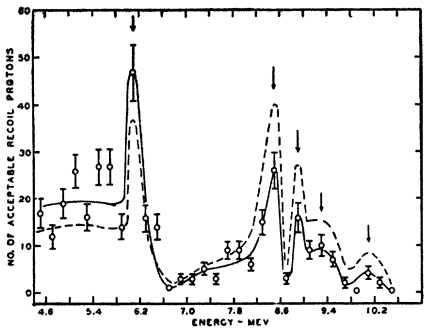

FIG. 2. Energy distribution (observed and corrected) ranging from 4.2 Mev to 10.5 Mev of the recoil protons projected in the forward direction by the neutrons from sodium irradiated by deuterons. Emulsion thickness 200 microns.

gamma-ray follows the 2.76-Mev gamma-ray. In the various proton scattering experiments, weak proton groups have appeared which correspond to levels between 2.0 Mev and 2.8 Mev. However, for reasons of intensity, these levels may be related to Mg^{25} or Mg^{26}. Separated magnesium isotopes have not as yet been employed in scattering experiments. The data of the present experiment are completely unambiguous, because Na^{23} is the single stable isotope of sodium. It is, of course, likely that other neutron groups may emerge at different angles of observation and different bombarding energies. The nuclear energy levels of Mg^{24} as determined by several different methods are summarized in Table I.

TABLE I. Nuclear energy levels of Mg^{24}.

Neutron scattering	Proton scattering Rochester, 1941	Proton scattering Rochester, 1943	Proton scattering Princeton, 1948	Disintegration of Na^{24}	$Na^{23}+D\rightarrow Mg^{24}+n'+Q$
			1.00		0.83
1.30		1.32	1.33		1.24
	1.37			1.38	
			1.54, 1.58		1.66
			1.98(?)		
	2.80	2.74	2.64(?)		
		3.88	3.97		
	4.07		4.17	4.14	4.16
			5.51		
			7.32		7.70
			8.30		8.64

The writer wishes to express his appreciation to Dr. E. L. Hudspeth and Mr. C. P. Swann of Bartol for many interesting discussions regarding the photographic plate technique and for the use of the Van de Graaff generator.

† Assisted by the joint program of the ONR and the AEC.

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Erratum: On the Difficulty of the Meson Theory of Nuclear Forces

[Phys. Rev. **75**, 1101 (1949)]

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FOR Eq. (1) read

$$W_{BA}=-\Sigma_I H'_{BI}H'_{IA}/(E_I-E_A). \qquad (1)$$

Decay Scheme of Te^{125m}

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June 20, 1949

A STUDY of Te^{125m} (58 days) with a 180° magnetic beta-ray spectrograph[1] had shown that besides the K, L and M conversion lines of the 109.3 kev transition, a weak line of 31 kev electrons was present. With a more intense source of Te^{125m}, Hill[2] succeeded recently in photographing a second weak line, thus identifying the first and the second line as L and M conversion electrons, respectively, of a 35.4 kev transition.

The present investigation was undertaken to decide the role of this transition in the decay scheme of Te^{125m} in order to be able to assign the spin change between the metastable state and the ground state which is of particular interest in this case.[3]

We have carried out the following experiments:

1. By the fluorescence method previously described[4] we have detected unconverted photons corresponding to the 35.4 kev transition. We observed characteristic fluorescence from reflectors made of various iodine compounds, but not from reflectors made of caesium or barium compounds. This is to be expected for a 35.4 kev photon. A comparison of the intensity of the fluorescence from iodine with that obtained from silver, where the Te K x-ray lines are critically absorbed, showed that approximately 15 unconverted gamma-rays are emitted per 100 K x-rays. This result was confirmed by Mr. Katz by means of critical absorption instead of fluorescence.[5]

2. Using two krypton filled Eck and Krebs counters and a coincidence circuit with a resolving time of 0.2 microseconds, we found photon-photon coincidences which were strongly reduced by insertion of Ag absorbers between the source and one of the counters. This result taken together with the fact that no line corresponding to the difference 109.3 kev−35.4 kev=73.9 kev has been observed either converted or unconverted, indicates that the 35.4 kev transition succeeds the 109.3 kev transition.

