The Particle Problem in the General Theory of Relativity.

IN a recent paper published in the *Physical Review* (Vol. **48**, 73), A. Einstein and N. Rosen have called attention to a possibility of accounting for atomic phenomena by the method of general relativity. Their essential idea consists in removing the singularities of the solutions of the field equations by a simple modification.

One will then have to treat physical space as consisting of two congruent sheets, the particle (neutral or electrical) being interpreted as a portion of space connecting the two sheets, *i.e.*, as a kind of bridge. The determinant of the components of the metric tensor vanishes at the surface of contact of the two sheets. Next, they recognise in the postulate of relativity which states that the motion of a particle takes place along a geodesic, a defect that the field and motion have been separated out. Einstein and Rosen regard that the concepts of particle and motion have to be treated as a part of the field itself. If there are several particles present, one should find a solution free from singularities of the space consisting of two sheets connected by many bridges if he adopts the above point of view. However, one cannot say whether regular solutions with more than one bridge exist at all.

The new field equations adopted by Einstein and Rosen are

$$g^2 R_{kl} = 0$$

instead of the old equations. This adoption would remove the singularities caused in the field equations by the vanishing of the g factors in the denominators of R_{kl}. The regular solution for the spherically symmetric static case is now

$$ds^2 = -4(u^2+2m)du^2 - (u^2+2m)^2(d\theta^2+\sin^2\theta d\phi^2) + \frac{u^2}{u^2+2m}dt^2$$

$$u^2 = r - 2m$$

instead of the Schwarzschild solution,

$$ds^2 = -\frac{1}{1-2m/r}dr^2 - r^2(d\theta^2+\sin^2\theta d\phi^2) + (1-2m/r)dt^2$$

which has a singularity for g_{11} when $r=2m$. In the new solution g vanishes when $u=0$, as g_{44} vanishes. The space can now be regarded as made up of two equivalent sheets corresponding to $u>0$ and $u<0$ joined by a plane $u=0$ or $r=2m$. Einstein and Rosen conceive of a bridge-like connection between the two sheets. They interpret it as a mathematical representation of an elementary, electrically neutral particle. This representation accounts for the non-existence of an elementary particle with negative mass, for one cannot regularise the Schwarzschild solution if it is so.

Just as in the above case of pure gravitational field, Einstein and Rosen have modified the field equations when both gravitation and electricity are present by multiplying the field equations by the factor g^2 and changing the sign of T_{ik}. They find the regular solution for a static spherically symmetric case with an electrostatic field as

$$ds^2 = -du^2 - (u^2+\epsilon^2/2)(d\theta^2+\sin^2\theta d\phi^2) + [2u^2/(2u^2+\epsilon^2)]dt^2$$

$$u^2 = r^2 - \epsilon^2/2$$

taking $m=0$. Einstein and Rosen believe that the massless solutions are the physically important ones to interpret an elementary electrical particle. One can see that the above solution is free from singularities and that the space is divided into two congruent sheets and that the charge is represented by a bridge between the two sheets. According to this, the most elementary electrical particle has no gravitating mass.

In the conclusion, they say, "Nevertheless one should not exclude *a priori* the possibility that the theory may contain the quantum phenomena. Thus it might turn out that only such regular many-bridge solutions can exist for which the 'charges' of the electrical bridges are numerically equal to one another and only two different 'masses' occur for the mass bridges, and for which the stationary 'motions' are subject to restrictions like those which we encounter in the quantum theory. In any case here is a possibility for a general relativistic theory of matter which is logically completely satisfying and which contains no new hypothetical elements."

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