Session 5

Artificial Aurora, Airglow and Clouds

Dynamics and structure of artificial clouds in the experiments under CRRES project

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Optical observations carried out in June-August 1991 in Cuba and onboard the scientific vessel "Professor Zuobov" allowed to study the features of the structure and dynamics of artificial neutral and ion barium clouds generated in the ionosphere over the Caribbean region from the CRRES satellite. The paper describes optical instruments used in experiments. Observations showed that the ion cloud is formed at a distance of 10-18 km from the injection point and is followed by a conic structure stretched along the satellite orbit after the neutral cloud. A beam of Ba^+ ions is noted to form and move along the geomagnetic fields lines into the Southern Hemisphere with V=4.5-5.0 km/s. The total period of barium cloud observation amounted to 14 hours. Irregularities of various scales are revealed in the cloud, making up some units of kilometers in the dense forward section of the cloud and several kilometers in its tail. Spectral observations indicate the occurrence of barium ions directly after injection.

OPTIC MODEL OF AN ARTIFICIAL COSMOSOL CLOUD

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A model of solar light scattering on artificial cosmosol spherical cloud is developed on the basis of numerical solution to the radiation transfer equation. The model allows to calculate radiation field with due regard for any order of dispersion ratio of variation substances and their mixtures at a random concentration distribution along the radius. Optic images of clouds are modeled under different observational conditions. The intensity of output radiation as a function of substance distribution within the cloud is also evaluated Colour variations of the artificial structure are obtained on the basis of spectral dependences of intensities. Calculated results are shown to satisfactorialy agree with experimental data from cosmosol clouds observations.

"COLOUR DYNAMICS" OF AN ARTIFICIAL BARIUM CLOUD

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Dynamics of radiation intensity distribution in the pictorial plane is calculated using the model for the population of power levels of neutral and ionized barium under the influence of UV and visible solar light flux. Calculations take account of radiation transfer in an optically thick artificial glowing cloud (AGC) consisting of barium vapours. A colour image of the loud is obtained for various observation anglel on the basis of the colometric XYZ model. Model estimates are compared to optic observations of barium clouds in rocket and satellite experiments. Solar illuminated barium AGC is shown to display colour distribution variations at different phases of cloud evolution.

The investigation of the field-aligned current generation during the injection of plasma jet into the magnetosphere

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The report presents a consideration of geophysical effects due to the propagation of high-velocity plasma jet on the height of 500 km. The plasma jet will be injected by the explosive cumulative generator with the velocity 20÷30 km/sec. Possibility of field-aligned current generation is considered. The currents are closed in the ionosphere. The disturbances which produced by currents and fast particles in the ionosphere are estimated. The main phenomena at jet injection in the magnetosphere can be simulated in a laboratory experiment. The parameters of the experiment which permit to reproduce the main phenomena are considered. The fountain pinch plasma generator is used in the laboratory experiment as a source of the plasma jet.

ON THE PROBLEM OF THE FRANK'S HOLES FORMATION IN THE UPPER ATMOSPHERE.

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Frank's holes formation visible in the fluorescent resonant dayglow oxygen emission 130 nm of the Upper Atmosphere is investigated. It is shown that Frank's holes can be a result of meteors entering the Upper Atmosphere. The gaseous shell of meteor "rakes up" an ambient gas. It is shown that for a downward view nearly along the meteor trajectory a significant brightness decrease in the spot with a diameter of tens kilometers must occur. In this case the full meteor mass can be <100 Kg that is much lesser than mass of small comets considered by Frank.

Optic observations of artificial clouds in the ionosphere

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The paper presents summarized data on the dynamics, structure and optic parameters of artificial disperse, neutral and ion clouds generated in rocket experiments at 120-200 km. Described are the ground and aircraft complexes used for object observations, as well as software means for digital processing of cloud images. Dynamic, structural and optic parameters of clouds are considered as a function of generation height, phase of cloud development, and solar illumination conditions. Spectral and polarization parameters of clouds are given. Optic results are compared to model estimates of cloud glow.

OPTICAL OBSERVATIONS IN ACTIVE EXPERIMENTS AND ATMOSPHERIC RESEARCH

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The ground-based and spaceborne optical devices for active experiment and atmospheric emission investigations in the upper atmosphere are discussed. The TV-cameras with low light level television tube (intensified SIT vidicon, isocon and image intensified isocon) are basic devices of ground-based observations. The three-channel spaceborne photometer was disigned for investigation of optical emissions generated in the ionosphere active experiments on electron and plasma beams injection from a satellite.

The comparison of modern low light level imagers used for geophysical research are given. Parameters and features of TV-tube, image intensifier, intensified CCD and resistive anode device for atmospheric research are discussed. The outlook of image systems for space and ground-based observations are considered.

THE MIDNIGHT OBSERVATIONS OF LITHIUM AND BARIUM CLOUDS IN THE CRRES G-06 AND G-08 RELEASES

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Low light level TV and intensified photographic observations in the CRRES G-06 and G-08 releases from Cuba, Sorroa are reported. In the CRRES G-06 Li release at 04:15:00 UT, 12 February 1991 the expanding shell was recorded during 190 sec with non-filtered intensified camera. The centre of the release was observed in the Hydra, = 08:42, = 01.0. Quasi-spherical shell expanded within the velocity of 4.6 km/sec. The shape of the shell is non-spherical probably due to initial release assymetry.

