Annual Review of Astronomy and Astrophysics*

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Soviet Astronomy has decided to publish a review of this annual, well known (although not always accessible) to anyone working professionally in the field of natural sciences on the nature of the universe, so there is no need to give a general characterization of the publication. The highly professional and current reviews of timely subjects appearing in the annual are now conferring benefit and giving reading pleasure to a second generation of professionals. It is not at all easy to review such an encyclopedic publication, since it touches upon questions ranging from the physics of interstellar (circumstellar) grains to cosmology. Thus, I would not dare to consider this note to be a rigorous scientific review, but rather the impressions of an interested reader.

This volume contains 16 reviews and one introductory paper, which should be of interest not only to astrophysicists but also to most physicists and historians of science (especially of Soviet science). V. L. Ginzburg, with his typical originality, called this essentially scientific, astrophysical autobiography "Notes of an amateur astrophysicist." The paper is full of historical facts about the development of high-energy astrophysics and radio astronomy, brief, aphoristic philosophical remarks, and bold and complex evaluations.

The reviews that follow are arranged in thematic "disorder," so that, disregarding the table of contents, I have grouped them with respect to the scales of the objects studied.

Results obtained in observations of planets in the millimeter and centimeter ranges are discussed in the review by I. de Pater. Such observations provide valuable information in a study of the very surface layer of planets and planetary atmospheres. If an optically thick cloud layer is present, only radio observations enable one to look below the cloud envelope. The properties of planetary magnetospheres are studied from synchrotron emission at centimeter wavelengths. The technical aspects of observations with an interferometer (the VLA) and methods of reducing (deconvolving) observations (CLEAN, MEM, and the Gerchberg–Saxton method) are discussed briefly in the review. The main content consists of the results of radio observations with high angular resolution and the spectra of solar system planets.

Solar physics is the subject of two reviews. In a review of solar convection, H. C. Spruit, A. Nordlund, and A. M. Title discuss some advances in the past decade, both in observations of the manifestations of solar convection and in theory. They consider that such complex phenomena observed on the solar surface as horizontal flows, exploding granules, etc., are described well by numerical models. On the basis of such calculations, it can be suggested that broad (far larger than the scale of granules), isentropic, ascending streams, interbedded with geometrically smaller, descending streams, are formed below the solar surface. Such streams cannot be described as the result of a "turbulent cascade" of transitions of streams from large scales to the scale of granules. Methods of solar seismology and high-resolution spectroscopy are promising for revealing the nature of the streams.

The role of the magnetic field was hardly discussed in that review. In the review by B. C. Low, in return, in which the equilibrium and stability of the solar corona and eruptive and other magnentohydrodynamic processes are discussed, particular attention is paid to the role of the magnetic field. Moreover, the study of the corona is treated not as a field of application of ready information from the physics of MHD phenomena but as an instrument for the primary acquisition of that information.

A considerable share (six) of the reviews fall to the physics of stars, which was the start of astrophysics and now forms the basis for a greatly expanded list of objects for astrophysical study. R. P. Kudritzki and D. G. Hummer consider quantitative spectrscopy to be the most effective means of studying hot stars. By quantitative spectroscopy, they mean the systematic acquisition of precise spectroscopic data and their analysis by detailed quantitative modeling of the observed objects in order to make the best estimates of the parameters of a star, including its chemical composition. This definition could well be broadened ("quantitative astrophysics," for example), in principle, but at such scales that would be too optimistic; in the field of the study of hot stars, however, one can now say that quantitative spectroscopy has arrived. The present-day observational technique and theory of photospheres, in particular, make possible a precise quantitative analysis of such difficult to observe objects as white dwarfs. For the nuclei of planetary nebulae (m_v down to 14^m), the temperature and gravitational acceleration have been determined to within $\sim 10\%$. This makes it possible to estimate the mass of a white dwarf to the same accuracy, which is very important for theory.

