It is to be noticed (Fig. 3) from the flight of October 31 that the ratio of the flux of the heavy nuclei tracks, which have more than 12 delta-rays per 100μ, during the day to those during the night is 2.1±0.6. If it is assumed that the flux of heavy nuclei tracks is an exponential function of the atmospheric pressure between 1.0 and 6.4 cm of Hg, then the flight of November 30 gives a ratio of 3.0±1.1 between the flux during the day to that at night.

Within experimental error of five percent the rates of production of stars given in Fig. 1 are the same during the day and the night, which strongly indicates that the proton and alpha-particle components of the cosmic radiation do not exhibit any appreciable diurnal variation.

The experimental evidence presented here indicates that there is a large change in the intensity of heavy nuclei between day and night. Since the measurements refer to tracks having more than 12 delta-rays per 100μ, the data refers to nuclei having, on the average, an atomic number greater than 10. It is not clear from this investigation whether or not this large diurnal variation applies only to heavy nuclei of relatively low energies. They could then possibly originate from the sun.

A more detailed study of the diurnal variation of heavy nuclei with the time of day and as a function of the energies of the particles may lead to a new approach regarding their origin.

We wish to thank Mr. J. Litwin for assistance in scanning the plates used in this experiment.

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

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Detection of the π-μ-Decay with a Scintillation Crystal†

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THIS letter summarizes the preliminary results of an experiment from which it is hoped to obtain an accurate and direct measurement of the mean life of the π^+-meson. The experimental arrangement is shown schematically in Fig. 1.

Mesons are produced in a carbon or beryllium target T by γ-rays from the M.I.T. synchrotron. Some of the π-mesons pass through an absorber A_1 ($\frac{1}{4}$ in.-Pb+$\frac{1}{4}$ in.-Al) traverse a 2 g/cm^{-2} stilbene crystal X_1 (facing a 1P21 photo-multiplier, PM$_1$), a 2 g/cm^{-2} bakelite absorber A_2, and stop in a 1 g/cm^{-2} stilbene crystal X_2 (facing a 5819 photo-multiplier, PM$_2$). Practically all of the μ-mesons (range 0.1 g/cm^{-2}) arising from the decay of the stopped π^+-mesons come to rest in the same crystal X_2 and subsequently decay, giving rise to positrons. The arrival of the π^+ meson, the disintegration of the π^+-meson, and the disintegration of the μ^+-meson produce light flashes that are detected by the photo-multiplier PM$_2$. The resulting pulses are amplified by a distributed constant amplifier, delayed 10^{-7} seconds by a coaxial cable, and displayed on a high writing-speed oscilloscope. The over-all resolution of the crystal and electronic equipment is sufficient to measure the time between arrival and decay of π^+ mesons when this time is $3\cdot10^{-8}$ seconds or greater. The pulses from PM$_2$ are also presented on a second slower oscilloscope for the purpose of observing the decay electron from the μ-meson. The sweeps of the two oscilloscopes are triggered simultaneously by coincidences between PM$_1$ and PM$_2$. The two oscilloscopes are photographed with the same camera on a continuously moving film.

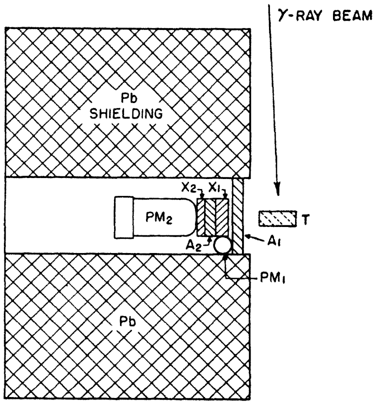

FIG. 1. Experimental arrangement for detecting the π-μ-e-decay.