In the CRRES G-08 experiment at 03:30:00 UT in February 17, 1991 the spherical cloud was observed expanding within the rate of 0.8 km/sec from the point with coordinates = 09:38.0, = 03.27.0. At the time about 90 sec after release a bar appeared inside of the nebula, which is oriented along the projection of B onto the image plane. The spherical cloud became indetectable after 200 sec. The bar had been developed into a jet, expanding along the magnetic field with the velocity of 2.5 km/sec. The jet westward drift transverse to the magnetic field was detected at 180 sec after release. Drift velocity increased gradually from 0.66 km/sec (200 sec) to 1.75 km/sec (800 sec) and remained constant till the end of observation (one hour after release). By the end of the observations the jet length was up to 5000 km. The diameter stable less than 100 km. It should be noted that the extention of jet northward was slover than the southward, and after 500 sec elongation in the north part of the jet practically stopped. Probably it was due to jet entering in the Earth' shadow (coordinates of the centre of the shadow were = 10:00, =+12.2, radius 11.3) and brightness of the nothern part of the jet was lower than the threshold of detection.

Electric field determination of remnant ionization cloud of meteor trails

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In the night sky about 10 sporadic meteors/hour are seen visually. During meteor showers the amount of visual meteors could be 50–100 meteors/hour. The meteors become usually visible at an altitude of 110–120 km and they disappear at around 80–100 km. Beside the visual luminosity they ionize the air. When a meteor hith the atmosphere with a velocity of about 30 km/s it ionizes the atmospheric atoms and molecules and after couple of seconds a long expanding ionization tube remains.

EISCAT radar is capable to observe meteoric ionization clouds. During Dec 1990 an optical and EISCAT campaign were made to measure auroras with high temporal and spatial resolution. Beside the auroras some strange short living phenomena were observed. They were due to the meteor trails, which pass the radar beam within about 2 seconds. Because the integration time in the radar was 0.2 seconds and the spatial resolution was 1.05 km the meteor trail shows details in the measurements.

The Geminids meteor shower was active during our optical and radar campaign. From TV-recordings we found about 80 Geminid and less than 10 sporadic meteor. Unfortunately none of those gave direct signature in the radar, no ionization cloud could be seen within 2 minutes after the visual meteors. Totally 6 meteoric ionization trails were found from the measurements of 70 hours. Most of those are from Geminid meteors. Their structure, drift speed and direction can be determined. This gives information about the electric field at an altitude of the meteor beam. Eiscat has measured the electric field at an altitude of 255 km. The two electric fields have been compared.

INTERACTION OF INJECTED ELECTRONS WITH ENERGY MORE THAN 100 KEV WITH ATMOSPHERE

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A model for calculation of the energy distribution of electrons during interaction of relativistic electrons with the atmosphere is suggested. It is based on the solution of kinetic equation subject to relativistic corrections. Electron distribution function is derived for energies from the threshold level of inelastic losses up to the primary beam energy taking into account primary flux geometry. Relying on these results, the ion production rate, the column rates of a number of emissions including bremsstrahlung one, and the atmospheric heating over the area of action of the electron flux are calculated.

INTERACTION OF PROTON FLUXES WITH ENERGY MORE THAN 10 MeV WITH ATMOSPHERE

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A model for calculation of the energy of secondary electrons generated during penetration of the proton flux into the atmosphere is suggested. It is based on the solution of kinetic equation for electrons. Spatial distribution function of secondary electrons is derived for energies from threshold level of inelastic losses up to the source energy. Relying on these results, the ion production rate and the column rates of a number of atmospheric emissions caused by proton flux itself as well as by secondary electrons are calculated. It is shown that the contribution of secondary electrons into the above-mentioned processes exceeds substantially the effect of proton flux per se.

Long-lived ion clouds in the ionosphere: experiments and model estimates

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Papers /1, 2/ reported on the observations of long-lived (up to 14 hours) barium clouds generated in lowlatitude ionosphere under CRRES experiment and some rocket experiments. To describe the evolution of ion clouds, a three-dimensional model is developed on the basis of a solution to a complete system of transfer equations in a diffuse approximation with due regard for the external electric field. Could evolution is numerically modeled for experimental conditions. Model estimates are compared to experimental optic and radiophysical data on the evolution of long-lived ion clouds.

PECULIARITIES OF BARIUM ION CLOUD DYNAMICS IN CRRES CARIBBEAN RELEASES IN THE IONOSPHERE (OPTIC DATA)

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We present optical data of cloud dynamic peculiarities in CRRES Caribbean ionospheric barium releases. The data were obtained by LLL TV-devices near magnetic zenith point from research vessel. The ion 'skidding' effects were observed in G-9, G-11a releases. The 'skidding' distance in G-9 is 18 km, in G-11a - 14 km. In G-11a release 'quick braking' effect was observed as the thin ion 'track' of 8-11 km lenghts from release point to the west edge of ion cloud. The high velocity edge of ion/neutral fraction wieving as shock wave was observed during barium clouds dispersion in G-9, G-11a and G12 releases.The velocity of edge is equal about 7 km/s. A few fine-scale ion filaments (striation effect) before sharp edge of main ion cloud was registered in the G-9 release. Transverse geomagnetic field line size of filaments is at range 1-3 km. The wave structure of ion sheet border in the G-11a release was observed during barium cloud evolution. The scale of ion sheet "surface waves" is 10-14 km and the amplitudes are in range of 1-4 km. The ion 'track' mentioned above has wave deformation also.

Optical phenomena in the near space during the operation of rocket engines and space instruments

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The paper presents the results of ground optical observations of artificial structures and ionospheric glow during rocket launches and the operation of spacecraft engines. A UN telescope on the Astron telescope was used to study artificial structures from the space. Measurements in the near space revealed large-scale (up to 500-1000 km) dust cloud generated during rocket launches and the operation of the spacecraft engines. It was revealed that during the operation of the spacecraft engine the nucleus of condensed particles occurring in the centre of the wake and amounting to 10 km is surrounded by a region of supraback ground ionospheric glow in the line 630.0 mm which makes up 200 km in diameter. Glow mechanisms of artificial structures are discussed.