Determination of the sign of the Lande factor of diatomic molecules in the ground and excited states by the Hanle effect

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The paper presents and analyzes analytic equations which in terms of polarization moments describe the crossing signals of magnetic sublevels in a zero magnetic field (Hanle effect) of dispersion form under linearly polarized excitation in the case of extremely weak pumping (linear response of the system) during Q and P, R-type transitions in diatomic molecules with high values of angular momentum $J \gg 1$. The case of efficient optical pumping by devastation is discussed, in which there is manifested a superposition Hanle signal of dispersion form of the ground and excited states related to an optical transition. The paper gives the results of experiments conducted on $^{39}K_2$ molecules during $X\,^1\Sigma_g^+ \rightarrow B\,^1\Pi_u$ excitation with the 632.8-nm line of a He–Ne laser and $^{130}Te_2$ molecules during $XO_g^+ - AO_u^+$ excitation with the 488.0 and 514.5-nm lines of an Ar^+ laser. From the signals of dispersion form obtained, the signs of the Lande factors of the combined states have been determined.

INTRODUCTION

The magnetic moments of diatomic molecules are determined not only by the orbital and intrinsic moments of the electrons and nuclei, but also by the molecular rotation (see for example Refs. 1 and 2). A rigorous calculation of the magnetic moment for a specific electronic–vibrational–rotational (EVR) level is possible only in the case of pure Hund-type coupling.[1,3] Thus for a-type coupling, the value μ_z of the projection of the magnetic moment on the direction of the external magnetic field B is[1]

$$\mu_z = -\frac{(\Lambda + 2\Sigma)(\Lambda + \Sigma) M'}{J'(J'+1)} \mu_0 = g_{J'} M' \mu_0 \qquad (1)$$

where Λ and Σ are the projections of the orbital and spin angular momenta of the electrons on the molecular axis, M' is the magnetic quantum number of angular momentum J', $g_{J'}$ is the Lande factor, μ_0 is the Bohr magneton; the energy change in field B is $\Delta W_B = -\mu_z B$. Using Eq. (1), McClintock *et al.*[4] calculated the Lande factor for the EVR level of Na_2 ($B\,^1\Pi_u$, $v' = 10$, $J' = 12$) with $\Lambda = 1$, $\Sigma = 0$, which leads to $g_{J'} = -1/J'(J'+1)$. This state was used in Ref. 4 to conduct the first experiment on the Hanle effect for diatomic molecules by means of laser-induced fluorescence, and thus the lifetime was determined. The equations for Hund coupling types b and c are given in Ref. 5. However, for states in which $\Lambda = \Sigma = 0$ or the projection of the total angular momentum is $\Omega = 0$, equations of type (1) give zero

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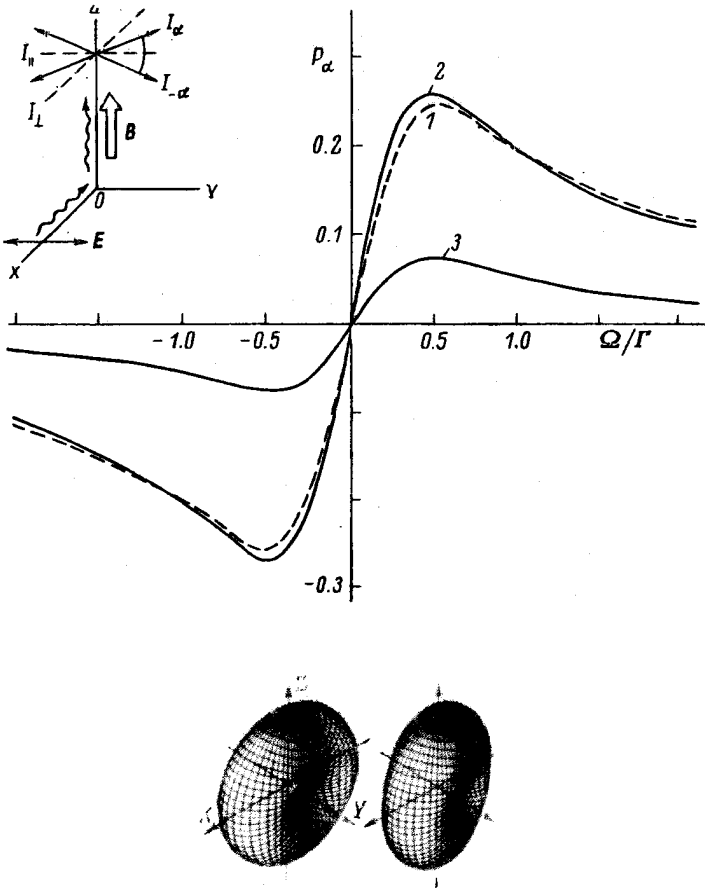

