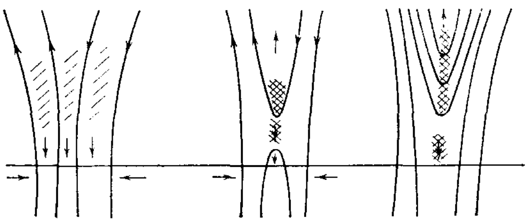

though the lines of force must diverge. The normal chromosphere borders on the corona, where the temperature and the heat conductivity are high. On account of the flow of heat from the corona the upper part of the chromosphere vaporizes so that the boundary moves down lower than in a model without heat conductivity. When the magnetic arc passes low over the chromosphere, no corona is formed in it because the closed arc does not receive the heat flux. This results in a chromosphere-type of gas arc which is higher than the average level. The pressure of the gas falls with altitude, whereas in the surrounding corona it is practically constant. For this reason external pressure compresses the filament until the magnetic pressure counterbalances it. This explains the small thickness of the filament.

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V. L. Ginzburg, Pulsars—Present State of the Problem.

Introduction. A. Hewish has pointed out[1] that November 28, 1967 is the generally agreed upon date of the detection of pulsars. The first report of the discovery of pulsars was published in the February 24, 1968 number of Nature. Since then, already about 500 published articles have been devoted to experimental and theoretical investigation of pulsars. For about a year there has been observed a certain saturation on this question in the sense that no new results of a fundamental, qualitative character have appeared. In this connection the survey of this saturation made at one of the sessions of the Division of General Physics and Astronomy[2] in 1969 is still meaningful. The available experimental data have been compared in greater detail in[1]. For this reason we will cite below only briefly the contents of that part of the report which reflects the essential theoretical ideas regarding pulsars (for more details, see[3]).

1. The nature of pulsars. Attempts have been made to connect pulsars with neutron stars, white dwarfs, double stars, and objects of "a new type." When account is taken of the gravitational radiation, the hypothesis that pulsars are double stars becomes untenable. Now there is no basis for considering pulsars as objects of "a new type." If long-period and short-period pulsars are identical in nature, as is most probable, then pulsars cannot be rotating or pulsating white dwarfs as well as pulsating neutron stars. On the contrary, all pulsars can be identified with rotating neutron stars, with the period of the pulsar equal to the period of the rotation of the star or, in a certain particular case, to half of this period. Thus, it is quite probable, although it has not been rigorously proven, that pulsars are rotating neutron stars.

2. Rotating magnetized neutron stars. Upon transformation of a star into a neutron star, the moment of inertia is greatly reduced. For this reason it can be expected that neutron stars rotate rapidly (with an angular velocity $\Omega \lesssim 10^3$). It is equally probable that as a result of the compression of the well-conducting original star the magnetic field in the neutron star is very strong ($N \lesssim 10^{12}$–10^{13} Oe). The magnetic moment m of the star, generally speaking, need not coincide with the direction of its angular velocity Ω. By the same token we obtain for pulsars, in a natural manner, a model of an inclined rotator (of a rotating magnetized neutron star with non-coinciding axes of rotation and of magnetic symmetry).

3. Structure of neutron stars and pulsars. In connection with an insufficiently exact knowledge of the equation of state of matter at ultrahigh densities ($\rho \gtrsim 10^{11}$ g-cm^{-3}), quantitative calculations for neutron stars are still unreliable. Nevertheless, it can be thought that for a "typical" neutron star the mass is $M \sim 0.5$, the radius is $r_0 \sim 10$–30 km and the density at the center is $\rho_c \sim 10^{15}$ g-cm^{-3}. At densities of $\rho \lesssim 3 \times 10^{11}$ g-cm^{-3} the material of the star consists of atomic nuclei and electrons, i.e., it is in a plasma state. If the thin surface layer of gas is not considered, the plasma part of the star is solid, that is, if forms a crust (here we are speaking about stars with a temperature of $T \lesssim (1-5) \times 10^8$ degrees; neutron stars can be hotter only immediately after they are formed). In the region of densities of $3 \times 10^{11} \lesssim \rho \lesssim 5 \times 10^{13}$ g-cm^{-3} the solid plasma crust contains also neutrons, the number of which grows with increasing density. Finally at densities of $\rho \lesssim 5 \times 10^{13}$ cm^{-3} the star consists basically of neutrons with an admixture of several percent of protons and an equal number of electrons (mesons and hyperons in a noticeable quantity appear only when $\rho \gtrsim 10^{15}$). The neutron-proton-electron region of neutron stars is liquid and consitutes, as it were, a mixture of neutron, proton, and electron liquids. There are strong reasons to suppose that in neutron stars the neutron liquid is in a superfluid state and that the proton liquid is in a superconducting state. Evidence in favor of the correctness of such a hypothesis, although it is still not proof of it, can be found in the analysis of the change of the period of the pulsar PSR 0833-45 in Velx Vela X after the abrupt change of its period observed in 1969. In one way or another a study of the discontinuities and other non-monotonic disturbances in the course of the secular increase of the period of the pulsars opens up prospects for "peeping" inside neutron stars.

