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Long range forces and broken symmetries

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There are reasons for believing that the gravitational constant varies with time. Such a variation would force one to modify Einstein's theory of gravitation. It is proposed that the modification should consist in the revival of Weyl's geometry, in which lengths are non-integrable when carried around closed loops, the lack of integrability being connected with the electromagnetic field. A new action principle is set up, much simpler than Weyl's, but requiring a scalar field function to describe the gravitational field, in addition to the $g_{\mu\nu}$. The vacuum field equations are worked out and also the equations of motion for a particle.

An important feature of Weyl's geometry is that it leads to a breaking of the C and T symmetries, with no breaking of P or of CT. The breaking does not show itself up with the simpler kinds of charged particles, but requires a more complicated kind of term in the action integral for the particle.

1. The long-range forces

Long-range forces are those that fall off inversely proportional to the square of the distance between the interacting bodies, as distinct from short-range forces, that fall off exponentially. There are two known long-range forces, the gravitational and the electromagnetic.

The gravitational field is very well explained by Einstein's theory, which accounts for it in terms of the curvature of space. This has led people to believe that the electromagnetic field should also be ascribed to some property of space, instead of being merely something embedded in space, and thus it would require one to set up a more general space than the Riemannian space which underlies Einstein's theory. The more general space would then account for both the gravitational and the electromagnetic fields and would provide a unification of the long-range forces.

Soon after the appearance of Einstein's theory, a solution of the problem was proposed by Weyl. The curvature of space required by Einstein's theory can be discussed in terms of the notion of the parallel displacement of a vector, the transport of a vector around a closed loop by parallel displacement resulting in the final direction of the vector differing from its initial direction. Weyl's generalization was to suppose that the final vector has a different length as well as a different direction, which is a very natural generalization of Riemannian space.

With Weyl's geometry there is no absolute way of comparing elements of length at two different points, unless the points are infinitely close together. The comparison can be made only with respect to a path joining the two points, and different paths will lead to different results for the ratio of the two elements of length. In order to have a mathematical theory of lengths one must set up arbitrarily a standard of length at each point, and then refer any length that turns up in the