den, bevor der Spulendraht auf das Nickelrohr gewickelt wurde. Beim Einbau ließ sich dann nicht immer ganz vermeiden, daß kleinere Luftmengen in das wasserstoffgefüllte Katalysatorrohr eindrangen. Es wird vermutet, daß dadurch die nur geringe oder auch ganz wegbleibende Umsatzerhöhung im Magnetfeld verursacht wurde.

Andererseits besteht auch die Möglichkeit, daß die hier angewandte Längsmagnetisierung des Katalysatorrohres einen kleineren Effekt bewirkt als die Quermagnetisierung der früheren Versuche.

Es ist dem Verfasser eine angenehme Pflicht, seinem verehrten Lehrer, Herrn Prof. Dr. E. Justi, für die Anregung zu dieser Arbeit, für das anhaltende Interesse und viele Ratschläge zu danken. Besonderen Dank schuldet der Verfasser auch den Herren Prof. Dr. J. A. Hedvall-Göteborg, Prof. Dr. M. Kohler-Braunschweig, Dr. H. P. A. Groll-Göteborg, Dr. R. Ochsenfeld-Braunschweig und Dr. H. v. Klitzing-Braunschweig für anregende Diskussionen und dem Direktor der Svenska Oljeslageri AB, Göteborg, Herrn H. E. Helmersson, für die finanzielle Unterstützung dieser Untersuchungen. Der Deutschen Forschungsgemeinschaft dankt der Verfasser für Leihgaben an Meßinstrumenten.

The Statistics of 29000 Stars Observed in Nuclear Emulsions in Kenya

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29182 stars observed at mountain altitudes in Kenya are analysed statistically. The analysis gives: — (1) An absorption thickness of 149 g/cm² near the geomagnetic equator. (2) The star frequency as a function of the total number of prongs in a star is the result of the composition of the emulsion. (3) The empirical formula of Teucher for the energy of the star producing particle can be used in our experiments. (4) The variation in the number of shower particles with the complexity of the star and the altitude appears to be in agreement with the Heisenberg theory of the plural production of mesons.

Nine stacks of Ilford G 5 nuclear emulsions were exposed to cosmic rays in Kenya, during the months of August, September and October, 1953. Out of these nine stacks three were exposed for 30 days on the top of mount Kilimanjaro- Gilmans point (37.20 E, 3.05 S and altitude 5964 M). In one stack the plates were all horizontal and 400 μ thick, in the second all the plates were inclined at 60° to the horizontal and were 200 μ thick, while in the third the plates were all vertical and only 100 μ thick. Another lot of three stacks was exposed for a period of 66 days on the top of mount Meru (36.45 E, 3.15 S and altitude 4566 M) and the remaining were exposed for 85 days at Nairobi (36.28 E, 0.35 S and altitude 1676 M). The arrangement and composition of the individual stacks at mount Meru and Nairobi were exactly similar to that at Kilimanjaro. A sufficient amount of emulsion, taking a few cc from each of the nine stacks, has been scanned. This has given us 12143 stars at Kilimanjaro, 10307 stars at Meru and 6732 stars at Nairobi; a total of 29182 stars.

Our exposures were carried out at mountain altitudes almost on the geomagnetic equator and the first thing that is interesting is the absorption thickness. The collected data are given in Table 1 and in Fig. 1. The other line in Fig. 1 represents Roederer's[1] data obtained at 21° S in Argentina.

Place	Height in M	Pressure in m. b.	Number of stars in m. l. per day
Kilimanjaro	5964	475	27.6
Meru	4566	565	15.1
Nairobi	1676	811	2.9

Table 1.

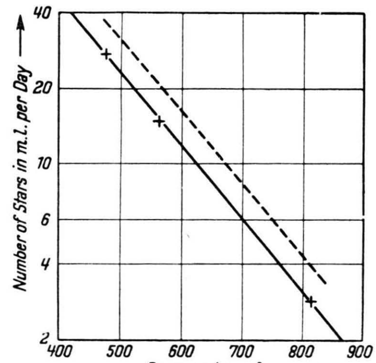

Fig. 1. Shows the frequency of stars as a function of the barometric pressure. Our observations —+— obtained near the geomagnetic equator. Roederer's observations – – – obtained at 21° S.

