TABLE I. Life-times of excited states.

	Parent	$\tau_{\frac{1}{2}}\times 10^{8}$ sec.	$E\gamma$ Mev
Au^{197}	Hg^{197}	0.8 ± 0.1	0.13
Fe^{57}	Co^{57}	11 ± 1	0.014
Cd^{111}	In^{111} Cd^{111*}	8 ± 1	0.247
Hg^{198}	Au^{198}	<0.4	0.411
Tl^{203}	Hg^{203}	<0.3	0.28

An^{197} appears in the 23 hr. Hg^{197} decay but not in the 18 hr. Pt^{197}. The probable energy of 135 kev is assigned on the basis of the decay scheme of Frauenfelder *et al.*,[2] and the fact that the delayed conversion electrons are more readily absorbed than those preceding the delay. The 1.1×10^{-7} sec. state in Fe^{57} appears in the decay of 270 d Co^{57}. The 14-kev gamma-ray has been established by magnetic spectrometer and proportional counter measurements of Hedgran and Deutsch (to be published). Assignment of the observed life time to this transition is based on absorption of the delayed and preceding radiations. Most of the counts in both components are due to iron K x-rays which are quite well detected with anthracene crystals. The upper limit of 4×10^{-9} sec. on the lifetime of the 411-kev state in Hg^{198} is established beyond doubt. It contradicts the result of MacIntyre[3] on the same transition. Besides the activities listed in Table I we studied and failed to find measurable periods in the decay of Ir^{192}, $Te^{121,123,125}$ (Sb and d), Au^{199}, Cs^{134}, Co^{60}, Rh^{106}. Bittencourt and Goldhaber[4] had reported a 3×10^{-8} sec. state in the decay of Te^{121} which we are not able to confirm. Figure 1 shows typical decay curves obtained.

Some of the radionuclides were obtained from the AEC, the others were prepared in the MIT cyclotron.

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[1] Deutsch and Stevenson, Phys. Rev. **76**, 184 (1949).

[2] Frauenfelder *et al.*, Helv. Phys. Acta **20**, 238 (1947).

[3] W. J. MacIntyre, Phys. Rev. **76**, 312 (1949).

[4] Bittencourt and Goldhaber, Phys. Rev. **70**, 780 (1946).

Applications of Total Reflection of Neutrons*

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TOTAL reflection of neutrons provides a powerful technique for the measurement of coherent scattering cross sections and phases. Some examples of its possible application are:

1. Low cross section.—A typical application would be to vanadium. Shull and Wollan[1] using crystal diffraction have been able only to set an upper limit of 0.1 barn for σ_{coh} and are unable to determine the sign of the amplitude. The critical angle for total reflection is given by

$$\theta_c=\lambda(NC/\pi)^{\frac{1}{2}},$$

where λ is the neutron wave-length, N is the number of nuclei per cc, and C is the coherent amplitude (or the average of the coherent amplitudes of the constituent nuclei in the case of compounds). Assuming $\sigma_{coh}=0.01$ barn, for $\lambda=4.4$A we find $\theta_c\sim 7$ minutes. The presence or absence of total reflection determines the sign of the amplitude without any precise measurements. Even for $\sigma_{coh}=0.01$ barn, θ_c will be ~ 4 minutes. Any impurities in the vanadium of the mirror could cause large errors. Another possible mirror would be vanadium carbide; for a vanadium cross section of 0.1 barn, the two possible signs of the amplitude give critical angles differing by ~ 20 percent.

2. Highly absorbing materials.—It is difficult to apply crystal diffraction methods to measurement of σ_{coh} for strong absorbers. But the real part of the index of refraction, and the critical angle depend very little on the absorption cross section.[2] With $\sigma_{coh}=1$ barn and $\sigma_{abs}/\lambda=2\times 10^{3}$ barns/A, the effect of the absorption on the critical angle is only $\sim$three percent. By mirror experiments it should be possible to measure σ_{coh} for Cd, B, and other strong absorbers. We should note that the shape of the reflection curve depends on the absorption.[3] In the presence of absorption we no longer obtain "total" reflection; the curve of reflectivity smoothes out as the absorption increases.

3. Coherent amplitude of hydrogen.—Measurement of critical angle for a given wave-length can be applied to a determination of the coherent amplitude of hydrogen by using hydrogen compounds as mirrors. This method has one great advantage over those previously used (ortho-parahydrogen scattering and crystal diffraction) in that no complicated calculations and no uncertain corrections are necessary. In total reflection we are dealing with the forward-scattered beam (zero-order Bragg reflection) so that form factors due to molecular structure or thermal agitation are *always* unity.

4. Neutron-electron interaction.—Here again the form factor for the electron scattering is unity so that the neutron-electron interaction contributes fully. For a tungsten mirror a neutron-electron interaction of 5000 volts will contribute 1.4 percent to θ_c. The nuclear amplitude would have to be determined by a separate experiment in which the electron form factor is made to approach zero (e.g., by use of short wave-lengths).

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* Condensed from Argonne National Laboratory Report-4298 (May 12, 1949).

[1] C. G. Shull and E. O. Wollan (unpublished).

[2] M. L. Goldberger and F. Seitz, Phys. Rev. **71**, 294 (1947).

[3] A. H. Compton and S. K. Allison, *X-Rays in Theory and Experiment* (D. Van Nostrand Company, Inc., New York, 1935), p. 305 ff.

Note on Rotational Universe

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THE model of rotational universe was proposed by Gamow,[1] and studied in detail by Gödel.[2] The angular velocity calculated by Gödel is $2(\pi\kappa\rho)^{\frac{1}{2}}$ where κ is Newton's gravitational constant and ρ is the density of the universe. This result is rather strange because the angular momentum is not conserved during expanding. Assume that the universe is an ellipsoid of major axes "a" and minor axis "b", the rotation is along the minor axis, then the angular momentum in classical sense is

$$m=\tfrac{2}{5}Ma^{2}2(\pi\kappa\rho)^{\frac{1}{2}},$$

where M is the mass of the universe. During expanding, ρ is only decreasing inversely as a^{2} or a^{3} and so m will be increasing as a or $a^{\frac{1}{2}}$. This is impossible except introducing new concept or new mechanism.

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[1] G. Gamow, Nature **158**, 549 (1946).

[2] Kurt Gödel, Rev. Mod. Phys. **21**, 447 (1949).

On the Hyperfine Structure of the $^{2}P_{\frac{1}{2}}$ State of Tl^{205} and Tl^{203}

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IT has been found that an atomic beam of thallium may be evaporated from an iron oven of the type conventionally used in molecular beam research and that the beam may be detected by the formation of positive ions on a hot oxidized tungsten filament. It has therefore been possible to observe the hyperfine