Science Session of Division of General Physics and Astronomy, USSR Academy of Sciences

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A science session of the Division of General Physics and Astronomy of the USSR Academy of Sciences was held on September 27 and 28, 1972, in the Conference Hall of the P. N. Lebedev Physics Institute. The following papers were presented at the session:

1. I. D. Karachentsev. The Dynamic Conditions in Galactic Systems and the Problem of Latent Matter.

2. I. M. Kopylov and R. N. Kumaĭgorodskaya. Certain Distinctive Features of the Structure of the Atmospheres of Magnetic Stars.

3. M. I. Elinson. Problems of Functional Microelectronics.

4. K. A. Valiev. Present-day Semiconductor Microelectronics and the Prospects of its Development.

5. S. V. Bogdanov and D. V. Sheloput. The Current State of Acoustooptics.

We publish below summaries of the papers presented.

I. D. Karachentsev. The Dynamic Conditions in Galactic Systems and the Problem of Latent Matter. Galactic Systems of different scales—binaries, groups, clusters, and superclusters—indicate a discrepancy between the mass estimates computed from the virial theorem under the condition of stationarity of the systems and those determined from the internal rotation of the galaxies. The magnitude of this discrepancy attains one-two orders of magnitude and, on the average, increases when we go from binaries and groups to clusters of galaxies. There are alternative possibilities for the explanation of the virial paradox: either the galactic systems are stabilized by unobservable matter, or they are nonstationary and break up.

The following forms of latent matter have been suggested for the stabilization of the galactic systems: 1) independently indiscernible dwarf galaxies, 2) a homogeneous cosmological background, 3) dust, 4) neutral and ionized gas, and 5) invisible massive objects. Analysis of the optical data on galactic systems, as well as of the data on x-ray, L_α and ratio fluxes from clusters and the Metagalaxy as a whole does not support the existence of latent matter in quantities necessary for the stability of the systems.

The idea that the galactic systems are in a nonstationary state is at variance with certain observational data. The age of the disintegrating galactic systems is of the order of 3×10^8–3×10^9 years, whereas the theory of stellar evolution yields for the age of the stars in the elliptic galaxies an estimate of $(1-2)\times10^9$ years. The virial-mass surplus has been recorded for the majority (70–90%) of the galactic systems that have been studied, and, according to the latest data, only ≈5% of the galaxies generate a diffuse background between the systems. A significant discrepancy is observed between the velocity dispersions for the galaxies and members of clusters. As a way out of the indicated contradictions, we consider a phenomenological model according to which a nonstationary galactic system is formed through successive fragmentations of massive objects identified as galactic nuclei.

The following procedures are suggested for choosing between the stability and disintegration hypotheses for galactic systems: 1) investigation of the shape and substructure of clusters, 2) determination of the type of motions in the systems from the radial velocities and the intergalactic distances, 3) correlation analysis of the radial velocities and the apparent magnitudes of the galaxies in groups and clusters with large angular diameters, 4) investigation of the effects of the interaction in isolated binary galaxies, and 5) analysis of the kinematics of "ultraclose" binary galaxies.

Optimum programs are suggested for observations in large telescopes for the elucidation of the dynamical state of galactic systems.

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[3]I. D. Karachentsev, Astrofiz. Issled. (Izv. SAO AN SSSR) 5, 3 (1972).
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I. M. Kopylov and R. N. Kumaĭgorodskaya. Certain Distinctive Features of the Structure of the Atmospheres of Magnetic Stars. The spectra of stars possessing strong and, as a rule, variable fields have a number of remarkable distinctive features. To these pertain the anomalous intensity of the lines of certain elements, the variability of the intensities and radial velocities of these lines in time (with the period of the variation of the magnetic-field intensity). These so-called magneto-variable or peculiar stars also exhibit periodic brightness and color variations.

Spectral investigations that have thus far been carried out have shown that the atmospheres of magneto-variable stars have a specific structure and, apparently, an anomalous chemical composition, which is connected with the presence of the high-intensity magnetic fields. However, the nature of the influence of the magnetic field on the formation of such atmospheres still remains obscure.

A spectrophotometric investigation of the magneto-variable star α^2CVn, using a series of high-resolution (linear dispersion 1.3 Å/mm) spectrograms, enabled us to obtain new data on the distinctive features of the structure of the atmospheres of this and similar stars.

