations, researches and their results, achievements and problems in its operation, possible prospects of the station development.

### A Brief Description of the Station

The station of joint observations is in Stepanivka village of Poltava region, 20 km from Poltava in the north-easterly direction. The station coordinates are: 49º 37' 49" north latitude, 34º 49' 21" east longitude. The height above the sea level is about 110 meters. The surrounding area is flat, the soil is sandy black soil.

The station has four observation points and the network of wall elevation bench marks (see the figure).

1) The fundamental geodynamic point (it is equipped in the basement of the building; there are main 1.1 and additional 1.2 bases; the diameter of the main base is 1.67 meters, it has three marks; the diameter of the additional base is 1.14 meters, it has one mark; the vertical through-holes through all floors of the building are above the bases; an inclined through-hole toward the north celestial pole is also above the main base).

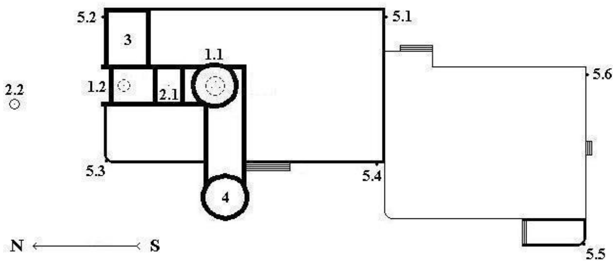
2) The point of geodetic determinations (it has two places of observation: 2.1 is the main point in the form of a four-legged steel tripod on a metal grid, attached to the iron-concrete plate, which is located above the third floor of the building on its load-bearing walls; the mark is embedded under the tripod in the plate; 2.2 is the azimuthal point, in the form of the ground elevation bench mark, it is located 383 m to the north from the main one).

3) The point of linear-angular geodetic determinations; it was built as a new pavilion for satellite laser ranging; it is located in the north-eastern part of the building above its second floor.

4) The point of astrogeodetic and geophysical determinations (it occupies the western tower of the building, a pavilion for zenith-polar astronomical observations was planned to be equipped on the third floor of the tower).

5) The network of wall elevation bench marks in the laboratory building (bench marks 5.1-5.6).

The figure shows the three-story part of the building (in a very thick line), the two-story part of the building (in a thick line), the one-story part of the building (in a thin line), the projections of the bases that are in the underground floor of the building (in a dotted line).




*The Figure. The Scheme of the Station of Joint Observations (reference designations are given in the text)*

### The Description of Performed Types of Observations, Their Goals and Results

It is clear from the station name that several types of observations for the purpose of geodynamics can be performed at the station. Geodetic determinations constitute the largest part of the already made determinations for the present; regular geophysical determinations and accompanying meteorological ones are carried out. Astronomical determinations have not yet been started; reducing measurements are fulfilled only in part.

***Geodetic Determinations.*** Classical geodetic measurements (of angles, distances, elevations) and satellite observations were conducted at the station during the period of its creation and operation.

*Satellite Laser Ranging (SLR).* Experimental observations of low-orbit artificial Earth satellites Ajisai, Topex, Adeos and others were conducted through LD-2k during 1994-1997 at Point 4, in its upper part, where the pavilion of laser rangefinder observations was, to determine changes of station coordinates and the gravity field of the planet. Nekrasov V.V. and Tyshchuk M.F. carried out the observations in the mode of testing hardware and its modernization. The initial processing of the observations was made in PGO, and the main one was performed in the Main Astronomical Observatory of NAS of Ukraine. If at the beginning of the observations the accuracy of measuring distances to the satellites was 1.5 meters, the accuracy reached at a later stage was 0.4-0.5 meters. But also it was not enough at that time. The main reason for the low accuracy of the observations was outdated electronic equipment. The design of the hemispherical dome with a vertically oriented slit that is typical for astronomical pavilions also created significant difficulties in SLR. Therefore, the observations were stopped at this Point and the construction of a new pavilion for laser rangefinder (Observation Point 3) was started. However, the construction was not completed because of funding cuts due to the decrease of the number of SLR points in Ukraine and termination of the observations in Poltava.

