Scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics, USSR Academy of Sciences (24–25 December 1975)

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A joint scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics was held on December 24 and 25, 1975 at the Conference Hall of the P. N. Lebedev Physics Institute. The following papers were delivered:

1. *P. N. Kholopov*, Stellar Associations and the Problem of Star Formation.

2. *P. V. Shcheglov*, Reducing Atmospheric Noise in Astronomical Observations from the Surface of the Earth.

3. *V. B. Fiks*, Directional Atom-Nucleus Collisions in Single Crystals—a Method of Measuring the Lifetimes of Short-Lived Nuclei and Investigating Crystals.

4. *A. A. Komar*, ψ-Particles: The Experimental and Theoretical Situation.

We publish below brief contents of three of the papers.

P. N. Kholopov, *Stellar Associations and the Problem of Star Formation.* The paper points out inconsistencies of the concept in which stellar associations are of low spatial density and dynamically unstable, which was advanced in the late 1940s[1] when our understanding of the composition and nature of these formations was still quite imperfect. Stellar associations are not systems "of a new type" with low spatial density consisting either of spectral class O–B stars or of T Tauri-type variables, as is still being affirmed in occasional papers.

Stellar associations, which were discovered back at the beginning of our century, are groupings of irregular variable stars of comparatively low luminosity and spectral classes A–M, which are known as Orion variables (of which the T-Tauri variables are a variety) and are closely associated with gas and dust nebulae; if stars of the early spectral classes O–B are observed in these groupings, they are called OB associations, and otherwise T associations. At the end of the 1940s, signs of a continuing process of star formation were observed in these systems. [1]

Analysis of features of stellar associations points to the conclusion that the associations are emerging star clusters (or groups of such clusters) at the earliest stage of their development—in the process of gravitational condensation from diffuse matter. [2]

There are two varieties of groups of hot stars with high luminosity: young and emerging star clusters on the one hand and star clouds on the other. Until recently, these systems were lumped into a single general category and usually called OB associations, although star clouds are themselves conglomerates of various clusters and associations.

A characteristic structural feature of star clusters is a dense central thickening—a core surrounded by a significantly less dense coronal region that is dynamically stable in the field of Galactic tidal forces. [3] Forming star clusters differ in structure and composition from formed structures. They are associated with diffuse nebulae and generally consist of subclusters of Orion variables that were subsequently transformed into stars of constant brightness. Gravitational collapse of the subcluster system transforms it into a cluster with a single core and a corona beyond which we find stars that have been ejected from the system at velocities exceeding the escape velocity. Aarseth and Hills[1] made the corresponding computer calculations of the dynamic evolution of a protocluster model consisting of a chain of subclusters.

The "expansion" effects that have been reported for subsystems of bright members in certain associations are generally rather doubtful. What is usually observed is not a general expansion and decay of the association, but merely expulsion of single stars from it in a process that is particularly intensive at the earliest stage in its existence and is governed by the initial gravitational collapse of the subclusters. The existence and decay of superdense prestellar bodies of unknown nature from which stars are supposed to form is a hypothesis that is occasionally advanced to explain such phenomena, but it does not follow from observations and it diverts us from study of the actual star-forming processes that take place in the interior of dark diffuse gas-dust nebulae—systems with negative total energy.

The modern theory of gravitational condensation of

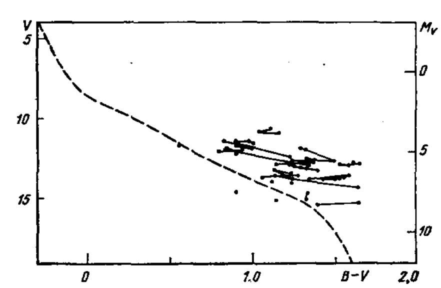

FIG. 1.

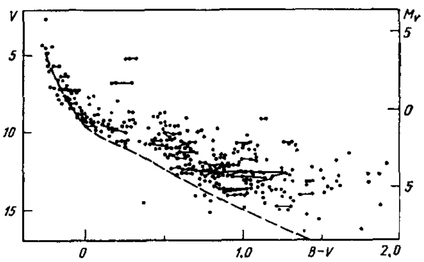

FIG. 2.

stars from diffuse matter enables us to understand various effects that are observed in stellar associations and explains not only the structuring of the star clusters that emerge and the observed velocity field of their members, but also the physical composition of the formations, which is characterized by the form of the stellar magnitude (V) vs. color index ($B-V$) diagrams of the members of T associations (Fig. 1) and OB associations (Fig. 2).

The associations are of the same nature. Any OB association contains stars of the T Tauri type. On the other hand, it may be supposed that the T associations are precursors of OB associations. This is indicated by the presence of compact HII regions and infrared radiation sources in dark nebulae.