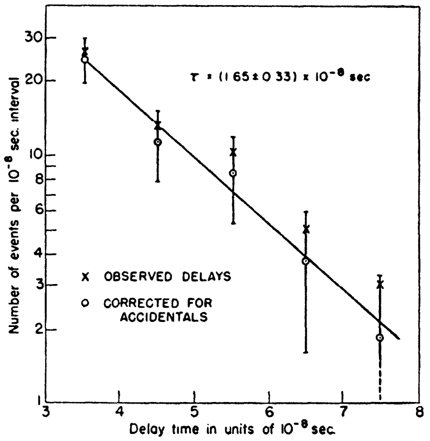

FIG. 2. Distribution of delayed events. The standard errors indicated are those for the data corrected for accidentals.

The synchrotron was operated at 315 Mev at a repetition rate of 2 pulses per second. Each pulse was about 100μsec. long, and produced an ionization of 0.025 roentgens in a Victoreen thimble r-meter surrounded by $\frac{1}{4}$ in.-Pb and placed in the beam 3 meters from the target.

In about 12 hours of operation some 25,000 pictures were taken, among which about 100 showed closely spaced double pulses. We selected a group of 57 satisfying the following criteria:

(1) time separation between 3 and $8\cdot10^{-8}$ sec.; (2) first pulse greater than $\frac{3}{2}$ and second pulse greater than $\frac{1}{2}$ of the average pulse produced by a minimum ionizing particle traversing 1 g/cm^{-2} of the crystal; (3) an additional pulse occurring within 5.7 μsec. which could be interpreted as being due to the electron from the decay of a μ-meson. The time distribution of these 57 double pulses is shown by the crosses in Fig. 2, in which the abscissa is the delay and the ordinate is the number of events per 10^{-8} sec. interval. We interpret these 57 events as being due mostly to π^+-decay processes. The following arguments confirm our interpretation:

(a) the time distribution (corrected for accidentals) of the additional pulses occurring within 5.7 μsec. is consistent with the known mean life of 2.15 μsec. for the μ-meson;

(b) events such as these plotted on Fig. 2 may occur by chance. However, the computed number of chance events over the period of observation is only 1.5 per 10^{-8} sec. interval. Measurements between $8\cdot10^{-8}$ sec. and $20\cdot10^{-8}$ sec. indicated the existence of a background of this magnitude. Sixteen events satisfying criteria (1) and (2) above, but not (3), (i.e., events *unaccompanied* by a third pulse) show a distribution of delays consistent with the hypothesis that most of these events are accidental. The absolute number is also consistent with this hypothesis.

(c) Delayed pulses might conceivably be produced by unexpected fluctuations in the light emission of the crystal or by some short-lived induced radioactivity. This, however, is ruled out by the observation that 70 percent of the closely spaced double pulses are followed by a third pulse interpretable as a μ-decay while only 30 percent of all the sweeps show a second pulse.

(d) By extrapolation of the decay curve of Fig. 2 back to zero time, we conclude that about 1.5 π^+-mesons were stopped in each gram of crystal per hour. A Kodak NTB nuclear emulsion placed near the crystal indicated that about 1.2 π^+-mesons were stopped in each gram of emulsion per hour.

The circled points in Fig. 2 show the number of delayed pulses corrected for accidentals. By fitting an exponential curve to these points[1] one finds for the mean life of π^+-mesons the value $\tau=(1.65\pm 0.33)\times 10^{-8}$ sec. Within the rather large statistical errors involved, this value of the mean life agrees with the value $\left(1.97{}^{+0.14}_{-0.17}\right)\times 10^{-8}$ sec. obtained by Martinelli and Panofsky[2] on the decay of π^+-mesons in flight, and with the value $\left(1.11{}^{+0.31}_{-0.22}\right)\times 10^{-8}$ sec. obtained by Richardson[3] on the decay of π^--mesons in flight.

We wish to thank the members of the M.I.T. synchrotron staff who have cooperated in making these measurements. Professors Bruno Rossi and Matthew Sands have contributed much encouragement and sound advice. We thank Mr. W. B. Smith who constructed and assisted in the testing of most of the equipment, and Mr. A. Grubman who grew the stilbene crystals.