*Observations in the Global Navigation Satellite System (GNSS).* Several series of GNSS-determinations were conducted at point 2. Today we have the results of coordinate determinations of the campaigns of 1999 and 2012, the coordinate changes between these epochs for the main 2.1 and the azimuthal 2.2 observation points. The campaign of 1999 was performed by specialists of the Ukrainian State Aerogeodetic Enterprise under the direction of Antoshchuk A.O. and Zagoruyko V.O. with our participation. The GNSS-receivers Trimble 4000 SSE were used. The duration of the observations was two days. The campaign of 2012 was performed by Stakhiv D.V. from SSPE "Poltava Geodetic Center" with our participation. The GNSS-receivers Trimble 5700 were used. Measurements at the main point lasted for one day, and at the azimuthal point they were taken in two series and five-hour and four-hour observations were performed. Observational data were processed in the Research Institute of Geodesy and Cartography (Kyiv). Besides that, we calculated azimuths, chord lengths, arc values of the segment 2.1-2.2, and their changes.

The main point of geodetic determination 2.1 is included in the state geodetic network as "URAN-Stepanivka". It is referred to a special group of points of GNSS-determination, located mostly at observatories and observational stations. Determinations at the point were performed for creation and support of the state geodetic network, as well as for some other researches.

*Tacheometric Determinations.* They were performed at the main point of geodetic determinations 2.1 in 2000 by Samoilenko O.M. group from the Ukrainian State Research and Production Center of Standardization, Metrology and Certification and with our participation. Electronic tacheometer Sokkia SET500 was used. The purpose of the work was creation of a local coordinate network (LCN) at the joint observations station. The azimuthal point of geodetic determinations 2.2, the point of astrogeodetic and geophysical determinations 4 and the centre of antenna field of radio-telescope URAN-2 were also included to the LCN in addition to the mentioned point 2.1. As a result all points of the LCN were determined in the state system of coordinates and the azimuth of the direction 2.1-2.2 was transferred to other directions of the network.

*Geometric Levelling.* We have been performing levelling works periodically since 2001. Local levelling network (LLN) of the JAGGO-station consists of the marks of observation points 1.1, 1.2, 2.1, 2.2 and the network of six wall elevation bench marks 5.1-5.6. The purpose of these works is determination and control of altitude stability of the observation points and laboratory building of the radio-telescope. The altitude linking of the LLN to the state levelling network and seven series of determinations of elevations in the network have been made at present. Height changes of the marks and bench marks relative to the mark of the fundamental geodynamic point 1.1 have been obtained. Levels H-3, H-05, HB-1 were used for measurements.

***Geophysical Observations.*** Similarly to geodetic determinations, we also plan to perform various geophysical measurements at the station. But only tilt observations are conducted so far.

*Tilt Observations.* *S*ince 2009, we have been performing continuous weekly experimental determinations of the Earth's crust tilts at the main base 1.1 of the fundamental geodynamic point using four tiltmeters with arcsecond levels. There are two tiltmeters in the direction of the meridian (NS) and two ones in the direction of the prime vertical (WE). The main goals of the observations are: to study the stability of the main fundamental base at the station of joint observations in Stepanivka viliage, to study long-time Earth crust tilts in the direction NS and WE, to study such a well-known peculiarity of tilt observations when different tiltmeters give different results at the same base. The technique of parallel tilt observations with mutual control at the same base is used in the current study. 5.5 years series of tilt determinations have been received. Preliminary conclusions about the character of the tilts in this place, their features in different parts of the base have been made.

***Meteorological Observations.*** Meteorological determinations always accompany geodetic, geophysical, astronomical observations, and they are auxiliary in most cases. If meteorological determinations are conducted regularly and over a long period of time, they acquire independent significance and also allow to conduct some researches of meteorological character. A similar situation has also developed at our joint observation station. At first, determinations of atmospheric parameters and environmental parameters at the main base 1.1 of the fundamental geodynamic point only accompanied regular tilt observations, and now, they are a separate type of observations, having clear periodicity and significant duration.

