time intervals between the isothermal exposures and the measurements, the samples were stored in liquid N_2.

It follows from the foregoing data that the curve showing the transition of the sample into state 1 is close to the curve of pure Sn ($T_c = 3.72°K$); this is to be expected, since the sample comprises then a eutectic of Sn and Bi. The sample in state 2 has $T_c = 7.88°K$. Keeping the sample at temperatures higher than -95°C decreases T_c and greatly broadens the temperature interval in which the transition takes place, although during the start of the exposure the temperature at which the transition begins changes only slightly. Only after a prolonged exposure to -80°C is a two-step curve observed (the second transition occurs at a value of T close to T_c of Sn enriched with Bi[4]). Finally, exposure to 0°C leads to a considerable change of T_c of the sample.

Thus, the phase obtained by applying high pressure to the alloy has $T_c = 7.88°K$, which greatly exceeds T_c of pure Sn. This phase is stable up to -105°C. Its decay occurs during the time of isothermal exposures to $t > -105°C$ and proceeds quite slowly. Even prolonged exposure to 0°C does not restore the alloy to the equilibrium state. A Bi-Sn alloy (50 at.%) was transformed in [5] to a homogeneous state (i.e., a solution with β-Sn structure) by abrupt quenching to -196°C. The question whether the structure of the phase studied by us coincides with the structure of the quenched phase remains upon and calls for additional x-ray structure studies.

[1] P. W. Bridgman, Proc. Amer. Acad. Arts. Sci. 82, 101 (1953).
[2] E. G. Ponyatovskii, DAN SSSR 159, 1342 (1964).
[3] E. G. Ponyatovskii, FMM 16, 622 (1963).
[4] W. F. Love, Phys. Rev. 92, 238 (1953).
[5] R. H. Kane, B. C. Giessen, and N. I. Grant, Acta Met. 14, 605 (1966).

*The serial numbers correspond to the numbers on the figure.

THE COTTON-MOUTON EFFECT IN OPTICALLY ORIENTED VAPORS OF ALKALI METALS

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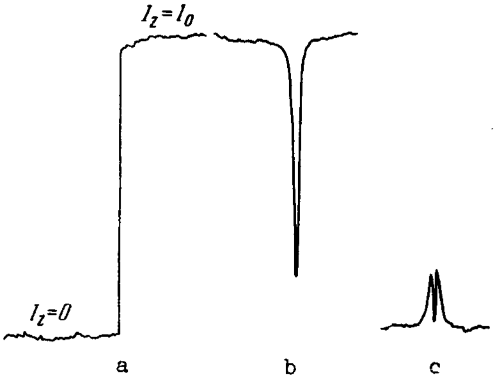
Submitted 17 April 1967
ZhETF Pis'ma 6, No. 1, 473-476 (1 July 1967)

The Cotton-Mouton effect (linear birefringence of light propagating in a medium perpendicular to a magnetic field $H_0 \| OZ$) [1], like the Faraday effect, is brough about by induced anisotropy of the dielectric constant of a medium situated in a magnetic field. Under ordinary conditions, the Cotton-Mouton effect is exceedingly small and has been observed so far only in liquids and a few glasslike solids [2,3], since the degree of polarization of the molecules of the material is very small even in strong magnetic fields. In this paper we describe, apparently for the first time, the Cotton-Mouton effect in a gaseous medium, namely in optically oriented saturated Cs^{133} vapor at 25°C. The possibility of observing magneto-optic phenomena in optically oriented vapor or gas, in spite of the very low pressure of the latter ($\sim 10^{-5}$ mm), is based on the high degree of polarization of the medium in experiments on optical orientation. The degree of polarization is then determined by the intensity of the pump light and is practically independent of the external magnetic field; it can reach ∿ 80% in some cases [4].

A theoretical analysis with allowance for the expression obtained in [5] for the polarizability of the medium under optical orientation conditions has made it possible to describe both the Faraday effect observed earlier [6] in Na vapor and the Cotton-Mouton effect. A detailed exposition of the results of the theoreticlal and experimental investigation will be published later. We confine ourselves here only to a brief description of the observed phenomenon.

Cs^{133} vapor in a cell with paraffin-coated walls is oriented along the $\vec{H}_0$ direction by circularly polarized radiation from a cesium lamp. A second resonance-radiation beam propagates perpendicular to $\vec{H}_0$ and is linearly polarized, the polarization vector making an angle ψ with $\vec{H}_0$. After passing through the cell, the light of the second beam is analyzed with a linear analyzer whose transmission direction makes an angle $\gamma = \psi + \pi/2$ with $\vec{H}_0$, after which the light intensity is registered with a photodetector. To increase the signal/noise ratio and exclude the influence of the orienting-beam light scattered by the cell, the transverse beam is intensity-modulated at an arbitrarily chosen low frequency Ω. The amplification and subsequent processing of the signal are likewise carried out at the frequency Ω. Application of the orienting light beam polarizes the Cs^{133} vapor in the cell, imparting to the latter the properties of a birefringent medium. After passing through the cell, the linearly-polarized radiation becomes elliptically polarized, and the intensity of the light incident on the photodetector increases. The maximum change of light intensity is observed, in agreement with the theory, at $\psi = \pi/4$. The ellipticity can be cancelled out only by introducing a phase plate, and has a quadratic dependence on the intensity of the orienting-beam light (i.e., on the population difference in the optically-oriented spin system); this dependence is characteristic of the Cotton-Mouton effect.