FIG. 1. Calculated Hanle signals of dispersion form in diatomic molecules for a linear response.

and the magnetic moment is determined by the rotational motion of the molecule.[6] In the majority of cases, it is difficult to predict in advance not only the value but also the sign of the Lande factor, and therefore, the chief sources of information in this case are experiments, which have been few in number. References 7 and 8 studied the BO_u^+ states of $^{80}Se_2$ with $\Omega = 0$. In Ref. 6, the method of radio-frequency resonance in molecular beams was used to determine the magnetic moments of $X^1\Sigma_g^+$ states for alkali dimers Li_2, Na_2, K_2, Rb_2, and Cs_2 without selection according to the VR levels v'', J''. Moreover, for $Li_2(X^1\Sigma_g^+)$, it was also determined that the direction of the magnetic moment coincides with angular momentum J (the Lande factor will be assumed positive in this case). Brooks *et al.*[6] concluded that the contribution of nuclear rotation was decisive. To determine the magnetic moment of an individual VR level (α'', v'', J'') of the ground electronic state α'', we recently[9-11] used nonlinear variants of methods of interference of magnetic sublevels during laser optical pumping: beat resonance for $^{130}Te_2(XO_g^+, 6.53)$,[9] Hanle effect,[10] and quantum beats in a transition process[11] for $^{39}K_2$ ($X^1\Sigma_g^+$, 1, 73). However, the sign of the Lande factor was not determined in these experiments.

One of the possibilities of determination of the sign of g is given by the Hanle effect, which consists in depolarization of fluorescence by an external magnetic field.[12] However, in the traditional geometry of the experiment (Fig. 1), involving measurement of the degree of linear polarization $P(I_\parallel - I_\perp)/I_\parallel + I_\perp)$, where $I_{\parallel,\perp}$ is the intensity of fluorescence polarized parallel or perpendicular to vector E of the exciting light, the dependence on magnetic field B is a Lorentzian form

$$P_L(B) = \frac{P_L(0)\,\Gamma_2^2}{\Gamma_2^2 + 4g^2B^2\mu_0^2/\hbar^2}, \tag{2}$$

and therefore, information on the sign of the magnetic moment is lost. Here Γ_2 is the alignment relaxation rate.[13] As is well known,[3] the sign of the Lande factor is usually measured in a Hanle signal of dispersion form by recording the intensities polarized at an angle of $\pm 45°$ to vector E (i.e., $\alpha = \pm 45°$ in the diagram of Fig. 1). Then

$$P_{45°}(B) = \frac{I_\alpha - I_{-\alpha}}{I_\alpha + I_{-\alpha}} = \frac{2\mu_1 g B P_L(0)/\hbar}{\Gamma_2^2 + 4\mu_0^2 g^2 B^2/\hbar^2}. \tag{3}$$

Signals of such form were recorded, for example, in Ref. 7 for the $^{80}Se_2$ B–X band.

In the present work, the device of polarization moments is used to analyze the type of signals of dispersion form $P_\alpha(B)$ for an arbitrary angle α and Q and P, R-type transitions in diatomic molecules with large angular momenta $J \gg 1$. In order to determine the sign of the Lande factor of the ground state, the dispersion shape of a nonlinear Hanle signal is analyzed in the case where the signal from the ground state is superimposed on the Hanle contour of the excited level (such an effect was first recorded in Ref. 14 for signals of Lorentzian shape). The results of an experiment involving determination of the sign of the Lande fctor of the ground electronic state of potassium $^{39}K_2(X^1\Sigma_g^+)$ and tellurium $^{130}Te_2(XO_g^+)$ dimers are presented.

