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Meetings and Conferences

SCIENTIFIC SESSION OF THE DIVISION OF GENERAL PHYSICS AND ASTRONOMY AND THE DIVISION OF NUCLEAR PHYSICS; USSR ACADEMY OF SCIENCES (24-25 NOVEMBER, 1971)

Usp. Fiz. Nauk 107, 325–328 (June, 1972)

A scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics, USSR Academy of Sciences was held on November 24 and 25, 1971 at the conference hall of the P. N. Lebedev Physics Institute of the USSR Academy of Sciences. The following papers were delivered at the session:

1. K. I. Gringauz, R. Z. Sagdeev, and B. A. Tverskoĭ, The Mechanism of Magnetospheric Substorms.
2. D. Ya. Martynov, Close Binary Stars and their Significance for the Theory of Stellar Evolution.
3. B. M. Bolotovskiĭ and V. L. Ginzburg, The Cerenkov and Doppler Effects in the Case of Sources Moving at Velocities Greater than the Velocity of Light in Vacuum.
4. A. A. Kolomenskiĭ, M. S. Rabinovich, and Ya. B. Faĭnberg, Collective Methods of Particle Acceleration in a Plasma and in Heavy-Current Electron Beams.
5. L. S. Bogdankevich and A. A. Rukhadze, Problems of Heavy-Current Relativistic Electron Beams.

We publish below brief contents of some of the papers.*

D. Ya. Martynov. Close Binary Stars and Their Significance for the Theory of Stellar Evolution

Although binary and multiple stars outnumber single ones, theories of stellar evolution have been constructed until recently for single stars. At the same time, the development of binary stars, and close binaries in particular, is different in many respects: owing to the relative proximity of the components, there is an active interaction between the stars forming the pair. On the other hand, it is precisely the binary stars that make it possible for us to determine such important characteristics of stars as their mass, dimensions, density, and even the brightness distribution over their disks. It is understood that the binary star must be investigated by spectroscopic and photometric methods. For understanding of the physical properties of stars, therefore, particular interest attaches to stars that are simultaneously spectroscopic and photometric binaries (the so-called eclipsing variables).

Among these stars we encounter combinations of representatives of all star classes: main-sequence stars, giants, super-giants, subgiants and white dwarfs, old novae, and recurrent dwarf novae. No binary pulsars have been observed, and the search for so-called "black holes" or collapsars—stars that have undergone gravitational collapse—among the binaries has thus far been unsuccessful.

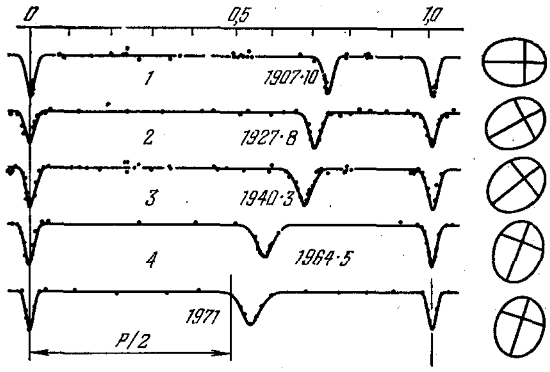
*A paper by B. M. Bolotovskiĭ and V. L. Ginzburg on the subject of the authors' report has already been published in this journal (106, No. 4, (1971)[15, No. 2, (1972)], and therefore no summary of this report is given here (Editor's note.).

The evolution of the single star is determined by the rates of nuclear reactions, which are, generally speaking, slow in small stars and fast in massive stars. But it always takes either billions of years or millions (excluding critical phases). At the same time, rapid mass transfer from one component to the other may arise in close binary systems during the evolution of the components, with the result that the first component develops hundreds of times faster and clearly observable changes take place in the star over a few thousand years. The originally more massive star of the pair becomes the secondary component as a result of mass loss and, evolving rapidly, it passes through the later stages in stellar development to the white-dwarf stage at an accelerated rate.

Theories of evolution with mass transfer are capable of explaining qualitatively almost all star combinations encountered in star pairs. However, these theories still extend the nuclear evolution of the single star too directly to the double-star component, taking account only of its loss of mass. At the present time, the problem of the theory is to move from the celestial-mechanical treatment of mass transfer to the gasdynamic treatment with consideration of the magnetic fields and the effects of the rapid rotation and tidal interaction of the components.

Collapsed stars may be sought among the components of binaries in those cases in which large values of the so-called mass function, which is proportional to the mass of the invisible component, are observed. With certain additional assumptions, this mass can be estimated and, in particular, estimation may yield a mass greater and even much greater than the mass of the visible component. But then the question arises: how can it come about that the more massive star is invisible while the less massive star is visible? A possible answer: the less massive star is a collapsar. There is nothing forced in this conclusion: if the visible star has an excess luminosity of 5–10 times and the invisible star has a similar deficiency, the latter will "elude" spectral analysis.

