of the diffusion barrier. It should be noted that the terms dependent on time are omitted in eq. (1) as they are not essential for the relaxation process.

The Hamiltonian (1) is similar to the Hamiltonian used in ref. 3 for the derivation of the spin diffusion equations. Following this work one can have the following equation for the inverse temperature of nuclei:

$$\frac{\partial \beta_I}{\beta t} = D(\theta)\Delta\beta_I - \frac{\beta_I - \beta_e}{\tau_e}, \quad D(\theta) = \Lambda(\theta)D, \quad \frac{1}{\tau_e} = \frac{C(\theta)}{r^6}$$

$$C(\theta) = \frac{4}{15}(\gamma_e\gamma_I)^2\, S(S+1)\sin^2\theta\, \frac{\tau}{1+(\tau\omega_I)^2}$$

where τ is the correlation time of the magnitude S^z, r is the distance from the nuclear spin to a magnetic ion. $D(\theta)$ and D are the diffusion coefficients when saturation is taken into account and when it is not taken into account respectively. The diffusion barrier is not taken into account in the given expressions. Its expression in the double rotating system is easy to obtain following ref. 4 ($\delta(\theta) = |\cos\theta/\Lambda(\theta)|^{\frac{1}{4}} \cdot \delta$), where δ is the diffusion barrier qhen the saturation is not taken into account). If $b(\theta) \gg \delta(\theta)$ ($b(\theta)=0.68[C(\theta)/D(\theta)]^{\frac{1}{4}}$ [4]), then the diffusion barrier is not essential and we obtain for the unique relaxation time: $T_n(\theta) = R^3/[D^3C(\theta)|\Lambda^3(\theta)|]^{\frac{1}{4}}$. When $b(\theta) \ll \delta(\theta)$ we obtain $T_n(\theta) = (R\delta)^3|\cos\theta/\Lambda(\theta)|^{\frac{3}{4}}/C(\theta)$. The results obtained show that near the "magic" angle θ_0, determined by the condition $\Lambda(\theta_0) = 0$ the relaxation time increases. That is quite clear, because when $\theta \to \theta_0$ in one case $D(\theta)$ decreases and in the other case $\delta(\theta)$ increases and that makes relaxation more difficult. When $(\Omega-\omega_I^0)^2 \ll \omega_1^2$ we obtain: a) when $b(\theta) \gg \delta(\theta)$ $T_n(\theta) \sim \omega_1^{\frac{1}{2}}$ if $\tau\omega_I \gg 1$ and $T_n(\theta)$ does not depend on ω_1, if $\tau\omega_I \ll 1$; b) when $b(\theta) \ll \delta(\theta)$ $T_n(\theta) \sim \omega_1^{\frac{5}{4}}$ if $\omega_I\tau \gg 1$ and $T_n(\theta) \sim \omega_1^{\frac{3}{4}}$ if $\omega_I\tau \ll 1$. In conlusion we shall note that the presented results are very different from the result $T_n \sim \omega_1^2$ which is obtained for the mean relaxation time.

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LIFTING OF A ZEEMAN DEGENERACY BY INTERACTION WITH A LIGHT BEAM

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Observation on the ground state sublevels of an atom of light shifts much larger than the width of the levels is reported. The lifting of the Zeeman degeneracy in zero magnetic field by a light beam leads to a change in the Zeeman energy level diagram.

The quantum theory of the optical pumping cycle [1] predicts that the atomic sublevels of the ground state are broadened and shifted by the interaction with an incident light beam, the shift (broadening) being due to the non resonant (resonant) wavelengths. These effects have been observed on ^{199}Hg [2]. We have recently considerably improved the experimental method: we observed light shifts about twenty times larger than the linewidth [3]. This makes possible the study of the lifting of a Zeeman degeneracy of an atom in zero magnetic field by a non resonant light beam.

