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VISUAL OBSERVATIONS OF AURORAE DURING THE IGY IN THE SOVIET UNION*

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Introduction

The 50-th anniversary of the International Geophysical Year (IGY 1957-1958) attracts the attention of researchers and historians of science, since during the period of IGY on the basis of international cooperation there were for the first time carried out global geophysical studies of our planet. They allowed to obtain impressive scientific results, recognized by the general public and had an effect on the results of scientific studies of subsequent epochs.

A special place in the IGY program was held by visual observations of aurorae, which provided a unique possibility, for those times, to determine the regions of intrusion of energetic charged particles into the upper atmosphere from the outer space and their dynamics (based on observations in high latitudes) or the level of planetary geophysical activity (based on observations in middle and low latitudes). The program of visual observations of aurorae had a mark of personal interest of CSAGY President and Reporter for Aurora and Airglow S.Chapman in those studies.

W.Schröder (EOS, 88, N12, 20 March, 2007), when discussing the history of the organization and the carrying out of visual auroral observations, mentions the names of researchers from the USA (C.Gartlein and G.Sprague), England (J.Paton), Germany (C.Hoffmeister), Canada (P.Millmann). Meanwhile, in the international planning and then during the organizing of such observations in the Soviet Union, an exclusively important part was played by concrete scientists rather than by impersonal Soviet Academy of Sciences or the Geophysical Committee. We, who used to be active participants in the IGY program have decided to make the filling of this extensive gap in Schröder's description.

Visual observations

The leader of the program of visual observations of aurorae and the organizer of the observational network in the Soviet Union during the IGY was Nikolay Vassilievich Pushkov (1903-1981), director of IZMIRAN at the time and the deputy chairman of the Soviet Geophysical Committee. As a member of CSAGY, Pushkov was together with Chapman, Gartlein, Paton and Millman at the origins of the international program of visual observations of aurorae and the methods of observations implementation, that were accepted for the period of IGY were based on their recommendations.

N.Pushkov became interested in aurorae studies at the starting period of his scientific career. In the 30-ies of the last century, he and his co-authors published 2 scientific papers dealing with the connection of aurorae with magnetic activity. There were used the results of visual observations of aurorae in Franz-Josef Land (~ lat. 82^0 N, lon. 60^0 E) and of the network of meteorological stations. As he was taking part in the development of the scientific program of IGY, N.Pushkov returned to studies of aurorae. In IZMIRAN there was established a group for collecting, systematization and analysis of visual observations. To obtain more uniform data by the beginning of IGY there was made up and wide spread an instruction covering aurorae observations by volunteers, amateur-astronomers and meteorologists [1]. It was recommended to perform observations only along the geomagnetic meridian rather than all over the sky. Information about the longitudinal extension of luminosity was supported by 620 points, which observation results from the USSR territory were collected at IZMIRAN. Their location is presented in Fig. 1 [2]. In winter 1954-1955 in the Western sector of the Soviet Arctic (lat. $67^0 \div 83^0$ N, lon. $50^0 \div 110^0$ E) hourly auroral observations were carried out at 50 meteorological stations [3]. The collected material allowed both to specify a number of some previously known facts concerning the dimensional distribution of aurorae and to acquire some experience in the organization of uniform observations within an extensive network.

The main method of obtaining information about the frequency of appearance, intensity and distribution of aurorae within high latitudes during the IGY was taking their photographs by an all-sky camera. It was supplemented with visual observations in the middle latitudes. Both types of observations covered practically the entire globe and provided a global picture of luminosity distribution. Observations collected at IZMIRAN were then systematized, which allowed to determine at every hour the UT geomagnetic latitudes of aurorae appearance and their propagation towards the equator (auroral index).

