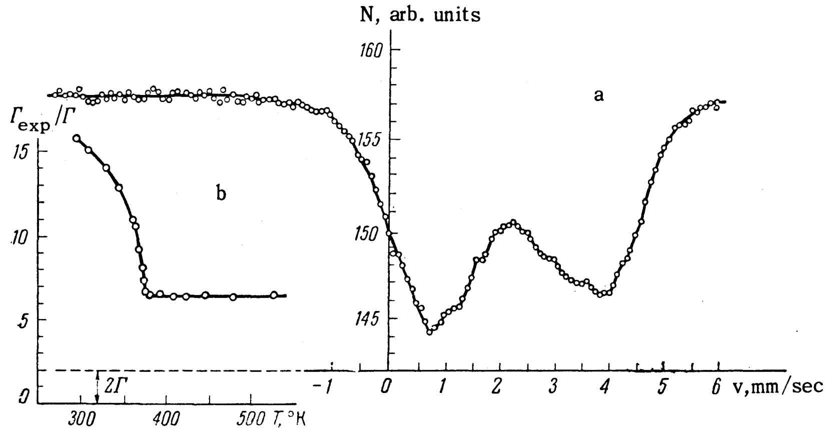

FIG. 2. a) Resonance absorption spectrum for 23.8-keV γ quanta in Sn^{119} nuclei contained in $FeSn_2$ at room temperature; absorber thickness 28 mg/cm^2; source was SnO_2. b) Temperature dependence of spectrum width Γ_{exp} for Sn^{119} nuclei in $FeSn_2$.

H_n at the tin nuclei in $FeSn_2$. An estimate based on data for the Mössbauer effect for impurity tin nuclei in iron[5] gives a value of approximately 25 kOe for H_n at room temperature. The asymmetry of the spectrum indicates that in addition to the magnetic splitting there is also a shift of the components due to quadrupole interaction of the Sn^{119} nucleus with the inhomogeneous electric field.

Such an interpretation of the spectrum shown in Fig. 2a agrees with the data on the temperature dependence of the Mössbauer effect. Figure 2b shows the temperature dependence of the spectrum width Γ_{exp} measured at half height. This dependence also indicates a magnetic origin of the splitting of the line when $T < T_N$ (cf. Fig. 1b). The considerable broadening of the line for $T > T_N$ can be explained by the assumption that there is quadrupole interaction (the width of the source line was approximately $2.5\,\Gamma$).

The experimental data on the Mössbauer effect for the tin nuclei also give us a value for the magnetic transition temperature of the compound by observing the kink in the curve of $\Gamma_{exp}(T)$. This gives $T_N = 378 \pm 3$°K.

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OBSERVATION OF RADIOACTIVE DECAY WITH EMISSION OF PROTONS

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As the number of neutrons in the nucleus decreases with constant Z, the binding energy of the last proton decreases. Proton decay then becomes energetically possible. This question has been discussed by a number of authors.[1-7] The proton can be emitted either from the ground state of the nucleus or from an excited state after β^+ decay. In the case of the former the half-life is determined by the penetrability of the Coulomb barrier and the reduced width for the proton; in the case of the latter it is equal to the half-life of the β^+ activity of the parent nucleus. The possibility of the simultaneous emission of two protons by the nucleus has been considered by Gol'danskiĭ.[5,6]

Neutron deficient nuclei are produced with a large probability by accelerated heavy ions. We have reported[8,9] on experiments in which it was shown that isotopes emitting protons in radioactive decay are produced in the reactions Ni + Ne^{20}. Delayed protons were also recorded when aluminum was bombarded by high energy protons.[10]

In the present experiment, as in the previous ones, a nickel target was bombarded by Ne^{20} in the internal beam of the multiply-charged ion cyclotron of the Joint Institute for Nuclear Research. With the aid of other equipment, we confirmed the results of our previous experiments[8,9] and obtained new data. The products of the nuclear reactions in the nickel target were stopped in a rotating aluminum disk 50 μ or 9.3 μ thick and were brought to the entrance window of a telescope consisting of a thin proportional counter and a silicon surface-barrier detector. The use of such a telescope made it possible to measure simultaneously the energy of the particle and the ionization density, which enabled us to separate the protons from the α particles. The sensitive layer of the silicon detectors was 0.2 mm thick. The telescope volume was isolated by a vacuum from the remaining volume where the target, rotating disk, ion current indicator, and the moving frame with the absorbers and calibrated α source were located. The absorber or α source could be placed in front of the entrance window of the telescope.

The electronic equipment permitted the simultaneous recording of two pulse-height spectra from the silicon detector with the aid of 100-channel analyzers. The first spectrum consisted of particles with an ionization greater than $1/20$ of the ionization of the 4.7-MeV alpha particles used for the calibration; the second spectrum consisted of particles with $1/20$ to $1/4$ of ionization of alpha particles used for the calibration; the spectra were recorded in the intervals between the successive applications of the high-frequency voltage pulses on the cyclotron dees.

