TABLE II. *Reduction of west excess by lead.*

Cm Pb	West/East	Probable error
0	1.091	±0.0145
2	1.075	0.021
10	1.065	0.021
20	1.065	0.021
30	1.060	0.017

Consider now the interpretation of this effect. Suppose N_1 rays of whatever nature, capable of exciting the counters enter from the east; and N_1+N_2 enter from the west, where N_2 is the "west excess." The East-West experiment determines the ratio $(N_1+N_2)/N_1$ which is found at Mexico to be about 1.09; or, N_2/N_1 is 0.09. If the zenith angle is not changed, and lead is inserted in front of the counters, the number of counts recorded in unit time with the counters pointing east will be N_3, and west, N_3+N_4. The observations show that at Mexico N_4/N_3 is 0.06. A ratio of the rates gives $N_4N_1/N_2N_3=2/3$. In order to evaluate experimentally N_1/N_3, the counting rates were determined with and without lead in front of the counters, other conditions being kept unchanged. The ratio thus obtained for N_3/N_1 was 0.6 ± 0.04. The value of N_4/N_2 is therefore experimentally determined as 0.41. We see, therefore, that less than half the particles which produce the west excess have energies sufficient to enable them to penetrate 30 cm Pb.

From the data of Anderson[3] on penetrating power, we find that particles of electronic charge and mass require about 10^9 volts to penetrate 30 cm lead. This estimate is almost certainly not in error by fifty percent; but even larger departures will not invalidate the conclusion that in the equatorial latitudes a large fraction of the particles which produce the west excess are of far too low energy to have ever been able to come from outside into our atmosphere through the blocking effect of the earth's magnetic field. The observations in Peru strengthen this conclusion, for in Peru it requires energies of above about 8×10^9 volts to penetrate the earth's field.

It appears, therefore, that the counting tubes are excited predominantly by secondaries produced within the earth's atmosphere. The distribution of energies of the secondaries as shown by the ratio of N_4/N_2 as 0.4 is, moreover, in good agreement with the measures of Anderson, who finds in cloud chambers that more than half the secondaries are of energies below 10^9 volts. It should be borne in mind, however, that these secondaries will follow the general direction of the incoming primaries, ejection as observed in cloud chambers taking place mainly in the forward direction. This direction will not be materially altered by the earth's field, owing to the short range of the secondaries, and is consequently independent of the sign of the charge of these particles.

A series of electroscope observations to study the penetrating power through various metals, and the transition effect; the total intensity at various altitudes; and the latitude effect was also made, which will be reported in detail later. The latitude run shows an increase of 6 ± 1 percent in the total intensity of the radiation at sealevel as measured in an unshielded electroscope on the trip from Panama to Los Angeles; and no change within the limits of error (±1 percent) from Peru to Panama.

The author wishes to take this opportunity to thank the Peruvian Minister of Marine and Aviation, and Commandantes Gilardi, Bellatin and Escanlante, whose cooperation made possible the electroscope observations at the highest altitudes; Mr. F. F. Hixson of the Central Railway of Peru, who put the facilities of the railway at the author's disposal; Dr. R. Monges Lopez for assistance in Mexico; Dr. Vinelli and Mr. Roden of the Cailloma mines, thanks to whom the observations at Cailloma were obtained; and to Mr. L. S. Blaisdell, Dr. G. A. Wagner and Mr. T. L. Blackwood for various assistance to the expedition. Thanks are also due to Captains Nielsen and Anderson on whose ships the latitude runs were made. The expedition was made possible by a grant from the Carnegie Corporation of New York, to be administered by the Carnegie Institution of Washington to Professor R. A. Millikan who along with Drs. Bowen and Neher collaborated in the planning and equipping of the expedition and in the analyses and interpretation of the results.

S. A. KORFF

California Institute of Technology,
Pasadena, California,
May 26, 1934.

[3] C. D. Anderson, Phys. Rev. **44**, 406 (1933).

Some Remarkable Multiple Sunset Flashes in Southern California

In a letter in *Nature*[1] I have described successive green flashes occurring at the same sunset in connection with clouds and the ocean. When the sun sets over a hill with a curved outline in the path of the rays several successive flashes may also be seen. Thus I have seen first a flash at the northern edge of the image, then at the southern edge, and then at or near the middle. The color in a single flash often appears at the sharp end or ends of the image first, and advances inward.

Green and blue flashes of a far more interesting character often occur when the sun sets over the ocean, or a low lying cloud, with its image greatly distorted on account of the inhomogeneity of the atmosphere. Thus on one occasion the image (over the ocean) became almost perfectly rectangular and remained of appreciably the same width as the height gradually diminished. Finally a green flash appeared at the northern end; then two other green flashes, one at the southern end and one in the middle, all disappearing together.

