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 **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 **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.

[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;

*Valuable help in this research was extended to me by I. D. Rozhanskiĭ.

and in the "fire-like" group are placed flame, light, heat, and combustible fumes. All bodies consist supposedly of one primary matter and are constructed of invisible particles (σῶματα). Each group of bodies is characterized by the shape of its particles. Plato considered the shape of regular polyhedrons as "most plausible." He ascribed a cube shape to particles of the first group, an icosahedron shape to particles of the second group, an octahedron shape to particles of the third group, and a tetrahedron shape to particles of the fourth group. According to Plato, groups 2, 3, and 4 can be transformed into each other because the facets of an icosahedron, an octahedron and a tetrahedron are equilateral triangles. When they collapse into separate triangular plates (facets) the hollow polyhedrons are reconstructed and change into each other. The "earth-like" cubes (of the first group) are deprived of this possibility. Plato considered polyhedrons and triangles as ponderable particles. He even asserted that they are fastened to each other with "numerous miniature brads."* Each of the four groups embraces an enormous number of substances which are distinct from one another only by the dimensions of their invisible polyhedrons.

Plato described in detail the process of mutual transformation of the various kinds of matter. Penetration of the "sharp" particles of fire into the "water-like" solid phase causes melting. Fiery tetrahedrons break the icosahedrons of the melt into plates and causes them to restructure themselves as "air-like" octahedrons of vapor. The removal of particles of "fire" leads to a congealing and precipitation of the solid phase from the melt. Conservation of the original number of triangular plates is rigorously observed in all these processes of particle restructuring. Plato expressed this in the form of original balance equations of this type:

1 "water" → 2 "air" + 1 "fire"

(i.e., 20 triangles of water are transformed into 2×8 triangles of air + 4 triangles of fire). Besides this rule governing the quantitative side of such processes, Plato formulated phase-equilibrium laws that determine the directions of the processes (up to this time, historians have not paid attention to this). So, the first phase-equilibrium law asserts that identical particles do not destroy each other because a homogeneous system is always in a stable equilibrium and rest. The second law states that in the presence of several phases (for example, a mixture of "fire-like" and "water-like" particles) there arise movements, i.e. a battle between them, during which the phase that is less stable and is less concentrated is subjected to destruction; its particles are restructured and take the structure of the predominant phase. Finally, the third phase-equilibrium laws deals with the mixture of two phases that are approximately identical in stability and concentration. The battle between them leads to a dissociation of the particles that continues until either the particles of one of the phases gather together and are precipitated or the particles of this phase are restructured into a homogeneous mass similar to the other phase and are dissolved in it.

*For this reason, Heisenberg's treatment of these triangles as mathematical abstractions [6] is mistaken.

In the light of these laws Plato examined not only the "mixture" of fire and liquids, but also the solutions of solid salts in water. Thus we find here a comprehensive system of molecular physics without a parallel in the science of antiquity. Plato's physics was not understood by the ancient natural philosphers (e.g., Aristotle), but it turned out to have had an influence on physicists and chemists from the 16th to the 18th centuries.

[1] F. Rosenberger, History of Physics, Transl. ed. by I. Sechenov, Part 1, M.-L., 1933.
[2] E. Hoppe, Handbuch der Physik, Band 1, Kap. 1. Geschichte der Physik, Berlin, 1926, pp. 8–9.
[3] Platon, Oeuvres complètes, tome X, "Timaée", texte établi et traduit par Albert Rivaud, Paris, 1925.
[4] Eva Sachs, Die fünf platonischen Körper (Philologische Untersuchungen 24), 1917.
[5] Ch. Mugler, La physique de Platon, Paris, 1960.
[6] W. Heisenberg, Physics and philosophy, N. Y., 1958, p. 69.

I. D. Rozhanskiĭ, On the Question of the Rise of Atomic Theory in Antiquity

The problem of the rise of ancient atomic theory is among the most puzzling problems in the history of science. From what we know about the atomic theory of Leucippus and Democritus it follows that it was a systematic and well-developed doctrine. Were there precursors of it in Greece or in other countries? If not, then what was the nature of the stimuli that prompted the early Greek thinkers to come to the idea of the atom as the smallest structural unit of matter? The well-known Aristotelian explanation deriving the atomic theory from the teaching of the Eleatics is from this point of view insufficient. In order to understand how the idea of the atom could be conceived in this epoch when both physics and scientific methods of research were non-existent, it is useful to examine several characteristics of prescientific thought in general. One of these characteristics was the operation of pairs of opposite concepts, such as light and dark, right and left, even and odd, and others, to which special, occasionally magical meaning was ascribed. A specific feature of Greek psychology was that the most important of the pairs like this was the pair limited—limitless. This was precisely the pair that was in first place in the system of Pythagorean opposites which, according to the words of Aristotle, played a primary role among the Pythagoreans. The idea of the limited for the Greeks of this epoch was equivalent to ideas of order, shape and harmony; the opposite idea of the limitless expressed disorder, formlessness, and disorganization. Translated into a cosmic scheme of things the pair limited–limitless turned out to be related to another pair that was also exceptionally characteristic for Greek thought, namely the pair cosmos—chaos.

The beginning of the 5th Century B.C. in Greek science was characterized by formulation of a whole series of concepts which in the preceding epoch either still did not exist or were still being only vaguely outlined. In particular, it was precisely at this time that there arose a sharp awareness of the idea of spatial infinity.