With a 10-μ nickel target bombarded by Ne^{20} ions of energy ~ 140 MeV, we recorded two groups of particles of approximately the same intensity at energies of 2.5—3 and ~ 5 MeV. The ionization of these particles was $1/20$ to $1/4$ that of the 4.7-MeV alpha particles, where the ionization of the particles of higher energy was approximately one half the ionization of the 2.5—3 MeV particles. Figure 1 shows the pulse-height spectra.

We carried out experiments in which aluminum absorbers 15 and 30 μ thick were placed in front of the telescope entrance window. Moreover, we decreased the thickness of the sensitive layer of the detector. The range of the recorded particles proved to be much larger than for α particles of the same energy. The results of the experiments with the absorbers and also the value of the ioniza-

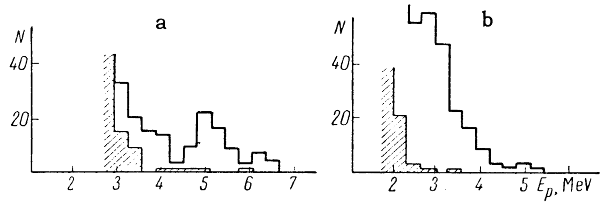

FIG. 1. Spectra of protons obtained with a 15μ absorber in front of entrance window of telescope. The spectra obtained with a 200μ Al absorber (β background) are shown dotted. a) disk 50μ thick; sensitive layer of silicon detector ~ 200μ; b) disk 9.3μ thick; sensitive layer of silicon detector ~ 90μ.

tion of the particles permitted us to conclude unambiguously that the charge of the recorded particles was unity. It is most natural to assume that these are protons. We measured the half-life of the proton emitter. For the emission of protons of energy of about 5 MeV, it proved to be somewhat less than 0.1 sec. The half-life of the emitter of 2.5—3 MeV particles was approximately 25 sec (see Fig. 2).

When we replaced the nickel target by copper, tantalum, and aluminum targets, the group of protons of lower energy was no longer present, while the group with an energy of ~ 5 MeV remained, but the yields were $1/3$, $1/2$, and $1/5$, respectively, of the previous value.

We also carried out experiments permitting a crude estimate of the range of the proton-emitting nuclei. For this we placed an aluminum absorber 9.3 μ thick between the target and disk. The group of protons with energy 2.5—3 MeV was not detected. The range of nuclei emitting protons of energy ~ 5 MeV was greater than 9.3 μ Al. The results of the experiments with different targets and data on the ranges of the activity made it possible to conclude that protons of energy ~ 5 MeV are emitted in the radioactive decay of the products of transfer reactions. The mass of these isotopes does not ap-

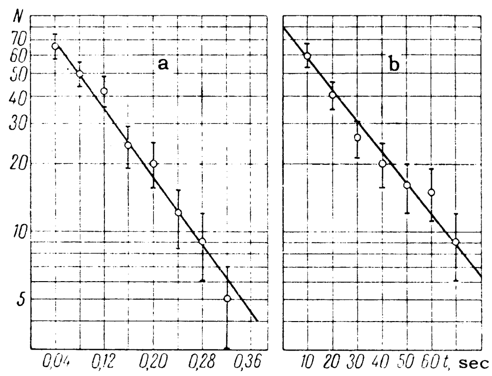

FIG. 2. Decay curves of proton emitter: a) group of protons of energy ~ 5 MeV; b) group of protons of energy 2.5–3 MeV.

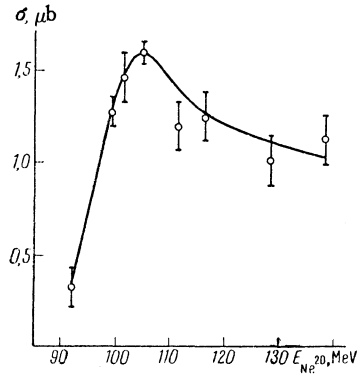

FIG. 3. Excitation function for emitter of 2.5–3 MeV protons. Nickel target 2μ thick. The relative errors are shown.

pear to differ greatly from the mass of Ne^{20} (for example, Ne^{17}, Mg^{20}, etc.). The isotopes emitting the 2.5—3 MeV protons are apparently produced in reactions of the type Ni(Ne^{20}, xpyn). The form of the excitation function (see Fig. 3) obtained with a target $2\,\mu$ thick and an aluminum disk $9.3\,\mu$ thick for 2.5—3 MeV protons also agrees with the latter conclusion.

From the energy of the protons and the half-lives, it is most probable that the protons are emitted from the excited nucleus after β^+ decay. However, we cannot completely exclude the possibility that the protons are emitted from the ground state of p-active nuclei.

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