An estimate of the K shell conversion coefficient can be made from the photon-photon coincidence rate observed. The absolute efficiency for K x-rays of the region in which we are interested was obtained by using a Te^{121} source, where K electron capture from the 17 day ground state leads to an excited state of 610 kev in Sb^{121} which decays promptly to the ground state.[6] If it is assumed that each 610 kev gamma-ray is preceded by K electron capture (thus ignoring small contributions from capture of electrons in higher orbits), the absolute efficiency ϵ for detecting K shell holes (equal to the efficiency of detecting K x-rays multiplied with the fluorescence yield) is obtained. If we further assume that the unconverted gamma-ray is detected by our Kr counter approximately as efficiently as a K hole and that the fractions η_{K_1} of the 109.3 kev radiation and η_{K_2} of the 35.4 kev radiation are converted in the K shell, the following relation holds:

$$A=\frac{\eta_{K_1}\times\frac{N_{12}}{N_1}}{2\eta_{K_1}\epsilon-\frac{N_{12}}{N_1}}.$$

Where A denotes $(\eta_{K_2}+\gamma_2)$, γ_2 being the fraction of unconverted gamma-rays per 35.4 kev transition and N_{12}/N_1 the number of coincidences per single count for the Te^{125m} source measured in a geometry identical to that used for the determination of ϵ. For η_{K_1} we used the previously determined value 0.54[1]. Our coincidence experiments yielded the following values:

$$\epsilon=(1.1\pm0.1)\times10^{-3}$$

$$\frac{N_{12}}{N_1}=(0.8\pm0.1)\times10^{-3}$$

from which it follows that A is close to 1.

TABLE I. Theoretical lifetimes and conversion coefficients.

	$\frac{N_{e_K}}{N_\gamma}$	$\frac{N_{e_L}}{N_\gamma}$	$\tau^{a,b}$	$\eta_{K_2}{}^b$	$\frac{N_\gamma{}^b}{N_e+N_\gamma}$
Electric dipole	3	0.41	9.6×10^{-13} sec.	0.68	0.23
Magnetic dipole	6.8	0.63	1.3×10^{-6} sec.	0.80	0.12
Electric quadrupole	17	36	2.0×10^{-7} sec.	0.31	0.018
Present work			$<5\times10^{-8}$ sec.	0.6–0.8	0.15–0.20

[a] Expected lifetime of excited state, corrected for internal conversion.
[b] For the calculation of these values conversion for shells higher than the L-shell has been neglected.

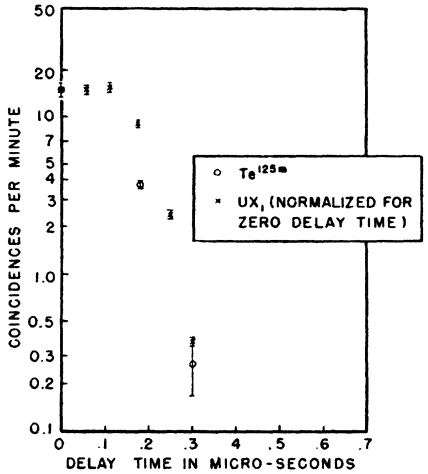

FIG. 1. Delayed photon-photon coincidences from Te^{125m}.

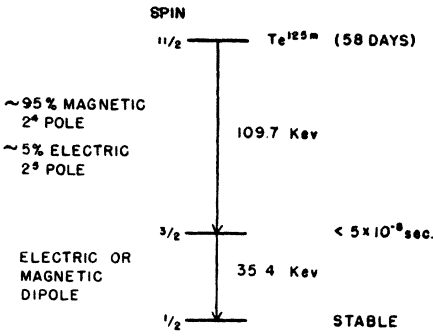

FIG. 2. Proposed decay scheme of Te^{125m}.

