E. B. Aleksandrov and V. S. Zapasskiĭ. *Magnetic resonance in the noise in the intensity of scattered light.* The spectroscopy of fluctuations of scattered light as a method for studying the structural and dynamic properties of macromolecular systems is based on the classical theory of light scattering and there are no fundamental difficulties in the interpretation of the experimental data. In application to microscopic objects—atoms and molecules—this technique, which can appear in the role of high-resolution spectroscopy, exhibits peculiarities associated with the peculiarities of quantum-mechanical measurements and with the need for taking into account quantum effects in the interaction of radiation with matter. Detailed analysis of these questions has made it possible to formulate the conditions that must be met in order for the internal dynamics of microparticles to be reflected in the spectrum of the fluctuations of the scattered radiation.[1]

The main advantages of the fluctuation approach are determined by the unique possibility of studying completely disordered ensembles of particles combined with virtually unlimited spectral resolution. The disadvantages of this technique include its low sensitivity or, more precisely, the low information flux density in a powerful, but low-noise scattered light flux and, as a consequence, the need for integration of the signal over a long time using modern integration technology—multichannel spectrum analyzers with integration of the parallel type.

E. Hahn *et al.*[2,3] recently reported the first observation of an NMR spectrum using the method of recording the induction signal from nuclei precessing in a disordered manner; this method is a new direction in radiospectroscopy. It was possible to observe the disordered fluctuations of the magnetization of the sample at the magnetic resonance frequency by using a SQUID with an effective noise temperature of 0.2 K as the precession signal amplifier.

The possibility in principle of observing resonance noise of nuclear magnetization was pointed out in F. Bloch's first paper on NMR,[4] and it was later discussed in detail in Refs. 5 and 6. At the same time, the first experimental work in which the disordered precession of the spins of a paramagnetic substance was observed was peformed by us[7] by the method of spectroscopy of fluctuations of the Faraday rotation accompanying the propagation of light probing a paramagnetic material transverse to the direction of magnetization. In this arrangement of the experiment the fluctuations of the magnetization of the medium at the electron paramagnetic resonance frequency were converted to phase (polarization) modulation of the probing light. In other words, the magnetization fluctuations characterized by energy $\hbar\gamma H$ (γ is the gyromagnetic ratio and H is the magnetic field intensity) were converted in this case into fluctuations of the flux of light quanta with energy $\hbar\omega \gg \hbar\gamma H$. This scale conversion of the energy of the measured physical field radically affects the experimental possibilities of fluctuation spectroscopy, since the detection of noise modulation of the flux of high-energy photons does not impose any strong requirements either on the dark noise of the photodetector or the input noise level of the amplifier. This is what determines the advantages of the optical technique for detecting magnetization noise over direct detection of the induction signal.

The specific advantages of noise spectroscopy, which fundamentally distinguish it from all existing methods for detecting magnetic resonance, are linked with the possibility of observing resonance in the absence of magnetic polarization of the medium, when the populations of the magnetic sublevels are equal. Under these conditions a regular induced magnetic resonance signal is impossible, while spontaneous fluctuations of the magnetization remain under any conditions, including at zero temperature and vice versa, at arbitrarily high temperatures. In addition, the "spontaneous" magnetic resonance spectroscopy could be useful in those cases when the experimental conditions preclude high-frequency irradiation of a paramagnetic substance. In a certain sense the spontaneous magnetic resonance technique is simpler than the traditional technique: since the sample need not be excited with a coherent field this technique does not require a high-frequency channel and thus need not be tied to a specific frequency, like the standard EPR spectrometers.

Of course, the traditional induced magnetic resonance technique will remain the dominant technique in the future owing to its much higher sensitivity when the material is magnetically polarized (in the limit, by a factor of N^2, where N is the number of spins in the paramagnetic material. The viability of the method of spontaneous magnetic resonance depends largely on the level of development of the technique of spectral analysis of electric signals and the possibility of long-time parallel integration of the spectra. Since Ref. 7, significant progress has been achieved in this direction, so that successful future applications of the noise technique in the spectroscopy of magnetic resonance and relaxation in solids as well as the development of this new direction of magnetic spectroscopy can be expected.

[1]E. B. Aleksandrov, Yu. M. Golubev, A. V. Lomakin, and V. A. Noskin, Usp. Fiz. Nauk **140**, 547 (1983) [Sov. Phys. USP **26**, 643 (1983)].

[2]T. Sleator, E. L. Hahn, C. Hilvert, and J. Clark, Phys. Rev. Lett. **55**, 1742 (1985).
[3]E. L. Han, Proc. 23rd Congress AMPERE on Magnetic Resonance, Rome, 1986, p. 3.
[4]F. Bloch, Phys. Rev. **70**, 460 (1946).
[5]G. V. Skrotskiĭ and A. A. Kokin, Zh. Eksp. Teor. Fiz. **36**, 933 (1959) [Sov. Phys. JETP **9**, 659 (1959)].
[6]A. I. Filatov, in Proceedings of the Ural Polytechnical Institute, Series on Atomic and Molecular Physics (in Russian), Ural Polytechnical Institute, Sverdlovsk, 1969, No. 172, p. 23.
[7]E. B. Aleksandrov and V. S. Zapasskiĭ, Zh. Eksp. Teor. Fiz. **81**, 132 (1981) [Sov. Phys. JETP **54**, 64 (1981)].

Translated by M. E. Alferieff