It seems to us that the results can be interpreted in the framework of the collinear model of ferrimagnetism, if it is assumed that the magnetic moments of the ions situated in non-equivalent positions are antiparallel. Then the saturation magnetization per formula unit at 0°K should amount to $m_{Ni}/3 = 2\mu_B/3$ (μ_B is the Bohr magneton), and the specific magnetization should be 18 G-cm^3/g. In experiment we observe at 77°K a smaller moment. This can be attributed to the fact that the temperature of the measurements was rather high (more than one-half of T_C).

Figure 2 shows the dependence of the magnetic moment on the temperature in the basal plane in a field of 14 kOe (curve 1), and also the spontaneous magnetic moment in the basal plane (curve 2) and along the c axis (curve 3), obtained by linear extrapolation to H = 0 in accordance with the law $m = m_0 + \chi H$. The dashed section of the curve corresponds to temperatures at which the linear extrapolation gives approximate results. The appearance of a spontaneous moment near T_C along the hexagonal axis is apparently connected with the sharp decrease of the anisotropy constants or the appearance of a cone of easy magnetization directions on approaching the Curie point.

Thus, $RbNiF_3$ is a transparent ferrimagnet of the ferroxplan type.

[1] Yu. P. Simanov, L. R. Batsanova, and L. M. Kovba, Zh. neorg. khimii 2, 2410 (1957).

[2] W. Rudorff, H. Kandler, and D. Babel, Z. anorgan. und allgem. Chem. 317, 261 (1962).

[3] A. Zalkin, K. Lee, and D. H. Templeton, J. Chem. Phys. 37, 697 (1962).

[4] K. Lee, A. M. Portiss, and G. L. Witt, Phys. Rev. 132, 144 (1963).

ORIENTATION OF Cd^{111} NUCLEI BY 3261 Å RESONANT RADIATION

E. B. Aleksandrov and A. P. Sokolov

Submitted 11 March 1966
ZhETF Pis'ma 3, No. 10, 419-422, 15 May 1966

We have obtained appreciable orientation of Cd^{111} nuclei in vapor at a density on the order of 10^{14} cm^{-3} with the aid of circularly-polarized 3261-Å light. The method of orientation is similar in its main outlines to that used by the Kastler-Brossel group for odd mercury isotopes [1].

Figure 1 shows the structure of the ground 5^1S_0 state and first triplet excited 5^3P_1 state of the Cd^{111} ion in a magnetic field. Excitation of the atoms along the magnetic field by circularly-polarized light produces optical transitions accompanied by a change of the angular momentum m by unit - the angular momentum of the radiation is transferred to the electron shell and then to the nucleus via the hyperfine interaction connected with the shell. The angular momentum acquired by the atom is conserved on the average during spontaneous emission, and since the shell has no angular momentum in the ground state, the nuclei of the unexcited atoms become oriented. The process leads to an appreciable orientation of the ensemble, if the intensity of the orienting light is sufficient to overcome the thermal relaxation of the nuclei. The resultant orientation can be registered, for example, by determining the degree of absorption of the working radiation [2], since the probability of excitation of atoms with different nuclear-moment orientation are different (the relative probabilities of the transitions are indicated in Fig. 1).

