TABLE I. Energy Comparisons.

Comparison Pu^{239} with Po^{210} (5.298 Mev) Run	Gas in chamber	Energy for Pu^{239} in Mev	Energy for Pu^{238} from comparison with Po^{210}	Energy for Pu^{238} from comparison ^{9}with Pu^{23} (5.13_7 Mev)
1	N_2	5.13_8		
2	N_2	5.13_3		
3	Argon	5.13_8		
4 Samples reversed	Argon	5.13_9		
5 Original position	Argon	5.14_0		
6	Argon	5.14_0		
7	Argon	5.13_0		
Mean		5.13_7	5.49_6	5.49_5

argon gave the value in column four. This is the result of one extended run in argon. Finally, a cross comparison of Pu^{239} with Pu^{238} is shown in column five. This is the mean of two runs in argon. Here the alpha-energy for Pu^{239} was assumed to be 5.137 Mev, the value previously determined by comparison with Po. Although the almost exact agreement shown by the last two columns is undoubtedly somewhat fortuitous, the general consistency throughout the table cannot be considered so, since it is easily duplicated.

A series of runs with other samples, some deposited by electroplating instead of evaporation, is in good accord with the runs above. A weighted mean for all samples gives for Pu^{239} 5.140 Mev and for Pu^{238} 5.493 Mev. The consistency of the readings would indicate an error of about 0.1 percent. The ranges in air derived from these values and a range-energy curve[2] are 3.67 cm and 4.07 cm for Pu^{239} and Pu^{238}, respectively. The agreement is good between these values and the values 3.68 cm and 4.08 cm from previous[3] direct measurement of the ranges in air.

Measurement of the energies of various (n,p) reactions by this method are now in progress.

[1] Palevsky, Swank, and Grenchik, Rev. Sci. Inst. 18, 298 (1947).
[2] Holloway and Livingston, Phys. Rev. 54, 18 (1938).
[3] Chamberlain, Gofman, Segrè, and Wahl, Phys. Rev. 71, 529 (1947).

Phase Determination with the Aid of Implication Theory

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SINCE the implication diagram[1,2] provides the locations of atoms in crystals, there must be a close similarity between a Fourier representation of the implication diagram and the Fourier representation of the projection of electron density of the crystal on the same plane. The relation between the coefficients of the two series can be ascertained in several ways. A straightforward way, which is not difficult in cases of low symmetry, is to expand $FF^*(hkl)$ and then separate $F(h'k'l')$ from the rest of the expansion. For symmetries other than $\bar{1}$ it is then possible to eliminate most (if not all) of the unsymmetrical components. This is illustrated here for symmetry 2 parallel to c. By a simple manipulation, the expansion of $FF^*(hkl)$ can be arranged in the following form:

$$F^2_{hkl}=\underset{(a)}{\sum_j n_j f^2_{j,hkl}}+\underset{(b)}{F_{hkl}(P_0)}+\underset{(c)}{F_{hkl}(P_z)}$$
$$+\underset{(d)}{\left(\frac{f^2_{1,hkl}}{f_{1,2h2k0}}\right)F_{2h2k0}}+\underset{(e)}{\sum_j\left(\frac{f^2_{j,hkl}}{f_{j,2h2k0}}-\frac{f^2_{1,hkl}}{f_{1,2h2k0}}\right)F'_{2h2k0}}. \quad (1)$$

The expansion consists of five parts, which can be described in terms of the contribution of this term to the Patterson synthesis. (a) is a contribution to the origin peak, (b) represents the contribution on the Harker level to a non-Harker peak, and (c) represents a contribution on a non-Harker level to a general Patterson peak.

Term (c), which represents a very large part of the expansion, can be eliminated by the following manipulation: All terms are summed over l from $l=-L$ to $+L$, and each side of the equation is multiplied by $\cos 2\pi(hx+ky)$. The left side of (1) then represents the hk contribution to a Harker synthesis on level zero, and the parts of the right side of (1) represent the hk contributions to Fourier syntheses of quasi-electron density representations. In the complete syntheses, (c) vanishes because it represents a section on level zero, where there is no "density." The only way for this to occur is for each term $\sum_l F(P_z)$ to vanish independently. This eliminates the term $\sum_l F_{hkl}(P_z)\times\cos 2\pi(hx+ky)$. All terms are now divided by $\cos 2\pi(hx+ky)$. There remains

$$\sum_{l=-L}^{L}F^2_{hkl}=\underset{(a)}{\sum_{l=-L}^{L}\sum_j n_j f^2_{j,hkl}}+\underset{(b)}{\sum_{l=-L}^{L}F_{hkl}(P_0)}$$
$$+\underset{(d)}{\left(\frac{\sum_{l=-L}^{L}f^2_{1,hkl}}{f_{1,2h2k0}}\right)F_{2h2k0}}$$
$$+\underset{(e)}{\sum_j\left(\frac{\sum_{l=-L}^{L}f^2_{j,hkl}}{f_{j,2h2k0}}-\frac{\sum_{l=-L}^{L}f^2_{1,hkl}}{f_{1,2h2k0}}\right)F'_{2h2k0}}. \quad (2)$$

When non-Harker peaks can be recognized on the implication map, for example, by the non-appearance of satellites in certain symmetries,[1] term (b) can be allowed for. Relation (2) then provides the relation of F's to F^2's for twofold symmetry. The last term is a correction term which arises because all atoms do not scatter with the same power. When all atoms have about the same scattering power, as in many organic compounds and in many silicates, this term vanishes. In other cases, it can be evaluated from special position information or, more generally, from the locations of certain atoms provided by the implication diagram. Where these do not apply, then this term can be evaluated for its maximum value, in which case it sets determinable limits on the part of (2) which cannot be directly computed. Since the absolute values of the F's are known, it should not be difficult in most cases to decide on phases of the F's with the aid of (2).

