APPENDICES

APPENDIX I

The Methods of Computing Errors

1. The fluctuation of frequency distribution of star

Let n be the number of stars scanned in a volume v c.c. of an emulsion exposed in t days.

star rate, $R = \frac{n}{v \times t}$ stars/c.c/day.

The fluctuation of $R = \pm \frac{\sqrt{n}}{v \times t}$ stars/c.c./day.

2. The fluctuation of the west/east ratio.

The fluctuations of west/east ratio in the last column in table IV are calculated as follows :-

Let R = West/east ratio

N_1 = No. of star rate from west.

N_2 = " " " east.

$\therefore \quad R = \frac{N_1}{N_2}$

Δr = the fluctuation of R

$$\Delta r = \pm\sqrt{\left(\frac{\partial R}{\partial N_1}\right)^2 (\Delta N_1)^2 + \left(\frac{\partial R}{\partial N_2}\right)^2 (\Delta N_2)^2} \quad \text{---- (1)}$$

$$\frac{\partial R}{\partial N_1} = \frac{\partial (N_1/N_2)}{\partial N_1} = \frac{1}{N_2} \quad \text{------------(2)}$$

$$\frac{\partial R}{\partial N_2} = \frac{\partial (N_1/N_2)}{\partial N_2} = -\frac{N_1}{N_2^2} \quad \text{------------(3)}$$

substituting eq. (2) & (3) in (1); obtains :-

$$\Delta f = \pm\sqrt{\left(\frac{1}{N_2}\cdot\Delta N_1\right)^2 + \left(\frac{-N_1}{N_2^{\,2}}\cdot\Delta N_2\right)^2}$$

APPENDIX. II.

The Method of Fitting Equation by Least's Square of Indices

For equation of the type $N = A e^{-kn}$ (1)

we can take the natural logarithm of each side, getting

$$\ln N = \ln A - Kn \qquad (2)$$

where A and K are constant.

Consider the general form of linear equation

$$y = a_0 + a_1 x \qquad (3)$$

we can see that equation (2) is similar to equation (3), if and only if $y = \ln N$, $a_0 = \ln A$, $a_1 = K$ and $x = n$. That is the method of least squares can now be applied to the system (1).

Let the equation to be satisfied as nearly as possible be (N_0, n_0), (N_1, n_1), (N_2, n_2) ------ (N_m, n_m).

Then the equations of condition are

$$\ln N_0 = \ln A - K n_0$$

$$\ln N_1 = \ln A - K n_1$$

$$\ln N_2 = \ln A - K n_2$$

$$\ln N_m = \ln A - K n_m$$

The sum of the above equation is

$$\sum_{K=0}^{m} \ln N_K = \ln A \sum_{K=0}^{m} n_k^0 - K \sum_{K=0}^{m} n_K \tag{4}$$

To set up the normal equation, we multiply the equations of conditions by the coefficient of K in that equation and add, getting

$$n_0 \ln N_0 = \ln A\, n_0 - K n_0^2$$

$$n_1 \ln N_1 = \ln A\, n_1 - K n_1^2$$

$$n_2 \ln N_2 = \ln A\, n_2 - K n_2^2$$

$$n_m \ln N_m = \ln A\, n_m - K n_m^2$$

$$\sum_{K=0}^{m} n_K \ln N_K = \ln A \sum_{K=0}^{m} n_m - K \sum_{K=0}^{m} n_K^2 \tag{5}$$

Let $\sum_{K=0}^{m} n_K^0 = S_0$, $\sum_{K=0}^{m} n_K = S_1$, $\sum_{K=0}^{m} n_K^2 = S_2$,

$\sum_{K=0}^{m} \ln N_K = V_0$ and $\sum_{K=0}^{m} n_K \ln N_K = V_1$

Substituting in equation (4) and (5) , we get

$$V_0 = S_0 \ln A - S_1 K \tag{6}$$

$$V_1 = S_1 \ln A - S_2 K \tag{7}$$

Then solve for A and K.

The method of fitting the size distribution equation for:

a) the particle coming from the east:

Let the equation be $N = A e^{-Kn}$

for $2 < n < 5$

Tabulation

N	n^0	n^1	n^2	$\ln N$	$n \ln N$
7175	1	2	4	8.87837	16.75674
3695	1	3	9	8.21477	24.64431
867	1	4	16	7.19704	28.78816
163	1	5	25	5.09375	25.46875
	4	14	54	29.38393	95.65796
	(S_0)	(S_1)	(S_2)	(V_0)	(V_1)

Then $4 \ln A - 14 K - 29.38393 = 0$

$14 \ln A - 54K - 95.65796 = 0$

solve for $\ln A$ and K we get

$\ln A = 12.376$, $K = 1473$

$$\therefore \quad N = e^{12.376} \cdot e^{-1.437\, n} \qquad (8)$$

for $6 < n < 14$

Tabulation

N	n^0	n^1	n^2	**ln N**	**n ln N**
113	1	6	36	4.72739	28.36434
77	1	7	49	4.34381	30.40667
47	1	8	64	3.85015	30.80120
33	1	9	81	3.49651	31.46859
24	1	10	100	3.17805	31.78050
13	1	11	121	2.56495	28.21445
11	1	12	144	2.39790	28.77480
4	1	13	169	1.38629	18.02177
2	1	14	196	0.69315	9.70410
	9	90	960	26.63820	237.53642
	(S_0)	(S_1)	(S_2)	(V_0)	(V_1)

$$9 \ln A - 90 K - 26.63820 = 0$$

$$90 \ln A - 960 K - 237.53642 = 0$$

$$\ln A = 7.767 \, , \quad K = 0.296$$

$$\therefore \quad \ln N = e^{7.767} \cdot e^{-0.296 n} \qquad (9)$$

from eq. (8), let $e^{12.376} = A$

$$N = A e^{-1.437 n}$$

let $\quad A_1 = e^{7.767}$

$$\frac{A_1}{A} = \frac{e^{7.767}}{e^{12.376}} = 0.01013$$

from (9); $N = 0.01013 \, A \, e^{-0.296 \, n}$

b) The particle coming from the west.