*Observations of the Atmosphere.* These include: external temperature measurements at the station and estimation of cloudiness on the ten-point scale (since 2009), determination of wind direction and estimation of wind strength on the Beaufort scale (since 2010). They are carried out by us on a regular basis, weekly, twice during tilt observations. The main goal is to study links of atmospheric factors with crust tilts. As a result of these observations, the seasonal character of influence of the external temperatures on the tilts is clearly seen.

*Observations of the Environment at the Point.* These include temperature measurements in the basement at the main base 1.1 (since 2009) and determinations of directions of faint air flows (DFAF) over this base. They are also performed by us on a regular basis, weekly. The temperature is measured twice during tilt observations. Determinations of DFAF are made after tilt observations. The study of DFAF was started in 2011 at four points on the base. The number of determination points was gradually increased, and from the beginning of 2012 the determinations of DFAF have been conducted at fifteen points of the base. The purpose of these determinations is to study the influence of the environmental heterogeneity at the point on the results of the tilt observations, and the interrelation of the environment at the point and the atmosphere (since this basement has no perfect thermal isolation neither from the first floor, nor from the other basements, nor from the external environment, and there are some elements of heating system of the laboratory building). The performed observations evidence heterogeneity of the environment over the base and its certain influence on the results of measurements of the tilts.

### Unrealized Types of Observations

Part of the types of observations planned for conducting at the station of JAGGO have been already made or continue running. But there are still some that could not be carried out until now. There are some objective reasons and difficulties for this, which can be overcome, and our plans for starting astronomical measurements and expanding reducing ones can be realized.

***Astronomical Observations.*** Determining the coordinates (latitude, longitude) and azimuths by astronomical methods and means belong to the planned observations. They will serve as an independent method of determinations, and combined with geodetic ones they will give a possibility to obtain components of plumb line deflection in the meridian and the first vertical. Besides, it is known that regular monitoring of latitude, longitude, and azimuth changes only in one point allows to determine autonomously the Earth's pole coordinates.

On the way to conducting astronomical observations we face significant problems: the lack of portable instruments (field type) and significant building and practical difficulties. It was planned that astronomical observations could be carried out at all four points. However, due to objective technical, construction, financial and practical reasons they have not been started. For the present astronomical observations can be made only at the main point of the geodetic determinations (2.1).

***Reducing Determinations.*** They are selected by us as a separate group, as they play a special role at the station of JAGGO. All observation results at any points in different epochs must be reduced to the geometric centres (marks) of the fundamental geodynamic point 1 by means of the reducing measurements. They include measurements of angles, lengths of lines, elevations, as described in detail in works [10-12].

Today it is realized only in part, for transferring heights from the observation points and elevation bench marks to the fundamental geodynamic point through the vertical through-hole above the additional base 1.2 of this point. To transfer spatial, spherical, plane coordinates and azimuths it is necessary to ensure the opening of another vertical through-hole above the main base 1.1.

### Perspective of Metrological Measurements

The station of joint observations is an object created for comprehensive studies, determinations and measurements in different areas. Standard polygons for metrological control of various devices and measurements can be created at its basis.

Activation of GNSS-determinations at the point of geodetic observations 2 can provide creation of conditions for execution of metrological attestation of geodetic instruments at its basis.

There are conditions for creating a standard basis for metrological attestation of instruments for measuring angles and distances (such as theodolites, tacheometers, rangefinders) on the basis of the observation points 2 and 3, using the construction elements of URAN-2 radio-telescope, that are standing at the capital substructures, if to provide the station with appropriate modern instruments for measuring angles and distances that are widely used by various performers of geodetic works. But metrological studies do not yet have adequate state support, that restrains the development of the appropriate research bases.

### Conclusions

1. Despite great economic difficulties the station operates, it is used by us and stakeholders.
2. The data are accumulated at the observation points.
3. The main point of geodetic determinations 2.1 is included in the state geodetic coordinate network.
4. It is possible to create standard polygons for metrological attestation of geodetic instruments for measuring angles and distances on the basis of the observation points of the station.
5. There are opportunities for organization and research of new untraditional types of determinations of distances and angles at the station.

### References

1. Gozhy A.V., Tyshchuk N.F. Izuchenie vremennyh izmenenij napravlenija sily tjazhesti po dannym astronomicheskih nabljudenij //Tr. III mezhdun. Orlov.

konf. "Izuchenie Zemli kak planety metodami astronomii, geofiziki i geodezii". -Kiev,1994.- S.197-199.

