Auroral and Atmospheric Tomography

INFORMATION ANALYSIS IN AURORAL TOMOGRAPHY PROBLEMS

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The paper considers some problems which arise when using optic tomography techniques to study auroral glow. The important of information analysis when solving these problems is indicated. In particular, tentative studies of pecukiar features of the studied object, calculations of certain object parameters and recording devices allow to select most effective algorithms of reconstruction. Of great importance for reconstruction results is to take acount of nonequivalence of projections obtained from different directions. This enables to optimize the location of data collection instruments and caculative procedure of reconstruction. A due regard for noise interference is also essential, since in some cases it makes the reconstruction procedure inefficient. The above conclusions are confirmed by computer modeling.

THE AURORAL TOMOGRAPHY THE WAYS OF SOLVING THE PROBLEM

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Two ways of solving the auroral tomography task are suggested. The first way is the solution via triangulation algorithm and the second one is iterative. Probably only this two ways alow us to fix auroral tomography task. Triangulation algorithm can be applied to needle aurora structures and the iterative one can be used for large spatual diffusional noncomplex aurora. The triangulation algorithm is unusial: the processing of aurora stereopares realised with the help of human eyesight and using the calculation power of computer.

THE ESTIMATIONS OF INFORMATIONAL LIMIT OF THE AURORAL TOMOGRAPHY TASK

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On the base of researching of real aurora images and expected tecnical characteristics of ALIS registration system the informational limit estimations of auroral tomography task were received. This information allows us to estimate the theoretical limit of tomography resolution in our case. The informational map also presented. It was calculate on the expected geographical positions of the ALIS stations.

SIMULATION AND INFORMATIONAL ESTIMATIONS OF THE ALIS IMAGE REGISTRATION CHANNEL

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The way of solving of the auroral tomography task is depends upon the quality of auroral imaging in the ALIS ground-based station. The results of searching of the ALIS station tecnical components make possible to estimate the errors and the noise level caused of such elements as image intensifier, fiber optic reducer and CCD-camera. This estimations allow to create computer models of the ALIS channel distortion and to receive informational characteristics of the auroral images.

IMAGE PROCESSING IN KARHUNEN-LOEVE REPRESENTATION

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Karhunun-Loeve image representation is sufficiently compressed because of coefficients of such representation are non-correlated. However, large dimension of signal resisting to solving the spectral problem for correlation matrix. This fact was limited using of Karhunen-Loeve representation in most part of practical applications. The procedure of three-stage basic set construction, which took these restrictions off we have proposed. Some of typical examples of using the Karhunen-Loeve representation for image processing was described. Under compression memorising of few in number images set the compression ratio was tended to number of images in the set divided by number of using basic vectors. Under compression memorising of large in number set the compression ratio was tended to number of dots in image divided by number of using basic vectors. In this case the compression achieved several thousands. The Karhunen-Loeve representation under recognition of images was minimized significantly number of necessary evidences. Under of broken images processing in Karhunen-Loeve representation the matrix of transfer medium has low dimension and was converted easy.

IMPROVED NUMERICAL METOD FOR SOLVING INVERSE PROBLEMS OF ATMOSPHERIC OPTICS.

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The new numerical procedure is proposed for solving a set of algebraic equations being involved in typical problems to monitor optically atmospheric pollutions. In elaborating the method, the new iteration process of matrix inversion has been used. It permits the increased stability of the solution to be provided in simultaneous search of a large number of parameters. The method is based on the statistical estimation theory. It is optimal in accordance with the maximum likelihood method. Arbitrary a priori information, for example nonnegativity of values, estimations of sought parameters, restriction on correlations bettwen the parameters etc., can be used.The conformity with other well-known methods is analysed. In solving a set of linear equations, the method generalizes the known linear Phillips, Twomey refining methods and nonlinear Chahine method for the case of positively defined sought and measured values. For a set of nonlinear equations, the accordance with the Newton-Gauss and Levenberg-Marquardt methodsis discussed. The method is applied to problems of aerosol size distribution from phase function measurements and of the restortion of optical active component concentrations from measurements of spectral brightness backscatted by clouds.

Electron density profiles in auroral arc determined by optical and radar measurements

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In the case of thin auroral arc the emission profile measured as a function of zenith distance from one station may be converted into field aligned ionization profile with some assumptions. When any auroral form has been measured with three or more optical north-south oriented instruments, the horizontal and vertical luminosity profiles can be determined by tomographic inversion methot.

Some combined optical and EISCAT campaigns have been run during 1990–1993 to measure auroras with high temporal and spatial resolution. Beside the EISCAT radar two or three optical stations with TV–cameras and photometers have been in operation. If a bright auroral form pass the radar beam the position of the arc is well known. The weather has seldom been clear on all the optical stations to get data in such an event. If a scanning photometer has measured the same arc south of the radar station, the luminosity profile can be converted to ionization rate and electron density profiles.

We have obtained optical data of some discrete and bright auroral forms which show strong enhancement in the electron density. The vertical electron density profile has been determined by the EISCAT radar and from the optical measurements and the results have been compared.

SOME RESULTS OF 3-D AURORA RECONSTRUCTION BASED ON SINGLE TV IMAGE AND HEIGHT PROFILES OF BRIGHTNESS

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An analysis of auroral brightness height profiles have shown that their form in the absence of rays is approximately stable and only their amplitude changes. This fact allows to develop iterative algorithm for tomographic reconstruction of approximate 3-D aurora using single TV image and height profiles of brightness measured by rocket-borne photometers. Some results of 3-D aurora reconstruction are presented.

TOMOGRAPHIY RECONSTRUCTION OF A 3D-AURORAL LUMINOSITY DISTRIBUTION

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For the reconstruction of auroral luminosity a modified back-projection algorithm including the information sensitivity of tomographic experiment is suggested. The back projection algorithm is based upon tomographic functionals containing the photometric factors. This algorithm allows to obtain the reconstruction of auroral luminosity. To test the algorithm proposed for solving the problem of calculating the 3D spatial distribution of auroral luminosity according to the data from a network of ground based all-sky cameras, there was constructed a series of simulated "all-sky films". For this purpose, some artificial auroral homogeneous and rayed arcs were modelled. Then model all-sky images of the arc were calculated for a net-work of "cameras" by integrating the luminosity of the light sources along sight beams radiating from the camera sites under various zenith and azimuth angles with the angle resolution = 5 degrees. Comparison of the original and reconstructed distributions of the "auroral" luminosity has shown their reasonable agreement.

THE GENERAL PRINCIPLES OF FORMULATION OF INVERSE PROBLEMS FOR INTERPRETATION OF DATA

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The general approach is discussed to development of inversion methods of data interpretation. The approach is based on formulation of corresponding inverse problems. The fields of parameters to be measured and of those to be retrieved are considered to be related via some (nonlinear) operator implemented by the known forward problem and we consider the ways of inverting this operator for different situations to formulate the inverse problems. Three cases of inversion of the forward operator are considered: (i)immediate inversion; (ii) evaluation of the 1st variational derivative of the forward operator to be used in the linearised inverse problem and (iii) construction of the functional Taylor series for the inverse operator. The concrete applications to interpretation of data of optical sounding of planetary atmospheres are discussed, the relevant inverse problems of radiative transfer are formulated and results of some numerical experiments demonstrating feasibility of the approach proposed are presented.