[1] J. G. Roederer, Z. Naturforschg. **7a**, 765 [1952].

Our data give an absorption thickness of 149 g/cm². Roederer gets the same value for absorption thickness. His curve is almost parallel to our curve but lies above, indicating that he observes more stars in m. l. per day. The value[2] of the absorption thickness at 48°N is only 127 g/cm². The number of stars observed at this latitude in m. l. per day is still greater than in Argentina. It will thus be seen that the number of stars observed in m. l. per day goes on increasing as the latitude increases, whereas the absorption thickness appears to remain constant at first (at least up to 21°) and then begins to diminish.

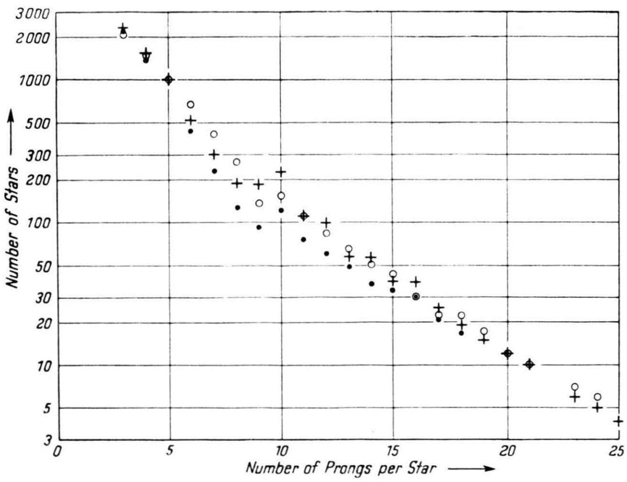

Fig. 2. Shows the frequency of stars as a function of the number of prongs in a star at different altitudes (+ Kilimanjaro, ○ Meru and ● Nairobi) normalised for $N=5$ at 1000.

In Fig. 2 is shown on a logarithmic scale the frequency of the different kinds of stars, classified according to the total number of prongs in each star. The stars observed at each of the three stations are indicated by a definite mark. For a comparison of the distributions at the three stations the curves are normalised for $N=5$ at 1000. It will be seen that the distribution curve at any place can be represented by two nearly straight portions which intersect at $N=7$ or $N=8$. There appears however, for values of $N=9$ or $N=10$, a small deviation from this general tendency. This deviation appears to show a small maximum superposed on the two intersecting straight lines. It is generally[3,4] assumed that the frequency distribution in the two branches is due to the composition of the emulsion. The light nuclei C, N and O can give rise to a maximum number of 6, 7 or 8 charged nucleons or heavy prongs. The first branch of the curve is attributed mainly to the stars produced by these light nuclei, whereas the second branch of the curve ($N>8$) is attributed to the stars produced by the heavier nuclei like Br or Ag present in the emulsion. If this is the correct explanation, then an intermediate element like sulphur, which is present in an appreciable amount, must show its presence by showing some typical characteristic stars produced by it. We suggest that the small deviations observed at $N=9$ and $N=10$, giving the impression of a small maximum at $N=10$, are due to the stars produced by the sulphur nuclei. These deviations could not be very large because of the relative smallness of the number of the sulphur atoms present.

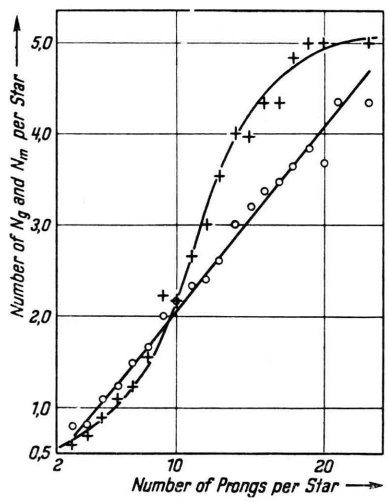

Fig. 3. Shows the number of grey prongs N_g (○) and meson prongs N_m (+) per star with different number of prongs, observed at Kilimanjaro.

