use the new type of cosmological solutions involving the angular momentum of the expanding universe (spinning universe).[5]

More detailed studies of Eqs. (1) leading to the observed abundance curve and discussion of further consequences will be published by one of us (R. A. Alpher) in due course.

* A portion of the work described in this paper has been supported by the Bureau of Ordnance U. S. Navy, under Contract NOrd-7386.
[1] G. Gamow, Phys. Rev. **70**, 572 (1946).
[2] D. J. Hughes, Phys. Rev. **70**, 106(A) (1946).
[3] V. M. Goldschmidt, *Geochemische Verteilungsgesetz der Elemente und der Atom-Arten.* IX. (Oslo, Norway, 1938).
[4] See, for example: R. C. Tolman, *Relativity, Thermodynamics and Cosmology* (Clarendon Press, Oxford, England, 1934).
[5] G. Gamow, Nature, October 19 (1946).

A Beta-Ray Spectrometer Design of Quadratic Resolution-Solid Angle Relationship

S. Frankel
Frankel and Nelson, Los Angeles, California
February 16, 1948

In a β-spectrometer for use with low intensity sources it is advantageous to collect electrons emitted by the source in as large as possible a solid angle consistent with the required resolution. In conventional spectrometers the usable solid angle, Ω, is proportional to the momentum spread, $\delta p/p$, for small δp. (δp is the half-intensity width observed for a point source of monoenergetic electrons.) The double focusing spectrometer[1] has a more favorable proportionality constant than the constant field magnetic lens ("solenoid") spectrometer. The thin-lens spectrometer has a still less favorable constant.[2] Figure 1 shows approximate Ω *vs.* $\delta p/p$ curves for these designs.

Witcher[3] has shown that the solenoid spectrometer brings monoenergetic rays having nearly the same initial angles with the axis, γ, to a "ring-focus" between the source and counter, nearer the latter (Fig. 2). By placing baffles inside and outside this ring-focus the resolution may be improved without decreasing Ω. The resolution attainable is approximately that shown in Fig. 1 for rays with $30° < \gamma < 60°$, somewhat poorer outside this range. For small Ω, $\delta p = 0(\Omega^2)$. Since the improvement in resolution attainable in this way seems not to be widely appreciated, it may be useful to direct attention to it.

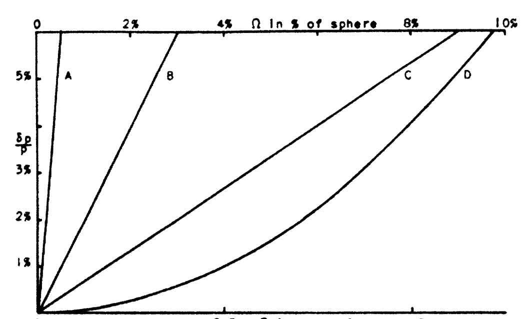

Fig. 1. Momentum resolution, $\delta p/p$, *vs.* solid angle, Ω, of rays used: (A) A typical thin-lens spectrometer.[2] (B) Solenoid spectrometer for small γ. (C) The Siegbahn-Svartholm double focusing spectrometer. (D) The ring-focus baffled solenoid spectrometer. All curves are approximate and refer only to a point source.

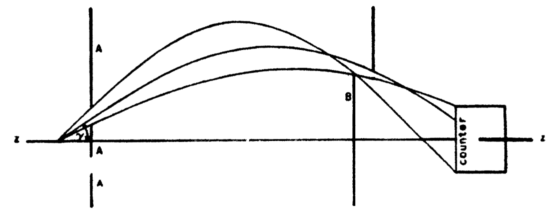

Fig. 2. Paths of electrons in a homogeneous magnetic field. $z-z$, axis of symmetry. Azimuthal motion of electrons not indicated. (A) Baffles defining range of γ. (B) Ring-focus baffles.

Changing the energy of the electrons (or the field strength) without change in the range of γ uniformly expands or contracts the paths shown in Fig. 2 about the source as the fixed point. The best resolution is therefore obtained by placing the ring-focus baffles so that their defining edges lie on a cone with vertex at the source and axis parallel to the magnetic field.

It seems likely that a similar ring-focus exists in a thin-lens spectrometer and has similar favorable properties. Thus it is probably possible to combine the copper and power efficiency of the thin-lens design with a favorable resolution *vs.* solid angle curve. The position and properties of this ring-focus could be found experimentally (e.g., by the use of moveable baffles) or by numerical integration of the electron path equations.

The source diameter just sufficient to impair the momentum resolution is of the order of $(\delta p/p)\cdot\tan\gamma\cdot$(radius of curvature) for the solenoid spectrometer either with or without the ring-focus baffles. Thus when an extended source is desirable (e.g., with a source of low specific activity) the improvement in counting rate at fixed resolution shown in Fig. 2 is genuine, while the improvement in resolution at fixed counting rate is in part specious.

[1] Siegbahn and Svartholm, Nature **157**, 872 (1946).
[2] T. Lauritsen, private communication.
[3] Clifford M. Witcher, Phys. Rev. **60**, 32 (1941).

The Hard Component of Cosmic Radiation as Affected by the Variation in Air Mass Distribution with Latitude

Kenneth M. Kupferberg
Department of Physics, New York University, New York
and
Kepco Laboratories, Inc., Flushing, New York
February 20, 1948

It is the purpose of this note to call attention to a phenomenon which will complicate the interpretation of the latitude effect. The variation in height of the main mesotron production region with geographic latitude introduces variations in the intensity of the hard component comparable to the variations presently attributed to the geomagnetic latitude effect.

