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Summary. — A formulation of gravity based on the maximum four-dimensional Yang-Mills gauge symmetry is studied. The theory predicts that the gravitational force inside matter (fermions) is different from that inside antimatter. This difference could lead to the cosmic separation of matter and antimatter in the evolution of the Universe. Moreover, a new gravitational long-range spin-force between two fermions is predicted, in addition to the usual Newtonian force. The geometrical foundation of such a gravitational theory is the Riemann-Cartan geometry, in which there is a torsion. The results of the theory for weak fields are consistent with previous experiments.

1. - Introduction.

Recently an idea of formulating a theory of gravity based on the Yang-Mills gauge symmetry (1) and the maximum four-dimensional symmetry (2) has been discussed (3). In the present paper, the idea is explored further and is improved so that it can be applied to different matters or arbitrary number of different fermions. It leads to the interesting implication that the gravitational forces for matter and antimatter are not exactly the same. This dif-

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ference of forces could lead to the cosmic matter-antimatter separation in the evolution of the Universe. The theory also predicts the existence of a gravitational long-range spin-force between two spin-$\frac{1}{2}$ particles, as discussed in ref. (2). This suggests that the Riemann geometry is not a suitable and adequate foundation for physical space-time. One must employ the more general Riemann-Cartan geometry which involves a Cartan torsion tensor related to the gravitational spin-force.

According to the Yang-Mills’ idea, the gauge fields are intimately related to the invariance concept at every point in space-time and they are postulated to be the basic dynamical fields. However, the metric tensor of space-time is defined to be a function of gauge fields. It must be stressed that the Yang-Mills gauge symmetry (1) implies that a) the gravitational Lagrangian should be quadratic in the gauge field strength and b) the interaction is characterized by a dimensionless coupling constant. These are major departures from the Einstein theory of gravitation (based on Riemann geometry) which involves a dimensional coupling constant and, thereby, suffers serious divergences in higher-order amplitudes.

Why should one generalize the Riemann geometry for physical space-time? It is obvious that the Universe is full of stable fermions. And we know that the framework of Riemann geometry is not suitable to accommodate spinor fields. Physically, the most reasonable generalization of general relativity is, in my opinion, to combine the elegant symmetry principles of general covariance and Yang-Mills gauge fields and to pursue their logical consequences. The path of logical reasoning is not straightforward because sometimes one has to make definitions which may not be unique. (Of course, only experiments have the final say.)

To identify the gravitational field as a gauge field is not an absolutely straightforward matter, although gravity is clearly intimately related to the concept of gauge fields. The first question is: what is the gauge group for gravity? Different physicists used different groups to construct actions for gravity (4,5). Even when they use the same gauge group, they end up with very much different actions for gravity (9). This indicates that it is highly nontrivial to apply symmetry arguments to the case of gravity. Such a flexibility also reflects the fact that experimental evidences for gravity are very few. So far we have only four classic tests, namely red-shift, perihelion precession,
