

increasing n_{ch} is observed for any pair combination.

Thus, the experimental data on the ϕ -distributions contradicts qualitatively the most widely used MPM variant. We note that for the reaction $pp \rightarrow pp2\pi^+2\pi^-$ at $p_0 = 23 \text{ GeV}/c$ such a contradiction was noted earlier in [1], but in [3] the same data were reconciled with the MPM by taking resonance production into account³⁾. The present results cannot be noticeably altered by taking into account the experimentally observed resonance-production frequency. It is not excluded, of course, that the obtained data can be explained within the framework of the MPM for example at the expense of making the nodes much "heavier" (clustering).

A more detailed analysis of the two-particle correlations in pN collisions at accelerator energy will be the subject of a subsequent paper.

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INHOMOGENEOUS BROADENING OF EPR SPECTRA UNDER CONDITIONS OF RAPID ROTATIONAL DIFFUSION

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It was observed in [1, 2] that inhomogeneously broadened EPR lines are saturated by a monochromatic microwave pulse, several dips appear on the line contours. The widths of the dips are much smaller than the width of the envelope. This phenomenon, called discrete saturation, was attributed in [2, 3] to the presence of forbidden transitions produced as a result of hyperfine dipole interaction of the electron spin of the paramagnetic center with the nuclear spins of the solid matrix. In these experiments, however, the width of the envelope was as a rule larger than the nuclear zeeman frequency, $\Delta H > \gamma_n H_0$, so that the forbidden transitions corresponding to simultaneous flipping of the electron and nuclear spins, could not be separated, since they were within the limits of the EPR line envelope. In addition, the propagation of the saturation within the inhomogeneously broadened EPR line (its homogenization) was not investigated. In the present paper we show, with the EPR spectrum of a stable iminoxyl radical in a plastic crystal, that discrete saturation is indeed connected with forbidden transitions and is accompanied in this case by fast homogenization. The choice of a plastic crystal to serve as a matrix was dictated by the possibility of separating the allowed and forbidden transitions in the EPR spectrum [4], owing to the line narrowing under conditions of rapid rotational diffusion, which characteristic of plastic crystals, which have as a rule globular molecules and highly symmetrical cubic lattices [5]. The investigations were performed in cyclohexane and camphor crystals in the plastic region. The results turned out to be qualitatively the same,

and we present below data for cyclohexane, into which the radical $\text{C}_6\text{H}_{11}\text{N}^\bullet$, previously used to

investigate rotational diffusion in viscous and polymer media [6, 7] was introduced at a concentration $\sim 10^{18} \text{ cm}^{-3}$. The measurements were performed by the electron-electron double-resonance method (EDR) developed in [8]. The EDR method consists of a stationary saturation of one of the lines of the multicomponent EPR spectrum with a strong microwave pump field, followed by observation of the influence of this saturation on the intensity of other spectral lines with the aid of a weak microwave field of another frequency. An EDR spectrometer with $\nu_0 \sim 9300 \text{ MHz}$ is described in [9]. The EDR signal is separated by modulating the pump at the same frequency, 330 Hz, at which the observation is carried out. Forbidden transition

³⁾ We note that to obtain agreement with the MPM the author of [3] had to assume an anomalously large heavy-isobar production cross section.

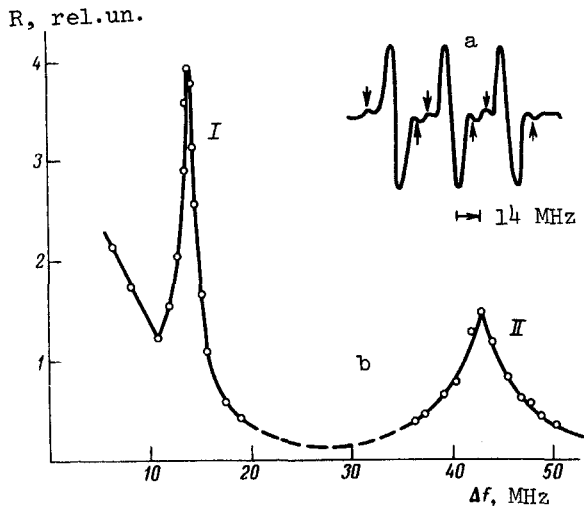


Fig. 1. a) Spectrum of aminoxyl radical in cyclohexane. b) Amplitude of EDR signal of hfs component with $m_{N^{14}} = 0$ vs the difference of the pump and observation frequencies: I) saturation in the forbidden transition region, II) saturation of neighboring nitrogen hfs line.

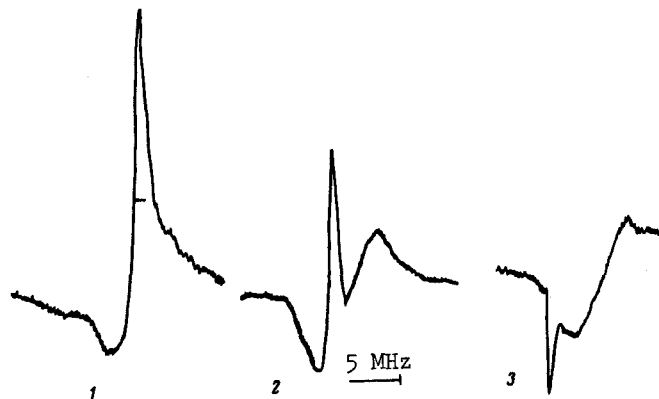


Fig. 2. EDR spectra of component with $m_{N^{14}} = 0$ in saturation of the forbidden transition and sweep of the observation frequency. The spectra (1 - 3) correspond to a shift of the saturation point along the line.

