region 26000 - 31000 cm^{-1}, the exchange interaction induces "double" electron-magnon ($\nu = 2\nu(0) + 2\nu_\mu$) and electron-vibrational magnon ($\nu = 2\nu(0) + \nu_m + \nu_\mu$) transitions, as the result of which the selection rules pertaining to the purely electron transition $2^3\Sigma_g^- \to 2^1\Sigma_g^+$ is violated and an appreciable intensity of this transition is ensured ($\nu(0)$ - frequency of the transition in the free molecule, ν_m - molecule vibration frequency, ν_μ - frequency of magnon excitation).

Similar results which offer evidence of the magnon origin of the bands were obtained by us also for other transitions ($2^3\Sigma_g^- \to {}^1\Delta_g$ and $2^3\Sigma_g^- \to {}^1\Delta_g + {}^1\Sigma_g^+$), but the appearance of a non-zero orbital angular momentum in the excited state makes the interpretation of these transitions complicated. Detailed data on the investigation of these transitions will be published later.

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EXCITATION OF FORBIDDEN AND ALLOWED RADIATIVE TRANSITIONS IN A $CaF_2:Dy^{2+}$ CRYSTAL IN A MAGNETIC FIELD

V. P. Zakharchen'ya, I. B. Rusanov, and A. Ya. Ryskin
A. F. Ioffe Physico-technical Institute, USSR Academy of Sciences

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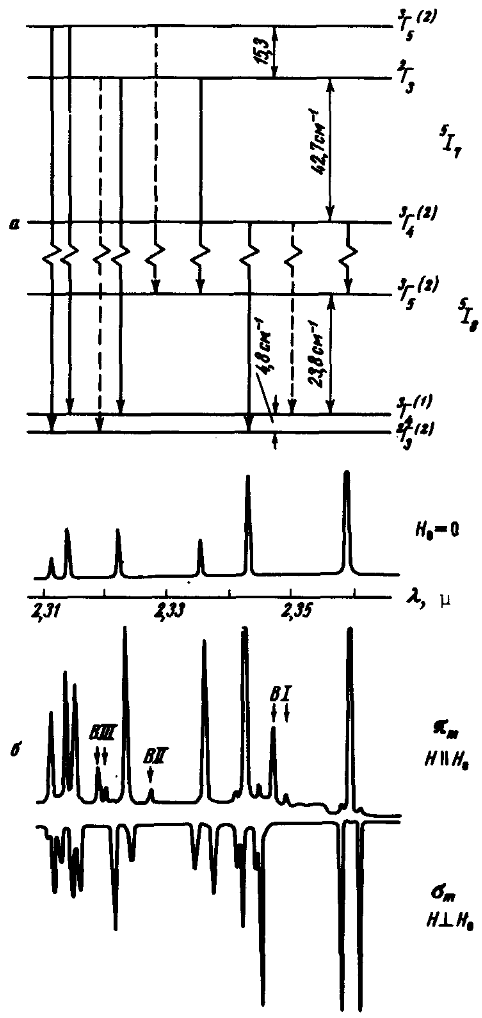
The emission spectrum of a $CaF_2:Dy^{2+}$ crystal has in the 2.3 μ region a group of lines due to magnetic dipole transitions between the Stark sublevels of the excited ${}^5I_7$ state and the ground state ${}^5I_8$ of the Dy^{2+} ion. The spectroscopic and magnetic-optical investigations of $CaF_2:Dy^{2+}$ [1,2] have made it possible to identify the scheme of the Stark sublevels and to identify the observed lines with different allowed transitions in a crystal of symmetry O_h (see the figure). A characteristic feature of the Stark structure of the states ${}^5I_8$ and ${}^5I_7$ is the fact that several components are close to one another. Particularly close are the components ${}^2\Gamma_3^{(2)}$ and ${}^3\Gamma_4^{(1)}$ of the state ${}^5I_8$ ($\Delta = 4.8$ cm^{-1}) and the components ${}^2\Gamma_3$ and ${}^3\Gamma_5^{(2)}$ ($\Delta = 15.3$ cm^{-1}) belonging to ${}^5I_7$. The complicated splitting of the closely lying sublevels in the magnetic field is due to their interaction with one another. Contributing to the strong interaction is the fact that the g-factors of the Stark sublevels are large in the system under consideration. The interaction of the levels ${}^3\Gamma_4^{(1)}$ with ${}^2\Gamma_3^{(2)}$ of the ground state in a magnetic field leads, for example, to splitting of the latter [3].

Investigating the influence of a strong magnetic field on the emission lines of $CaF_2:Dy^{2+}$, we observed another manifestation of the interaction of the levels, namely the appearance of a Zeeman picture of the line B-III (λ = 2.320 μ) corresponding to the forbidden transition ${}^2\Gamma_3\ (I_7) \rightarrow {}^2\Gamma_3^{(2)}\ (I_8)$. The line appears at field intensities of only 4 kOe. With increasing field, the line intensity increases, and its doublet splitting is observed at an experimental geometry corresponding to the notation on the figure. A Zeeman effect of a line that does not exist at $H_0 = 0$ is thus observed.



a - Stark sublevels of the Dy^{2+} ion in a field of symmetry O_h and optical transitions between them. The dashed lines denote transitions which are excited in the field. b - Emission spectra of the transitions ${}^5I_7 \rightarrow {}^5I_8$ of divalent dysprosium in the absence of a field and in a field of H_0 = 12 kOe, with $H_0 \parallel C_4$.

