On the Abundance of I^{129}, Te^{118}, and Pt^{190}

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EVIDENCE that I^{129} must have a very long half-life, of the order of 10^8 years, has been presented by Katcoff.[1] From his value for the neutron capture cross section of I^{129} and the I^{130} yield of normal iodine irradiated with slow neutrons, he obtains an upper limit of from 0.3 to 3 parts per 10^6 as the amount of I^{129} present in normal iodine. Nier[2] has reported an upper limit of 25 parts per 10^6 based on mass spectrographic analysis.

In the present work a 60° mass spectrometer was used, the design being similar to one already described by Nier.[3] Iodine vapor was introduced into the spectrometer through a capillary leak and ionized by electron impact. The separated ion beams were detected and amplified by an electron multiplier of a design similar to that described by Allen.[4] Examination of I^+ ions revealed a small peak in the mass 129 position less than 1 part in 3×10^6 relative to the 127 peak. The 129 peak found, however, can be attributed to DI^+ ions whose presence was signaled by a HI^+ peak about 0.2 percent as large as the I^{127+} peak. It is concluded that if I^{129} does exist in nature its abundance must be less than 3 parts in 10^6 relative to I^{127}.

In a recent article H. Duckworth[5] pointed out that on the basis of regularities in a plot of the atomic number *versus* atomic weight of the lightest stable isotope of elements with even atomic number one would predict the existence of Pt^{190}, Te^{118}, and Gd^{150}. The same author and co-workers[6] conducted a mass spectrographic analysis of Pt and found Pt^{190}. Their measurements were made using a double focusing mass spectrograph similar to Dempster's and employed photographic plates for the detection of ions. They report the abundance of Pt^{190} as 0.006 percent with an accuracy of 20 percent.

Using the same 60° spectrometer mentioned above but with the usual ion collector and electrometer current amplifier,[3] the existence of Pt^{190} has been confirmed but the abundance found to be greater than reported by the discoverers. Pt vapor was obtained by evaporation of metallic Pt from a heated Pt coated tungsten filament. This type of source did not provide a sufficiently constant ion beam to permit the usual accuracy of measurement and also there were small amounts of impurity present. Correlation of the Pt^{190} peak to the Pt^{192} peak with a variation of five in intensity indicated, however, that within the accuracy of the measurements the impurities were negligible. Figure 1 shows a typical spectra obtained in the mass region 188–200. Assuming the abundance of Pt^{192} to be 0.78 percent[7] the abundance of Pt^{190} is found to 0.012 percent with an accuracy of about ten percent.

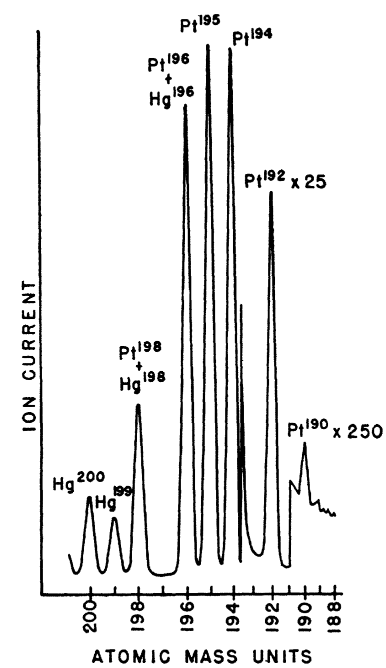

FIG. 1. Mass spectrum of platinum showing new isotope Pt^{190}. The mercury peaks are due to residual vapor in the apparatus.

In the case of Te no Te^{118} was found, but an upper limit of 0.0003 percent was placed on its abundance. Te vapor was obtained by evaporating the metal in a small oven. Examination of Te^+ spectrum revealed small peaks at mass 118 and at neighboring masses. Lack of correlation with the known Te peaks, however, indicated they were due to impurities. In any event the limit set on the Te^{118} abundance corresponds to the height of the observed 118 impurity peak.

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[1] S. Katcoff, Phys. Rev. **71**, 826 (1947).
[2] A. O. Nier, Phys. Rev. **52**, 937 (1937).
[3] A. O. Nier, Rev. Sci. Inst. **18**, 398 (1947).
[4] J. S. Allen, Rev. Sci. Inst. **18**, 739 (1947).
[5] H. E. Duckworth, Phys. Rev. **75**, 1438 (1949).
[6] Duckworth, Black, and Woodcock, Phys. Rev. **75**, 1438 (1949).
[7] Inghram, Hess, and Hayden, Plutonium Project, Report ANL-4012, p. 7 (July, 1947).