4. The electrodynamics of rotating magnetized neutron stars. When it is in a vacuum the rotating magnetized neutron star that is an inclined rotator radiates low-frequency electromagnetic waves and also ejects charged particles from the surface of the star. As a result, the angular velocity of rotation of the star decreases. From this we can evaluate the magnetic field H_0 on the surface of the star, which turns out to be very

strong ($H_0 \sim 10^{12}-10^{13}$ Oe). Allowance for the influence of the plasma surrounding the star can, however, essentially change the situation and the estimate $H_0 \sim 10^{8}-10^{9}$ Oe can likewise not be excluded. A self-consistent determination of the parameters of plasma in the vicinity of a neutron star must be regarded as one of the main (and still unsolved) problems of the theory of pulsars. Only after this can there be hope of estimating the field of the star, or explaining the question about the secular variation of the angle between the magnetic moment $\mathbf{m}$ and the angular velocity Ω, etc.

5. The mechanisms of radiation of pulsars. Optical and x-ray radiation of the pulsar NP 0532 in the Crab Nebula can be regarded as incoherent radiation of an aggregate of particles. We are most probably dealing here specifically with incoherent synchrotron radiation of relativistic electrons. Conversely, radio-frequency radiation of pulsars must be connected with some kind of coherent radiation mechanism because the brightness temperature of the radio-frequency radiation of pulsars is exceptionally high ($T_b > 10^{20}$ degrees).

Two essentially different types of coherent mechanisms of radiation are known—the antenna and maser mechanisms. The antenna mechanism in its simplest form operates when the particles form clusters with dimensions less than the length of the radiation waves. In cosmic conditions, however, the emergence and stability of such clusters are very improbable. Coherent mechanisms of the maser type do not require the formation of clusters; their action is based on the wave amplification that results from the inverted energy-level population. The maser mechanisms (several of these are known) are quite effective and, in principle, completely capable of explaining all the peculiarities of the radio-frequency radiation of pulsars. (This also applies to a number of components of solar radio-frequency radiation and to the cosmic radio-frequency radiation of OH and other molecules.)

6. Several models of the radiant regions of pulsars. Construction of specific models of the radiant regions of pulsars is hindered not in connection with the question about the mechanism of radiation, but basically as a result of the absence of information about the density and other characteristics both of the plasma and of the magnetic field near the pulsars. In particular, the type of directivity pattern of the radiation of the pulsars remains unclear. This diagram can be, for example, "pencil-like" with an axis coinciding with the direction of the magnetic dipole $\mathbf{m}$. Another possibility is a "knife-like" diagram located in the plane of the magnetic equator of the star. In the report, as an example, are cited the several possible parameters of the radiant regions of the pulsar NP 0532. The heart of the problem lies, however, not so much in the selection of these parameters on the basis of the data about the emission spectrum as in the creation of a self-consistent picture of the plasma envelope of the pulsar. If this problem could be successfully resolved, then the question about the radiation of the pulsars would probably be more or less self-evident.

7. Use of pulsars in astronomy and physics. The discovery of pulsars is especially essential from the viewpoint of the possibility of studying neutron stars and their activity (in particular, their role in supernova envelopes). But pulsars can be and in fact already are used also for solving other important astronomical problems: for determining the dispersion (of the quantity of electrons on the line of sight between a pulsar and the earth) and the rotation of the plane of polarization in interstellar space, for studying the inhomogeneities of the interstellar environments, and for several other purposes.

Concluding Remarks. In conclusion, several remarks of a general nature were made concerning the development of astronomy and physics in their connection with the study of neutron stars which are pulsars.

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[1] A. Hewish, Paper at 14-th General Assembly of the International Astronomical Union (19 August, 1970); A. Hewish, Highlights of Astronomy, 1970; see also Ann. Rev. Astron. and Astrophys. 8, 265 (1970).

[2] Usp. Fiz. Nauk 99, 514 (1969) [Sov. Phys.-Uspekhi 12, 800 (1970)].

[3] V. L. Ginzburg, Paper at 14-th General Assembly of the International Astronomical Union (19 August, 1970), Usp. Fiz. Nauk 103, 393 (1971) [Sov. Phys.-Uspekhi 14, (1971)].

Ya. G. Dorfman, New Results from the Study of Plato's Physics

Plato's ideas about physics are contained mainly in his dialog "Timaeus." In the literature on the history of physics they have been rarely cited and have been variously evaluated.[1,2] F. Rosenberger regards these ideas as meaningless, but E. Hoppe acknowledges them to be the highest achievement of atomic theory in antiquity. "Timaeus" has been studied and translated into modern languages almost exclusively by philologists and philosophers[3,4,5]. For this reason I undertook a detailed study of the original and of the translations of "Timaeus." This made it possible to refine our information about Plato's physics and to explain a series of new peculiarities in it.* A report read in Athens by a certain "most educated astronomer and naturalist," Timaeus, constitutes the basic subject-matter of this work dating from the middle of the 4th century B. C. In this report mystical legends about the ideal World subordinated to the Mind alternate with scientific description of the actually observed World subordinated to Necessity, i.e., the law of Nature. "Most plausible" ideas about the structure of matter and of the inner mechanism of physical processes are examined here along with empirical facts.

At the base of Plato's physics lies a classification of all bodies observed by us into four species (γένη) or four groups: 1) "earth-like," 2) "water-like," 3) "air-like," and 4) "fire-like." These four groups of bodies (briefly designated as earth, water, air and fire) are neither chemical elements nor aggregate states in the usual sense. In the "earth-like" group Plato put all practically non-melting solid bodies (stones and ores); in the "water-like" group are put bodies which can exist both in a solid and in a liquid state (metals and water); in the "air-like" group are put vapors and air;

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