quadrupole charge $D^{e}_{\alpha\beta}$ over the surface can radiate a highly collimated beam of electromagnetic waves in a direction perpendicular to the surface. A quadrupole of mass $D^{m}_{\alpha\beta}$, proportional to $D^{e}_{\alpha\beta}$, will not emit the corresponding gravitational power, since the angular distribution of the intensity of the gravitational radiation

$$dI^{m} = k(36\pi c^{5})^{-1}[\tfrac{1}{4}(\dddot{D}^{m}_{\alpha\beta}n_{\alpha}n_{\beta})^{2} + \tfrac{1}{2}(\dddot{D}^{m}_{\alpha\beta})^{2} - \dddot{D}^{m}_{\alpha\beta}\dddot{D}^{m}_{\alpha\gamma}n_{\beta}n_{\gamma}]d\Omega$$

differs radically from the angular distribution of the electromagnetic intensity, given by

$$dI^{e} = (36\pi c^{5})^{-1}[\tfrac{1}{4}\dddot{D}^{e}_{\alpha\beta}\dddot{D}^{e}_{\alpha\gamma}n_{\beta}n_{\gamma} - \tfrac{1}{4}(\dddot{D}^{e}_{\alpha\beta}n_{\alpha}n_{\beta})^{2}]d\Omega.$$

In particular, dI^{m} vanishes in the direction in which dI^{e} has a maximum.

3) In the case when $k_{m}L \ll 1$, the radiator becomes a pointlike quadrupole, and (14) yields a result identical with the time-averaged $1/45\ (kc^{-5})\dddot{D}^{2}_{\alpha\beta}$, where $D_{\alpha\beta}$ is the tensor of the quadrupole moment of the system, including the energy of the electromagnetic field.

4) The author does not believe that passive detectors of gravitational waves can be realized in principle. Active detectors, i.e., generators of gravitational waves, can measure, in principle, the radiation from another source. This question will be dealt with in a future paper by the author (with F. Cooperstock and G. Ludwig).

EFFECT OF UNIAXIAL COMPRESSION ON THE PARAMAGNETIC RESONANCE OF Nd^{3+} IN $CaWO_4$

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An investigation of the spectra in a deformed crystal is the most direct method of determining the interaction between an impurity ion and its environment [1,2]. The effect of pressure on EPR spectra was investigated so far for iron-group ions [3]. We observed the influence of uniaxial pressure on the EPR of certain rare-earth ions in single-crystal scheelites. The present communication is devoted to Nd^{3+} in $CaWO_4$.

The main term $4f^{3}\ {}^{4}I_{9/2}$ of neodymium in the $CaWO_4$ lattice splits into five Kramers doublets spaced ~100 cm^{-1} apart. At 4.2°K, the line from the lower doublet is observed, with $g_{\parallel} = 2.03$ and $g_{\perp} = 2.54$ [4] (we do not consider the hyperfine structure). Pressure applied to the crystal adds to the ordinary spin-Hamiltonian with effective spin 1/2 a perturbation $\mathcal{H}'$ linear in the magnetic field and in the spin [5]:

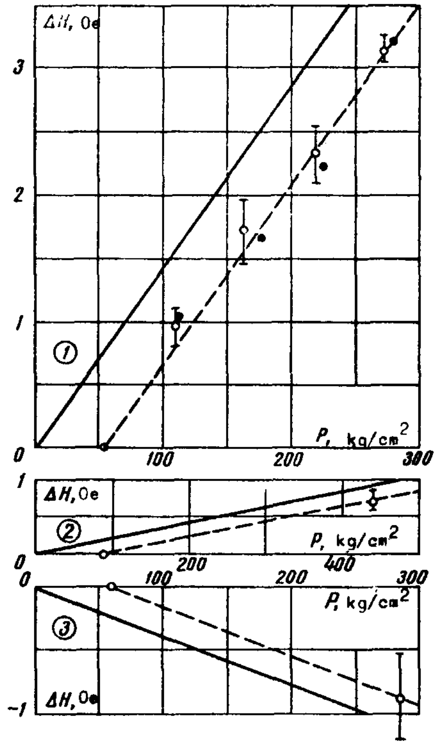
$$\mathcal{H}' = G_{ik\ell m}S_{i}H_{k}u_{\ell m}. \qquad (1)$$