The Zenith Angle Dependence of Flux of the Hard Cosmic-Ray Component up to 36,000 Feet*

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THE counting rates of Geiger tube telescopes containing 8 and 10 cm of Pb absorber were measured in B-29 aircraft in the neighborhood of Inyokern, California, (43°N geomagnetic latitude) from 2250 to 36,000 feet during April 1947. These telescopes were similar to one used by Schein and Wilson[1] (see corner of Fig. 1) and the dimensions are given as follows:

(1) All copper walled Geiger tubes; 2.54-cm outside diameter, 2.38-cm inside diameter and 13.9 cm in effective length, (2) Pb absorber between A and B and between C and D, 2-cm thick, (3) Pb absorber between B and C, 6-cm thick, (4) Pb absorber on sides of C, 2-cm thick by 6-cm high each side.

The Geiger tube outputs were connected such that all tubes bearing the same letter were in parallel; the tubes numbered C_1 and C_2 were also independent. The data were taken at a zenith angle setting of 0° and in the geographical north, east, south, and west directions with a zenith angle setting of 45°, where the zenith angle was measured between the vertical and the plane of symmetry of the telescopes parallel to the axis of revolution of the Geiger tubes. A paper tape recording was made, at each altitude, of the coincidence counting rates ABC, BCD, $(ABC+BCD)C_1C_2$ and $(ABC+BCD)E$. From this recording, it was then possible to find the net counting rates, due to single particles, for telescope ABC and telescope BCD.** It is felt that this is a realistic assignment of single particle events since the counting rates $(ABC+BCD)C_1C_2$ and $(ABC+BCD)E$ account for a high percentage of the multiple particle events of narrow and wide angular spread, respectively.

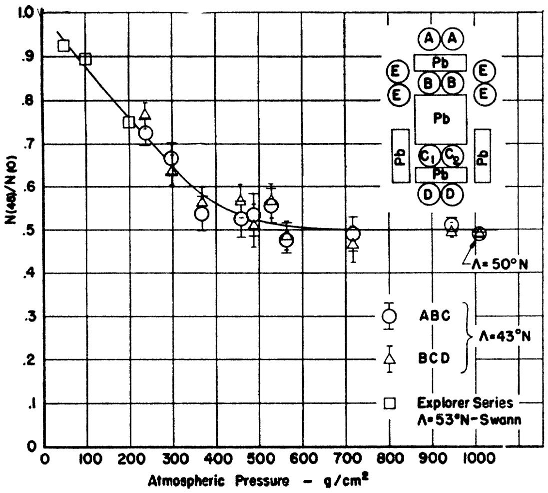

FIG. 1. Variation of the ratio of counting rates at zenith angles 45° and 0° with atmospheric pressure.

The variation with atmospheric pressure of the ratio of the penetrating particle counting rate at zenith angle setting 45° to that of 0° for the telescopes *ABC* and *BCD* is shown in Fig. 1, and this ratio is seen to be essentially the same for these two telescopes. The counting rate used for the numerator of this ratio was the average of the counting rates in the north, east, south, and west directions. The vertical bars indicate the statistical probable error of each point. The over-all correction made for counter dead-time, resolving time, counter efficiency, and recording circuit efficiency was less than 1 percent for the highest counting rate. The percentage of multiple particle events subtracted was the same for the case where the zenith angle setting was 0° as for the case where it was 45° for each of the two telescopes. These events accounted for from 1 percent at sea level to 18 percent of the net counting rate at 36,000 feet in the case of the *ABC* telescope and from 1 percent at sea level to 24 percent of the net counting rate at 36,000 feet in the case of the *BCD* telescope. Similar data, multiple particle events not excluded, obtained with narrow angle, non-leaded telescopes in the Explorer Balloon Flight Series[2] are shown for comparison.***

It is interesting to note the agreement between the zenith angle dependence of the total flux (Explorer Series) and that of the hard component (present work) at 200 g/cm^{-2}.