2. Gozhy A., Tyshchuk M. On the using of astronomical data for the test of some geophysical hypotheses //Proceedings Systemes de Reference Spatio-Temporels 1995, edited by N.Capitaine, B.Kolaczek, S.Debarbat. -Warsaw,1995.-P.170.

3. Gozhy Adam, Tyshchuk Nikolaj. O celesoobraznosti prodolzhenija dolgovremennyh astroopticheskih nabljudenij za izmenjaemost'ju koordinat //Trudy Vseros. konf. "Sovremennye problemy i metody astrometrii i geodinamiki".-S.-Peterburg,1996.- S.273-276.

4. Gozhy A., Tyshchuk M. On the principles of the astrooptical observations continuation for the changes of coordinate stations nowadays and in the future //Proceedings Systemes de Reference Spatio-Temporels 1997, edited by J.Vondrak & N.Capitaine. -Prague,1997.-P.202-204.

5. Gozhy A., Tyshchuk N., Novikova Ju. O celesoobraznosti i principah prodolzhenija astroopticheskih nabljudenij za izmenjaemost'ju koordinat //Kinematika i fizika nebesnyh tel. Prilozhenie.-Kiev,1999,№1. – S.109-110.

6. Gozhy A.V. Pro docil'nist' stvorennja v Ukrai'ni dekil'koh punktiv sumisnyh astronomichnyh, geodezychnyh i geofizychnyh sposterezhen' v glybokyh vertykal'nyh shahtah //Geodezija, kartografija i aeroznimannja.-L'viv,2000, №60, S.11-15.

7. Gozhy A. Obgruntuvannja docil'nosti stvorennja v Ukrai'ni special'noi' merezhi punktiv sumisnyh kompleksnyh astronomichnyh, geodezychnyh i geofizychnyh sposterezhen' za zminoju i'h prostorovogo polozhennja //Suchasni dosjagnennja geodezychnoi' nauky ta vyrobnyctva: Zb. nauk. pr.-L.,2003.-S.98-102.

8. Gozhy A. On expediency of creation in Eurasia network of unified points of joint astronomical, geodetic and geophysical determinations of their position changes //Proceedings Systemes de Reference Spatio-Temporels 2003, edited by A.Finkelstein and N.Capitaine. –St. Petersburg,2003.-P.238-239.

9. http://www.cbk.poznan.pl.

10. www.pecny.cz.

11. http://pgo.geoplanet.org.

12. Gozhy A., Tyshchuk M. Stvorennja stancii' sumisnyh astronomichnyh, geofizychnyh i geodezychnyh sposterezhen' dlja potreb doslidzhen' z geodynamiky //Kinematika i fizika nebesnyh tel. Prilozhenie.-Kiev,1999,№1. –S.113-114.

13. Tyshchuk M., Gozhy A. Stvorennja eksperymental'noi' stancii' sumisnyh astronomichnyh, geodezychnyh i geofizychnyh sposterezhen' //Suchasni dosjagnennja geodezychnoi' nauky ta vyrobnyctva: Zb. nauk. pr.-L.,2003.-S.103-109.

14. Tyshchuk M., Gozhy A. On reduction of results of joint astronomical, geodetic and geophysical observations to one geometrical centre //Kinematika i fizika nebesnyh tel. Prilozhenie.-Kiev,2005,№5. –S.369-371.

15. Tyshchuk M. Pro pryvedennja rezul'tativ vyznachen' koordynat na dopomizhnyh punktah sposterezhen' do osnovnogo geometrychnogo centra //Suchasni dosjagnennja geodezychnoi' nauky ta vyrobnyctva: Zb. nauk. pr. Vypusk II (14). -L'viv, 2007. – S.68-72.

## The Operation of the Joint Astronomical, Geodetic and Geophysical Observation Station near Poltava

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The current situation at the station of joint astronomical, geodetic and geophysical observations in the Stepanivka village is briefly described, namely: the purpose of the station, its structure, types of the performed observations, their goals and results, achievements and problems in the operation of the station, possible prospects of its development.