for $2 < n < 5$

<u>Tabulation</u>

N	n^0	n^1	n^2	ln N	n ln N
6106	1	2	4	8.71703	16.43406
5105	1	3	9	8.54676	25.64028
2616	1	4	16	7.86938	31.47752
643	1	5	25	6.46614	32.33070
	4	14	54	31.59931	105.88256
	(S_0)	(S_1)	(S_2)	(V_0)	(V_1)

then;

$$4 \ln A - 14 K - 31.599 = 0$$

$$14 \ln A - 54 K - 105.882 = 0$$

$$\ln A = 11.200 \, , \quad K = 0.943$$

$$N = e^{11.200} \, e^{-0.943 \, n} \qquad (10)$$

for $6 < n < 14$

Tabulation

N	n^0	n^1	n^2	ln N	n ln N
123	1	6	36	4.81218	28.87308
69	1	7	49	4.23411	29.63877
46	1	8	64	3.82864	30.59712
35	1	9	81	3.55535	31.99815
26	1	10	100	3.25810	32.58100
20	1	11	121	2.99573	32.95303
13	1	12	144	2.56495	30.77940
8	1	13	169	2.07944	27.03272
4	1	14	196	1.38629	19.40806
	9	90	960	28.71079	263.86133
	(S_0)	(S_1)	(S_2)	(V_0)	(V_1)

then ;

$$9 \ln A - 90\, n - 28.71079 = 0$$

$$90 \ln A - 960\, n - 263.86133 = 0$$

$$\ln A = 7.065 \quad , \quad n = 0.388$$

$$\therefore \quad N = e^{7.065}\, e^{-0.388\, n} \qquad (11)$$

Let $A = e^{11.200}$, $A_1 = e^{7.065}$

from (10) : $N = A\, e^{-0.943\, n}$

$$\frac{A_1}{A} = \frac{e^{7.065}}{e^{11.200}} = 0.015$$

from (11) : $N = 0.015\,A\,e^{-0.388\,n}$

BIBIOGRAPHY

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(1) Elster J. and Geitel H. Physik.Z., 1, 11, (1899).

Geitel H. Physik.Z., 2, 166, (1900).

(2) Wilson C.T.R. Proc. Cambridge Phil. Soc., 11, 32, (1900).

(3) Ruther-ford E., and Cooke H.L. Phys. Rev., 16, 183, (1903).

(4) Hess V.F. Physik.Z., 12, 998, (1911).

Physik.Z., 13, 1084 (1912).

Physik.Z., 14, 610 (1913).

(5) Kolkorster W. Verhandl. deut. physik Ges., 15, 111, (1913).

Verhandl. deut. physik Gess., 16, 719, (1914).

(6) Stormer C. Z. Astr. Phys., 1, 237, (1930).

(7) Epstein P. Proc. Nat. Acad., 61, 212 (1948).

(8) Lemaitre G. and Vallarta M.S. Phys. Rev., 43, 87 (1933).

(9) George E.P. and Wilson J.G. Progress in Cosmic Ray Physics. Vol. 1, P. 395, Amsterdam: North Holland Publishing Co., 1957.

(10) Barrett P.H., Bollinger L.M., Coecni G., Eisenberge Y., and Greisen K. Rev. of Mod. Phys. 24, 133, (1952).

(11) Brown R., Camerini U., Fowler P.H., Heitler H., King D.T. and Powell C.F. Phil. Mag. 40, 862, (1949).

(12) Bohr N., and Kalckar F. Proc. Cop. 14, No. 10, (1937).

(13) Bethe H.A. Rev. of Mod. Phys. 9. 69, 245 (1937).

(14) Weisskopf J. Phys. Rev. 52, 295 (1937).

(15) Bagge E. Ann. Phys. Lpz. 33, 389, (1938) ;
Cosmic Radiation P.128 edited by Heisenberge, New York: Dover Publications (1946).

(16) Harding J.B. Nature Lond. 163, 440, (1949).

(17) Le Courteur K.J. Proc. Phys. Soc. A63, 259, (1950).

(18) Hazen W.E. Phys. Rev. 65, 67, (1944).

(19) Powell W.M. Phys. Rev. 60, 413, (1941).

(20) Page N. Proc. Phys. Soc. A63, 250, (1950).

(21) Dilworth, C.C., Occhailini P.S., Payne R.M. Nature 162, 102, (1948).

(22) Dharmaphanija Charoen and Suttipongse Thaworn "Ground Level Cosmic Ray Stars at Latitude 13° 46' N." Journal of The National Research Coucil of Thailand Vol. 3 June , 1962

(23) Wilkins J.J., Goward F.K. Proc. Roy. Soc. (London) A63, 1173, (1950).

(24) Telegdi V.L. Phys. Rev. 87, 196 (1952).

(25) Wilkin J.J. and Coward F.K. Proc. Roy. Soc. (London) 288, 376 (1955).

(26) George E.P. and Jason A.C. Proc. Phys. Soc. (London) A62, 243 (1949).

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