Here i, k, ℓ, m = x, y, z; $u_{\ell m} = \frac{1}{2}(\partial u_{\ell}/\partial x_{m} + \partial u_{m}/\partial x_{\ell})$ is the strain tensor. The tensor G determines the magnitude of the effect. It is symmetrical in the second pair of indices, and its remaining properties are determined by the symmetry of the local field. In this case the symmetry is S_4 [6], but we can assume D_{2d} with good approximation [7]. Then G has eight independent components, and $\mathcal{H}'$ takes the form

$$\mathcal{H}' = G_{12}(H_xS_xu_2 + H_yS_yu_1) + 2G_{66}(H_xS_y + H_yS_x)u_6 + G_{13}(H_xS_x + H_yS_y)u_3$$
$$+ 2G_{55}(H_xS_z + H_yS_z)u_5 + G_{31}H_zS_z(u_1 + u_2) + 2G_{75}(H_zS_xu_5 + H_zS_yu_4) \qquad (2)$$
$$+ G_{11}(H_xS_xu_1 + H_yS_yu_2) + G_{33}H_zS_zu_3.$$

In contradistinction to [5], the coordinates are Cartesian throughout. The notation is:

$$xx = 1,\ yy = 2,\ zz = 3,\ yz = 4,\ xz = 5,\ xy = 6,\ zx = 7. \qquad (3)$$



Shift of EPR line of Nd^{3+} in $CaWO_4$ under the influence of uniaxial pressure. Dashed - averaged experimental curve. The shifts were measured relative to the line position at a certain initial pressure. Solid - actual plot of shift vs. pressure, obtained by parallel transfer to the origin. Numbered open circles: 1 - P ∥ [100], H ∥ [010]; 2 - P ∥ [110], H ∥ [110]; 3 - P ∥ [001], H in (001) plane; filled circles: P ∥ [010], H ∥ [100].

The measurement results are shown in the figure. They yield three linear combinations of the components G:

$$G_{11}s_{12} + G_{12}s_{11} + G_{13}s_{13} = -13 \times 10^{-32}\ \mathrm{cm^3/G}, \qquad (4)$$

$$G_{11}s_{13} + G_{12}s_{13} + G_{13}s_{33} = 3.7 \times 10^{-32}\ \mathrm{cm^3/G}, \qquad (5)$$

$$(G_{11} + G_{12})(s_{11} + s_{12}) + 2G_{13}s_{13} - 2G_{66}s_{66} = -4 \times 10^{-32}\ \mathrm{cm^3/G}. \qquad (6)$$

No reliably measurable line shift was observed at pressures P ∥ [100] and P ∥ [110], and at H ∥ [001]. This yields the additional relation:

$$G_{31} \approx \frac{s_{13}}{s_{11} + s_{12}} G_{33}. \tag{7}$$

The elastic tensor s, defined by

$$-u_{ik} = s_{iklm}\sigma_{lm} \tag{8}$$

for $CaWO_4$, was not measured, but the results of [8] show that $s \sim 10^{-12}$ $cm^2/dyne$, yielding the estimate

$$G \sim 10^{-20} \text{ erg/G}. \tag{9}$$

Even this preliminary estimate leads to a few interesting conclusions, particularly to a comparison of the Kramers doublets belonging to the ions of the iron group and of rare earths. Tucker [9] made measurements on the Kramers doublet of the ion Co^{2+} ($3d^7$) in MgO and obtained (in our notation) $G \sim 10^{-19}$ erg/G. Thus, the direct coupling of the Nd^{3+} ion to the $CaWO_4$ lattice turns out to be unexpectedly small and, most curiously, smaller than for Co^{2+} in MgO. This contradicts the current opinion that rare-earth ions are more strongly coupled dynamically to the lattice than the iron-group ions.

[1] W. M. Walsh and N. Bloembergen, Phys. Rev. 107, 904 (1957).
[2] A. A. Kaplyanskii, Optika i spektroskopiya 7, 677 (1959).
[3] E. B. Tucker, Proc. of IEEE 53, 1547 (1965).
[4] N. E. Kask, L. S. Kornienko, A. M. Prokhorov, and M. Fakir, FTT 5, 2303 (1963), Soviet Phys. Solid State 5, 1675 (1964).
[5] N. G. Koloskova, Paramagnitnyi rezonans (Paramagnetic Resonance), Kazan' Univ. Press, 1964, p. 115.
[6] W. B. Mins, Phys. Rev. A140, 531 (1965).
[7] L. Ya. Shekun, FTT 8, 1717 (1966), Soviet Phys. Solid State 8, in press.
[8] D. Gerlich, Phys. Lett. 12, 314 (1964).
[9] E. B. Tucker, Phys. Rev. 143, 264 (1966).

SELF-FOCUSING OF POWERFUL LIGHT BEAMS BY THERMAL EFFECTS

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Self-focusing [1-3] of powerful light beams is usually associated with the Kerr effect and electrostriction [3-5], since these are the very mechanisms that lead to the strongest dependence of the dielectric constant of a substance on the field amplitude. The purpose of this communication is to call attention to a possible self-focusing of light by heating of the medium in the field of the wave 1).

The dielectric constant of a medium, taking heating into account, can be represented