* Devoted to the 50th anniversary of International Geophysical Year

At the CSAGY Assembly in Moscow (August 1958) the procedure of collection, storage and distribution of observations materials, collected during the IGY via World Data Centers (WDC) was adopted. One of the universal WDC was established in Moscow as an IZMIRAN unit. The Assembly made a decision to publish on a regular basis the auroral index in "Calendar Record for the IGY" and to make up visoplots, which give an idea of the spatial-temporal distribution of aurorae. Auroral indices and visoplots were determined in eight longitudinal zones, which borders were geomagnetic meridians every 45^0 : zone 1 – Atlantic, zone 2 – Western Europe, zones 3, 4 and 5 – territory of the USSR, zones 6, 7 and 8 – Pacific ocean and North America. The WDC in Moscow was in charge for compilation of indices and visoplots in three sectors on geomagnetic longitudes of $100^0 – 235^0$. The total visoplots summary based on the data of all World Centers was published in [4]. The auroral index was still continued to be determined at the WDC on a regular basis even after the completion of international projects and was published by J.V.Lincoln in J.Geophys.Res.

The period of IGY fell on the years of extraordinarily high solar activity. The successful termination of this grand scientific and research program predetermined the direction and continuation of international cooperation in the field of auroral studies also in the subsequent years of the solar activity decline. During the period of IQSY (International Years of the Quiet Sun 1964-1965) the collection of observations and their exchange between the WDC was continued [5]. Observation results from 450 points were collected at IZMIRAN. In contrast to the IGY period, the collected data were put on punch-cards to be then sorted out by punch card computer systems. The monthly set of punch-cards on the average amounted to 20,000, while going up to 30,000 in some winter months. The analysis results of the equatorial boundary of aurora position in the zenith, of latitudinal frequency distribution of appearance of uniform and ray forms of aurora in the zenith, of daily variations of the appearance frequency of various forms within the interval of corrected geomagnetic latitudes of $62^0 – 72^0$ and of variations of auroral position in the cycle of the solar activity are presented in [5].

Sergei Ivanovich Isayev (1906-1976) was a pioneer of visual observations of aurorae in the Soviet Union. After his graduation from the University, he took part in 1932-33 in observations of aurorae and geomagnetic field variations within the framework of the program of the Second International Polar Year at the Matochkin Shar observatory (Novaya Zemlya). Being a veteran of the WWII, awarded several times during his military service, after the war he came back to auroral studies. He participated in high latitude expeditions, which were carrying out observations of auroras in the Kola Peninsula in 1948-1949. The obtained results were used as a basis of his PhD thesis (1954) "Geographical distribution of aurorae and their relation with geomagnetic and ionospheric disturbances". In 1952, S. Isayev became the head of Murmansk department of IZMIRAN, whereas in 1960 he became the director of the Polar Geophysical Institute (PGI) newly established in the Kola Peninsula.

Due to the IGY an extensive program of comprehensive studies of aurorae, of magnetic field variations and the ionosphere sounding was launched in the Kola Peninsula. In the early 1957, on the initiative of S.Isayev All-union courses were organized for preparation of aurorae observers, who then were sent to remote polar stations to perform observations, using C-180 and C-180-S cameras. He took an active part in the preparation of the publication of the new Atlas of Aurorae, which IAGA decided to publish due to revision of the aurorae forms classification. S.Isayev became a member of the committee for preparation of the Atlas, which appeared in 1963 [6].

Photographic observations

This kind of observations in the Soviet Union in the period of IGY was directed by Alexander Ignatyevich Lebedinsky, at the time the chairman of Aurora and Airglow section of the Geophysical Committee. He started his aurorae observations in 1948-1950 during the complex expeditions to the Kola Peninsula in the area of Murmansk. In that period A.Lebedinsky built and used in observations original equipment, allowing to carry out automatic one minute photographing of the sky using all-sky camera (C-180) and patrol spectrographs (C-180-S) [7]. Equipment of that type was widely employed during the IGY at dozens of Soviet stations in the Arctic and Antarctic. His extensive experience in studying aurorae, acquired in the first expeditions, allowed A. Lebedinsky to take an active part in the development of scientific programs of auroral studies during the IGY. In the end of 1957 A.Lebedinsky undertakes a long travel through the Arctic, inspects auroral stations and helps to adjust the operation of all-sky cameras due to the beginning of the IGY.