A differentiated study of the contours of the hydrogen lines H_γ, H_δ, H_8, and H_9 showed that the various contour parameters vary synchronously with the phase of the variation of the stellar magnetic field, but the largest variations occur with the central parts of the contour—with the halfwidth ($\Delta\lambda_{0.6}$), the central intensity (R_0), and the total intensity (W_0) of the line cores (Fig. 1). The

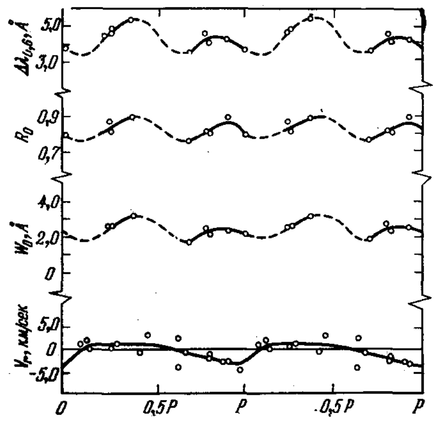

FIG. 1

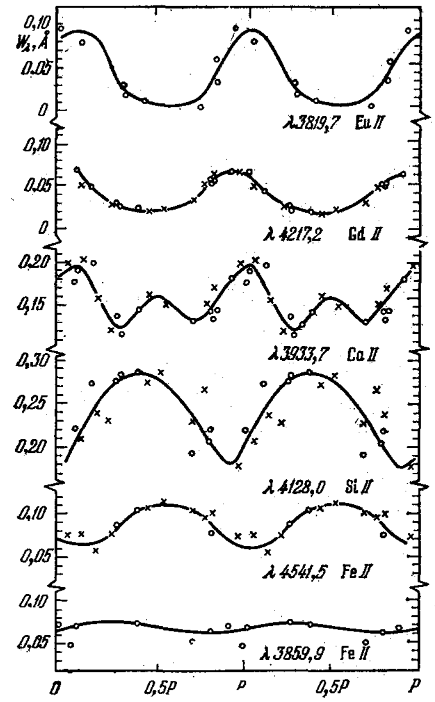

FIG. 2

outer parts of the lines (the wings) vary insignificantly. It follows from this that as the magnetic-field intensity H_e varies, the largest variations occur in the outermost surface layers of the atmosphere (optical depth $\tau_\lambda \le 0.1$), whereas in deeper-seated atmospheric layers penetrating into the photosphere ($\tau \sim 0.6$) the physical conditions remain almost unchanged[1].

To study the variations of the line parameters (W_λ, $\Delta\lambda$, and R_0) as the phase for the other chemical elements varied, the elements were divided in advance into three groups: the light elements (Si, Mg .....), the elements of the "iron peak" (Ti, Cr, Fe, ...), and the rare earths (Eu, Gd, Ce, Pr, Dy, ...). The problem was to determine more accurately the nature of the variation of the line parameters for each of these elements, which would facilitate the elucidation of the causes of variability and the study of the influence of the magnetic field on the distribution of the elements over the stellar surface. We discovered the following[2]:

a) The variations of the above-listed line parameters of each given element are synchronous.

b) The nature of the time variation of the line parameters, as well as of the radial velocity v_r and the magnetic-field intensity H_e (the data on v_r and H_e were taken from [3] and [4]) is not only different for the elements pertaining to the three cited groups, but inside each group as well. There are quite important differences in the behavior of the lines of elements with close atomic characteristics (Fig. 2; variations of W_λ with the phase).

The totality of the enumerated variations can be explained in the framework of the "inclined rotator" hypothesis, in accordance with which a magnetic star rotates as a rigid body about an axis in general not coinciding with the magnetic axis, and according to which the chemical elements are not uniformly distributed over the stellar surface, but are concentrated in "spots" of different dimensions.

Proceeding from this hypothesis, we attempted to use our data on spectral variability[2] to study the disposition, dimensions, and structure of such spots, as well as to determine the physical conditions and chemical composition at such spots and on the stellar surface as a whole.

In fact, it has been found[2,5] that Si II and Mg II in general concentrate near the positive magnetic pole (the concentration is weak and is different for Si II and Mg II); Ca II is preferentially distributed in the form of two broad rings along the magnetic latitudes +20° and −20°; Ti II, Cr I, Cr II, and Fe II (Fe I) are concentrated in the vicinity of the magnetic equator in four extended spots (see also[3]), but the centers of these spots for the cited elements do not coincide; the rare-earth elements concentrate near the negative magnetic pole, but differ noticeably both in the degree of concentration (e.g., Eu II, Sm II, and Ce II) and in the disposition of the zones of greatest concentration relative to the magnetic pole (e.g., Eu II, Gd II, Pr II).

It turned out that it is difficult to find two chemical elements whose distributions over the stellar surface are exactly the same. If we take into account the conclusion arrived at in the study of the hydrogen lines, that "spottiness" is a phenomenon that is probably most strongly manifest in the outermost layers of the atmosphere and vanishes as we go over to deeper-seated layers[1], then it becomes perfectly clear that it is "dangerous" to formally apply to magnetic stars the traditional methods of investigating the structure, physical conditions, and chemical composition of stellar atmospheres (growth curves, model constructions etc.).