The assumption of a cosine power law variation of directional flux with zenith angle is suggested by the well-established $\cos^2\theta$ zenith angle dependence of the hard component flux at low altitudes.[3] Thus, if it is assumed that the directional flux, $J(\theta)$ (particles cm^{-2} sec.$^{-1}$ steradian^{-1}), at zenith angle θ, independent of azimuth, has the form:

$$J(\theta)=J(0)\cos^n\theta,\quad 0\leqq\theta\leqq\pi/2,$$
$$J(\theta)=0,\quad \pi/2<\theta\leqq\pi;$$

then from consideration of Fig. 1, the exponent, n, must vary with altitude.

To find the manner in which the exponent, n, varies with altitude, the ratio of the counting rates of these telescopes in the 45° and vertical positions, N(45°)/N(0°), has been calculated after the method of Greisen[3] for various assumed values of the exponent, $0\leqq n\leqq 2$, from the expression for the directional counting rate given in terms of the directional flux, the solid angle and the area of the telescope

$$N(\theta)=\eta\int_\sigma\int_\Omega J(\theta)d\Omega d\sigma \text{ sec.}^{-1},$$
$$J(\theta)=J(0)\cos^n\theta,\quad 0\leqq\theta\leqq\pi/2,$$
$$J(\theta)=0,\quad \pi/2<\theta\leqq\pi,$$

where η is the over-all efficiency of the system. In making this calculation, proper account has been taken of the spread of zenith angles within the acceptance angle of the composite telescopes *ABC* and *BCD*.

The values of n which gave a calculated ratio, N(45°)/N(0°), equal to the experimental one at each atmospheric pressure are plotted as a function of atmospheric pressure in Fig. 2. These values of the exponent are independent of the experimental arrangement. Again the points from the Explorer Balloon Flight

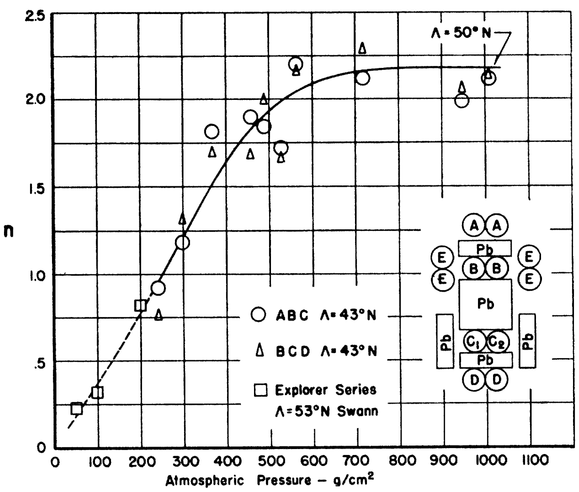

FIG. 2. Variation of n with atmospheric pressure assuming $J(\theta)=J(0)\cos^n\theta$.

Series are included and are seen to follow the same trend, even though they correspond to the total rather than the hard component of the flux.

* This work was supported by the Navy Bureau of Ordnance under Contract NOrd 7386.

[1] M. Schein and V. C. Wilson, Rev. Mod. Phys. 11, 292 (1939).

** In particular:

$$ABC_{\text{net}}=[ABC-ABC_1C_2-ABCE+ABC_1C_2E],$$
$$BCD_{\text{net}}=[BCD-BC_1C_2D-BCDE+BC_1C_2DE].$$

[2] W. F. G. Swann, Rev. Mod. Phys. 11, 242 (1939).

*** It is to be noted that the present experimental measurements have been made at only two zenith angles; therefore, they do not establish the form of the zenith angle law.

[3] K. I. Greisen, Phys. Rev. 61, 212 (1942) and references therein.

Angular Correlation of Delayed Radiations

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THE energy-lifetime relation of nuclear transitions and the internal conversion coefficient in the case of gamma-ray emission do not always lead to unique assignments of spin and relative parity values to excited energy levels of nuclei. It is therefore fortunate when two transitions follow each other in cascade, since, then, observation of the relative direction of emission of the two radiations frequently yields the necessary spectroscopic information. With coincidence circuits the method has been applied to transitions following each other in instantaneous succession.[1] The major experimental difficulties are in this case due to scattering effects and the presence of annihilation radiation.

We have extended the method of radiations which are delayed with respect to each other. Using delayed coincidence circuits, angular correlations can at present be measured when the lifetime of the intermediate state lies between about 10^{-8} and 10^{-2} sec. This state may be a metastable energy level or a short-lived alpha-