Scientific session of the Division of General Physics and Astronomy, USSR Academy of Sciences (25–26 October 1978)

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A scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics of the USSR Academy of Sciences was held on October 25 and 26, 1978. The following papers were delivered:

1. *G. S. Krinchik*, Magnetooptical study of surfaces.

2. *A. F. Andreev*, Thermodynamics of liquids below the Debye temperature.

3. *É. E. Berlovich*, Study of nuclei far from the β-stable band.

4. *V. S. Letokhov*, Detection of single atoms and nuclei by methods of laser spectroscopy.

5. *G. N. Flerov and Yu. G. Oganesyan*, Synthesis and discovery of superheavy elements.

We publish below brief contents of four of the papers.

G. S. Krinchik. *Magnetooptical study of surfaces.* The magnetooptical method of studying the surface magnetic properties of crystals[1] is based on the following two premises: 1) at absorption-coefficient values of the order of unity, visible light penetrates into the crystal to a depth of less than 500 Å in the reflection process; 2) the magnetooptical effects in which the intensity of the reflected light varies or the polarization plane rotates are proportional to the magnetization of the ferromagnetic. Thus, having determined this coefficient of proportionality in the range of magnetic saturation for a given crystal, we are in a position to determine all of the basic magnetic properties of the surface layer by measuring the dependence of the magnetooptical effect on the magnetic field strength. If we are dealing with magnetic crystals that are transparent in the visible region of the spectrum, special measurements can be made in the ultra-violet in order to reduce the penetration depth of the light to the desired value by increasing the absorption cooefficient. Finally, if, in addition to this limit on the penetration depth, we introduce spatial limiting of the light pencil, i.e., if we minimize the size of the area from which the light is reflected, we arrive at a magnetooptical method for measuring the magnetic properties of micron-size areas of the surface.[2] Under an optical microscope with good resolution, the illuminated area can be reduced to about 1 μm^2, so that the volume of the "specimen" whose magnetic properties are measured drops below 10^{-3} cm^3. We cite certain examples of the use of these methods to solve various physical and applied problems.

a) *Surface magnetism of hematite.*[3] Magnetooptical investigation of magnetization on the "low-symmetry" faces of hematite single crystals has shown that the magnetic states of the crystal in the interior and in the surface layer are qualitatively different. This effect is due to spontaneous formation of a superficial transitional magnetic layer of the domain-boundary type, which, in turn, results from a change in the symmetry of the surroundings of the surface magnetic ions. The thickness of this transitional layer can be varied from a few microns to zero by varying an external magnetic field. Calculation indicated that the surface magnetism of hematite may be cuased by magnetic-dipole interaction between superficial magnetic ions, except that "propagation" of the transitional layer into the crystal occurs as a result of exchange interaction.

b) *Formation of a thin ferromagnetic layer on the surface of austenitic steel.*[4] Heating of type ÉP-838 nonferromagnetic austenitic chrome-manganese steel (a first-wall structural material for thermo-nuclear reactors) at temperatures of 400-1100 °C under hard vacuum results in the formation of a ferromagnetic layer a few microns thick on its surface. Its appearance is explained by vaporization of manganese, the basic austenitizing additive in this steeel. No similar ferromagnetic phase was observed to form on type SS-316 chrome-nickel steel. The appearance of the ferromagnetic layer indicates a γ-α phase transition in the surface layer, and in this case the magnetooptical method can be used for diagnostic purposes.

c) *Surface segregation of nickel in nonferromagnetic nickel-zirconium catalysts.*[5] It has been know for some time that the catalytic activity of nickel-zirconium catalysts increases from zero to a certain maximum value over a few hours. Magnetooptical investigation of the surfaces of these catalysts has shown that this activity increase is due to the formation of a thin ferromagnetic nickel layer under the oxide film on the surface. The formation of this sandwich structure in the surface region was established by magnetooptical sensing of the surface with light at various wavelengths.

d) *Domain-boundary structure in ferromagnetics.*[2] Studies of the magnetooptical properties of small surface areas at near-limit resolutions has made it pos-

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sible to obtain reliable signals directly from areas at which domain boundaries emerge at the surface in a ferromagnetic metal (iron) and a weak ferromagnetic (hematite). It has been shown that the structure of the domain boundary changes significantly as it approaches the surface; the formation of subdomains, modification of these subdomains under the action of an external magnetic field, and other effects have been observed.

e) *Study of the distribution of magnetization in micron elements.*[6] It will be appreciated that micron-resolution magnetooptics is useful not only in study of magnetic properties on specific areas of large specimens, but also for investigation of small ferromagnetic elements. These elements have been produced in response to the demands of modern integrated-circuit technology; they are components of cylindrical magnetic domain memory devices and thin-film magnetic heads; the range of applications of magnetic microelements will expand continuously in the future. The distribution of magnetization in these elements and their magnetic properties fully determine the functional parameters of the devices for which they are developed. Even the research done thus far on the controlling elements and elements of chevron detector circuits with cylindrical magnetic domains, together with work done on the magnetic circuits of integrated magnetic heads, has brought out a number of new factors that have changed existing concepts and provided data in support of sound theoretical design of devices incorporating these elements.

[1]G. S. Krinchik, Fiz. Tverd. Tela (Leningrad) **2**, 1945 (1960) [Sov. Phys. Solid State **2**, 1753 (1961)].

[2]G. S. Krinchik and O. M. Benidze, Zh. Eksp. Teor. Fiz. **67**, 2180 (1974) [Sov. Phys. JETP **40**, 1081 (1975)].

[3]G. S. Krinchik and V. E. Zubov, Zh. Eksp. Teor. Fiz. **69**, 707 (1975) [Sov. Phys. JETP **42**, 359 (1975)].

[4]G. S. Krinchik, L. V. Nikitin, L. I. Ivanov, G. G. Bondarenko, and G. M. Fedichkin, Dokl. Akad. Nauk SSSR **245**, 839 (1979) [Sov. Phys. Dokl. **24**, 285 (1979)].

[5]G. S. Krinchik, L. V. Nikitin, V. V. Lunin, and P. A. Chernavskiĭ, Fiz. Tverd. Tela (Leningrad) **21**, 599 (1979) [Sov. Phys. Solid State **21**, 354 (1979)].

[6]G. S. Krinchik, E. E. Chepurova, U. N. Shamatov, V. K. Raev, and A. K. Andreev, AIP Conf. Proc., **24**, 649 (1975). G. S. Krinchik, Zh. P. Lazzari, E. E. Chepurova, and U. N. Shamatov, Pis'ma Zh. Tekh. Fiz. **3**, 1209 (1977) [JETP Lett. **3**, 499 (1977)]. G. S. Krinchik, E. E. Chepurova, and U. N. Shamatov, IEEE Trans. Magnet., **Mag-14**, 1169 (1978).