the radical is under conditions of rapid rotational diffusion with a relaxation time $\tau_c \approx 5 \times 10^{-11}$ sec. The same Fig. 1 shows the dependence of the amplitude of the EDR signal obtained by sweeping the magnetic field through the resonance from a fixed difference of the observation and pump frequency. The relative changes of the EPR lines in Fig. 1b amount in this case to 1 - 4%. From a comparison of the EPR and EDR spectra we see that the width of the EDR line (I), corresponding to saturation of the forbidden transition ($\delta \approx 1.5$ MHz) is much less than either the EPR lines or the EDR line (II) corresponding to saturation of the neighboring allowed hyperfine splitting line $\Delta f_p = 44$ MHz. Figure 2 shows the EDR spectra obtained by sweeping the the observation frequency at fixed pump frequency and fixed magnetic field. Spectra 1 - 3 correspond to different positions of the saturated point on the forbidden line. A narrow line separated in frequency from the pump line by $\Delta f_3 = 14.2$ MHz appears in this case against the background of a broad line close to ΔH in width and corresponding to the decrease of the intensity of the entire allowed line. The width of the narrow line is $\delta \approx 1.4 - 1.6$ MHz. On the other hand, when the pump frequency is set at the frequency of the neighboring line of the allowed transition (Δf_p), only a broad line (ΔH) is observed in the EDR spectrum in accord with the result of Fig. 1b. It can be concluded from the experimental data that the EPR lines of both the allowed and the forbidden transitions are inhomogeneously broadened and consist of spin packets of width $\delta \sim 1.5$ MHz. Simultaneous observation of broad and narrow EDR lines (Fig. 2) indicates that homogenization proceeds via transfer of saturation to the greater part of the line, and not between neighboring spin packets. The absence of a narrow line at $\Delta f_p = 44$ MHz is explained by the same fact. In this case, the EDR effect itself is due to spin-lattice relaxation of the nuclei in the individual spin packet, and the pump-line homogenization causes the pump action to be transferred to the neighboring line not at the saturation point alone, but distributed over the line. Thus, depending on the saturation conditions, the EPR line behaves as if it were either homogeneously (Δf_p) or inhomogeneously (Δf_3) broadened. The inhomogeneous broadening of the EPR line is apparently due to dipole-dipole interaction of the unpaired electron of the radical with the cyclohexane protons, which is due in turn to the relative immobility of the centers of gravity of the molecules in the plastic crystal [5]. On the other hand, the anisotropic hyperfine interaction both with its own proton and with the N^{14}

1) All the results are given for $T = 230^\circ K$ and a pump field amplitude $\gamma_e H_1 \approx 0.8$ MHz

nucleus averages out to a very low value (~ 0.3 MHz) of the rapid rotational relaxation of the radical. A natural condition for the appearance of inhomogeneous broadening of the EPR line in a simultaneous observation of a narrow and a broad EDR signal will be the relation $T_{1e}V_h \leq 1$, where T_{1e} is the electron spin-lattice relaxation time and V_h is the homogenization rate. Using a value $T_{1e} \sim 10^{-6}$ sec [4] we find that $V_h/2\pi \leq 0.1$ MHz. This estimate shows that the width of this signal is apparently governed by the isotropic hyperfine interaction with the protons of the radical itself. The fact that the width of the broad component of Fig. 2 is independent of the concentration indicates that homogenization of the line is connected with a change of the orientation of the spins of the cyclohexane protons surrounding the radical. This change occurs in this case apparently as a result of molecular diffusion, whose coefficients in the plastic region exceed the coefficients of the spin diffusion [10] by several orders of magnitude [5].

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INDUCED β - γ CORRELATION OF THE DIRECTIONS FOR ALLOWED β TRANSITIONS

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A new type of β - γ direction correlation, which appears only in the presence of definite perturbations, is considered. This effect can be used to determine the characteristics of the excited states of nuclei and to detect acoustic nuclear resonance.

It is known that there are no β - γ direction correlations for allowed β transitions in the case of non-oriented initial states of the nuclei [1]. The reason is that the anisotropy of the γ -quantum angular distribution averaged over the polarizations is due to the even polarization moments that characterize the intermediate state of the nucleus, whereas an allowed β transition produces only odd polarization moments.

We consider in this paper the β - γ direction correlation induced by an external field. Unlike ordinary perturbed angular correlation, when a perturbation from outside the nucleus distorts an already-existing angular dependence, the induced β - γ correlation arises itself only in the presence of definite types of interaction.

The probability of photon emission in a direction \vec{n} is given by [2]

$$W(n) = \sum_{\ell, \mu} B_{\ell}(L, I, I_f) \mathcal{D}_{\ell\mu}^{(I)*} D_{0\mu}^{(\ell)}(n), \quad (1)$$

where B_{ℓ} are coefficients that depend on the multipolarity L of the radiation and on the spins I and I_f of the intermediate and final states of the nucleus. $\mathcal{D}_{\ell\mu}^{(I)}$ are even ($\ell = 2k$) polarization moments, and $D_{0\mu}^{(\ell)}$ is a finite-rotation matrix. The preceding allowed β transition yields