The main region of mesotron production is thought to be in the first 100-millibar (mb) segment of the atmosphere and a change in altitude of this 100-mb segment will cause a change in the mesotron intensity observed at a lower depth. A preliminary calculation has been carried out in which this change in mesotron intensity has been evaluated.

The variation in the air mass distribution with latitude has been compiled from the Radiosonde data by Haurwitz and Austin.[1] Figure 1 indicates the variation of the 100-mb pressure level with latitude; curves *II* and *III* represent the summer and winter averages, respectively, and curve *I* is an average of curves *II* and *III*. It is readily seen that the 100 mb level changes with latitude by as much as 1 km in winter and 0.6 km in summer.

Consider the variation in the mesotron intensity with latitude caused by the shift of the 100-mb level. As reference, the measuring instrument is placed at a 10-km elevation.[2] The change in the momentum of the mesotrons traversing the distance between the production region and the instrument will be neglected in the preliminary calculation. Assuming a momentum spectrum in the production region proportional to p^{-3} and a pure decay process, the mesotron intensity at the instrument is

$$I=\int_{p_0}^{\infty} dpKp^{-3}\cdot\exp(-\sigma h/pc), \tag{1}$$

where p is the momentum (ev/c), p_0 is the cut-off momentum of the instrument, h is the altitude of the production region above the instrument, σ is the mass to lifetime ratio of the mesotron, and c is the velocity of light. Integrating Eq. (1) yields

$$I=Kc^2/\sigma^2h^2\cdot[1-(1+\sigma h/cp_0)\exp(-\sigma h/p_0c)]. \tag{2}$$

If I_1 and I_2 are the mesotron intensities at the measuring instrument when the production region is a distance h_1 and h_2 above the instrument, respectively, the relative change in the mesotron intensity is given by

$$\delta I_1/I_1=1-I_2/I_1=1-h_1^2/h_2^2 \cdot[\{1-(1+\sigma h_2/cp_0)\exp(-\sigma h_2/cp_0)\}/\{1-(1+\sigma h_1/cp_0)\exp(-\sigma h_1/cp_0)\}]. \tag{3}$$

The percentage change in the mesotron intensity for changes in the altitude of the main production region with latitude is evaluated using Eq. (3) and curve *I* of Fig. 1. Figure 2 represents the results of this calculation, where curves *I* and *II* are computed for a momentum cut-off of the instrument of 0.5×10^9 ev/c and 0.2×10^9 ev/c, respectively. Curves *I* and *II* of Fig. 2 represent the variation in the mesotron intensity with latitude in which the height of the 100-mb level for each latitude was an average over the entire year for all longitudes. The percentage change of the mesotron intensity caused by the variation of the height of the mesotron production region with latitude will be larger or smaller than the average depending on the period of the year and the longitude at which the measurements are taken.

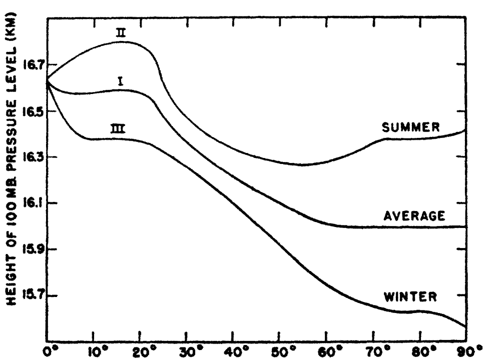

FIG. 1. Height of the 100-mb pressure level *vs.* latitude. Curve *II*, summer average; curve *III*, winter average; curve *I*, average of curves *II* and *III*.

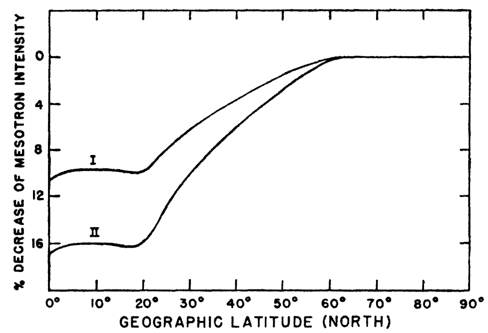

FIG. 2. Percentage decrease of mesotron intensity *vs.* geographic latitude. Curve *I* for momentum cut-off of instrument $p_0=0.5\times10^9$ ev/c. Curve *II* for momentum cut-off of instrument $p_0=0.2\times10^9$ ev/c.

Table I summarizes the percentage decrease of the mesotron intensity for reasonable variations in the position of the production region. The results in Table I are for the recording instrument at an elevation of 10 km and the reference level of the production region at 16 km (100-mb level).

TABLE I.

h_2-h_1 km	Percent decrease in mesotron intensity $p_0=0.5\times10^9$ ev/c	Percent decrease in mesotron intensity $p_0=0.2\times10^9$ ev/c
0.25	4.5 percent	7.0 percent
0.50	8.4	13.4
0.75	12.7	19.7
1.00	16.3	25.0
1.25	19.7	29.8
1.50	22.2	34.2
1.75	26.2	38.2
2.00	29.0	41.8

In order to evaluate the geomagnetic latitude effect of the hard component of cosmic radiation, a correction should be made to take into account the change in the mesotron intensity caused by the variation in air mass distribution which depends largely on geographic latitude. This effect and its implications will be reported in detail at a later date.

The author is pleased to acknowledge helpful discussions with Dr. S. A. Korff and Max Kupferberg.

[1] B. Haurwitz and J. M. Austin, *Climatology* (McGraw-Hill Book Company, Inc., New York, 1944), p. 58.

[2] Recent measurements of the geomagnetic latitude effect of the hard component have been made at this elevation by P. S. Gill, M. Schein, and V. Yngve, Phys. Rev. 72, 733 (1947).