In a recent paper, Euler and Heisenberg[1] have thoroughly discussed the hypothesis that the hard component of the cosmic rays consists of 'mesotrons' produced in the upper layers of the atmosphere by primary electrons or photons and then disintegrating, as predicted by Yukawa's theory of nuclear forces, with a life-time τ of the order of 10^{-6} sec. (τ is relative to a system in which the particle is at rest; whilst in a system in which the particle is moving with a velocity $v = \beta c$ the life-time becomes[2] $\tau^1 = \tau/(\sqrt{1-\beta^2})$.)

In practice, the particles may disintegrate before they are brought to rest by ordinary loss of energy only in a gas, since in a liquid or solid absorber a 'mesotron' of a given velocity βc is stopped within a time which is very small in comparison with $\tau/(\sqrt{1-\beta^2})$. By traversing a gas absorber, the intensity of the hard component would therefore be more reduced than by traversing a liquid or a solid absorber of the same stopping power.

It has been pointed out that this theoretical result is confirmed by Ehmert's experiments, which give a difference of the kind expected between the absorption curves of cosmic rays in air and water[3].

In connexion with this, it is perhaps worth while to direct attention to some similar results previously obtained by De Benedetti and myself in Eritrea (geom. lat. 11° 30′ N., 2,370 m. above sea-level)[4]. In these experiments the absorption of the cosmic particles was measured: (a) in lead, by interposing lead screens between two counters placed one above the other; (b) in air, by inclining the counter system, thus increasing the thickness of the air layer traversed by the particles. In a first experiment, each counter was surrounded by a cylindrical lead shield of 1·7 cm. thickness. Full absorption curves were taken; the lead curve begins with a steep decline (owing to the absorption of the soft component, which is not completely cut off by the lead cylinders) but it then becomes nearly horizontal. The air curve, on the contrary, descends smoothly, cutting the lead curve at about 120 gm./cm.^{2}.

In a further experiment, 4 cm. of lead was placed permanently between the counters (in addition to the lead cylinders) in order to avoid the disturbing effect of the soft component. One point only of each absorption curve was measured, namely, at 136 gm./cm.^{2} (12 cm.) lead and at 121 gm./cm.^{2} air (counter system inclined by 30°). The results were as follows:

	coinc./min.
Counter system vertical, lead cylinders + 4 cm. lead:	$0 \cdot 626 \pm 0 \cdot 009$
,, ,, ,, ,, ,, + 4 + 12 cm. lead:	$0 \cdot 575 \pm 0 \cdot 009$
,, ,, inclined, ,, ,, + 4 cm. lead:	$0 \cdot 516 \pm 0 \cdot 008$

Both experiments show very definitely that the hard component is much more reduced by air than by lead. The difference would have been still greater in absence of the earth's magnetic field, which acts in the sense of diminishing the observed air absorption, as the counter system was inclined in a *westerly* direction. We may correct for the magnetic influence approximately by taking the average of the intensities in the western and in the eastern direction, which differ, under the actual experimental conditions, by a factor of about 1·2. We shall use, therefore, instead of the measured value 0·516, the corrected value $\frac{1 \cdot 1}{1 \cdot 2} \times 0 \cdot 516 = 0 \cdot 473$ for the frequency of the coincidences at 30°.

The difference between the air and the lead absorption, for which no satisfactory explanation had been found at that time, can now easily be accounted for on the disintegration hypothesis. The inclined rays have, of course, to travel a greater distance than the vertical ones before they reach the counters.

We assume that all the observed 'mesotrons' are produced at a given depth R below the top of the atmosphere, where R, as pointed out by Blackett[5], has to be measured in the actual direction of the incoming particles. The difference $\triangle l$ between the paths of the particles, which, at an altitude of h km. above sea-level, are observed at a zenithal angle φ and in the vertical direction respectively, is then given by the formula:

$$10^{-5} \triangle l = \left(\frac{10 \cdot 33}{1 \cdot 29} \log \frac{1033}{R} - h\right)\left(\frac{1}{\cos\varphi} - 1\right) - \frac{10 \cdot 33}{1 \cdot 29}\,\frac{\log\cos\varphi}{\cos\varphi}.$$

Putting $h = 2 \cdot 37$, $\varphi = 30°$ and taking for R the value corresponding to the maximum of the Regener-Pfotzer curve, namely, 100 gm./cm.^{2}, we get $\triangle l \sim 4 \times 10^5$ cm.

On the other hand, since the loss of energy by ionization is about the same in 121 gm./cm.^{2} of air and in 136 gm./cm.^{2} of lead, we may assume that the relative number $\triangle n/n$ of mesotrons which disintegrate by travelling the distance $\triangle l$ is given by

$$\frac{\triangle n}{n} = \frac{0 \cdot 575 - 0 \cdot 473}{0 \cdot 626} = 0 \cdot 165.$$

This result enables us to calculate the life-time of the mesotrons. If we suppose, for reasons of simplicity, that they all have the same energy, say, ε times the rest energy μc^2, with $\varepsilon \sim 40$, we have:

$$\tau = \frac{\triangle l}{\beta c}\,\frac{n}{\triangle n}\sqrt{1-\beta^2} \sim \frac{\triangle l}{c}\,\frac{n}{\triangle n}\,\frac{1}{\varepsilon} \sim 2 \times 10^{-6} \text{ sec.}$$

We obtain, therefore, a life-time just of the order of magnitude previously given. Chiefly owing to the uncertainty in the value to be introduced for ε, the above estimate may be too low or too high by a factor 2.

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[1] Euler, H., and Heisenberg, W., *Ergeb. exak. Naturwiss.*, **17**, 1 (1938). The same point of view has been developed in a discussion at the Physical Institute in Rome. I am indebted to Prof. Bernardini for telling me of this. See also Blackett, P. M. S., Nature, **142**, 692 (1938).
[2] Bhabha, H. J., Nature, **141**, 117 (1938).
[3] Ehmert, A., *Z. Phys.*, **106**, 751 (1937).
[4] Rossi, B., *Ricerca Scient.*, **51**, 579 (1934); *Phys. Rev.*, **45**, 212 (1934); De Benedetti, S., *Ricerca Scient.*, **51**, 590 (1934); *Phys. Rev.*, **45**, 214 (1934).
[5] Blackett, P. M. S., see letter above. I am indebted to Prof. Blackett for a discussion on this point at the conference on cosmic rays held in Copenhagen on Oct. 25–29.

Range of Nuclear Forces in Yukawa's Theory

Four years ago, Yukawa, in an attempt to develop a relativistic theory of the interaction of heavy particles in nuclei, was led to predict the existence of charged particles of mass intermediate between those of the electron and the proton[1].

In view of the great interest and hope raised by the striking discovery in cosmic rays of particles having just the desired mass, which one is naturally