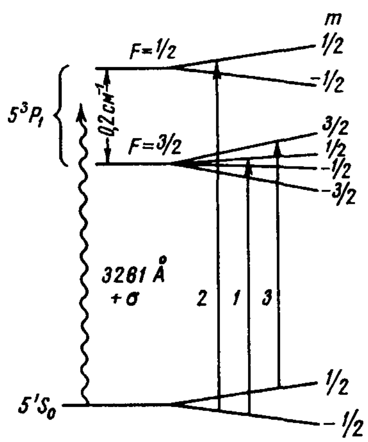

Fig. 1

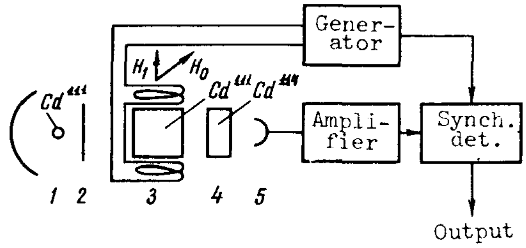

Fig. 2

The more the hyperfine splitting exceeds the natural line width, the greater the efficiency of the described process [3]. In this respect, the chosen 3261 Å line is quite favorable. Nonetheless, such a project of orienting cadmium nuclei has not even been discussed in the literature, in spite of successful orientation of an analogous object - mercury - by means of an analogous 2537 Å line (see [3]). This is apparently connected with the fact that the strength of the considered transition in cadmium is even 20 times smaller than in the case of mercury, for which great difficulty was involved in obtaining an orientation rate larger than the rate of the relaxation processes. It might appear that this circumstance would preclude the success of a similar procedure when applied to cadmium. However, in spite of the weakness of the 5^1S_0 - 5^3P_1 transition (oscillator strength 2×10^{-3}), the 3261 Å line has for several reasons an exceptional power in a gas discharge [4]. Estimates of the efficiency of the orientation process have shown that the existing sources of resonance radiation make it possible to count on total orientation in cadmium vapor nuclei with optical density of the order of 1, if it is assumed that the relaxation processes for Cd^{111} do not differ noticeably from the case of Hg^{199}.

The orientation of the cadmium was realized in the setup of Fig. 2. The light from high-frequency cadmium lamp 1 was passed through a circular polarizer 2 to a cuvette 3 with Cd^{111} vapor, saturated at 240°C. The transmitted light was passed through a gas filter 4 filled with Cd^{114} vapor. This filter selectively absorbed the hyperfine component F = 3/2 of the 3261 Å resonance line, thus increasing by several times the dependence of the brightness of the transmitted light on the state of the orientation of the nuclei (see the transition probabilities in Fig. 1). The transmitted light was registered with a photoreceiver 5.

The presence of orientation was established by means of a nuclear resonance signal.

To this end, an alternating magnetic field (4.8 kcs) perpendicular to the light ray was applied to the cuvette. The constant field of variable intensity was directed at an angle 45° to the light-beam axis. With such an arrangement, the magnetic resonance was accompanied by modulation of the transmitted light at the alternating-field frequency, and this served as the resonance signal [5].

Under the described conditions, we observed a distinct resonance signal with half-width of several cps in a field of 5.2 Oe, which approximately corresponds to the published value of the nuclear moment of Cd^{111}. The signal exceeded by two orders of magnitude the noise level, the receiver bandwidth being approximately 1 cps.

We propose to investigate in the future the character of the relaxation processes in the system and to attain a more complete orientation of the ensemble. The same method can be used to orient Cd^{113}. Cadmium is the third element (with mercury and helium), for which nuclear orientation has been attained by optical means.

The authors are deeply grateful to M. P. Chaika for help with the work, and also to A. M. Bonch-Bruevich for support and interest in this research.

[1] B. Cagnac and J. Brossel, Compt. rend. 249, 77 and 253 (1959).
[2] H. G. Dehmelt, Phys. Rev. 105, 1487 (1957).
[3] J. C. Lehmann and J. Brossel, Compt. rend. 258, 869 (1964).
[4] B. Budick, R. Novick, and A. Lurio, Appl. Optics 4, 229 (1965).
[5] H. G. Dehmelt, Phys. Rev. 105, 1924 (1957).

COLLECTIVE M1 TRANSITIONS OF EVEN NUCLEI

D. P. Grechukhin
Submitted 19 March 1966
ZhETF Pis'ma 3, No. 10, 422-424, 15 May 1966

A. S. Davydov [1], followed by D. P. Grechukhin [2], considered the collective M1 transitions of even nuclei. Their results were subjected to criticism in [3] by Lipas, whose conclusions were subsequently repeated in [4,5]. We shall show below that this criticism is incorrect, since not all the relations between the classical quantities are valid for quantum operators.

In phenomenological models of collective quadrupole excitations of nuclei one assumes as a postulate that the motion of a nucleus can be described by the collective variables $\hat{\alpha}_{2m}$ and $\hat{\pi}_{2m}$ satisfying the symmetry and commutation relations:

$$\hat{\alpha}^{*}_{2m} = (-)^{m}\, \hat{\alpha}_{2-m}; \quad \hat{\pi}^{*}_{2m} = (-)^{m}\, \hat{\pi}_{2-m}; \tag{1}$$

$$\hat{\pi}_{2m}\, \hat{\alpha}_{2m'} - \hat{\alpha}_{2m'}\, \hat{\pi}_{2m} = -i\hbar\delta_{mm'} . \tag{2}$$

The Hamiltonian of the system is accordingly written