Much more remarkable flashes appear when atmospheric stratification causes, as it often does, the sun's image to be distorted in such a way that the sides are more or less serrated like those of a Japanese lantern or an accordion

[1] Barnett, Nature, March 22, 1930.

bellows. When the serrations are sufficiently marked, one layer after another in succession, beginning with the uppermost, separates itself from the lower part of the image, becomes narrower horizontally and much thinner vertically, turns green or blue, often at least at the pointed extremities first, and disappears. In the last two or three years I have repeatedly witnessed this phenomenon, obtaining all the way from two to six green and blue flashes. In the one case in which six colored flashes were certainly observed, the serrations were quite deep, the sun's disk was not very red, and all or nearly all the flashes were distinctly *blue*. The last layer at disappearance became whitish, as the upper edge of the image often does when the sun sets red. When the serrations are not deep and the layers are thin, the layers may shrink horizontally without becoming distinctly separated from the lower image, the pointed and colored ends moving inward slowly until the layer disappears.

In one very interesting case the sunset over the ocean red and oval (as usual becoming flatter beneath), but at first without noticeable serrations. As the sunset progressed the image became sharply divided by a horizontal line, ending in somewhat deep and sharp depressions. Below the line the image was distinctly and uniformly yellowish green, above the line uniformly reddish, or reddish yellow, the redder portion having an area perhaps three-quarters that of the whole image. As the sunset progressed further, the color again became homogeneous and red and the depressions disappeared, while the image took on the form of a rectangle capped by an isosceles triangle with somewhat rounded top. The top of the triangle now came off, turned blue, and disappeared. Then in between the point at which this disappearance occurred and the flattening disk another blue flash appeared, where nothing had been visible before. The image then became more and more flattened, and thinner vertically, without changing appreciably in horizontal width, and disappeared red (as the image often does).

Most of these observations were made with one inch achromatic binoculars magnifying about six diameters.

S. J. Barnett

University of California at Los Angeles and
California Institute of Technology,
May 31, 1934.

The Magnetic Moment of the Neutron

Our application[1] of the g-formula to the spin and orbit of a neutron in the nucleus is only partially correct, although the result (neutron $= -0.6$ magneton) is not affected. But the coordination of l and j in the tables is to be changed. The correct theory together with important generalizations is given meantime independently by I. Tamm and S. Altschuler.[2] They find the value -0.5 similar to ours. We do not agree with the analysis of H. Schueler[3] who gives the neutron -1.65 magnetons.

Alfred Landé
D. R. Inglis

Ohio State University,
June 7, 1934.

[1] Inglis and Landé, Phys. Rev. **45**, 842 (1934).
[2] Tamm and Altschuler, Comptes Rendus de l'Acad. des Sciences de l'USSR **1**, 458 (1934).
[3] Schueler, Zeits. f. Physik **88**, 323 (1934).

Remarks on Super-Novae and Cosmic Rays

We have recently called attention to a remarkable type of giant novae.[1] As the subject of super-novae is probably very unfamiliar we give here a few more details which are not contained in our original articles.

1. Distribution of super-novae

In our calculations we made use of the assumption that on the average one super-nova appears in each galaxy every thousand years. This estimate is based on the occurrence of super-novae in the following galaxies,

Our own galaxy	in 1572
Andromeda	1885
Messier 101	1907

These three systems are located within a sphere of radius 12×10^5 light years.

In the Virgo cluster, which contains about 500 nebulae, six super-novae were found on plates taken during the last thirty years. As a curiosity we mention that in N.G.C. 4321, which is a member of Virgo, two super-novae have appeared in 1901 and 1914, respectively.

In the same interval of 30 years six additional super-novae were found in isolated nebulae.

We wish to emphasize that all of these finds are chance finds since a systematic search for super-novae has been organized only recently.

From the estimate of one super-nova per galaxy per thousand years it follows that 10^7 super-novae appear per year in the 10^{10} nebulae which are contained in a sphere of 2×10^9 years radius (critical distance derived from the red shift of nebulae). If cosmic rays come from super-novae their intensity in points far away from any individual super-nova will be essentially independent of time.

2. Comparison with the lifetime of stars

The lifetime of stars is supposed to be of the order of at least 10^{12} years. A nebula contains about 10^9 stars. These estimates, combined with the frequency of occurrence of one super-nova per galaxy per 10^3 years suggest that the super-nova process might occur to every star once in its lifetime, marking perhaps the cessation of its existence as an ordinary star. We realize that this suggestion is highly speculative in view of the possibility that the frequency of occurrence of super-novae may depend on time and in view

[1] W. Baade and F. Zwicky, Proc. Nat. Acad. Sci. May, 1934.