(or probability) of the radiation is approximately the same at the normal and complex frequencies [basically, frequencies are radiated which are close to $\omega_c(\theta_c)$]. Under these conditions, the populations of levels i and k will be the same in the stationary state.

In a number of multilevel systems we deal with bunches of atoms or molecules with two appropriate levels. The radiation from a bunch which is smaller than the wavelength of interest is coherent and similar to the radiation of a spin system placed in a magnetic field.[7] However, the faster-than-light radiation of such bunches or of individual atoms and molecules or paramagnetic or ferromagnetic particles is scarcely of practical interest (even with $n \sim 30$ the hydrogen atom can acquire a velocity $v > c/n$ only when its kinetic energy is 5×10^6 ev). On the other hand, it is completely feasible to consider faster-than-light radiation of electrons which move along a magnetic field in which the role of the medium is played by a metal slow-wave structure, a dielectric, or a plasma located near the beam. If the velocity component perpendicular to the field $\mathbf{v}_\perp$ is zero only Cerenkov radiation is possible. If, however, $\mathbf{v}_\perp \neq 0$ and the condition $v_\perp/v_\parallel \ll mc^2/E \ll 1$ is fulfilled the electrons radiate in the same way as two perpendicular oscillators which lie in the plane of $\mathbf{v}_\perp$ and move through the field with a velocity $v_\parallel$. The faster-than-light Doppler radiation, which appears when $v_\parallel > c/n(\omega)$, causes electron transition to higher levels, i.e., the excitation of transverse oscillations. As a result the velocity $v_\parallel$ is reduced and, for example, with $n = \text{const}$ the excitation stops when $v_\parallel = c/n$. In a case of great practical interest, namely, the sporadic radio waves from the sun,[8] the motion of the electrons in the magneto-active plasma medium is anisotropic. Hence in Eq. (1) we must replace n by $n_j(\theta, \omega)$ where j denotes the type of proper wave (ordinary or extraordinary). Dispersion cannot be neglected and the expression for the radiated energy is strongly divergent.[9] The author proposes to consider faster-than-light Doppler electron radiation in detail in a subsequent paper.

[1] I. M. Frank, Izv. Akad. Nauk SSSR, Ser. Fiz. **6**, 3 (1942); J. Phys. (U.S.S.R.) **7**, 49 (1943).

[2] V. L. Ginzburg and I. M. Frank, Dokl. Akad. Nauk SSSR **56**, 583 (1947).

[3] V. L. Ginzburg, J. Exptl. Theoret. Phys. (U.S.S.R.) **10**, 589 (1940); J. Phys. (U.S.S.R.) **2**, 441 (1940).

[4] V. L. Ginzburg and I. M. Frank, Dokl. Akad. Nauk SSSR **56**, 699 (1947).

[5] V. L. Ginzburg, Dokl. Akad. Nauk SSSR **56**, 145 (1947); V. L. Ginzburg and V. Ia. Eidman, J. Exptl. Theoret. Phys. (U.S.S.R.) (in press).

[6] L. D. Landau, Z. Physik **45**, 430 (1927); F. Bloch, Physik. Z. **29**, 58 (1958); V. Weisskopf and E. Wigner, Z. Physik **63**, 54 (1930); **65**, 18 (1930).

[7] R. H. Dicke, Phys. Rev. **93**, 99 (1954); V. M. Fain, Usp. Fiz. Nauk **64**, 273 (1958).

[8] G. G. Getmantsev and V. L. Ginzburg, Dokl. Akad. Nauk SSSR **87**, 187 (1952); V. V. Zhelezniakov, Usp. Fiz. Nauk **64**, 113 (1958).

[9] V. Ia. Eidman, J. Exptl. Theoret. Phys. (U.S.S.R.) **34**, 131 (1958), Soviet Phys. JETP **7**, 91 (1958).

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CHANGE IN WIDTH OF BOUNDARY LAYER IN FERROMAGNETS BY MEANS OF THE MAGNETO-OPTICAL KERR EFFECT

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ATTEMPTS to measure the width of the boundary layer between ferromagnetic domains have been heretofore by the method of powder patterns with the use of an electron microscope.[1] In the final analysis, however, this method determines not the true width of the boundary layer, but the width of the path occupied by the magnetic suspension. In this work we employ in principle a method proposed by Krinchik,[2] based on the use of the polar magneto-optical Kerr effect.[3] This method permits direct measurement of the width of the boundary layer.