DISPERSION FORM OF THE HANLE SIGNAL OF DIATOMIC MOLECULES DURING WEAK EXCITATION

Let the radiation exciting the $(\alpha'',v_a'',J_a'')\to(\alpha',v_b',J_b')$, optical transition (or, in abbreviated form, $a\to b$) be directed along the X axis (Fig. 1) and linearly polarized parallel to the Y axis. We will follow the intensity of fluorescence I_α on the $(\alpha,v_b',J_b')\to(\alpha'',v_c'',J_c'')$ transition, or $b\to c$, linearly polarized at an angle α to vector $\mathbf{E}\|Y$. The discussion will be conducted in terms of polarization moments (PM)[13,15] with the use of asymptotic equations in the case $J\to\infty$.[16] The equation for intensity is

$$I_\alpha=(-1)^\Delta\sum_K\sqrt{2K+1}\,C^{K0}_{1-\Delta1\Delta}\sum_Q(-1)^Q f_Q^K\Phi^K_{-Q}(\alpha), \tag{4}$$

where $\Phi_Q^K(\alpha)$ is a function introduced in Ref. 15; f_Q^K is the PM of the excited state of rank K and projection Q; $C^{\alpha\alpha}_{b\beta c\gamma}$ are Clebsch-Gordan coefficients; $\Delta=J_b'-J_c''$. In our case, $K=0$ and 2, and $\Phi_0^0=-1\sqrt{3}$, $\Phi_0^2=-1\sqrt{30}$, $\Phi^2_{\pm2}=(1/2\sqrt{5})e^{\pm i(\pi+2\alpha)}$ are nonzero.

The Q transition ($J_b'=J_{a,c}''$). The f_Q^K values are determined by the Dyakonov function during absorption and, in the case where the light field does not change the population of the ground EVR level (α'',v_a'',J_a''), from which the absorption takes place, can be written in the form

$$f_0^0=\frac{1}{3}\frac{\Gamma_p}{\Gamma_0}\varphi_0^0,\quad f_0^2=-\frac{1}{15}\frac{\Gamma_p}{\Gamma_2}\varphi_0^0,\quad f^2_{\pm2}=-\frac{1}{5\sqrt{6}}\frac{\Gamma_p}{\Gamma_2\mp2i\Omega}\varphi_0^0.$$

These equations follow directly from Eq. (2) of Ref. 11. Here φ_0^0 is the PM of the ground state of zero rank, corresponding to the particle concentration in the a level, Γ_p is the absorption rate, and Γ_0 is the rate of population relaxation. Substitution for f_Q^K in Eq. (4) gives

$$\left.\begin{aligned}I_{\pm\alpha}^{(Q)}&=\frac{\Gamma_p\varphi_0^0}{3}\left[\frac{1}{3\Gamma_0}+\frac{1}{15\Gamma_2}+\frac{1}{5}\left(\frac{\Gamma_2\cos\alpha\pm2\Omega\sin2\alpha}{\Gamma_2^2+4\Omega^2}\right)\right],\\ P_\alpha^{(Q)}&=\frac{0.4\Omega\sin2\alpha}{(\Gamma_2^2+4\Omega^2)\left(\frac{1}{3\Gamma_0}+\frac{1}{15\Gamma_2}\right)+0.2\Gamma_2\cos2\alpha}.\end{aligned}\right\} \tag{5}$$

Here the frequency $\Omega=g_bB\mu_0/\hbar$. For diatomic molecules with $J\gg1$, apparently, the approximation $\Gamma_0=\Gamma_2=\Gamma$ is permissible; for Te_2 (AO_u^+), this is shown in Ref. 17. Then Eq. (5) becomes simplified:

$$P_\alpha^{(Q)}=\frac{2\frac{\Omega}{\Gamma}\sin2\alpha}{2\left(1+4\frac{\Omega^2}{\Gamma^2}\right)+\cos2\alpha}. \tag{6}$$

It is evident that the dependence of the degree of polarization on Ω/Γ has a dispersion form. For the usually selected angle $\alpha=45°$ we obtain

$$P_{45°}^{(Q)}=\frac{\Omega/\Gamma}{1+4\Omega^2/\Gamma^2} \tag{7}$$

Equation (7) is shown by curve 1 in Fig. 1; the extrema are located at $\Omega/\Gamma=\pm0.5$, and the corresponding values of the degree of polarization are ±0.25. However, these power values are not the highest ones. Determination of absolute extrema of $P_\alpha^{(Q)}$ from the two variables α and Ω/Γ from Eq. (6) gives the value of the angle $\alpha_m=(1/2)\arccos[-1/(2+\sqrt{3})]\approx52.8°$ and $\Omega/\Gamma=\pm\sqrt[4]{12}/4\approx\pm0.465$, with $P^Q_{\alpha_m}\approx\pm0.2588$. Thus from the standpoint of obtaining the highest values of the degree of polarization, the optimum angle for Q-type transitions is not $\alpha=45°$, but $\alpha_m=\pm52.77°$. It is true that the gain in signal amplitude obtained is small, of the order of 3.5% of the maximum; the Hanle contour is shown in Fig. 1 (curve 2).

