intensity maximum of the frequency spectrum excited by the beam lies in the region of resonant absorption in the inhomogeneous magnetic field of the probkotron. In this case, intense x-rays are observed, with energies greatly exceeding the beam energy (the average x-ray energy for the conditions of Fig. 2 is 30 keV). On deviating from optimal conditions, i.e., when the spectrum of the maximally excited frequencies is shifted above or below the probkotron cyclotron frequencies, the heating efficacy decreases sharply. The efficacy increases with increasing mirror ratio, as does the hardness of the plasma x-rays [2], owing to the broadening of the resonance-absorption band. It is seen from Fig. 2 that the oscillation intensity in the region of the growing field of the second mirror is low. It can therefore be assumed that the most effective energy transfer from the high-frequency oscillations to the plasma particles occurs in the decreasing-field region of the first mirror, whereas the second mirror serves to capture the particles into the trap. The particles that have acquired in the resonance-absorption region an energy sufficient for reflection from the second mirror, are captured in the trap. They travel many times through the region of resonance absorption, as a result of oscillations between the mirrors, and continuously gain in energy. Stochastic cyclotron resonance is thus the plasma-heating mechanism.

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NUCLEAR QUADRUPOLE DIFFRACTION OF RESONANT GAMMA RADIATION IN A TELLURIUM SINGLE CRYSTAL

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The diffraction of resonant gamma radiation by nuclei situated in intracrystalline fields has a number of distinguishing features [1 - 6] due to the dependence of the Mossbauer-scattering amplitude on the magnetic field direction and on the orientation of the electric field gradient (EFG) axes at the location of the scattering nucleus.

We report here the results of diffraction experiments on the scattering of the resonant gamma radiation from Te^{125m} by a tellurium single crystal. It was previously suggested [7] that pure nuclear Bragg quadrupole reflections can appear in such a case. The kinematic theory of diffraction in nuclear γ-resonance scattering in crystals containing Mossbauer nuclei with an inhomogeneous electric field was developed earlier by Aivazyan and Belyakov [4], who also analyzed the conditions for the occurrence of nuclear quadrupole reflections. No experimental studies of this unique feature of Mossbauerography were made so far, however.

The tellurium crystal has trigonal syngony (space group $P3_121$). The principal EFG axes at the tellurium nuclei make a constant angle to the C axis, but are differently oriented in a helical chain of tellurium atoms [8], so that the chemically equivalent tellurium atoms become non-equivalent scatterers in

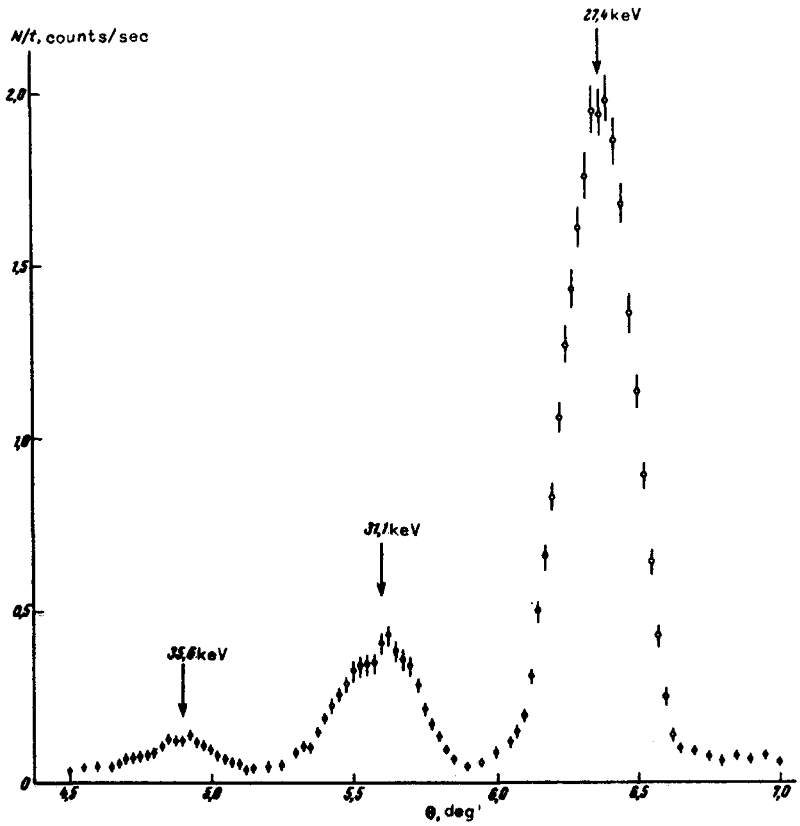

Fig. 1. Emission energy spectrum of source based on Te^{125m}, obtained by reflection from the (200) plane of single-crystal LiF.