In August of 1958 at the CSAGY Assembly in Moscow and at the Regional Auroral Conference in Uppsala, Sweden it was recommended to perform an exchange with copies of ascafilms, collected at WDCs. It was also recommended that the IGY Annals should include a volume dedicated to all-sky camera data in the form of ascaplots. Ascaplots are diagrams, which summarize the information recorded on ascafilms. For each station it shows when the aurora was photographed, in which of the three areas of the sky (north area, zenith area and south area) and what was its intensity. In the Soviet Union ascafilms from the stations were sent out to the Moscow University (MSU) to A.Lebedinsky. To be able to send their copies to other WDCs as well as for making ascaplots based on them some preliminary processing of films was necessary. This labor consuming work involving watching hundreds kilometers of films and making up ascaplots was done jointly by the group of MSU and IZMIRAN researchers.

The prepared ascaplots were sent via the WDC to the Uppsala Ionospheric Observatory to W.Stoffregen. Under his editorship ascaplots were then published in the Annales of the IGY [8]. The analysis of observations material included in the ascaplots, led to scientific results that substantially changed the ideas about the position of auroral zone, that had existed during a century. It turned out that aurorae existed practically continuously along the auroral oval, asymmetrically oriented relative to the geomagnetic pole – in the night hours at $\Phi \sim 67^0$ and in the day hours at $\Phi \sim 77^0$. The oval is fixed in space relative to the Sun and the Earth rotates below it. The near midnight sector of the oval glides above the Earth's surface along the geomagnetic parallel $\Phi \sim 67^0$, whereas the day sector of the oval glides along the geomagnetic parallel $\Phi \sim 77^0$, thus explaining the existence of the "basic" and the "second, near pole" zones of aurorae [9, 10]. Therefore, the analysis of observations of the IGY period resulted in generalization of the concept of zone of the most frequent appearance of aurorae in the zenith, which is fundamental for geophysical science. Later on satellite observations identified a close connection of auroral oval with plasma domains of the magnetosphere. Along the auroral oval hot corpuscles flow down from magnetosphere into ionosphere. Along this flowing, one can observe intensification of some geophysical phenomena: along the magnetic lines of force, supported by the oval, there occur intense ELF/VLF electric and magnetic waves; strong electrojets flow in the ionosphere in the E layer; areas of anomalously increased ionization appear in F and E regions, the ionosphere structure becomes non-uniform. The oval naturally fits in the large-scale structure of the geomagnetic field, compressed in the day side of the Earth by the solar wind and are elongated in tail on the night side. Ascaplots also allowed to fulfill the goal, preplanned by S.Chapman prior to the beginning of IGY –to build maps of isoaurorae, the lines of equal frequency of aurorae appearance in the zenith, based on IGY materials. Such maps are presented in Fig.1 [10] for the northern hemisphere separately for night and day hours. An invited talk, dedicated to basic spatial-temporal regularities in aurorae was presented at a Joint IQSY/COSPAR Symposium held in London in July 1967 and was published in [11].

A group of astronomer from Kiev University lead by S.K. Vsekhsvyatsky and E.A. Ponomaryov actively participated in the IGY aurora researches. In Tiksi Bay a wide range of electromagnetic geophysical event including aurora was measured. Observations using C-180-S spectrographs provided extensive material for identification of reciprocal position of electron and proton aurorae, differences in auroral spectra along the oval and in the polar cap as well as at different hours of local time, cyclic changes of spectra of various auroral types.

The material received during the years 1957-1966 at some Soviet Arctic and Antarctic station using patrol spectrographs C-180-S has been analyzed. It is shown, that in the years of the solar activity maximum (1957-1959) in auroral zone (Φ = 60-67^o) proton aurora (emission H_α) and electron aurora (emission $1PGN_2$) were mainly observed, which during great magnetic disturbances were accompanied by red aurora of the type A (λ 630.0 – 636.4 nm). In polar cap the most typical in this period was aurora of slight intensity, but in the spectrum of which the red oxygen lines of λ 630.0 – 636.4 nm predominated.

In the years of solar activity minimum (1962-1966) in auroral zone usually proton and electron auroras predominated, but in this period red aurora of the type A were not observed. In the polar cap, at least in Mirnyy (Φ = 77^o S), the character of auroral glow was changed. According to the observations of 1962 and 1963 there was registered aurora the spectral characteristic of which was of the same character as that of the auroral zone [12].