P, R transitions ($J_b'=J_c''\pm1$). We will consider the fluorescence during P, R-type transitions in the cycle $J_a''\to J_b'\to J_c''$. In this case, $\Delta=\pm1$ in Eq. (4). The relationship between the nonzero PM of the upper state f_Q^K and lower state φ_0^0 is expressed[11] as $f_0^0=(\Gamma_p/3\Gamma_0)\varphi_0^0$, $f_0^2=(\Gamma_p/30\Gamma_2)\varphi_0^0$ and $f^2_{\pm2}=\Gamma_p\varphi_0^0/(\Gamma_2\mp2i\Omega)10\sqrt{6}$. The intensity is

$$\begin{aligned}I_{\pm\alpha}^{(P,R)}&=(f_0^0/3)+(f_0^2/6)-(1/\sqrt{6})\,\mathrm{Re}\,(f^2_{\pm2}e^{-i(\pi\pm2\alpha)})\\&=(\Gamma_p\varphi_0^0/3)[1/3\Gamma_0+1/60\Gamma_2+(\Gamma_2\cos2\alpha\pm2\Omega\sin2\alpha)/20(\Gamma_2^2+4\Omega^2)].\end{aligned} \tag{8}$$

The expression for the degree of linear polarization $P_\alpha^{(P,R)}$ in the case $\Gamma_2=\Gamma_0\equiv\Gamma$ is

$$P_\alpha^{(P,R)}=\frac{2\frac{\Omega}{\Gamma}\sin2\alpha}{7\left(1+4\frac{\Omega^2}{\Gamma^2}\right)+\cos2\alpha}. \tag{9}$$

The optimum value of angle α can be found, as in the case of Q transitions, as $\alpha_m=(1/2)\arccos[-1/(7+4\sqrt{3})]\approx47.1°$ corresponds. Hence for P, R-type transitions, the Hanle contour for the optimum angle α_m is practically indistinguishable from the contour for $\alpha=45°$ [Fig. 1, curve 3)].

For $J\gg1$, using the classical representation, one can construct the pattern of spatial distribution of angular momenta $\mathbf{J}_b$ of the excited state (for more details see below) which clearly illustrates the essence of the Hanle effect. The representations for P, R transitions are shown in Fig. 1 (bottom right); they correspond to the values $\Omega/\Gamma=0$ and 1/2. This form of spatial distribution of angular momenta is due to the fact that for P, R-type transitions in the classical model, the oscillating dipole is rigidly connected to the internuclear axis of the molecule and rotates together with it about $\mathbf{J}$.[18] It is evident that the distribution of angular momenta $\mathbf{J}_b$ rotates about $\mathbf{B}$ in a direction dependent on the sign of the Lande factor.

MANIFESTATION OF THE HANLE DISPERSION SIGNAL OF THE GROUND STATE

We will turn to the case in which one cannot neglect the coherence of the ground state, arising during the emptying of the latter during absorption $a\to b$, if the absorption rate Γ_p is comparable to the rate γ of population by nonradiative processes. The effect is achieved during laser optical pumping[19] and makes it possible to observe the Hanle effect of the ground state[14] for Q transitions to $Na_2(X^1\Sigma_g^+)$, $K_2(X^1\Sigma_g^+)$ and (Ref. 20) for the P, R transitions of $Te_2(XO_g^+)$. In these studies, Hanle signals of Lorentzian form were recorded. We will follow the manifestation of the superposition Hanle signal of dispersion form from the ground and excited states (an analysis of the situation for circularly polarized excitation is given in Ref. 21). Now in the ground state there are not only the PM φ_0^0 (population), but also moments $\varphi_q^\varkappa$ of higher ranks $\varkappa$ ($\varkappa$ being an even number for the excitation scheme of Fig. 1). To find the PM of the excited state f_q^k which determine the fluorescence intensity in accordance with Eq. (4), it is necessary to solve the system of equations of motion for f_Q^K and $\varphi_q^\varkappa$. In many

