A12.4 gravity and quantum mechanics.

Basic idea.

A great deal has been made of the fact that general relativity is the outlier in the theory of the physical universe. The other forces can be unified, primarily through the use of an internal symmetry group, but gravity seems not to fit. We will attempt to make a simplistic case here that that is not the case. In the proposed scheme, gravity is a theory of the vacuum state of quantum mechanics.

The basic idea is that gravity is, in a sense, a theory about mass. But mass is a child of special relativistic quantum mechanics because mass follows, via group representation theory, from the Lorentz invariance and linearity of quantum mechanics. Also the Higgs boson, which is presumed to give mass to particles, is in the realm of special relativistic quantum mechanics (rather than general relativity). So we conjecture that there is a close connection between gravity and 'conventional' strong-electro-weak quantum mechanics (where general relativity is not relevant).

A concentration of mass might change the structure of the vacuum.

How might such a theory be implemented? We know that particles—quarks, electrons and so on—polarize the vacuum; that is, they affect the microscopic structure of the vacuum. So it is conceivable that a macroscopic concentration of particles might slightly change the **macroscopic structure** of the vacuum. For example, it might slightly change the density of particle-like functions that make up the vacuum. Or it might change the vacuum's 'local' energy-momentum density. The smallness in the change of the structure of the vacuum could account for the smallness of the gravitational constant.

This appears to be problematic because there is not a well-developed theory of the vacuum. But one need not solve the whole vacuum problem to set this up. One probably only needs certain properties of the 'single-particle' density matrix, perhaps the local energy-momentum density, of the vacuum. That is, the proposal is that gravity is a macroscopic theory of the vacuum in the presence of concentrations of matter. The equations of general relativity are presumed to be the mathematical means of dealing with this macroscopic theory of the vacuum rather than being an entirely separate force.

Space-time.

(This section only makes sense after reading Part IV.) How would one derive the gravitational equations? I am not certain. But it would presumably have something to do with the way in which a space-time grid is superimposed on the macroscopic situation. In a vacuum, when there are no concentrations of matter, the vacuum state is invariant under the P_μ, and the x_μ are defined by $P_\mu x_\nu = \pm i\delta_{\mu\nu}$. But when there are concentrations of matter then (presumably) the vacuum state is not invariant under the "local" space-time generators and, very roughly, the x_μ are defined by something like $P_\mu(\eta)(x_\nu(\eta)\Psi_{vac}(\eta)) = \pm\delta_{\mu\nu}\Psi_{vac}(\eta))$. From this, plus an assumption about the properties of the vacuum, I conjecture that one could derive the general relativistic equations connecting space, time, and densities of matter. (Note that the local P_μ has two roles; it generates the local x_μ; and its expectation value is proportional to the local energy-momentum density.) This scheme, where space, time and matter are ‘emergent’ rather than ‘fundamental’ properties (that is, they are properties of the *solutions* rather than being built directly into the original equation) may make it easier to conceptually understand how matter could alter space and time.