

**Experimental researches on the ionospheric and low atmospheric phenomena
related to the super power aurora :
light streamers, auroral audibility and anomalous ozone**
(The working program to be proposed as one of the subjects of the all Russia wide
co-operation for the coming International Polar Year (IPY) period)

I. The contemporary state of the problems

1.1 Summary of the experimental research history related to the auroral audibility).

This part of the proposed project is, in fact a real challenge for the humanity at least since all previous experimental attempts to get experimental recordings of the extremely weak aurora sounds associated with a super power aurora (SPA) finished with a failure. For example, in 60-ies the US scientists carried out the special experiment using a few dozens of the best (highly sensitive) microphones distributed over rather extended square in the Alaska snow desert. Experimental efforts lasting for a few years finished in a failure (see, e.g. the report presented to one of the AGU sessions somewhere in middle of 80-ies). So that up to now days the information about auroral sounds exists only in anecdotal form (in form of retellings made by witnesses) nevertheless that the whole history of similar retellings exceeds more than 200 years.

According to contemporary understanding there are at least two physical mechanisms those could be behind the most puzzling feature of auroral sounds: an absence of any time delay between the moment of fast movements of auroral forms and moment of hearing of the accompanying sounds by human ears (see, e.g. the popular review titles as “Sizzling skies” and published in “New Scientist” weekly magazine (6 January 2001) by Colin Keay, (a physicist at the University of Newcastle in Australia who is one of the pioneers of these studies). The mechanisms are the followings:

- 1) low atmospheric discharge induced by enormously great amount of electric charges accumulated at ionospheric altitudes during the SPA events. The matter is that the FACs attributed to the super power aurora are so extremely strong and fast moving (millions of amperes and up to 10 km/s, respectively) that real auroral ionospheric conductances are not able to close these FACs by the horizontal ionospheric currents carried mainly by massive inertial ions.. That’s why the great amount of electric charges has to be accumulated near the bottom of the dynamo layer (at altitudes around ~100 km). The situation seems to be quite physically analogous to the low atmospheric lightning phenomenon. The huge charges are able to induce the low atmospheric coronal discharge, which, in its turn, creates the acoustic signals accompanying the “aurora borealis dance”.
- 2) Retransduction of the ordinary E-M waves (VLF-emissions) associated to such aurora into the acoustic and heat waves. The process of the retransduction requires an existence in the surrounding air of special objects similar to e.g. ice needles those can absorb the E-M waves and later to transform their energy into emitted acoustic or heat waves. By the way, as far as we see, a lack of similar re-transducers in the Alaska snow desert could be the reason why the above mentioned experimental attempts finished with the failure.

1.2 The anomalous ozone associated with the SPA events.

The numerous witnesses used to report about the smell of ozone which they often felt during the SPA events. Obviously, that the above evidences seem to be quite natural at least in the framework of the 1-st above discussed SPA physical mechanism since a coronal discharge is well known as a powerful generator of the low atmospheric ozone.

1.3 Extremely low altitudes of the auroral luminosity often associated with the SPA events according to systematic of the testimonies of the witnesses. Such a phenomenon often called as auroral light streamers often are reported to be seen up to altitudes of a few km above the Earth surface. Most probably their physical nature could be analogous to streamers associated with the low atmospheric lightning. However, the experimental testing of the similar working hypothesis is obviously needed.

II. Multi-instrumental approach planned for the experiments

According to our experience the following multi-instrumental measurements have to be carried out during the coming IPY intervals in order to get really new data allowing us to solve the enigma of the SPA physical nature.:

1. TV-recordings of the super power aurora (SPA) with maximum possible space and time resolution. (Special TV cameras having a huge dynamic range are needed).
2. Recordings of the related VLF-emissions having both noisy (wide spectral) and tonal (narrow spectral) properties.
3. All-weather monitoring of the vertical component of the low atmospheric electric fields or low atmospheric currents.
4. Recordings of the auroral sounds with a special type of extremely sensitive microphones provided by the special heating facility allowing to operate them in the extremely low (frozen) outdoors temperatures.
5. Monitoring of the whole set of the standard low atmospheric meteorological parameters
6. Monitoring of low and high (30-40 km) atmospheric ozone
7. Monitoring of auroral absorption.
8. Monitoring of the UHF radio emissions.
- 9.

III The responsibility sharing between the institutions involved in the project

An agreement for co-operation achieved in the framework of the project between several Russian institutions such as: Institute of the Earth Physics (IFZ, Moscow); the Polar Geophysical Institute of the Kola branch of the RAS (PGI, Apatity); Institute of the Solar-Earth Physics of the Siberian branch of the RAS (ISZF, Irkutsk); Institute of Cosmic Physical Researches and Aeronomie, (IKFIA, Yakutsk) and related institutions of the Kamchatka branch of the RAS allows us to cover more 150 degrees of the longitude by well equipped ionospheric and low atmospheric observatories. Such a unique spatial size of the co-ordinated measurements, hopefully, will allow us to make recordings of the extremely tricky SPA phenomenon.