The circularly polarized (non resonant) light beam B_1 which produces the light shift, propagates along the Oz direction. In the ground state $6\,^1S_0$ of ^{199}Hg (nuclear spin $I = \frac{1}{2}$) which has two sublevels, the effective Hamiltonian which describes

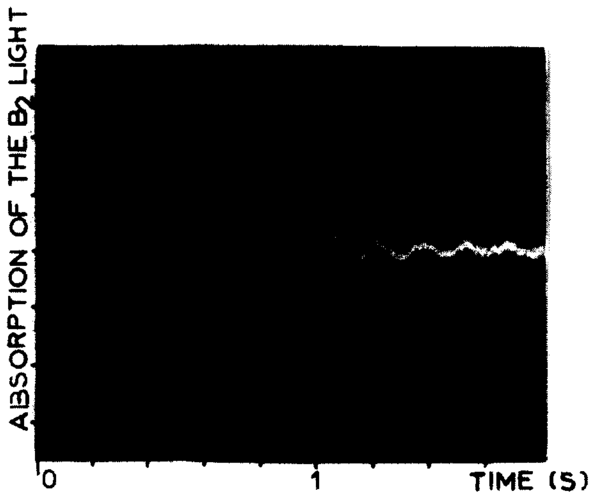

Fig. 1. Larmor precession of the ^{199}Hg nuclear spins in the fictitious magnetic field, H_s. associated to the light beam B_1. detected on the absorption of the B_2 light.

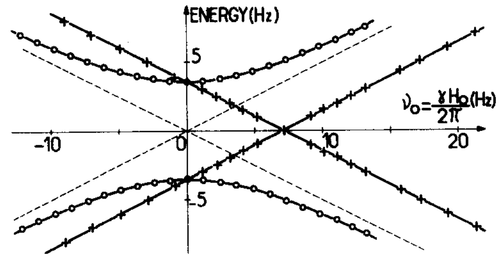

Fig. 2. Zeeman diagram of the ground state of ^{199}Hg perturbed by a non resonant light beam, B_1. Points: Experimental data (+ : B_1 and H_0 parallel, o : B_1 and H_0 perpendicular). Full lines: theoretical curves. Dashed lines: normal Zeeman effect.

the effect of B_1 is a two by two Hermitian matrix which can always be expanded in Pauli matrices. So, the effect of B_1 is equivalent to the one of a (fictitious) magnetic field, H_s, proportional to the B_1 light intensity and parallel to Oz (this can easily be shown through symmetry considerations). Fig. 1 shows the Larmor precession of the nuclear spins in this fictitious field. The experiment is performed in the following way: first, B_1 is off; in zero magnetic field, the nuclear spins are oriented in the Ox direction by a pumping light beam B_2 which propagates along the Ox direction and which is choosen in such a way that it does not produce anly light shift. Then, B_1 is suddenly introduced. The nuclear spins start to precess around H_s, and this produces the observed modulation of the absorption of the B_2 light. As the splitting produced by B_1 is larger than the width of the levels, several oscillations occur during the relaxation time.

By the techniques described in ref. 3, we have also measured the energy splitting between the two sublevels of the ground state under the action of the light beam B_1, for different values of the static magnetic field H_0 parallel either to Oz or to Oy. The Hamiltonian is $\mathcal{H} = \gamma\ (H_s I_z + H_0 I_u)$, γ, gyromagnetic ratio; $u = z$ or y. The observed energy diagram is shown in fig. 2 and is in excellent agreement with the theoretical predictions (shown by the full curves). If H_0 is parallel to Oz, the diagram looks like a translated Zeeman diagram: the two atomic sublevels still cross each other, but for a non *zero magnetic field value* $H_0 = -H_s$. If H_0 is parallel to Oy, the eigenvalues of $\mathcal{H}$ are $\pm\ \gamma \sqrt{H_s^2 + H_0^2}$: the two levels now anticross. For $H_0 \ll H_s$, the splitting is essentially due to the light beam B_1, the orientation of which determines the eigenstates of $\mathcal{H}$ (eigenstates of I_z). If $H_0 \gg H_s$, the structure of the energy diagram is determined by H_0 and the eigenstates of $\mathcal{H}$ are those of I_y. This situation might be compared to what is found in a Back-Goudsmit diagram, the light shift playing the role of a hyperfine structure.

We are studying similar effects on ^{201}Hg ($I = \frac{3}{2}$) where the action of the light beam is not equivalent anymore to the one of a fictitious magnetic field.

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