Equalities of a similar nature exist for each Harker level of each symmetry. It should be noted that the phases of only a fraction of the coefficients of the electron density series can be determined in this way. The fraction is ¼, ⅓, ½, or 1, corresponding, respectively, to the implication ambiguity of 4, 3, 2, and 1. Therefore, if an electron density map is computed using the terms whose coefficients are determined in this manner, n possible positions appear for each atom in the crystal structure, where n is the ambiguity coefficient of the implication. The wrong positions can only be removed by supplying the electron density series with the missing terms.

[1] M. J. Buerger, "The interpretation of Harker syntheses," J. App. Phys. 17, 579–595 (1946).
[2] M. J. Buerger, "The solution of ambiguities arising in crystal structure analysis," Am. Soc. for X-Ray and Elec. Diff., abstracts of papers given at the 1947 summer meeting, Ste. Marguerite Station, Quebec, pp. 21–23.

The East-West Asymmetry of the Hard Component of the Cosmic Radiation*

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THE east-west asymmetry of the total cosmic radiation at altitudes above 5 cm Hg was found by Johnson[1] to be only about 7 percent. From this it was concluded that the primary radiation consisted of nearly equal numbers of positive and negative particles. On the basis of the experiments of Schein, Jesse, and Wollan,[2] it was proposed in 1941 that the majority of the primaries consist of protons. Arley,[3] combining these ideas, suggested that the primaries consist of equal numbers of positive and negative protons. To test whether or not most of the hard component, which has a small asymmetry at sea level, is actually produced by positive primaries, we measured the east-west asymmetry of particles penetrating more than 22 cm of Pb over a considerable latitude range at a high altitude.

The counter telescopes were mounted in a B-29 airplane in such a way that the zenith angle could be adjusted. In flight, the plane flew back and forth over the same course, with each telescope pointing alternately to the east and to the west so as to average out any systematic differences in their counting rates. The counters were connected both in threefold and in fourfold coincidence. However, only the fourfold data were used here in computing the asymmetry. An estimate of the correction required for the shower counting rate was obtained by counting the showers which tripped four counters with one counter moved out of line. The asymmetry was corrected by using this value of the shower rate. According to Johnson,[4] the showers show no asymmetry. A shower counting rate higher than that actually observed would decrease the observed value of the asymmetry. Dead time and resolving time measurements were made and the single counting rates of the counters were checked in flight. Errors in the asymmetry due to these causes were found to be negligible. The ground counting rate was determined between flights as a check on the operation of the equipment.

Flights were made between the geomagnetic latitudes of 27° 18′ North and 58° 30′ North with the telescopes at a 45° zenith angle. The results are shown in Table I. The asymmetry increases from a low value at the northern end to a value of over 45 percent at the southern end of the flights.

A flight was made to 27° 30′ North geomagnetic latitude to explore the effect at other zenith angles. The telescopes were at a zenith angle of 60° on the way south and at 30° on the way back. The results are given in Table II.

Table II shows that the east-west asymmetry undergoes large fluctuations with zenith angle at a latitude near 33° North. This effect is of considerable interest in connection with the problem of the primary radiation. It is planned to continue these measurements in the near future.

The latitude effect of mesotrons passing through 21 cm of Pb as a function of altitude was measured by Gill, Schein, and Yngve.[5] Using the observed value of the latitude effect, the large asymmetry of 46 percent detected for a zenith angle of 45° between latitudes of 27° and 32° is in general agreement with the theory of Lemaitre and Vallarta,[6] provided that all of the primaries which produce mesotrons of energies greater than about 6×10^8 ev are positively charged. The lower limit of the mesotron energy is derived from the ionization loss in the atmosphere between the average height of their production[7] and the pressure altitude of 31,000 feet.

TABLE I. Latitude dependence of the east-west asymmetry at 45° zenith angle.

Geomagnetic latitude range	27° 18′ 32° 00′	31° 00′ 35° 40′	35° 00′ 40° 25′	39° 30′ 43° 00′	45° 00′ 50° 00′	50° 00′ 54° 00′	54° 00′ 58° 30′
Pressure altitude	34,500 ft.	32,000 ft.	31,000 ft.	37,000 ft.	31,000 ft.	31,000 ft.	31,000 ft.
East-west asymmetry $\frac{E_w-E_e}{1/2(E_w+E_e)}$	0.46±0.07	0.27±0.07	0.14±0.06	0.17±0.03	0.09±0.05	0.13±0.05	0.01±0.06

TABLE II. East-west asymmetry at 30° and 60° zenith angle for a pressure altitude of 31,000 feet.

Geomagnetic latitude range	27° 55′ 31° 05′	31° 05′ 35° 35′	35° 35′ 41° 00′	27° 30′ 32° 07′	32° 07′ 35° 35′	35° 35′ 40° 10′
Zenith angle	30°	30°	30°	60°	60°	60°
East-west asymmetry $\frac{E_w-E_e}{1/2(E_w+E_e)}$	0.4±0.1	−0.02±0.09	0.003±0.07	0.02±0.13	0.2±0.1	−0.06±0.1