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.

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COLLECTIVE M1 TRANSITIONS OF EVEN NUCLEI

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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

$$\hat{H}\,(\hat{\alpha}_{2m}\;\hat{\pi}_{2m}) = \frac{1}{2B_2}\sum_m \hat{\pi}_{2m}\,\hat{\pi}^*_{2m} + V\,(\hat{\alpha}_{2m}). \tag{3}$$

Within the framework of these assumptions, the angular momentum operator of the nucleus $\hat{I}_\mu$ is defined uniquely by the commutation relations for the spherical components of $\hat{I}_\mu$ ($\mu = 0;\ \pm 1$), namely:

$$\hat{I}_\mu\,\hat{I}_\nu - \hat{I}_\nu\,\hat{I}_\mu = \hbar\sqrt{2}\;C^{\kappa}_{|\nu|\mu}\;\hat{I}_\kappa, \tag{4}$$

$$\hat{I}_\nu\,\hat{I}^2 - \hat{I}^2\,\hat{I}_\mu = 0, \tag{5}$$

where

$$\hat{I}^2 = \sum_\mu (-)^\mu\,\hat{I}_\mu\,\hat{I}_{-\mu}.$$

$$\hat{H}\,\hat{I}_\mu - \hat{I}_\mu\,\hat{H} = 0, \tag{6}$$

$$\hat{H}\,\hat{I}^2 - \hat{I}^2\,\hat{H} = 0. \tag{7}$$

In addition, if $\Psi_{\Lambda\lambda}$ is the eigenfunction of the Hamiltonian $\hat{H}(\hat{\alpha}_{2m}\;\hat{\pi}_{2m})$, corresponding to the state with total angular momentum Λ and projection λ on the quantization axis, then

$$\hat{I}_\mu\,\Psi_{\Lambda\lambda} = \hbar\sqrt{\Lambda(\Lambda+1)}\;C^{\Lambda\lambda+\mu}_{\Lambda\lambda 1\mu}\;\Psi_{\Lambda\lambda+\mu}\,, \tag{8}$$

$$\hat{I}^2\,\Psi_{\Lambda\lambda} = \hbar^2\,\Lambda(\Lambda+1)\,\Psi_{\Lambda\lambda}\,. \tag{9}$$

Relations (4) - (9) define uniquely the structure of the operator $\hat{I}_\mu$:

$$\hat{I}_\mu = i\sqrt{6}\,(-)^\mu \sum_{m_1 m_2} C^{2m_2}_{1-\mu 2m_1}\;\hat{\pi}_{2m_1}\;\hat{\alpha}_{2m_2}\,. \tag{10}$$

On the other hand, we can consider the angular momentum of a drop of ideal liquid

$$\vec{L} = \int \rho(\vec{r})\,[\vec{r}\times\vec{V}]\,dv\;;\qquad L_\mu\;(\mu = 0,\ \pm 1). \tag{11}$$

Expanding L_μ in a series in the deformation parameters (see [3]), we obtain

$$L_\mu = \sum_{n=0}^{\infty} L^{(n)}_\mu\,. \tag{12}$$

In each term of the series $L^{(n)}_\mu$ we go over from the classical quantities α_{2m} and $B_2\dot{\alpha}^*_{2m}$ to the operators $\hat{\alpha}_{2m}$ and $\hat{\pi}_{2m}$, and obtain then a sequence of operators

$$L^{(n)}_\mu \to \hat{I}^{(n)}_\mu\;;\qquad L_\mu \to \sum_{n=0}^{\infty}\hat{I}^{(n)}_\mu\,. \tag{13}$$

In this sequence, however, only the term $\hat{I}^{(0)}_\mu \equiv \hat{I}_\mu$ satisfies all the requirements (4) - (9), whereas $\hat{I}^{(1)}_\mu$ does not commute with the Hamiltonian $\hat{H}$ (with $\sum_m \hat{\pi}_{2m}\,\hat{\pi}^*_{2m}$). Thus the series of the operators $\sum_m \hat{I}^{(n)}_\mu$ is not a representative of the angular momentum of collective excitations of even nuclei.

The magnetic dipole transitions are determined by the M1 operator

$$\vec{\mathfrak{M}} = \frac{1}{2c} \int [\dot{r} \times j_p(r)] dv; \quad \hat{\mathfrak{M}}_\mu \ (\mu = 0, \pm 1), \tag{14}$$

where j_p is the current of the nuclear transition.

Inasmuch as there are no other relations to limit the structure of the M1 operator, the operator $\mathfrak{M}_\mu$ of the M1 transition can in the general case be represented in the form of the series

$$\hat{\mathfrak{M}}_\mu = \frac{e}{2Mc} \sum_{n=0}^{\infty} g_n \hat{I}_\mu^{(n)} , \tag{15}$$

where g_n are parameters that must be chosen in accord with the experimental data. In the hydrodynamic model all the g_n are equal to Z/A. Of course, in principle we can conceive of collective-motion models in which $g_1 = 0$, but this is already a consequence of the model structure.

With respect to the error contained in [1,2], in the expansion of L_μ in powers of the deformation parameters α_{2m}, it should be noted that the inclusion of the next higher terms of the expansion of the velocity potential χ (see [3], formula (7)) leads only to a change in the numerical coefficient of the term $\hat{I}_\mu^{(1)}$ by a factor 9/8. This correction has no principal significance for our problem, and in addition the uncertainty of the coefficient g_1 is of the same order.

More detailed results of the analysis will be published in the journal "Yadernaya fizika."

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