Values for ηK_2 between 0.6 and 0.8 and for γ_2 between 0.15 and 0.20 are best compatible with all the data.

3. An attempt was made to measure the lifetime of the 35.4 kev transition. Figure 1 shows the number of photon-photon coincidences, consisting of the coincidences between K x-rays of the 109.3 kev transition and either K x-rays or the unconverted gamma-rays of the 35.4 kev transition, as a function of the delay between two Eck and Krebs counters. The technique used was the same as that described by Bittencourt and Goldhaber.[6] For comparison a "zero-delay" curve obtained by shooting UX_1 beta-rays through both counters is given. No noticeable delay was found, and we can estimate that the half-life is $<5\times10^{-8}$ seconds.

Table I shows the theoretical lifetimes and conversion coefficients[7] to be expected for the 35.4 kev transition, with either an electric dipole or magnetic dipole transition or an electric quadrupole transition. In the last line the experimental results are given.

It is seen that the experimental data are compatible with the first two cases, although the lifetime appears to be somewhat short for a magnetic dipole transition. However, since theoretical lifetimes are uncertain by a factor of the order of 100 this is not sufficient to rule out the possibility of a magnetic dipole transition.[8] The assumption of an electric quadrupole transition, on the other hand, seems to be definitely in disagreement with our data.

The spin of Te^{125} in its ground state has been recently measured by Mr. Fowles[9] in Professor Jenkins' Laboratory at Berkeley, and found to be $\frac{1}{2}$. This permits us to propose the following decay scheme (Fig. 2), which is definitive as far as spin assignments are concerned, but leaves the parity change for the second transition still indefinite.

* Supported jointly by ONR and AEC.
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[8] It may be pointed out here that present ideas on the nuclear shell model seem to favor a magnetic dipole transition in this case (see R. D. Hill's discussion for Te^{122}, reference 2).
[9] Private communication from Professor A. C. Helmholz.

On the Energy Band Structure of Insulators

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June 16, 1949

IT is a well-known fact that an insulator may become an n- or p-type semiconductor upon the introduction of a sufficient number of impurities. These "donors" and "acceptors" are known to stabilize the location of the Fermi level close to the conduction band or the uppermost filled band. Discussions of these phenomena often imply that the Fermi level of a good insulator is located in the center of the forbidden band. This letter wants to point out that this last possibility is rather remote and that an attempt to realize it is more likely to lead to uncontrolled spatial oscillations of the Fermi level between its n and p positions.

If we take, for instance, the case of diamond, we find that the product of electron and hole densities equals 10^{-8} cm^{-6}. Thus the electrons and holes which tend to stabilize the Fermi level in the center of the forbidden band are far too small in number to have any influence. Their role is restricted entirely to preventing the entry of the Fermi level into the filled or empty band. Within the forbidden region itself the location of the level becomes thus entirely dependent on the crystal imperfections and becomes subject to the fluctuations which they undergo. If we assume, for instance, that there exists, at a certain place, a number of low lying acceptors (as might be found in the neighborhood of a crack) then we will find that these acceptors will tend to attract negative charge. This negative charge cannot be supplied by the filled band unless the Fermi level approaches the latter closely. Thus the region acquires a net negative charge whose field lines must end up on the same donor impurity in the neighborhood. The potential which the negative region thus acquires is about equal to

$$V=-\frac{ne}{\epsilon a}+\frac{ne}{\epsilon d}$$

where n is the number of negative charges making up the imperfection, a the linear dimension of the region and d the mean distance to compensating positive charges. It is reasonable to assume $d\sim10^{-5}$, $a\sim10^{-8}$ and n a few units. The voltage thus obtained is considerably larger than 3.5 volts. The actual voltage drop will of course stop at the latter figure or earlier either because the