The co-operation within the project, in particular, includes the following sharing of the scientific task among the above listed institutions:

- 1) The PGI scientists have got an experience in aurora TV recordings using the Low Light Level TV cameras (LLLTV-camera) on the basis of Image intensifier + Charge Couple Device (CCD) or Intensifier + Silicon Intensified Target (I-SIT videocon). The dynamic range, temporal resolution and sensitivity of both devices could be acceptable for task of correlation of auroral sounds variations and auroral luminosity variations both in time and space.
- 2) For monitoring of the anomalous ozone generation processes attributed to the SPA events we plan to carry out the permanent measurement of the surface ozone content (SOC). There are at least two scientific teams experienced in such measurements: the PGI Arctic Atmosphere Laboratory and our Sodankyla Meteorologil Observatory colleagues
- 3) As known atmospheric electric field variation at the ground (surface) level are in a good correlation with aerosol density near this surface. That's why we plan to carry out measurements of aerosols during the SPA events by efforts of the Aerosol Physics laboratory specialists (headed by Prof. Lev Ivlev), Dept. of Atmosphere Physics of St.-Petersburg University.
- 4) For monitoring of the 3D picture of the large-scale spatial distribution of the ionization the project team plans to use an original method of the radio topography developed by the PGI group headed by Prof. E.D. Tereshenko in co-operation with the Moscow University group headed by Prof. Kunitsyn.
- 5) The scientific team headed by Prof. Eugene A. Mareev has a unique experience in analysis of the atmospheric electricity data (Institute of Applied Physics, Russian Academy of Sciences, Nizhny Novgorod, Russia). Recent studies of short period electric-field pulsations gave evidence for universal spectra of electric field fluctuations and aereoelectric structures in the atmosphere. We plan to use the original approach and data handling methods developed by this group for analysis of the vertical atmospheric E-field data attributed to the Super Power Aurora (SPA) events.

II. Specific details of the Experimental arrangements

The Polar Geophysical Institute (PGI) has got a unique experience of the experimental researches on the auroral audibility problems. In particular, in 1996-1998 a special experimental group including experienced acoustic specialist, engineers and so-called “aurora sound hearers” experienced in hearing of similar sounds in conditions of extreme silence of polar forests was organized under supervision of Prof. Leonid Lazutin.

Reports describing results obtained by this group were submitted to several IAGA Assemblies (1997, 1999) as well as to international acoustics congresses held (e.g. in Copenhagen, 1999 and Hong-Kong, 2001) but were not publicly presented to the scientific community due to financial shortages (problems). So that, the results are published still in form of abstracts of the corresponding reports (see, list of related references given below). However, now an extended article devoted to description of the multi-instrumental ground based and satellite data recorded during of one of super power aurora events is on the way to publication in *Annales Geophysicae*.

As known from systematics of the auroral audibility retellings (see, e.g. famous review of Silverman and Chant, 1973) auroral sounds accompanies only highly dynamical rayed aurora which is typical for auroral oval latitudes but not for the PC or cusp aurora. Therefore, the positions of the ground-based observatories specially orientied to the SPA-sound recordings should be limited by the auroral latitudes.

Moreover, the above mentioned requirement of the extreme silence needed for the successful recordings, dictates additional limitations to the reasonable positions of the observatories. Namely, all windy places similar to ocean banks (shores) or rather small ocean islands should be excluded from the list of the reasonable candidates.

According to our (the PGI) experience we can recommend such observatories as:

e.g. Lovozero, Sodankyla, Kiruna, Tixy Bay in the Northern hemisphere and Vostok from the list of Antarctic stations. However, in at least Russia Antarctic station the problem of acoustical noise created by portable electric power supply station “dizel” should be solved.

Group of the forecasting of the Solar activity from the S-PTb. University headed by Dr. Dmitry Ponyavin is planned to co-operate in the project. The methods used are based on the original approach developed by Chertkov and Pudovkin, 1987.

The PGI group headed by Dr. Tatyana Hviuzova experienced in forecasting of the super power aurora events using the Solar data base stored in Boulder, Colorado is planned to take part in the project.

The PGI atmospheric laboratory headed by Dr. Mikhail Beloglazov plans to carry out the permanent monitoring of the low atmospheric currents in Svalbard using method of so-called “long horizontal current string”: metallic string hanged at 4-10m altitude above the Earth surface and closed to artificial ground contact (“zazemleniye”) via highly sensitive galvanometer.

Geophysical dept. of the AARI headed by Prof. Oleg Troshichev is going to install similar facilities simultaneously in three Antarctic stations in the framework of the separate Russia-US co-operative program.