FERMI RESONANCE OF POLARITON WITH BIPHONON IN AN $LiNbO_3$ CRYSTAL

B.N. Mavrin and Kh. E. Sterin
Institute of Spectroscopy, USSR Academy of Sciences
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The Fermi resonance of a polariton with an overtone or composite tone in a $K_3Cu(CN)_4$ crystal was reported in [1], although the presence of intersecting polariton branches of classes A_1 and E in the resonance region admits also of another interpretation of the result [2]. According to the theory of Agranovich and Lalov [3, 4], observation of a gap in the polariton spectrum in the region of the overtone would prove the existence of a bound state of two phonons (biphonon) [5]. We have investigated in this connection the Fermi resonance in an $LiNbO_3$ crystal.

We used a Coderg spectrometer (France) and an He-Ne laser (λ = 632.8 nm, 50 mW). The specimen temperature was ~100°K; the slit width was 6 cm^{-1}; the laser beam divergence angle inside the crystal was 0.1°. We observed the 482, 536, and 836 cm^{-1} second-order lines, which were visible at the scattering geometries y(zz)x, y(zy)x, y(xy)x, and y(xz)x. Their intensity far from resonance was low, ~10^{-3} of the intensity of the fundamental frequencies.

We investigated resonance of the 634 cm^{-1} A_1 (630 cm^{-1} at room temperature) with the composite tone 536 cm^{-1} (256 A_1 + 279 A_1); the scattering geometry was y(zz)y, the polariton wave vector was in the xy plane, and the gathering angle of the scattered light was 0.5°. The resonance was reached by scanning the polariton towards the lower frequencies by decreasing the scattering angle θ. This resulted in a doublet (Fig. 1) whose low-frequency component first increased in intensity gradually, without shifting. The intensity of the components become practically equal near the maximum of the resonance. The shift of the high-frequency component of the doublet constituting the polariton then stops, and its intensity decreases. On the other hand, the low frequency component begins to shift and finally turns into the polariton (Figs. 1 and 2). In the entire region of the resonance $2° \geq \theta \geq 0°$ (θ inside the crystal) the doublet is a single state with polarization (zz); no lines are seen at the polarization (zx) (Fig. 1, IV), although the 536 cm^{-1} composite tone is seen in both cases (cf. supra). The resonant branches $\nu_p(\theta)$ (Fig. 2) form a gap of width 7 cm^{-1}. The authors of [6] have observed the same $\nu_p(\theta)$ at room temperature and $\theta \geq 0.91°$, and apparently noted no resonance.

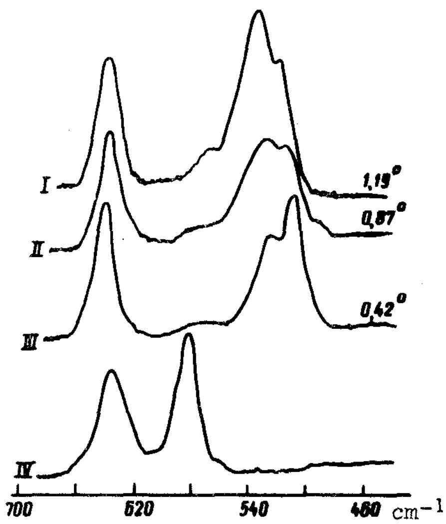

Fig. 1. Doublets near the maximum of the resonance: I - III) y(xx)y geometry; the 634 cm^{-1} A_1 line is seen as a result of reflection from the crystal face opposite to the observation side; IV) y(zx)y geometry, the picture is the same for all θ, since there is no polariton effect on the 634 and 580 cm^{-1} E lines.

The absence of first-order lines of classes A_1 and E, from our Fermi-resonance region, other than the investigated polariton,

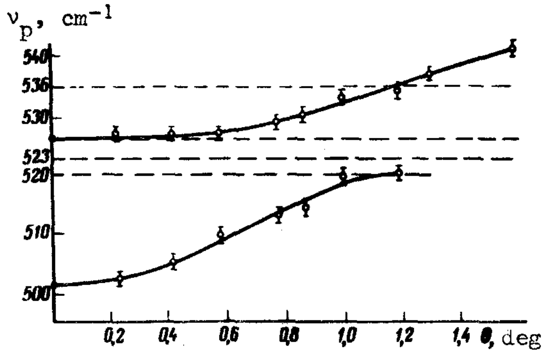

Fig. 2. Polariton frequency ν_p vs. θ in the region of the Fermi resonance.

exclude resonance between them [7]. Nor is the observed effect a resonance of the polariton with 536 cm^{-1}, as might be expected [8], since the center of the gap, 523 cm^{-1}, lies below the composite tone. In accord with the theory [3, 4], we assume that we have observed Fermi resonance of the polariton with the 523 cm^{-1} biphonon split from the composite tone 536 cm^{-1}. One can assume that the biphonon intensity is very low, and therefore it is not seen at $\theta = 90°$ and can be seen only as a result of the resonance. Thus, the Fermi resonance in $LiNbO_3$ offers indirect proof of the existence of a bound state (biphonon) in the crystal.

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[1] R. Claus and A.W. Schrotter, Opt. Comm. 2, 105 (1970).
[2] R. Claus, Phys. Lett. 31A, 299 (1970).
[3] V.M. Agranovich and I.I. Lalov, Fiz. Tverd. Tela 13, 1032 (1971) [Sov. Phys.-Solid State 13, 859 (1971)].
[4] V.M. Agranovich and I.I. Lalov, Zh. Eksp. Teor. Fiz. 61, 656 (1971) [Sov. Phys.-JETP 34, 350 (1972)].
[5] V.M. Agranovich, Fiz. Tverd. Tela 12, 562 (1970) [Sov. Phys.-Solid State 12, 430 (1970)].
[6] H.E. Puthoff, R.H. Pantell, B.G. Huth, and M.A. Chason, J. Appl. Phys. 39, 2144 (1968).
[7] G. Lamprecht and L. Merten, Phys. Stat. Sol. 35, 353 (1969).
[8] G. Herzberg, Infrared and Raman Spectra of Polyatomic Molecules, Van Nostrand, 1945.

EQUATORIAL KERR EFFECT IN IRON GARNETS

G.S. Krinchik and V.A. Krylova
Moscow State University
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We report here the results of the first measurements of the equatorial Kerr effect δ on single crystals of iron garnets of yttrium, europium, and terbium. We have observed that the change of the intensity of the reflected light upon reversal of the magnetic field reaches 5%, i.e., the equatorial Kerr effect in iron garnets greatly exceeds the maximum value of this effect in ferromagnetic d-metals. The most intense maxima on the δ curves have been identified with optical transitions in the tetrahedral Fe^{3+} ions. We have found that the rare-earth sublattice affects the intensity of the magneto-optical transitions in the Fe^{3+} ions.

We measured the change of the intensity of the p-component of linearly-polarized light upon reflection from a transversely-magnetized specimen (the magnetization vector was perpendicular to the plane of incidence of the light). The equatorial Kerr effect is then given by the formula $\delta = (I - I_0)/I_0$, where I_0 and I are the intensities of the light reflected from the demagnetized and magnetized specimen, respectively. The measurements were made at room