Mossbauer diffraction. Taking into account the scattering of the resonant γ radiation both by the electrons of the atoms and by the nuclei, we can write for the structure amplitude from the (hkℓ) plane

$$F(hk\ell) = F_R(hk\ell) + F_N(hk\ell), \tag{1}$$

where $F_R(hk\ell) = \sum_j^N f_{Rj} \exp 2\pi i(\vec{r}_j \cdot \vec{H})$ is the Rayleigh part of the structure amplitude and $F_N(hk\ell) = \sum_i^N f_{Ni} \exp 2\pi i(\vec{r}_i \cdot \vec{H})$ the nuclear part; N is the number of atoms per unit cell, and n the number of resonant nuclei; f_{Rj} and f_{Ni} are the amplitudes of the Rayleigh and resonant scattering, respectively; $\vec{r}_j$ and $\vec{r}_i$ are the radius vectors of the positions of the atoms j and i inside the unit cell.

The presence of the screw axis 3_1 in the tellurium structure in the pure Rayleigh (nonresonant) scattering leaves the reflections {000ℓ} with ℓ = 2n unsuppressed (n is the order of the reflection). In order that purely nuclear reflections appear in Mossbauer diffraction it is necessary to satisfy in (1) the condition $F_R(hk\ell) = 0$, which is attainable for any reflection {000ℓ} with $\ell \neq 3n$. Thus, in our case the reflection (0003) with Bragg angle θ = 5°4' corresponds to both contributions of F_{Rj} and F_{Ni} to the structure amplitudes, while the reflection (0001) and (0002), for which the Bragg angles are θ = 1°41' and θ = 3°22', respectively, should contain only F_{Ni} and should not be suppressed.

The experiments consisted in the following. A tellurium single crystal with natural Te^{125} content, grown in such a way that one of the faces had the index {000ℓ}, was mounted in a Mossbauer diffractometer [9] with constant source velocity. The source was a Te^{125m} compound having a single emission line of natural width and a Mossbauer-effect probability f = 0.50. The source activity was ~40 mCi. It is known that the half-life of the Te^{125m} isotope is relatively small, $T_{1/2}$ = 58 days, and the Mossbauer-transition probability is E_γ = 35.5 keV (λ_γ = 0.348 Å), i.e., much larger than for the long-lived isotopes of Co^{57} and Sn^{119m}, with which the earlier experiments on diffraction of γ-resonance radiation were performed. We therefore obtained first the diffraction spectrum of a source with an LiF crystal (Fig. 1), which showed that the Mossbauer emission in the source spectrum amounts to only 1/16-th of the x-ray spectrum with λ = 0.452 Å and one-third of that with λ = 0.398 Å.

To shorten the duration of the experiments, we investigated the diffraction spectra of only two reflections, (0003) and (0001). The gamma quanta emitted by the oscillating source passed through a collimation system (12 × 1.0 mm channel in a lead cylinder) and were incident on the tellurium single-crystal secured in the holder of a low-temperature chamber.

The scattered γ quanta were registered with an SRS-1 scintillation detector, discriminated in energy, and fed to scalar circuits. The background in the registered-energy window was 0.03 count/sec. The experiments were performed at 90°K. The spectra took 200 hours to obtain. Before the start of the Mossbauer-diffraction experiments, patterns of the diffraction of MoK_α radiation by the single-crystal tellurium were obtained for the region of existence of the reflections (0001), (0002), and (0003). These patterns revealed the presence of only the (0003) reflection.