According to Larson's calculations,[5] a star that emerges as a result of gravitational collapse of a protostar cloud (and is initially observed as an infrared object) becomes visible to the eye sooner the smaller its mass. This is why only stars of late spectral classes are seen in T associations (see Fig. 1) in the stage before they emerge onto the initial Main Sequence, which is represented by the dashed lines in Figs. 1 and 2. Stars of early spectral classes whose masses exceed two sun masses are not yet visible in these groupings, and become visible as already fully formed Main Sequence stars $3\cdot 10^6$ years after the appearance of the less massive members of the association, which have still not had time to come onto the initial Main Sequence. The T-associations are then transformed to OB associations (see Fig. 2).

[1]V. A. Ambartsumyan, Évolyutsiya Zvezd i Astrofizika [Stellar Evolution and Astrophysics], Izd-vo AN Arm. SSR, Erevan, 1947; Astron. Zh. 26, 3 (1949).
[2]P. N. Kholopov, Astron. Tsirkulyar, No. 847, (1974).
[3]P. N. Kholopov, Astron. Zh. 45, 786 (1968) [Sov. Astron 12, 625 (1969)].
[4]S. J. Aarseth and J. G. Hills, Astron. and Astrophys. 21, 255 (1972).
[5]R. B. Larson, Mon. Not. RAS 157, 121 (1972).

V. B. Fiks. *Directional Atom-Nucleus Collisions in Single Crystals—a Method of Measuring the Lifetimes of Short-Lived Nuclei and Investigating Crystals.* Methods of measuring the lifetimes of compound and excited nuclei (τ) are of great interest for nuclear spectroscopy, but it is quite difficult to find efficient "microclocks" for $\tau \lesssim 10^{-14}$ sec.

The region of existence of compound and excited nuclei with lifetimes of the order of 10^{-16}–10^{-14} sec is now least accessible to measurement, since the "shadow" method is used chiefly for times $\tau \sim 10^{-18}$–10^{16} sec and for nuclei that emit charged particles, and the method in which the Doppler shifts of γ-quanta are measured on deceleration of excited nuclei is ineffective for $\tau \lesssim 10^{-14}$ sec.

Directional atom-nucleus collisions of compound nuclei (CN) with neighboring atoms in single crystals can be used to turn the crystal into a "microclock" for measurements of $\tau \sim 10^{-16}$–10^{-14} sec, and the observed compound nuclei into indicators for study of crystals.[1–4] Let a monokinetic beam of particles (a) with a small angular divergence (~1–3°) be incident on a crystal consisting of A atoms, and let a beam B* of CN be formed in nuclear reactions of the type a + A → B* + b → c. By orienting the crystal relative to the nuclear beam B*, we can aim the CN along lines of nodes, thus causing collisions of B* nuclei with certain neighboring atoms. The following properties of directional collisions are essential:

1) By setting up nearly "head-on" collisions, it is possible with high probability to cause large-angle scattering, $\theta \geq \theta_0 \sim 1$. The probability of these collisions is $w(\theta 0) = 1 - \exp[-p^2(\theta_0)/\beta]$, where $p(\theta_0)$ is the impact parameter corresponding to the angle θ_0 and β is the mean square of the relative displacements of the B and A nuclei due to lattice-atom vibrations. The values of $w(\theta_0)$ for CN energies $\varepsilon \lesssim 10^6$ eV ($\beta \approx 10^{-18}$ cm^2) lie in the range from 10^{-1} to 1.

2) The collision probability maximum lies in a narrow range of angles $\delta\alpha \lesssim (\sqrt{\beta}/d_{1s})$ (d_{1s} are the distances between nodes).

3) Collisions with different neighbors can be set up by varying the distance d_{1s}. Thus, directional collisions can be used to vary the velocity and direction of motion of the CN substantially and for stepwise adjustment of the time of flight of the nuclei between collisions. Certain parameters of the emission of compound nuclei are related to the direction of motion of the nucleus and its velocity, e.g., the energy and angular distributions of the emitted particles, etc. By analyzing the emission spectrum for an "indicator" parameter, we can determine the lifetimes of the nuclei and study the collisions.[2–3] The "indicator" parameter might be the Doppler shift ω_D of the frequency of the γ-quantum (see Figure). The angular distributions of the particles might be measured in reactions with strong anisotropy of the angular distributions. The simplest example of such anisotropy due to the kinematics of the motion is the escape of slow neutrons near the threshold of (p, n) reactions. The nucleus lifetimes that become accessible to study with the aid of directional collisions range from 10^{-16} to 10^{-14} sec, since the displacements of the nuclei between collisions $d_{1s} \sim 10^{-8}$–10^{-7} cm and their velocities $v^* = 10^7$–10^8 cm/sec. This range may include "long-lived" compound nuclei that emit particles