As a conclusion we express our deepest gratitude to all the polar investigators, who carried out the visual and instrumental observations of auroras under exceptionally hard conditions of the Arctic and Antarctic.

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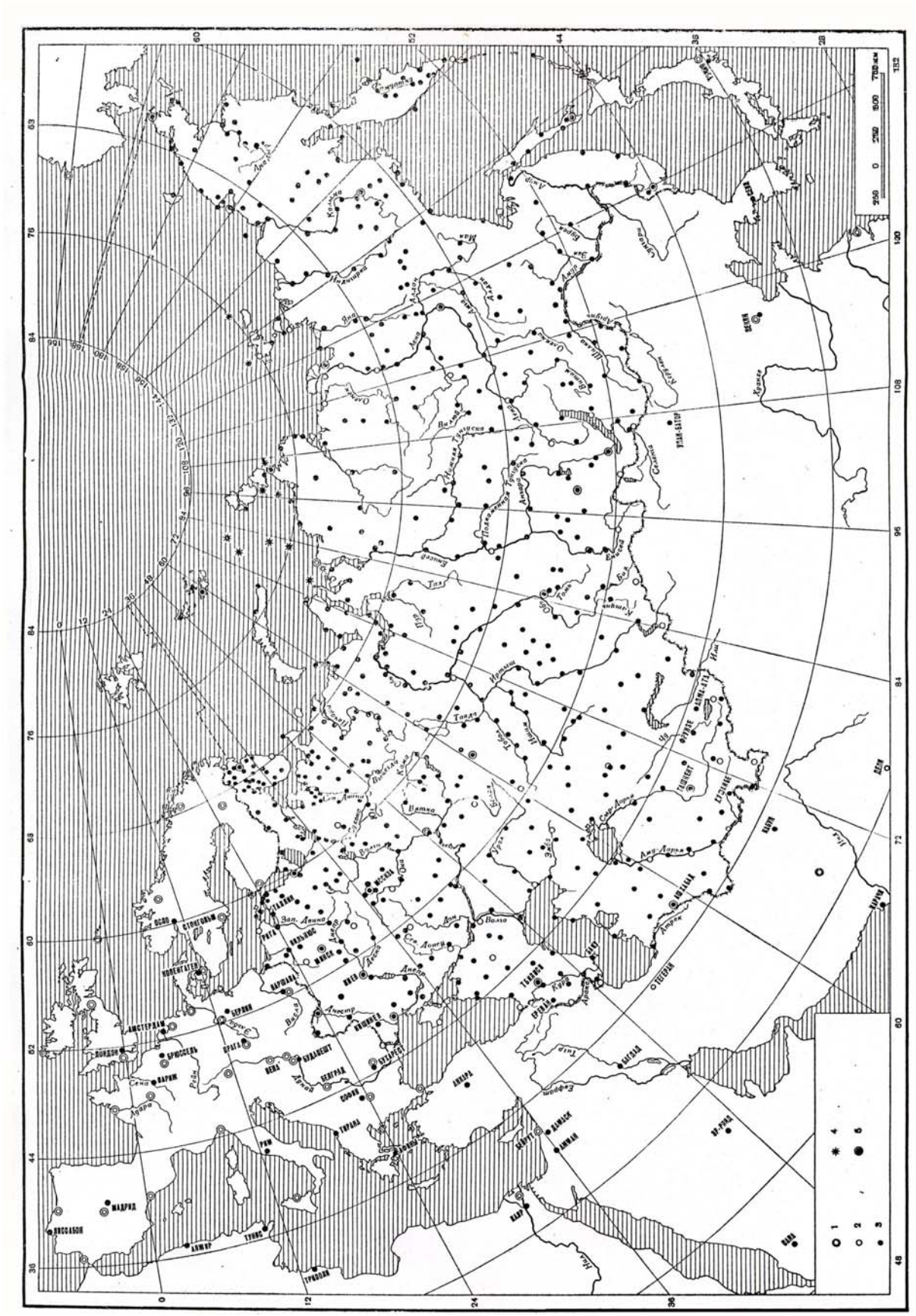

Fig. 1 [2] The map of the stations of aurora visual observations on the USSR territory during 1957-1959 years.