Immanuil Lazarevich Fabelinskiĭ (on his seventieth birthday)

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The scattering of light in condensed media is a subject that has occupied many investigators since the dawn of our century. Rayleigh, Smoluchowski, Einstein, Mandel'shtam, Brillouin, Landsberg, Raman–their names form a far from complete list of the prominent physicists closely associated with the study of light scattering. Rayleigh scattering, Raman scattering, the fine structure of Rayleigh scattering (the Mandel'shtam-Brillouin doublet, the wing of the Rayleigh line, etc.), the relation to the study of ultra- and hypersound–all this is classical physics, an area that appeared closed as far back as twenty years ago. Thus it was possible at that time to suppose that the study of light scattering had seen its heyday, and that it was not destined to become prominent among the flourishing branches of physics. The advent of the laser changed this situation radically, opening up possibilities that were undreamed of earlier.

This introduction seems appropriate to the present article, which is devoted to the 70th birthday of Immanuil Lazarevich Fabelinskiĭ, since he is a prominent physicist who has successfully studied and continues to study the scattering of light, both by the old methods and with the new ones that have appeared in the laser era.

Fabelinskiĭ was born on 27 January 1911 into the family of a physician in Graevo, Belostok Oblast'. After graduating from secondary school in 1929, he worked for two years as a factory lathe operator. He entered Moscow State University in 1931, completing his studies in its physics department in 1936 and remaining as a graduate assistant to do scientific work in the optics laboratory headed by G.S. Landsberg. At the MSU optics laboratory, and after 1943 in the Optics Laboratory of the P.N. Lebedev Physics Institute of the USSR Academy of Sciences, which was also directed by Landsberg, Fabelinskiĭ embarked on a systematic and goal-oriented investigation of light scattering and molecular acoustics. He received his Candidate's Degree in 1942 and his Doctorate in 1955.

During this "pre-laser" period of his career, Fabelinskiĭ succeeded in measuring the propagation velocity of sound at frequencies of the order of 10^{10} Hz in meticulously conducted experiments to study the fine structure of scattered light, and became the first to observe the dispersion of the velocity of sound in a whole series of liquids. These investigations also made it possible to determine the relaxation times of second viscosity of liquids.

Attempts made in various countries over a thirty-year span to detect fine structure in the spectral lines of light scattered by glasses had been unsuccessful, and its existence was even denied. In an extremely difficult experiment, Fabelinskiĭ managed not only to find fine-structure components in light scattered by glasses, but also to follow the kinetics of their changes as the material made the transition from the liquid to the vitreous state. The velocity of hypersound was found to change by a factor of nearly two during this transition.

The formula given in the literature for the distribution of scattered-light intensity between the components of the Mandel'shtam-Brillouin doublet and the central component did not agree with experiment. Fabelinskiĭ calculated this ratio using the sound-velocity dispersion that he had observed and obtained an expression that described the experimental data well.

An important direction taken by Fabelinskiĭ's work was study of the depolarized-light spectrum formed by time-varying anisotropy fluctuations (the so-called wing of the Rayleigh line). It was found possible to determine the anisotropy relaxation time in various liquids from the phenomenological theory, using the distribution of intensity over the frequencies in the Rayleigh-line wing. These times range from 10^{-10} to 10^{-12} sec (rotational diffusion of molecules) and from 10^{-11} to 10^{-13} sec (molecular vibrations).

Fabelinskiĭ published his fundamental monograph "Molekulyarnoe Rasseyanie Sveta" (The Molecular Scattering of Light) in 1965; in 1968 it appeared in an expanded English translation. This work has now become literally a classic and is, of course, cited very extensively worldwide.

The appearance of laser light sources opened up completely new possibilities for the investigation of matter both in the gaseous phase and in the condensed state. Fabelinskiĭ recognized these possibilities at once and proceeded to exploit them.

Fabelinskiĭ and his co-workers observed several new phenomena in short order. It was found, for example, that under certain conditions, the Rayleigh-line wing in liquids is not a monotonically decreasing function, as had been assumed in the "pre-laser" period, but consists of a doublet–i.e., fine structure had been discovered in the wing. The effect was interpreted as a result of the modulation of the scattered light by elastic transverse Debye waves propagating in the liquid. Soon thereafter, several laboraties confirmed the exist-

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ence of the phenomenon itself (in several dozen liquids) and the correctness of this interpretation. Detection of fine structure in the wing of the Rayleigh line marked a new turn in both optical and acoustic reserach, and one that is still being advanced successfully in various countries.

A study of the spectrum of depolarized scattered light in solutions in the range of the critical separation point that Fabelinskiĭ and co-workers made at the Academy of Sciences Physics Institute (FIAN) jointly with Samarkand University physicists led to discovery of a new phenomenon: strong narrowing of the Rayleigh-line wing as the solution approached the critical point.

Still another major direction in Fabelinskiĭ's work pertains to the interaction of powerful laser radiation with matter, Again in this area he is credited with the observation of totally new phenomena. One of them was stimulated scattering in the wing of the Rayleigh line. This effect arises as a result of nonlinear interactions of the strong exciting light, the initially weak wing of the Rayleigh line, and the internal motion of the medium. These interactions produce a spectral line comparable in intensity to the exciting line but shifted away from it in frequency. The formation of the stimulated Rayleigh-line wing is characterized by a power threshold of the primary light beam. This phenomenon (which was investigated in detail by Fabelinskiĭ and later by a number of foreign authors) plays a significant and even decisive role in self-focusing, for certain stimulated Raman scattering effects, and in several other cases.

Another new phenomenon of nonlinear optics, the stimulated entropy (temperature) scattering of light in liquids, which is governed by the electrocaloric effect, was also observed by Fabelinskiĭ and his colleagues. It consists of the appearance of a scattered-light spectral line that is frequency-shifted in the Stokes direction and comparable in intensity to the incident light. This phenomenon also appears only above a certain exciting-light power threshold.

Fabelinskiĭ and his co-workers recently detected a nonlinear phenomenon produced by the interaction of a mode of the medium's orientational motion with a longitudinal acoustic wave. In this phenomenon, a doublet appears in place of the single stimulated-scattering line of the wing when the incident and scattered light are polarized in a certain way.

Special note should be taken of Fabelinskiĭ priority in the observation of stimulated scattering in compressed gases. These results posed a number of new problems on which work is now being done both in the Soviet Union and in many foreign laboratories.

Fabelinskii has recently been engaged in successful studies of the spectral and temporal characteristics of stimulated Mandel'shtam–Brillouin scattering and the Rayleigh-line wing in resonators.

Fabelinskiĭ is the author of over 100 scientific papers and has two inventions to his credit. He has taught in the MSU physics department and in several insitutions of higher learning; he achieved the title of Professor in 1969. Many Candidates of Sciences have worked on their dissertations under his guidance, both at the FIAN and elsewhere. He organized and consults on light-scattering research at Samarkand University and he is also associated with several other scientific establishments. He was awarded the Lomonosov Prize of the USSR Academy of Sciences Presidium in 1966, and was elected a Corresponding Member of the USSR Academy of Sciences in 1979.

On Immanuil Lazarevich Fabelinskiĭ's seventieth birthday his friends and colleagues wish him vigor and health, continuing freshness of thought and action, and further success in science.

Translated by R. W. Bowers