The internal structure of a star cannot be observed directly. The validity of theories is tested by comparing the observed integral characteristics with those theoretically predicted. However, the rotation of the orbit in its plane in certain eclipsing variable systems permits direct investigation of the mass distribution within the star. Admittedly, the actual investigation of such phenomena will require decades. As an example, the figure shows the rotation of the orbit of RU Mon, a star that the author has been observing for more than 40 years, showing progressive changes in its brightness curve due to the rotation of the orbit. The right side of the figure shows the positions of the orbit relative to the observer (who views it fom below). The



first curve was obtained from Wendell's observations, and the others from the author's own.

A. A. Kolomenskiĭ, M. S. Rabinovich, and Ya. B. Faĭnberg. Collective Methods of Particle Acceleration in a Plasma and in Heavy-Current Electron Beams

Great strides have been made in recent years in the development and construction of various types of accelerators. However, it is becoming increasingly difficult to link further substantia-progress with even greater enlargement of the scales of classical installations, and the future development of this field will depend in many respects on radical increases in acceleration efficiency. Collective methods of acceleration, which, in principle, will make it possible to raise the specific energies by more than one or two orders of magnitude and obtain increments per meter of 0.1—1 GeV and more, are highly promising in this respect. The paper discusses certain methods that do not involve the use of relativistic electron rings (see, for example, Usp. Fiz. Nauk **96**, 377 (1968)[Physics Today **21**(2) (1968) and are under development at the P. N. Lebedev Physics Institute of the USSR Academy of Sciences and the Physico-technical Institute of the Ukrainian Academy of Sciences (Khar'kov).

There are two basic known sources of strong collective electric fields: the dense plasma and heavy-current relativistic electron beams. The Physico-technical Institute of the Ukrainian Academy of Sciences is doing original work on the acceleration of ions in density waves in a plasma, on the excitation of strong electric fields in the plasma-beam interaction, and on the suppression of instabilities and regularization of oscillations in plasma; a linear plasma betatron has been built.

The waves in the plasma that are necessary for particle acceleration can be excited either with external microwave generators in plasma waveguides or by electron fluxes. It appears that use of the interaction of strong relativistic electron beams with the plasma is especially promising. In essence, instability is used to excite plasma waves, and the most important problem in the development of plasma accelerators is to find ways to control the instabilities and, if necessary, suppress them. The following methods have been proposed and investigated for instability control: (1) preliminary modulation of the electron fluxes (in density and velocity) and (2) the use of an inhomogeneous plasma. Experiments have shown that impression of a signal at the system input whose strength is a very small fraction of that of the oscillations generated is sufficient to control the instability spectra.

The Academy of Sciences Physics Institute is conducting research toward the development of new collective methods using relativistic electron beams in which the beams are scanned and self-accelerated and ions are accelerated in self-phased electron plasmoids and in an ionization front in a gas. In the scanning method, an electron beam emanating from a certain point is rotated and forces trapped ions to accelerate. At a constant angular velocity of this rotation, it becomes possible to accelerate the ions continuously (and not pulsewise, as in other methods). In the self-acceleration method, some of the energy of the heavy-current beam goes into excitation of accelerating fields in passive structural elements (resonators, lines). This is accompanied by a redistribution of energy within the beam, i.e., some of the particles are accelerated at the expense of others.

In the acceleration of electrons and ions in self-phased electron bunches, the latter excite strong fields in a decelerating system, e.g., a waveguide with diaphragms or a chain of resonators. A large electron current corresponds to an high amplitude level of the longitudinal field. This is because the heavy-current beam can transport a large volume energy density through the waveguide and do so at relativistic velocity.

The method of ion acceleration by passage of an electron beam through a gas is being developed on the basis of an experimentally observed phenomenon in which a rather large number of ions acquired energies of the order of several MeV per nucleon. This effect arises from the fact that the electron beam in the gas forms ions and creates a comparatively slow-moving charge potential well, in which these ions are accelerated.

Research on collective methods has, incidentally, produced certain results that are of independent interest and presage the development of high-power microwave generators and the feasibility of efficient heating of plasma electrons and ions. Heavy-current pulsed electron accelerators developing energies of MeV order, in the development of which great progress has been made in recent years, constitute the main experimental base for the development of collective methods.

The following literature on the subject of the paper can be cited: Ya. B. Faĭnberg, Trudy VII konferentsii po uskoritelyam (Trans. 7th Conference on Accelerators), Vol. 2, Erevan, 1970, p. 465; M. S. Rabinovich, Trudy I Vsesoyuznogo Soveshchaniya po uskoritelyam (Trans. First All-union Conference on Accelerators, Vol. 2, Moscow, 1970, p. 473; A. A. Kolomenskii and I. I. Logachev, Proc. of the 8th Intern. Conference on High-energy Accelerators, Geneva, CERN, 1971, p. 587; L. N. Kazanskiĭ et al., Atomnaya Énergiya **30**, 27 (1971).

L. S. Bogdankevich and A. A. Rukhadze. Problems of Heavy-current Relativistic Electron Beams.

In recent years, high-powered, heavy-current electron accelerators have been built in many laboratories around the world in connection with the development of