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Superconductivity of Isotopes of Mercury*

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The superconducting transition temperatures of natural lead and the lead isotope obtained from the decay of uranium have been determined from resistance measurements by Kamerlingh Onnes and Tuyn[1] and by Justi.[2] In both instances, no detectable change in transition temperature between the natural element and the isotope was found.

In the measurements to be described, critical field *vs.* temperature curves for mercury samples enriched in various isotopes were determined by susceptibility measurements. The samples were obtained from the U. S. Atomic Energy Commission, and were prepared by electromagnetic separation. The average mass numbers for the enriched samples (samples 1, 2, 4) are shown in Table I; sample 3 is natural mercury.

Table I. Transition temperatures.

Sample	Average mass number	T_0(°K)
1	203.4	4.126
2	202.0	4.143
3	200.7	4.150
4	199.7	4.161

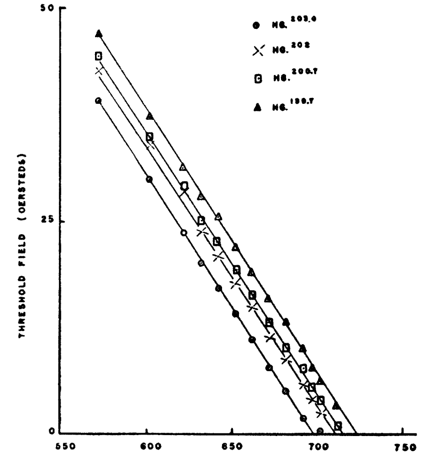

Fig. 1. The critical magnetic field as a function of the absolute temperature.

The samples varying in mass from 50 to 100 mg, were sealed under helium in capillaries about 0.5 mm i.d., giving samples about 3 cm long. A coil of No. 41 copper wire was wound around each capillary. The samples were placed in a Dewar vessel of liquid helium, and formed the secondary of a mutual inductance with a solenoid placed outside the shield Dewar. The solenoid was excited by a 1000 c/sec. oscillator, and produced a magnetic field at the sample of less than 0.1 oersted. The signal picked up by the sample coil was amplified and detected. The signal was balanced out with the sample superconducting, and then the detected signal was observed as a function of the magnetic field of a large Helmholtz coil surrounding the Dewars. The earth's magnetic field was canceled to 0.3 percent. When the magnetic field reached the neighborhood of the critical value at any temperature, there was a rapid increase in detected signal. The critical field was taken to be the average value in the transition interval. Figure 1 shows the critical field curves for the four samples. It is to be noted that there is a *systematic decrease of transition temperature with increasing mass.* The transition temperatures (in zero magnetic field), T_0, of the samples are given in Table I. The slopes of these curves at zero field agree within 1.0 percent; the magnitude of the slope is -204 ± 2 oersteds/°K.

Figure 2 is a plot of transition temperature *vs.* average mass number. The values obtained by Maxwell[3] for Hg^{198} and natural Hg are included. The slope of the line in Fig. 2 is 0.009 °K/(mass number).

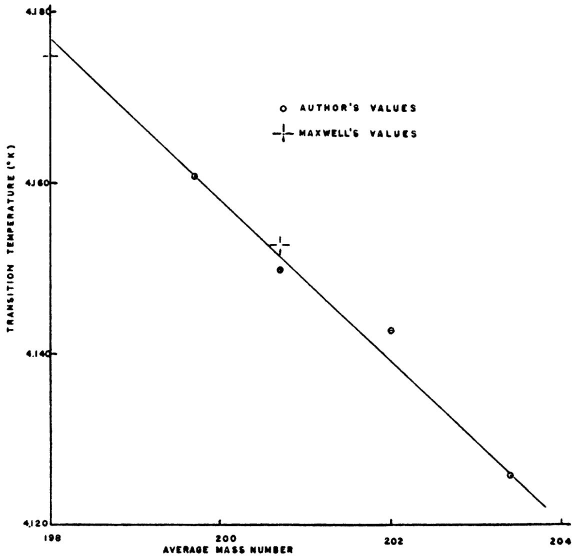

Fig. 2. The transition temperature *vs.* the average mass numbers of the isotopic mixtures.

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