Let us consider the Zeeman transition ${}^2\Gamma_3\ (I_7) \rightarrow {}^2\Gamma_3^{(2)}\ (I_8)$ in the case when the magnetic field is directed along one of the C_4 axes of a cubic crystal. The Zeeman sublevels of the states of the rare-earth ion are characterized in this case by irreducible representations of the group C_{4h} [4]. In particular, the Zeeman sublevels ${}^2\Gamma_3\ (\Gamma_1', \Gamma_2')$, ${}^3\Gamma_4\ (\Gamma_1', \Gamma_3', \Gamma_4')$, and ${}^3\Gamma_5\ (\Gamma_2', \Gamma_3', \Gamma_4')$ are characterized by the representations in the parentheses.

When $H_0 \parallel C_4$, the influence of the magnetic field on the ion is described by the expression $V_3 = g\beta J_z H_z$, where g is the spectroscopic splitting factor of the free ion, β is the Bohr magneton, and J_z and H_z are the projections of the total angular momentum and of the field on the z axis. In the first perturbation-theory approximation, the eigenstates of the Zeeman sublevels ${}^2\Gamma_3^{(2)}\ ({}^5I_8)$ and ${}^2\Gamma_3\ ({}^5I_7)$ in a magnetic field are of the form

$$|{}^2\Gamma_3^{(2)}\Gamma_2'>,\ |{}^2\Gamma_3^{(2)}\Gamma_1'> + A|{}^3\Gamma_4^{(1)}\Gamma_1'>$$

and

$$|{}^2\Gamma_3\Gamma_1'>,\ |{}^2\Gamma_3\Gamma_2'> + B|{}^3\Gamma_5^{(2)}\Gamma_2'>,$$

where

$$A = \frac{<{}^3\Gamma_4^{(1)}\Gamma_1'|V_3|{}^2\Gamma_3^{(2)}\Gamma_1'>}{E({}^2\Gamma_3^{(2)}) - E({}^3\Gamma_4^{(1)})} \text{ and } B = \frac{<{}^3\Gamma_5^{(2)}\Gamma_2'|V_3|{}^2\Gamma_3\Gamma_2'>}{E({}^2\Gamma_3) - E({}^3\Gamma_5^{(2)})}.$$

Obviously the coefficients A and B determine the mixing of the states in the magnetic field.

Using the selection rules in the groups O_h and C_{4h}, it is easy to determine the possible magnetic dipole transitions and their polarizations. It turns out that the Zeeman picture of the transition $^2\Gamma_3$ ($^5I_7$) → $^2\Gamma_3^{(2)}$ ($^5I_8$) should consist of two π_m components, the relative intensity of which depends only on the coefficients A and B. We actually observed in our experiments in the π_m polarization two lines of different intensity. The difference in the intensities of these Zeeman components is due to the fact that the coefficient B of $^2\Gamma_3$ ($^5I_7$) is smaller than A as a result of the fact that the level $^3\Gamma_5^{(2)}$ is farther away from $^2\Gamma_3$ than $^3\Gamma_4^{(1)}$ is from $^2\Gamma_3^{(2)}$ ($^5I_8$).

A similar excitation of a forbidden line is observed in the spectra of CaF_2 and SrF_2 activated with Sm^{2+} in fields of 110 kOe [5].

We observed also the appearance in a magnetic field of the two lines B-I and B-II (λ = 2.346 μ and λ = 2.327 μ), the intensity of which is vanishingly small in the absence of a magnetic field. As seen from the level scheme in the figure, both lines are connected with transitions that are allowed by symmetry. Their very low intensity at $H_0 = 0$ is an accidental circumstance, connected with the character of the electric field of the CaF_2 crystal, which splits the states $^5I_7$ and $^5I_8$ of the Dy^{2+} ion.

The excitation of symmetry-allowed lines B-I and B-II in a magnetic field and the excitation of the forbidden line B-III are connected with the interaction of the closely-lying Stark sublevels. For example, the excitation of the B-II line is connected with the interaction of the closely-lying levels $^2\Gamma_3$ and $^3\Gamma_5^{(2)}$ of the state $^5I_7$ in the magnetic field. When the lines are excited, the intensity of the Zeeman components of the closely-lying allowed intense lines decreases. A transfer of intensity takes place.

In conclusion we note that the excitation of the B-I line observed by us was recorded also in [1].

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PHENOMENOLOGICAL BARYON-MESON INTERACTION LAGRANGIAN THAT IS INVARIANT AGAINST THE CHIRAL GROUP SU(3) × SU(3)

D. V. Volkov
Physico-technical Institute, Ukrainian Academy of Sciences
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Recently Weinberg [1], Schwinger [2], and Wess and Zumino [3] proposed a method of constructing a strong-interaction phenomenological Lagrangian satisfying the current algebra of the chiral group SU(2) × SU(2) and the hypothesis of partial conservation of the axial current (PCAC), making it possible to obtain their various consequences in simple form.

The method proposed in [1-3] is apparently highly general and can be applied to different dynamic systems with Goldstone-particle spectrum, and is a phenomenological method of describing the interaction of such particles.