Figs. 3, 4 and 5 show the number of grey prongs N_g and the thin prongs N_m per star at the three stations. N_g represents prongs whose grain density lies between 100 and 160 grains per 100 microns and N_m represents those whose grain density is less than 100 grains per 100 microns. Our notation N_m thus includes all shower particles N_s (grain density less than 80 grains per 100 microns) and

[2] M. Teucher, Z. Naturforschg. **7a**, 61 [1952].
[3] N. Page, Proc. Phys. Soc. (Lond.), **63** A, 250 [1950].
[4] M. Birnbaum, N. M. Shapiro, B. Stiller and F. W. O'Dell, Phys. Rev. **86**, 86 [1952].

also particles in the intermediate range (80 to 100 grains per 100 microns) which are predominently mesons.

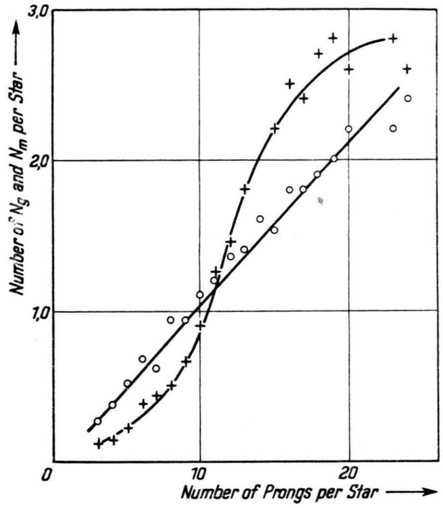

Fig. 4. Same as Fig. 3 for stars observed at Meru.

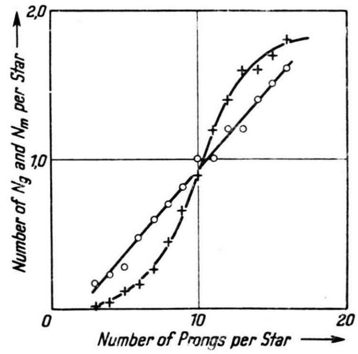

Fig. 5. Same as Fig. 3 for stars observed at Nairobi.

It will be seen that all the curves in the Figs. 3, 4 and 5 are similar. The actual values of N_g and N_m increase with the altitude of the place and also with the increasing complexity of the star. In all cases the value of N_g appears to increase linearly with the complexity of the star, whereas the value of N_m appears to increase at first slowly then more rapidly and finally appears to reach a constant maximum value; this maximum value of N_m depends in its turn on the altitude of the place concerned. The two curves of N_g and N_m intersect in all cases at about $N=10$.

If we substitute the maximum value of N_m for N_s in the formulae for the energy of the primary particle producing the star,

$E = 1.2\,N_s$, GeV (Teucher[5]),

or $E = 1500\,N_s + 155\,N_m - 100$, MeV (Roederer[1]).

Energy in GeV

Formula	Kilimanjaro	Meru	Nairobi
Teucher	6.0	3.36	2.16
Roederer	10.5	7.20	5.10

Table 2.

We get the following values of the primary energy at the three stations (Table 2). These energy values are not inconsistent with the value 14.2 GeV of the minimum vertical energy at the geomagnetic equator. Even then the value obtained from the formula of Roederer, 10.5 GeV for Kilimanjaro where the residual pressure is still 475 m. b. or more than three times the absorption thickness, appears rather high. The values obtained from the formula of Teucher, on the other hand, appear to be in better conformity with the altitudes and the cut of energy. This suggests that the empirical formula of Teucher obtained from statistics at balloon altitudes is also applicable to our results obtained at mountain altitudes near the geomagnetic equator.

Figs. 3 to 5 show that the number of grey prongs per star increases linearly with N, the total number of prongs in a star. But the number of m or meson prongs increases slowly at first, then more rapidly, finally reaching a maximum value. The general shape of this curve is similar to that of the current temperature curve in thermionic emission. Further the $(N_m - N)$-curve depends on the altitude in the same manner as the $(i - T)$-curve depends on the plate voltage. We suggest that the nature of the $(N_m - N)$-curve indicates that the emission of the mesons, like the thermionic emission is a statistical process, which is governed by the charge on the evaporating nucleus as well as the energy of the primary particle producing evaporation. Thus our experiments appear to give additional support to the plural process of meson production suggested by Heisenberg[6], in which many mesons can be produced in a single collision.

[5] Vide W. Heisenberg, „Vorträge über Kosmische Strahlung" Springer, Berlin, 1953. p. 89.

[6] W. Heisenberg, „Vorträge über Kosmische Strahlung" Springer, Berlin, 1953. p. 148.