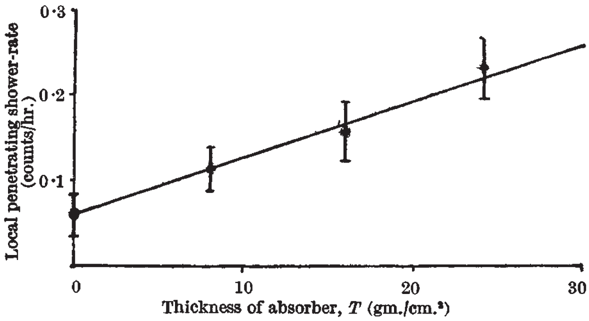

Fig. 2

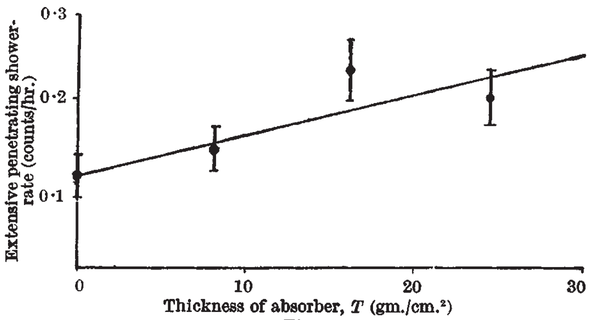

Fig. 3

figure) forming a single group of effective area 2,500 cm.² was placed near the top tray. Eightfold coincidences between P and at least one of the counters of the fourth tray were also recorded. These coincidences are due to extensive penetrating showers. Anticoincidences, that is, P coincidences not accompanied by the discharge of any of the counters of the fourth tray, are then due to the local penetrating showers.

We have in the first instance measured the transition effect in paraffin. Various thicknesses of absorber 48 cm. × 48 cm. were placed close above the top tray in the position T (Fig. 1). Our results are given in Fig. 2, the deviations shown being standard deviations. From a comparison of the results for Manchester and Colombo, we obtain the following values for the transition effect of local penetrating showers :

	Shower-rate for $T=0$ (coincid./hr.)	Initial slope of transition curve	Estimated max. shower-rate (coincid./hr.)
Manchester	$0·051 \pm 0·008$	$5·7 \times 10^{-3}$	0·30
Colombo	$0·060 \pm 0·019$	$6·7 \times 10^{-3}$	0·35

It is seen that the transition effect in Colombo is of the same order as that in Manchester. Hence there appears to be no observable latitude effect of penetrating showers. We have also measured the transition effect of extensive showers and found an indication of an effect in paraffin. The actual increase observed is from $0·107 \pm 0·026$ coincidences/hour without paraffin to $0·208 \pm 0·035$ coincidences/hour under 24·3 gm./cm.² of paraffin. The effect is shown in Fig. 3.

It is hoped to publish elsewhere a detailed account of our work on completion.

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[1] Broadbent and Jánossy, *Proc. Roy. Soc.*, A, **190**, 497 (1947).
[2] Jánossy, *Proc. Roy. Soc.*, A, **183**, 190 (1944).

Origin of Cosmic Rays

It is important to decide whether or not the main sources of the cosmic ray particles are external to our galaxy. An external source seems, at first sight, to be established by the observed isotropy of the cosmic rays incident on the earth. But it has been claimed by a number of authors that this isotropy is simply a consequence of a magnetic field assumed to exist in interstellar space. The basis for this claim is that a *single* particle of energy η and charge e is deflected through an appreciable angle after travelling a distance d across a magnetic field of intensity H, provided

$$H \sim \eta/ed.$$

For η equal to 10^{10} eV., e equal to the electronic charge ($4·77 \times 10^{-10}$ E.S.U.), and d equal to the radius of the galaxy ($\sim 3 \times 10^{22}$ cm.), the necessary value of H is about 10^{-15} gauss. This value may be compared with the average interstellar field of about 10^{-20} gauss that would result if (i) every star possessed a magnetic moment equal to the commonly quoted magnetic moment for the sun ($\sim 1·5 \times 10^{34}$ C.G.S.); (ii) the stellar magnetic dipoles were all aligned parallel to each other.

Although, even with these favourable assumptions, the interstellar magnetic field is still too small to be of consequence in this connexion (by a factor $\sim 10^5$), it has nevertheless been argued (*a*) that the magnetic moment of the sun may be exceptionally small, (*b*) that the connexion between angular momentum and magnetic moment suggested by Blackett[1] leads to an interstellar magnetic field $\sim 10^{-10}$ gauss. In view of these possibilities it is desirable to consider the matter afresh.

We find that the effects of a magnetic field as high as 10^{-10} gauss are still negligible. A fallacy underlies the usual type of argument, because the question cannot be decided through investigating the behaviour of an isolated particle. It has been shown that the motions of the cosmic ray particles are not appreciably disturbed by the field, provided

$$H^2 \ll 4\pi W,$$

where W is the energy density of the rays. Using the observed value $W \sim 10^{-13}$ ergs per cm.³, this gives $H \ll 10^{-6}$ gauss, which is satisfied by a large margin even if Blackett's views are accepted.

The physical basis of the above inequality is easily understood. When this inequality is satisfied then, whatever the electromagnetic processes taking place within the particle distribution, the momentum density of a uniform beam of particles of energy density W is large compared with the average momentum density of the electromagnetic field. Our conclusion follows from the conservation of momentum, as applied to an assembly of particles moving in an electromagnetic field.

We see, therefore, that the main source of the cosmic rays must be external to the galaxy. An important consequence is that the source must be adequate to give an energy density $\sim 10^{-13}$ ergs per cm.³ not only in interstellar space but also in *internebular* space. One of us[2] has discussed elsewhere the implications of this conclusion.

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[1] Blackett, P. M. S., *Nature*, **159**, 658 (1947).
[2] Hoyle, F., *Mon. Not. Roy. Ast. Soc.*, **106**, 384 (1946).