It can be shown that the average normal component of magnetization of the boundary layer is represented by the quantity $2j_S/\pi$, where J_S is the saturation magnetization of the ferromagnetic region. A photomultiplier (FEU-18) was used to measure the variation, due to the rotation of the

plane of polarization, in light reflected from the boundary layer, and to measure the change in the light flux from the studied portion of the ferromagnetic region, magnetized normal to the surface to a value $2J_S$. The direct proportionality between the two measured quantities leads to the ratio

$$\Delta\Phi / \Delta\Phi' = ld / S',$$

where $\Delta\Phi$ is the change in the light flux from the boundary layer, $\Delta\Phi'$ is the change in the light flux from the studied section of the specimen normally magnetized to a value $2J_S/\pi$, l is the length of the boundary layer bounded by the area of the section considered, d is the width of the boundary layer, and S' is the area of the studied portion of the specimen.

As can be seen from this expression, d is determined by comparing the light fluxes and the areas.

We used an integral-balance circuit in conjunction with the FEU-18 photomultiplier[4] and a compensating setup, the MBI-6 microscope, and the SI-1 pulse synchroscope. The variation of the light flux reflected from the boundary layer was estimated from the value of the capacitor-charging photocurrent at the instant when the boundary layer was brought into the field of view of the microscope and the system was unbalanced. The variation of the light flux from the section of the ferromagnetic region normally magnetized to a value $2J_S/\pi$ was estimated from the value of the flux as measured directly by the galvanometer.

The area of the studied region was measured under the microscope with an ocular micrometer and an object micrometer.

The width of the boundary layer was determined for single crystals of iron silicide containing 3% silicon. The longitudinal measurements give a value of 0.8 microns for the width of the boundary layer.

[1] D. J. Craig, Proc. Phys. Soc. **B69**, 438 (1956).

[2] G. S. Krinchik, Физика металлов и металловедение (Physics of Metals and Metal Research) **3**, 549 (1956).

[3] A. V. Sokolov, Usp. Fiz. Nauk **50**, 161 (1953).

[4] L. A. Kubetskii, Вторично-электронные xx приборы (Secondary-Emission Devices), 1951.

Translated by J. G. Adashko
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NEGATIVE IONS OF IRON, COBALT, AND NICKEL

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IN all cases known at present, it is possible to attribute formation of atomic negative ions to the penetration of an additional electron into an incomplete outer group of equivalent electrons. It appeared to us that an electron affinity could be possessed also by such atoms that have an "open position" not on the periphery of the electron cloud but in its deeper portions. In connection with this, we undertook a search for negative ions of iron, cobalt, and nickel. In these elements there are two outer 4s electrons and an incompletely filled 3d group. We chose these elements also because we found mention made in the work of Schaefer and Walcher[1] of weak nickel lines in the spectrum of the negative ions emitted by an oxide cathode with a nickel core.

In our experiments we used a magnetic mass spectrometer with a resolving power of about 100. We obtained negative ions by exposing molecules containing the investigated atoms to the action of an intense beam of electrons. For working substances we chose the anhydrous dichlorides $FeCl_2$, $CoCl_2$ and $NiCl_2$. Analysis of the composition of the negative ions obtained upon introduction of vapors of these substances into the ion source of the mass spectrometer gave the following results:

$FeCl_2$. With operation of the ion source as usual for mass-spectroscopic determinations, lines for Cl^-, Cl_2^-, $FeCl^-$ and $FeCl_3^-$ were observed in the negative ion spectrum. For a higher temperature of the oven which contained the $FeCl_2$, lines appeared corresponding to Fe^- ions (masses 54 and 56). Pushing the operation of the source (25 ma, 70 v), the current of Fe_{56}^- ions could be raised to 5×10^{-13} amp (along with which the current of $FeCl^-$ and $FeCl_2^-$ ions was of the order of 10^{-10} amp).

$CoCl_2$. With ordinary operation of the ion source, ions of Cl^-, Cl_2^-, $CoCl^-$, $CoCl_2^-$ and also a weak line of Co_{59}^- were observed. By increasing the intensity of the electronic current and the density of the $CoCl_2$ fumes in the source, we could drive the current of Co^- ions to 3×10^{-13} amp.