cases, for the open (according to Ref. 18) cycle of optical pumping of diatomic molecules, use may be made of a model of the so-called completely open system, when as a result of nonradiative relaxation, states adjacent to the initial level (α'', v_a'', J_a'), supply only the population, and the reverse spontaneous transitions $b \to a$ are neglected. Equations in such form are given in Ref. 9; here they are written in the asymptotic limit $J \to \infty$, as in Ref. 16, where their structure and numerical solution algorithm are also analyzed. For steady-state excitation conditions, we have

$$\left.\begin{aligned}
&\Gamma_p\Big(\sum_{\varkappa q} {}^{K}_{Q} D^{\varkappa}_{qq} \varphi^{\varkappa}_{q} - \sum_{K'Q'} {}^{K}_{Q} D^{K'}_{Q'} f^{K'}_{Q'}\Big) - (\Gamma_K - iQ\Omega) f^{K}_{Q} = 0,\\
&\Gamma_p\Big(\sum_{KQ} {}^{\varkappa}_{q} D^{K}_{Q} f^{K}_{Q} - \sum_{\varkappa' q'} {}^{\varkappa}_{q} D^{\varkappa' q'}_{q'} \varphi^{\varkappa' q'}_{q'}\Big) - (\gamma_\varkappa - iq\omega_a)\varphi^{\varkappa}_{q} + \lambda^{\varkappa}_{q}\delta_{\varkappa 0} = 0\\
&{}^{\varkappa}_{q} D^{\varkappa'}_{q'} = (-1)^{\Delta}\sqrt{\frac{2\varkappa'+1}{2\varkappa+1}}\\
&\times \sum_{X} \sqrt{2X+1}\, C^{X0}_{1\Delta\, 1-\Delta} C^{\varkappa' 0}_{X0\,\varkappa 0} C^{\varkappa q}_{Xq-q'\varkappa' q'} \Phi^{X}_{q-q'}(0).
\end{aligned}\right\} \quad (10)$$

In Eqs. (10), induced transitions have been taken into account and $\Delta = J_b' - J_a''$. It is clear that the problem of determining the dependence of the observed quantities I_α and P_α on field B contains a large number of parameters. We though it desirable to show in Fig. 2 the results of calculations for the parameters occurring in experiments during Q transitions to K_2 (Refs. 10 and 14) and P, R transitions to Te_2 (Refs. 9 and 20), and a description of the experiment in the present study. In both cases, the width of the Hanle contour of the excited state was greater than that of the ground state, i.e., $g_a/\gamma \ll g_b/\Gamma$. PM with $\varkappa \leqslant 10$, $K \leqslant 2$ were considered in the calculations.

It is evident from Fig. 2 that the shape of the superposition Hanle signal substantially depends on whether the Lande factors of the combining states g_a and g_b have the same or different signs [their values, 1×10^{-5} (Ref. 10) and 1.9×10^{-4}, corresponded to ($X\,{}^1\Sigma_g^+$, 1, 73) and ($B\,{}^1\Pi_u$, 8, 73) for K_2]. In the case of different signs, the superposition

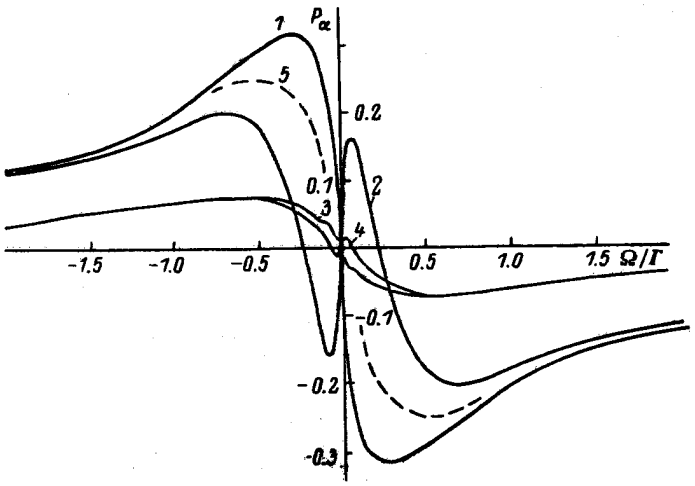

FIG. 2. Superposition Hanle signals of dispersion form ($\alpha = 45°$) calculated from Eqs. (9) and (10). Curves 1 and 2—for the Q transition with different and same signs of g_a and g_b: $\gamma_\varkappa = 3\times10^5$ sec^{-1}, $\Gamma_p = 3\times10^6$ sec^{-1}, $\Gamma_K = 86.2\times10^6$ sec^{-1}. Curves 3 and 4—for P, R transitions with different and same signs of g_a and g_b; $\gamma_\varkappa = 2\times10^5$ sec^{-1}, $\Gamma_p = 15.4\times10^5$ sec^{-1}, $\Gamma_p = 3\times10^5$ sec^{-1}. Curve 5 corresponds to graph 1 in Fig. 1.