Indeed, the growth curve method is based, for example, on the assumption, which is on the whole obvious for ordinary stars, that emission in the continuous spectrum and absorption in the lines develop on the entire stellar surface as a whole. In the case of magnetic stars this assumption, as we saw above, does not hold while the concept of "equivalent width" of a line assumes a completely different meaning. In other words, absorption in a line that forms at a spot should be correlated with the continuous radiation originating only from within the bounds of the area of the spot, and not from over the entire visible stellar hemisphere as a whole. To obtain the "true" equivalent line widths W_λ in a spot, the observed equivalent widths W'_λ should be multiplied by a certain factor $r = S_*/S(P)$, where S_* and $S(P)$ are the effective areas of the visible stellar hemisphere and the spot respectively. In the general form

$$W'_\lambda = \frac{\int_0^{2\pi}\int_0^{\pi/2} \Phi(\theta, \psi) G \sin\theta \cos\theta \, d\psi \, d\theta}{\int_0^{2\pi}\int_0^{\pi/2} D \sin\theta \cos\theta \, d\psi \, d\theta};$$

here $\Phi(\theta, \psi)$ in some general law of line-intensity distribution for some element over the surface of the star in the given phase. The integral in the numerator is S(P), in the denominator S∗; S∗ is easily found when the law of limb darkening of the continuous radiation is given.

From the comprehensive study of all the available spectral data, we derived for the law $\Phi(\theta, \psi)$ three expressions: $\sin^3\{a\varphi_m + [(1+a)\pi/2]\}$ for the rare earths (φ_m is the magnetic latitude, a is a parameter that is different for different elements); $\cos^2\alpha$ for the elements of the iron peak, where α is the angular distance from the center of the spot, and $\cos^2(\alpha/2)$ for Si II. The areas S(P) for the elements which have a sufficient number of the lines used for constructing the growth curves were computed for a number of phases. The procedure for finding the laws $\Phi(\theta, \psi)$ and the mathematical details of the computation of S(P) are presented in [5]. We constructed for the entire set of chemical elements more than 20 separate growth curves, from which we found, using the standard method, the "observable" values of the microturbulence velocities v'_t. Investigation of the problem showed that to obtain the true value (v_t) of the velocity in a given spot, the relation $v_t = v'_t r$ must be used. The values of r for different elements in different phases range from 1.5 to 5. This means that the values of v'_t obtained from a growth curve by the "standard" method should be increased 1.5–5 times. Computing the magnetic coordinates of the center of each spot on the stellar surface, we find that the turbulence velocities vary over the stellar surface from 1.5–2.0 km/sec near the equator to 11–13 km/sec at the latitude $\varphi_m = \pm 45°$.

The illustrative determination of v_t for α^2CVn already shows that if we want to study the atmospheres of magnetic stars through their spectra, then a substantial modification of the existing methods of investigation is necessary.

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M. I. Elinson. Problems of Functional Microelectronics. Microelectronics is the new scientific-technical direction in radioelectronics that is solving the problem of the construction of complex radioelectronic equipment with preset operational parameters, the requisite degree of reliability, and acceptable dimensional, energy, and cost characteristics by the method of cell (technological) and functional (physical) integration accompanied by equipment-component microminiaturization.

Microelectronics has produced a radical change in the approach to circuit design, has produced a permanent fusion of physics, chemistry, technology, circuit engineering and cybernetics, and has, in the final analysis, caused a radical reorganization of the electronics industry.

Cell integration has preserved the old principle of radioelectronics based on the fact that the realization of any function presupposes the development of an electrical circuit that operates according to the laws of circuit theory.

This is the cause of the sharp rise in the complication of equipment in proportion to the complication of the function to be performed. It turns out that even at the high and optimum degree of integration ($\gtrsim 10^3$ components to a crystal) equipment reliability, which will be required within the next few years, will be intolerably low.

A general formulation of the problem of the optimum physical realization of the means of processing large masses of information is necessary. One of the possible ideas for the solution of this problem is the idea of functional microelectronics (FME).

The essence of FME consists in an attempt to find a new system of basic radioelectronic elements which would, in contrast to the traditional elements (e.g., transistors), possess more abundant functional possibilities.

Several directions for FME are discussed: optoelectronic devices which are primarily applicable to the problems of bionics, since neuronlike cells are promising elements for the construction of the next-generation computers; new semiconductor devices, such as Gunn and S diodes, and devices with charge migration; acoustoelectronic devices based on the interaction of current carriers with acoustic waves; and magnetic devices based on the use of cylindrical magnetic domains.

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K. A. Valiev. Present-day Semiconductor Microelectronics and the Prospects of its Development. The most typical product of microelectronics is semiconductor integrated circuits, which are a group of electronic devices (transistors, diodes, resistances, capacitors) realized in a single technological process in a single semiconductor crystal and connected together by thin pellicular metallic conductors into an electronic device—"circuit." Typical values of the area of the integrated-circuit "crystal" range from 1 to 10 mm^2; the number of electronic devices constructed on such a crystal and joined into a circuit varies from scores to several thousands. The area occupied by one element on the crystal ranges from 10^{-3} to 10^{-2} mm^2. The electrical insulation of the elements from each other is realized by means of counter-biased p-n junctions or thin layers of a dielectric.

Figures 1 and 2 show the structures of the most typi-