The mass, evolutionary status, and precursors of white dwarfs are discussed in V. Weidemann's review. In this review, which is unusual for stellar evolutionists (or perhaps evolutionaries), since it contains not one figure, the main ideas (concerning mass, largely due to the work of the author of the review) bearing upon the questions under consideration are clearly identified. Since the mass distribution of white dwarfs is sharply peaked around $\sim 0.6\ M_\odot$, and the main evolutionary progenitors of white dwarfs are stars that have evolved along the asymptotic giant branch (the initial mass of such stars may be up to 6-8 $M_\odot$), the conclusion that a stage of very heavy mass loss exists is unavoidable. The logical chain then runs to OH = IR stars, planetary nebulae, and

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white dwarfs proper. Other statistically less significant progenitors of white dwarfs, such as horizontal branch stars, are also discussed. The subsequent evolution of white dwarfs is the subject of the review of F. D'Antona and I. Mazzitelli. They draw the following conclusions: 1) down to $\log(L/L_{\odot}) \approx 1$, the cooling time of white dwarfs is estimated unreliably from theory; 2) for $1 \gtrsim \log(L/L_{\odot}) \gtrsim -3.2$, the cooling time is estimated reliably; 3) for $\log(L/L_{\odot}) \lesssim -3.2$, the estimate is again unreliable. Possible paths of formation of neutron stars in binary systems are considered in the review by R. Canal, J. Isern, and J. Labay. Along with the main channel – the formation of a neutron star by the collapse of a massive star – an important mechanism is the collapse of a white dwarf due to accretion. Four other possible paths are discussed. The nature of rapidly rotating roAp stars, very rich objects from the astrophysical standpoint, is discussed by D. W. Kurtz. Such stars are inclined magnetic rotators that pulsate in the regime of nonradial p modes with period 4-15 min; they are also inclined pulsators. The models of planetary pulsators and many other physical aspects of these interesting objects discussed in the paper are difficult even to enumerate here. In contrast to the other scientific reviews, the review by J. C. Higdon and R. E. Lingenfelter, devoted to the source of gamma-ray bursts, contains many references to papers by Soviet astronomers (mainly E. P. Mazets's group).

There are many reviews on the physics of the interstellar medium. J. M. Dickey and F. J. Lockman present an "observational" review of the distribution and other characteristics of H I in the Galaxy. Principal attention is paid to the various (direct and indirect) observational possibilities, both the instrumental and the fundamental limitations, and the structure of the H I component in the Galaxy. In particular, yet another "best" (quotation marks by the authors of the review) model of the H I distribution perpendicular to the Galactic disk is offered. It seems that we know the properties of the gas in the transitional region between the gaseous disk and the halo less well than the properties of the disk and the halo themselves. Theoretical concepts about the hot interstellar gas – coronal gas, superbubbles, and supernova remnants – are the subject of a review by L. Spitzer, Jr. He specially singles out the beautiful model of the Galactic fountain, according to which the hot gas that is the product of supernova explosions is ejected into the halo, then condenses due to thermal instability, and falls onto the Galactic disk in the form of H I clouds. The formation dynamics of superbubbles (the hot contents of supershells, observations of which are considered in the review by Dickey and Lockman mentioned above) is discussed briefly. Superbubbles are treated, in turn, as individual features against the continuous background of x-ray emission in the 0.5-1 keV range in the review by D. McCammon and W. T. Sanders. The review as a whole is devoted to the sources of diffuse x-ray emission in the wide energy range from 70 eV to 10 keV. It is interesting that the giant H II zones discussed in the review by G. A. Shields, which are observed in other galaxies, may also be related evolutionarily to superbubbles and supershells. The morphology and kinematics of giant H II zones have been studied fairly well, in Shields's opinion, but their hydrodynamic evolution, interaction with clouds, role in star formation, etc., are sketchy, and the construction of a complete coherent representation of the physics of such objects is a matter for the future.

Two reviews with completely different subject matter, at first glance, are devoted to the same question, to a considerable extent: the transparency of the interstellar medium. J. S. Mathis considers the present state of the classical problem of interstellar extinction, as well as other sources of information about the properties of interstellar dust. He presents the most complete list (of those known to me) of dust models. It is noted that not one of the models (including that proposed by Mathis himself) is free of problems. The second review, by B. J. Rickett, devoted to the propagation of radio waves in the turbulent interstellar plasma, contains both information about the interstellar medium, obtained by studying the scintillation and scattering of radio waves, and about the conditions of radio seeing in it.

In one of the longest reviews, F. D. A. Hartwick and D. Schade discuss the spatial distribution of quasars. They conclude that the luminosity function of quasars is now well known up to $z = 2.2$, and the statistics are improving rapidly for $z \gtrsim 3$. As for the spatial distribution, the falloff in spatial density at $z > 3$ revealed by observations of the most luminous quasars must still be confirmed (or not) in observations of less luminous quasars. There are strong indications that quasars at $z \approx 1$ display greater clustering strength than do present-day galaxies.

This volume (like the earlier ones) certainly will not languish on bookshelves.

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Translated by Edward U. Oldham