of the excited state [Fig. 2 (curves 1 and 5)]. If the signs of g_a and g_b are the same, the extrema in dispersion structure from the ground and excited states are of opposite signs [Fig. 2 (curve 2)]. For P, R-type transitions, a similar situation is observed. The smaller relative amplitude of the additional structure arising from the ground state [Fig. 2 (curve 4)] was chiefly due to a lower value of the optical pumping parameter Γ_p/γ used in the calculations. A slight disturbance of the monotonicity of the signal increase for different signs of g_a and g_b [with values of 1.68×10^{-4} (Ref. 9) and 0.54×10^{-4} (Ref. 17)] on curve 3 is explained by the fact that the ratio g_0/γ to g_b/Γ is greater than for curve 1. Naturally, if the value of g_b/Γ is negligibly small in comparison with g_a/γ, the structure related to the ground state will also show up when the signs of g_a and g_b are different.

Since the solution of Eqs. (10) is fairly complex, it is of interest to represent graphically the spatial distribution of the angular momenta of the ensemble in the presence of an external magnetic field (Fig. 3). The distribution was obtained by computer with the use of a plotter, the method described in Ref. 22 being employed. This involved a change from the representation of the distribution of angular momenta by means of PM to the representation of classical probability density.[23–26] Figure 3 shows the case of P, R-type transitions which was realized in the experiment conducted in the present work: the signs of the g_a and g_b states were the same. It is evident that the angular momenta of the lower state are optically aligned primarily along the vector E of the exciting light. When the field B is applied along the Z axis, the distribution turns, and the anisotropy in the XY plane decreases. At the same time, the anisotropy in the excited state increases (elongation of the toroid along the X axis), and this corresponds to the manifestation of the Hanle signal of the ground state. This is due to the fact[20,25] that when the Hanle effect from the ground state has already been manifested, and it is not yet noticeable from the excited state [Fig. 3(condition 3)], the polarization P_L surpasses the value $P = \frac{1}{4}$ attained in the limit of weak excitation, i.e., the distribution anisotropy is greater than in Fig. 2 for $B = 0$. In the presence of even higher fields, the distribution of the excited state [Fig. 3 (condition 4)] up to complete anisotropy in the XY plane at the bottom and top [Fig. 3 (condition 5)].

EXPERIMENT

The above discussion shows that the Hanle superposition signal of the ground and excited states of dispersion shape makes it possible to determine the signs of the magnetic moments of the combining states. The experiment was aimed at obtaining such signals for the $^{39}K_2$ and $^{130}Te_2$ molecules.

The experimental arrangement is similar to the one used previously in Refs. 9, 10, and 20. The beam of an argon laser (of type LGN-402) or helium-neon laser (of type LG-38) was directed into a cell containing saturated vapor of tellurium or potassium. The cell was placed between the poles of an electromagnet and connected to a vacuum system. Fluorescence is observed along the magnetic field in accordance with the diagram shown in Fig. 1; this is accomplished by means of a tilting mirror placed between the magnet poles. The resonance series line convenient for recording