Cotton-Mouton effect in optically oriented Cs^{133} vapor. a - Onset of elliptic polarization of beam upon application of orienting light I_x; b - ellipticity near magnetic resonance vs. $\Delta\omega$ at $\phi = \pi/4$; c - the same at $\phi = 0$ and $\pi/2$.

Since the populations in the spin system can be equalized by a radio-frequency field, we should expect the isotropy of the medium to vanish near magnetic resonance in the system of the Cs^{133} atoms. A theoretical analysis has shown that in the presence of an rf field of frequency ω the dependence of the polarization ellipticity of the transverse light beam on $\Delta\omega = \omega - \omega_0$ is described by the following expressions:

when $\psi = \pi/4$:

$$S_1 = M_0^2 \frac{(\Delta\Omega^2 + 1)}{(\Delta\Omega^2 + 1 + \Omega_1^2)^2} 2\Omega_1^2 \left(\frac{1 + \Delta\Omega^2}{1 + \Delta\Omega^2 + \Omega_1^2}\right)^{1/2},$$

when $\psi = 0$ and $\pi/2$:

$$S_2 = M_0^2 \frac{\Delta\Omega^2 + 1}{\Delta\Omega^2 + 1 + \Omega_1^2}\left[1 - \frac{2\Omega_1^2(1+\Delta\Omega^2)^{1/2}}{(1+\Delta\Omega^2+\Omega_1^2)^{3/2}}\right].$$

where $\Delta\Omega = \Delta\omega\cdot\tau$, $\Omega_1 = \omega_1\tau$, $\omega_1 = \gamma H_1$, γ is the gyromagnetic ratio of the atoms in the ground state, and H_1 is the amplitude of the rf field. The function S_1 is similar in shape to the inverted absorption curve, and S_2 is similar to the square of the dispersion curve.

The figure shows the following experimental results: a - appearance of ellipticity in the polarization of the transverse light beam when the orienting resonant radiation I_z is turned on; b - dependence of the degree of ellipticity on $\Delta\omega$ on going through magnetic resonance at $\psi = \pi/4$, and c - the same depndence when $\psi = 0$ and $\pi/2$. The agreement between the experiment and theory is satisfactory.

[1] A. Cotton and H. Mouton, Compt. rend 145, 229 (1907).
[2] M. V. Vol'kenshtein, Molekulyarnaya optika (Molecular Optics), Gostekhizdat, 1951.
[3] A. V. Sokolov, Opticheskie svoistva metallov (Optical Properties of Metals), Fizmatgiz, 1961.
[4] J. Brossel, Rendiconti S. I. F. XVII Corso, 187,1962.
[5] G. W. Series, Proc. Phys. Soc. 88, 995 (1966).
[6] F. Strumia, Nuovo Cimento 44B, 387 (1966).

NUCLEAR MAGNETIC RESONANCE ON PROTONS IN SOME PARAMAGNETIC SALTS

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Submitted 21 April 1967
ZhETF Pis'ma 6, No. 1, 476-479 (1 July 1967)

Nuclear magnetic resonance (NMR) can be observed in a paramagnet if the line broadening due to the interaction with the electron spins is small. According to [12],

$$\Delta\omega = \frac{(\gamma_1 H_{loc})^2}{\omega_{exc}}.$$

Resonance was therefore observed either in magnetically-dilute salts, when H_{loc} is small [4], or in salts with large exchange interaction (large ω_{exc}) [1-3,5].

There exist, however, a number of salts in which NMR can be observed. These are the salts customarily used for adiabatic demagnetization - alums, Tutton's salts, and double nitrates [6]. In spite of the fact that ω_{exc} is small, the distance from the paramagnetic center to the protons is relatively large ($r \approx 4 - 6$ Å), and $H_{loc} \sim r^{-3}$ is small.

The theory of NMR in paramagnets is given in [7]. According to [7], the line width $\Delta\omega$ depends on the field and should vary strongly when

$$\omega_e = \gamma_e H_0 \approx \sqrt{2}\,\omega_{exc}.$$

There are no published data on NMR in paramagnets in this region; this is dealt with in the present paper.

We observed resonance in potassium chrome alum and ferric ammonium alum, and also in cupric-ammonium and manganese-ammonium sulfates. The samples were ellipsoids cut from single crystals in the manner described in [9]. A Pound-Knight pickup was used [8].

We obtained the following results:

1. In fields 1 - 3 kG all the investigated salts, except cupric-ammonium sulfate have large paramagnetic absorption, exceeding the nuclear absorption by three orders. However,