therefore suitable for observations of any peculiarities arising out of this coupling term. In such cases $|\dot{\phi}|_{max}$ will be quite large and the approximate differential equations

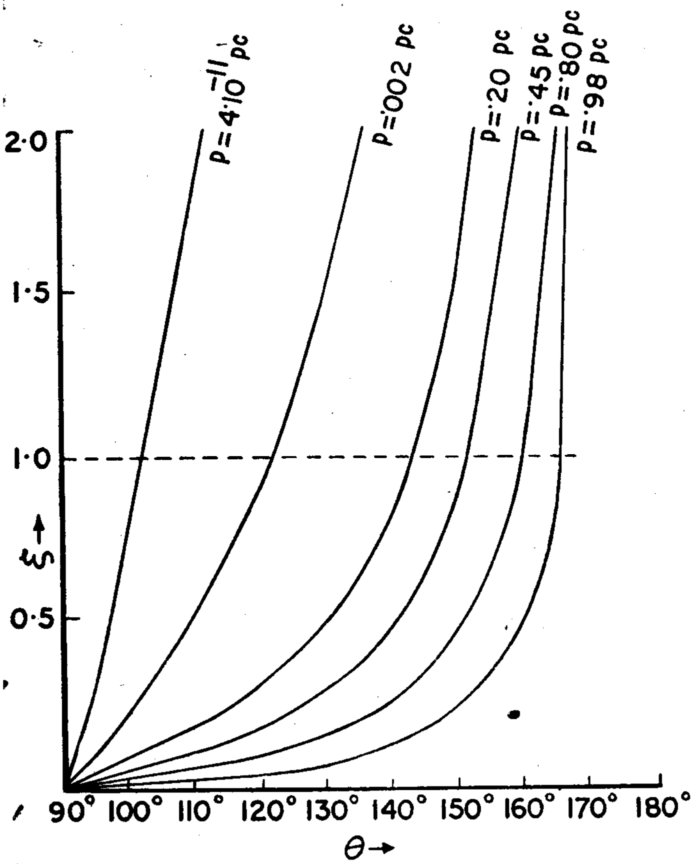

Fig. 8

will no longer be valid. Though this does not necessarily imply that the large $|\dot{\phi}|$ is solely responsible for the triple splitting, as has been suggested by Rydbeck, it cannot be denied that the nature of propagation may be profoundly modified. As no one has yet been able to give an exact treatment of the differential equations, it is not safe to make any definite statement about the nature of this modification.

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86. OCCURRENCE OF STRIPPED NUCLEI OF NEON IN PRIMARY COSMIC RAYS

(*Nature*, **167**, 476, 1951)

Bradt and Peters, in their analysis of the primary cosmic radiation as observed in the out-of-the-atmosphere observations with the plate technique, have given the completely stripped nucleus of neon as one of the main components of the heavier cosmic particles. In fact, the relative abundance is given as almost the same as that of oxygen-16 (*vide* Fig. 13, p. 66, of their paper).

It appears that if the identification of the stripped nucleus of neon as one of the main constituents of primary cosmic particles be correct, and is confirmed by subsequent observations, it constitutes a very strong argument against the hypothesis that the sun is the source of cosmic particles received on the earth[2,3]. For to have stripped nuclei of neon from the sun, it must be first demonstrated that neon exists on the sun and is at least once ionized on the photosphere or the chromosphere. The evidence on these points, as will be shown presently, is absolutely negative, in spite of the fact that strong lines of Ne and Ne^{+} occur within the solar range of wave-lengths (3,000-10,000 A.)

It is true that the fundamental lines of Ne and Ne^+ occur in the far ultra-violet, and the lines which occur in the solar range belong to the transitions:

$$\left.\begin{array}{l} 1s^2.2s^2\,(2p^5.3s-2p^5.3p) \text{ or higher transitions for Ne} \\ 1s^2.2s^2\,(2p^4.3s-2p^4.3p) \text{ or higher transitions for Ne}^+ \end{array}\right\} \quad (A)$$

But the physical conditions on the sun, as we know, are such that if neon existed there at even moderate strengths the lines of Ne, Ne^+ belonging to the above-mentioned combinations could not escape detection, at least in the flash spectrum of the sun. An analogous case is afforded by He and He^+, which have their fundamental lines in the extreme ultra-violet; but of the higher transition lines, only λ 10,830·38, $1s.2p\,^3S_1-1s.2p\,^3P_1$ is found as an absorption line in the Fraunhofer infra-red spectrum[4]; and none of the other lines of He, $1s.(2s\,^{1,3}S-np\,^{1,3}P)$, $1s.(2p\,^{1,3}P-nd)$, is found ordinarily in the Fraunhofer spectrum, except when the solar atmosphere is disturbed. But the lines $1s.2p\,^{1,3}P-1s.nd\,^{1,3}D$, which include the well-known D_3 and other higher transition lines of helium, are found in great strength in the solar chromosphere; thus proving that though helium exists in great strength in the higher solar atmosphere, it is difficult of observation in the Fraunhofer spectrum owing to the large excitation potential of its excited levels, which can give rise to Fraunhofer lines by absorption. But determinations of the abundance of helium to hydrogen in the chromosphere can be obtained on certain plausible assumptions, and are variously given as 1 : 14, 1 : 33, etc.

The presence of ionized helium in the flash spectrum is indicated through the line λ 4,685·91, $\nu=4N\left(\frac{1}{3^2}-\frac{1}{4^2}\right)$. This is unexpected, on account of the high ionization potential of helium (24·465 volts), and the extra excitation required to raise normal He^+ to the 4-quantum levels. The physical mechanism producing He^+ in the chromosphere is still unknown, and the reader may be referred to a suggestion which I myself have made[5].

If neon were present at some strength in the sun, we could expect, from analogy with helium, that lines of both Ne and Ne^+ would be present in the flash spectrum of the sun. But, in spite of laborious attempts, not a single coincidence of the numerous lines of Ne and Ne^+ belonging to combinations (*A*) could be found in the table of the flash-spectrum of the sun published by Menzel[6] (1931) or Mitchell[7] (1947). We must, therefore, conclude that both Ne and Ne^+ are definitely absent from the atmosphere of the sun.

So far as I know, no lines of neon or of any inert gas except helium have been found in the spectra of stars belonging to the main sequence. Forbidden lines of Ne^{2+}, Ne^{3+}, Ne^{4+} are found in the spectra of the nebulosity which is formed from gases ejected by a nova, and lines (*A*) of Ne and Ne^+ have been found in certain *B*- and *A*-stars, which show abnormal characteristics like τ-Scorpii. These form less than 10^{-4} times the number of stars the spectra of which have been examined, and we are therefore driven to the conclusion that occurrence of Ne and Ne^+ in these rare bodies is due to some extraordinary cosmogenic process. The attempt of Harrison[8] to prove the existence of neon in the interior of the sun from opacity data is inconclusive, as his arguments can equally well apply to neighbouring elements like fluorine or sodium.

There is therefore at present no positive evidence of the presence of Ne or Ne^+ in the sun or the usual run of stars, and this is a strong point against the hypothesis of the solar origin of our local primary cosmic ray particles. The theories which ascribe a high cosmic abundance to neon are not borne out by stellar data.

I wish to express my indebtedness to Dr. B. Peters for discussion of these points during the conference on elementary particles held at Bombay in December 1950, under the auspices of the Tata Institute of Fundamental Research.

Institute of Nuclear Physics,
Calcutta University, Jan. 17.

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