Scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics, USSR Academy of Sciences (27–28 October 1976)

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A joint scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics of the USSR Academy of Sciences was held on October 27 and 28, 1976, at the conference hall of the P. N. Lebedev Physics Institute. The following papers were delivered:

1. *O. M. Belotserkovskiĭ*, New Numerical Models in Mathematical Physics and Problems of Interaction of the Solar Wind with Cosmic Objects.

2. *A. M. Gal'per, V. G. Kirillov-Ugryumov, and B. I. Luchkov*, Discrete Sources of Cosmic Gamma Radiation.

3. *A. A. Stepanyan*, The Object Cygnus X – 3 as a Generator of Superhigh-Energy Gamma Quanta.

4. *S. K. Esin*, Status of Work at the Los Alamos Meson Factory.

5. *N. K. Abrosimov*, Plans for the Leningrad Institute of Nuclear Physics Accelerator Complex and Research on It.

We publish below brief contents of the papers.

O. M. Belotserkovskiĭ. *New Numerical Models in Mathematical Physics and Problems of Interaction of the Solar Wind with Cosmic Objects.* Direct numerical modeling of complex problems in gasdynamics (computer experiments) are performed on the basis of the Euler, Navier-Stokes, and Boltzmann equations. The basic principles of the numerical experiment are formulated and studies of various gasdynamic problems with complex internal structure are reported.

Transonic motion regimes (supercritical flows past bodies with passage through the speed of sound), turbulent flows with "injection" of a jet into the main stream, and diffraction problems are discussed. Flows in the separation zones behind the stern of the body are studied both for the limiting cases of the flow and at various Reynolds numbers. The motion of a rarefied gas at various free-stream Mach numbers is considered for the case of a shock-wave-structure problem. A system of control tests is developed to estimate the error of the results.

These approaches split the physical processes at the time steps and use the convergence of the process to solve steady-state problems. The main purpose of these studies consists in the attempt to derive sufficiently general mathematical and numerical models for the complex problems of mathematical physics in the presence of large deformations, displacements, various types of interactions, etc. The approach is used both to solve the Euler equations (the "large-particle" method)[1–4] and the Navier-Stokes equations (splitting method, method of "fluxes"),[5,6] as well as in numerical modeling of rarefied gas flows (the statistical method of "particles in cells").[7–9]

By way of example, we present two results of a numerical experiment to investigate separation zones and turbulent flows with jet "injection." For a case of flow past a finite axisymmetric body, Fig. 1 represents the interaction of the main supersonic stream (Mach number $\mathbf{M}_\infty = 3.5$) with a sonic axial jet flowing out against the main stream from a nozzle situated on the symmetry axis of the body.[4] The interaction observed is complex: a detached shock wave *ABCD* and a turbulent mixing subregion *OLMNPO* with a system of compression shocks form ahead of the body, a separation zone *GST* astern of it, and so forth. Figure 2 shows the wake decay pattern at various times behind a circular cylinder for flows of a viscous incompressible fluid at a Reynolds number $\mathbf{Re} = 10^3$ (at the times indicated, we observe growth of the dead zone, followed by "collapse" and

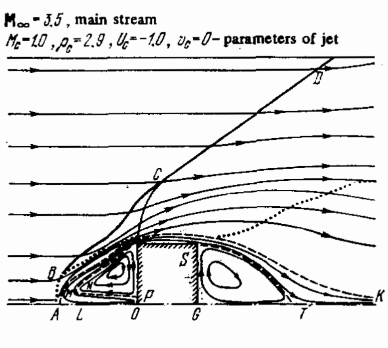

FIG. 1.

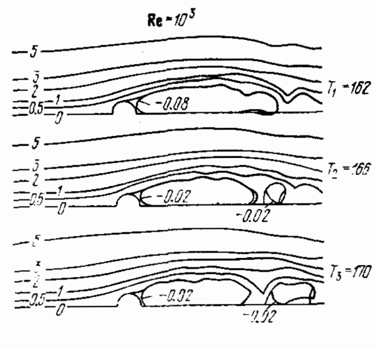

FIG. 2.

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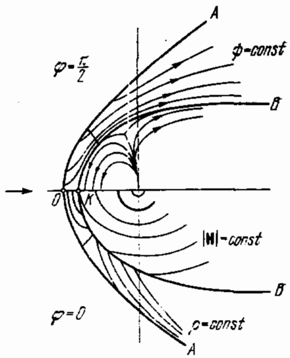

FIG. 3.

ejection of fluid from the dead zone).[5]

The following problems from space physics are considered[10]:

1) The interaction of the solar wind with the intrinsic magnetic field of a planet (spatially three-dimensional problem).

2) Interaction of the solar wind with the ionic component of a comet's atmosphere.

3) Interaction of the solar wind with the ionosphere of a planet that does not have its own magnetic field.

The equations of ideal single-fluid magnetogasdynamics were used in numerical analysis of all of these problems.

Figure 3 presents a typical result of calculation of the interaction of the solar wind with the earth's magnetosphere. It shows the positions of the collisionless shock-wave AO, the magnetopause BK (which bounds the geomagnetic cavern), the zone of neutral points, streamlines, and lines of constant density and field strength (the plane $\varphi=0$ is perpendicular to the direction of the magnetic dipole).[10]

Compared to the field experiments, the computer numerical experiment is much cheaper economically and in some cases (when the physical experiment is difficult to carry out) it is the only tool available to the investigator.

[1]O. M. Belotserkovskiĭ and Yu. M. Davydov, Nestatsionarnyĭ metod "krupnykh chastits" dlya resheniya zadach vneshneĭ aerodinamiki (The Nonstationary Method of "Large Particles" for Solution of Problems in Exterior Aerodynamics). Preprint, Computer Center, USSR Academy of Sciences, Moscow, 1970.
[2]O. M. Belotserkovskiĭ and Yu. M. Davydov, Zh. Vychislit. Mat. Mat. Fiz. 11, 182 (1971).
[3]M. W. Evans and F. H. Harlow. The Particle-in-cell Method for Hydrodynamic Calculations. Los Alamos Scient. Lab. Rept. LA-2139 (1957).
[4]O. M. Belotserkovskiĭ (ed.), Chislennoe issledovanie sovremennykh zadach gazovoĭ dinamiki (Numerical Investigation of Contemporary Gasdynamics Problems), Nauka, Moscow (Computer Center, USSR Academy of Sciences), 1974.
[5]O. M. Belotserkovskiĭ, V. A. Gushchin, and V. V. Shennikov, Zh. Vychislit. Mat. Mat. Fiz. 15, 197 (1975).
[6]O. M. Belotserkovskiĭ and L. I. Severinov, *ibid.* 13, 385 (1973).
[7]V. E. Yanitskiĭ, *ibid.*, p. 505.
[8]V. E. Yanitskiĭ, *ibid.* 14, 259 (1974).
[9]O. M. Belotserkovskiĭ and V. E. Yanitskiĭ, *ibid.* 15, 1195, 1553 (1975).
[10]O. M. Belotserkovskiĭ, in: V. Ya. Mitnitskiĭ, Proc. of US–USSR Seminar, Space Research Inst. of the USSR Academy of Sciences (November 17–21, 1975), NASA, p. 121.