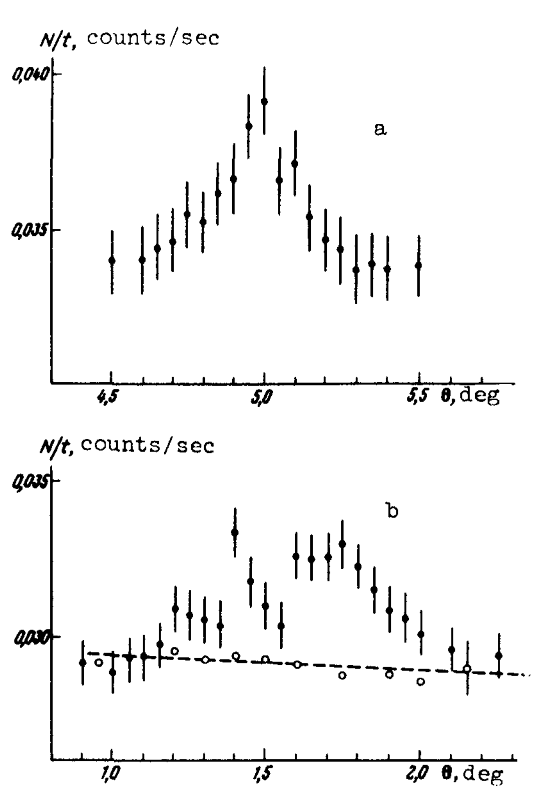

Fig. 2. Diffraction spectra of nuclear γ-resonance radiation scattered by single-crystal Te: a) in reflection from the (0003) plane in the absence of resonance, $V = V_\infty$, b) in reflection from the (0001) plane for the case when the nuclear resonance scattering mechanism is turned on, $V = V_{res}$ = 1.9 mm/sec.

Figure 2a shows the (0003) Bragg peak obtained by reflection of the Mossbauer γ radiation from the Te single crystal at $V = V_\infty$, i.e., in the absence of resonant scattering of the γ quanta. Figure 2b shows the pure nuclear-quadrupole maximum (0001), the angular width of which exceeds the width of the (0003) maximum. The nuclear quadrupole maximum was obtained at a source velocity $V = V_{res}$ = 1.9 mm/sec, i.e., when the nuclear mechanism of scattering is turned on. The dashed line in Fig. 2b corresponds to the counting rate in the absence of resonance, $V = V_\infty$. It should be noted that the very existence of pure nuclear quadrupole maxima is direct evidence of only the presence of different orientations of the EFG at the Mossbauer nuclei. A subsequent analysis of the polarization and intensity of the hyperfine structure of the Bragg maxima makes it possible to determine the orientation of the EFG axes and the coordinates of the resonant nuclei [10].

Experiments are continuing in this direction.

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ELECTRON DENSITY IN TUNGSTEN CRYSTAL ACCORDING TO NEUTRON-ELECTRON INTERACTION DATA

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The most thoroughly investigated interactions between the neutron and the atom are the nuclear and magnetic ones (in the former case, the neutron interacts with the nucleus of the atom), and in the latter with the electron shell). These interactions are characterized by an amplitude on the order of $b \sim 10^{-12}$ cm. There exist, however, weaker interactions having a different nature. These include the relativistic neutron-electron (ne) interaction (cf., e.g., [1]). The experimental determination of the amplitude a_{ne} of this process entails great difficulties, since this effect is very small (the ne-interaction amplitude is smaller by four orders of magnitude than that indicated above, i.e., $a_{ne} \sim 10^{-16}$ cm).

One of us proposed in [2] a method of determining a_{ne}. It is based on measurements of the intensity of the diffraction reflections of monochromatic neutrons from a tungsten single crystal strongly enriched with W^{186}. In this case the nuclear scattering is very small, owing to the interference between the resonant and potential scattering of the neutrons, and the magnetic scattering, if it exists at all, is not coherent. Preliminary results of these measurements were given in [3].

We plotted the electron-density distribution by using the intensities of neutron reflection from all planes of the [00ℓ] zone of a tungsten crystal enriched to 90.7% with the isotope W^{186}. Since ne scattering of neutrons by atoms is characterized by the same angular dependence as x-ray scattering (the geometric relations are assumed to be fully identical in both cases), the same electron-distribution density should be obtained by both methods.

The reflection intensities were measured with a multicrystal setup in the VVR-Ts reactor of a branch of our Institute [4]. We used monochromatic neutrons of wavelength λ = 1.145 Å. A spherical W^{186} sample of 5.5 mm diameter had in the range $\sin\theta/\lambda < 0.85$ approximately 44 reflections of which eight were