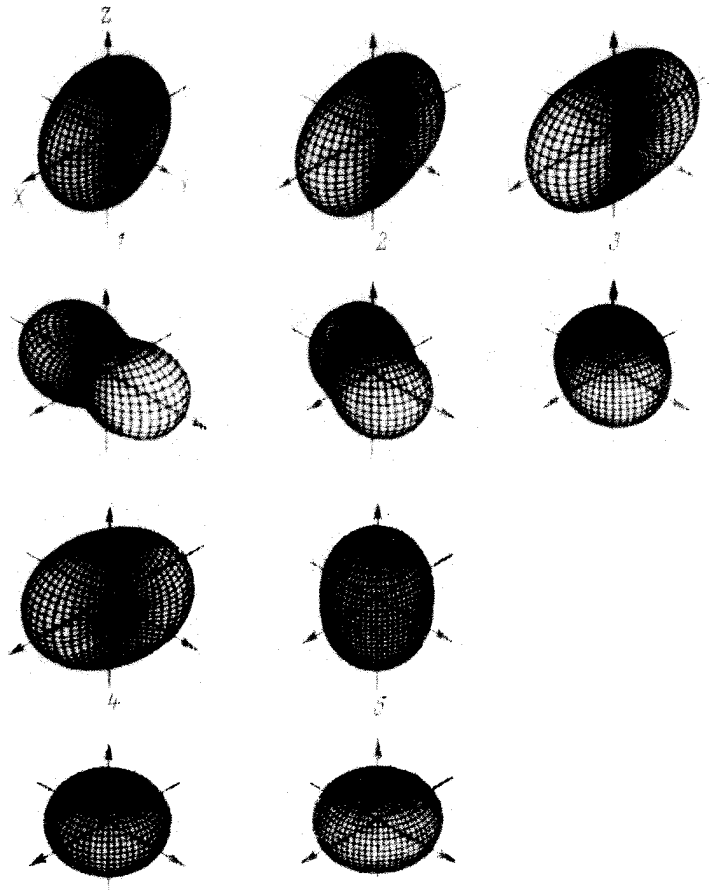

FIG. 3. Graphical representations of the spatial distribution of angular momenta of the ground (bottom) and excited (top) states in the presence of an external magnetic field B‖Z. The ratios ω/γ_x and Ω/Γ_K are respectively equal to: 1—zero, 2—1 and 0.05, 3—2.6 and 0.11, 4—10 and 0.46, 5—infinity; the probability density at the top contains the factor Γ_K/γ_x.

is isolated by a DFS-12 monochromator (0.5 nm/mm). The entrance slit of the DFS-12 is split heightwise into two parts, in front of which are placed polaroids at an angle of 45° and − 45° to E (Fig. 1). The corresponding portions of the exit slit are connected by means of light guides to two FEU-79 photomultipliers operating in the photon-counting mode. Thus single-electron pulses build up via two channels simultaneously, and their number determines the intensity $I_{\pm a}$.

In the $^{39}K_2$ molecule, the 632.8-nm laser line effectively excites a Q-type EVR transition ($X\,^1\Sigma_g^+$, 1,73) → ($B\,^1\Pi_u$, 8, 73); the VR numbers were identified in accordance with Ref. 27. The Hanle signal of dispersion shape on the Q_{1b} line of the resonance series is shown in Fig. 4 for two cases of pumping: weak ($\Gamma_p \ll \gamma$) and strong ($\Gamma_p \gtrsim \gamma$). In the first case, the experimental data are satisfactorily approximated by Eq. (7); solid curve 1 corresponds to $\tau_{sp} = 11.6$ nsec (Ref. 14) and to the value of the Lande factor $1/J_b'(J_b'+1) = 1.9\times10^{-5}$.

In the second case, the ratio Γ_p/γ was increased by raising the laser power and lowering T from 503 to 453 K; this reduces the relaxation rate γ owing to the collisions of K_2 with potassium atoms. Curve 2 of Fig. 4 clearly shows an appreciable narrowing of the signal caused by the superposition of the Hanle effect of the upper and lower states, but with no additional structure (hereinafter the dotted lines connect only the experimental points). Comparison with curves 1 and 5 of Fig. 2 makes it possible to state that the signs of Lande factors g_a and g_b of the ground and excited states are opposite. And, since g_b is caused by the orbital angular momentum of the electron in the 1Π state [see Eq. (1)], i.e., is negative, g_a is positive and due to the rotation of the nuclei. This conclusion is consistent with the result of the measurement of the sign of g_a for $Li_2(X\,^1\Sigma_g^+)$ in Ref. 6; see also Ref. 28.

