Despite the simplistic nature of this section it does hint at the germ of deep ideas. In the standard model of particle physics the electromagnetic and weak forces are unified into the so-called electroweak force, which has been very successful in predicting experimental results; at low interaction energies the weak and electromagnetic forces differ greatly, but at an energy above a few thousand GeV they become comparable.[38,39] They may be viewed as different aspects of a single force rather than as fundamentally different forces. Similarly the strong force is widely believed to become comparable and similarly unified with the electroweak force in some grand unified theory or GUT at energies of about $10^{16} GeV$, only a few orders of magnitude below the Planck energy.[39] Quite roughly speaking then, all the fundamental forces of nature are believed to become comparable near the Planck scale.

IX. SUMMARY AND FURTHER COMMENTS

We have tried to show that the Planck scale represents a boundary when we attempt to apply our present ideas of quantum theory, gravity, and spacetime on a small scale. To go beyond that boundary, new ideas are clearly needed.

There is much speculation by theorists on such new ideas. Here we will only mention three (of many) such efforts very superficially, and refer the reader to references 4 to 7. The first effort involves perturbative quantum gravity, studied for many years by many authors, notably by Feynman and Weinberg; in perturbative quantum gravity the flat space of special relativity is taken to be a close approximation to the correct geometry, and deviations from it are treated in the same way as more ordinary fields such as electromagnetism. Just as in quantum electrodynamics Feynman diagrams may be derived to describe the interactions between particles and the quanta of the gravitational field, called gravitons. The theory has the serious technical drawback that it does not renormalize in the same way as quantum electrodynamics, and in fact contains an infinite number of parameters and graviton interactions. Even more importantly it does not truly address the quantum nature of spacetime. The second and best-known effort involves super-string theory, or simply string theory, in which the point particles assumed in quantum field theories are replaced by one-dimensional strings of about Planck size. String theory purports to describe all particles and interactions, and has been studied intensively for decades, and is consistent with gravitational theory since it accommodates a particle with the properties of the graviton, that