In the $^{130}Te_2$ molecule, two EVR transitions in the AO_u^+–XO_u^+ band were studied, namely, the (XO_g^+, 6, 52) → (AO_u^+, 11, 53) transition during excitation with the 514.5-nm laser line and the (XO_g^+, 1, 132) → (AO_u^+, 11, 131) transition excited with the 488.0-nm line. The identification of the transitions is given here in accordance with the data of Ref. 29. The experimental conditions ($T = 600$ K, $[Te_2] = 2\times10^{13}$ cm^{-3}) were chosen such that according to Ref. 20, $\Gamma_p/\gamma \gtrsim 1$, and the manifestation of the nonlinear Hanle signal of the lower EVR level is visible. The results of the experiment are demonstrated by curves 3 and 4 in Fig. 4. It is evident from the large-scale structure of the graphs, which reflects mainly the shape of the Hanle contours of the excited levels, that the magnetic moments for (AO_u^+, 11, 53) and (AO_u^+, 11, 131) have different signs; this, by analogy with Ref. 8 for Se_2, indicates the presence of perturbations

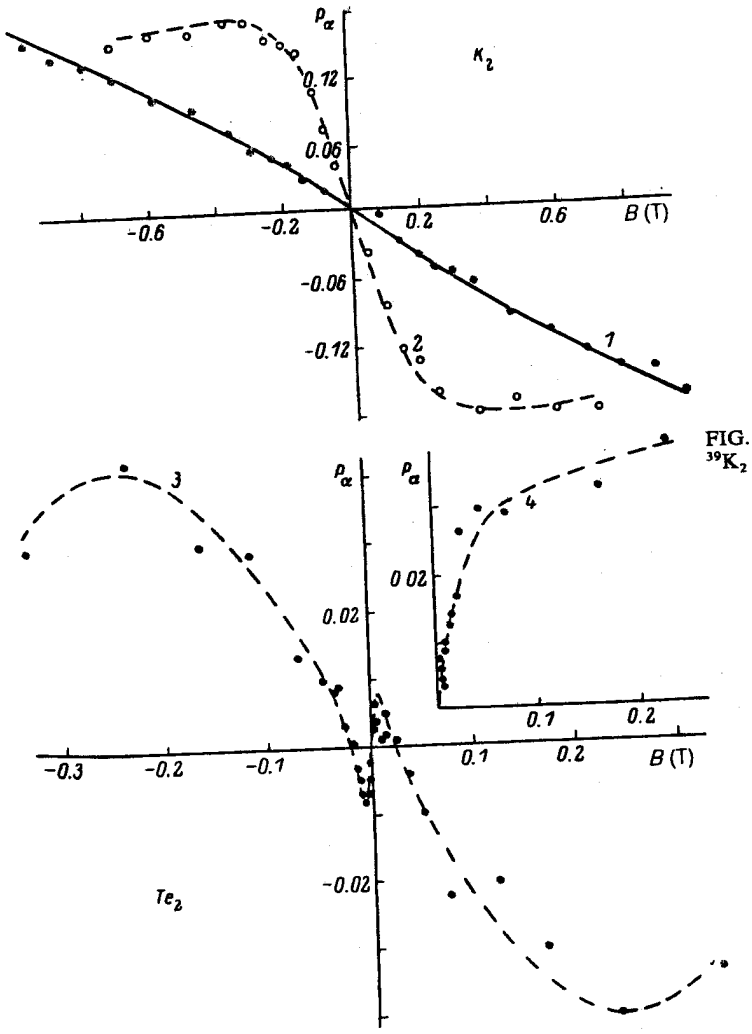

FIG. 4. Experimentally recorded Hanle signals of dispersion form for $^{39}K_2$ and $^{130}Te_2$.

in the AO_u^+ state of $^{130}Te_2$. Moreover, the sign of the Lande factor for (11, 131) is the same as for $K_2(B^1\Pi_u)$, i.e., negative, and for (11, 53), positive. Of interest is the establishment of the sign of the magnetic moment of the ground state $Te_2(XO_g^+)$, for which the absolute value of the Lande factor was determined in Ref. 9 as $g_a = (1.68 \pm 0.05) \times 10^{-4}$. Since curve 3 in Fig. 4 clearly shows a narrow (halfwidth of the order of 0.005 T) dispersion-form structure, the signs of the magnetic moments for (XO_g^+, 1, 131) and (AO_u^+ 11, 131) are the same. This follows from a comparison with calculated curve 4 in Fig. 2. Hence, the Lande factor of the XO_g^+, state of Te_2 is negative. This conclusion is consistent with the sign, which gives the approximate equation[3,5] $g_a = -4B''/\lambda''$, where B'' is the rotational constant, and $2\lambda'' = 1975$ cm^{-1} is the splitting between the XO_g^+ term and the higher-lying term $X1^+$ for the tellurium dimer.

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