A19.4 Gravitational models of collapse.

It has been proposed that gravity may be involved in collapse, either through a direct interaction as suggested by Penrose[1], [2] or through a model in which gravity leads to the fluctuating *w*'s [3], [4]. These proposals are consistent with the experimental results, which (if one assumes there is collapse) can be taken to imply that the coupling is proportional to the mass of the particle. I will not describe these models in detail but will instead emphasize that most of the difficulties given in Ch. 19 also apply to gravity-based collapse.

The Penrose model.

There is a slightly different arrangement of matter in the different versions of reality of the state vector. And because the arrangement of matter affects the curvature tensor, and therefore the definition of space-time, Penrose has suggested that the different versions create a 'tear' in the fabric of space-time. This tear is postulated to produce a force between the various versions of reality, and if enough particles are involved, the force is sufficient to snap the different versions back into just one version.

The primary problem here is that the quantum mechanical results of Ch. 10—that each version of reality evolves separately and that there can be no interactions between versions—still hold, even though space-time is different for the two versions. Thus if we stick with linear quantum mechanics, there can be *no interaction* between branches; that is, there can be no force, gravitational or otherwise, which collapses the different versions into a single version. So if Penrose is to pursue his model, he must spell out the details of this radical change to a non-linear theory of quantum mechanics in which the different versions of reality interact.

The second problem with the Penrose model is that there seem to be no random variables. Thus it is not clear how the process would lead to a random selection of states that obeys the $|a(i)|^2$ law.

The Stochastic Gravitational Model.

In this model, it is postulated, in essence, that there are fluctuations in mass distribution of the vacuum state. These can be related to the fluctuating variables *w* of A19.2. Thus the problem of item **(1)** in Ch. 19 is somewhat circumvented and one gains a feel for why the coupling should be proportional to the mass. But the cost is that one introduces additional assumptions about fluctuations of the vacuum, and all the other problems of Ch. 19 still remain.

In addition, the same problem encountered in Penrose's model is still there; linear quantum mechanics contains no interactions between versions—interactions which are necessary for collapse. And there is no quantitative argument that the vacuum fluctuations lead to the $|a(i)|^2$ probability law.

References

[1] R. Penrose, *Gen. Rel. Grav*. **28**, 581 (1990).
[2] Roger Penrose, *The Road to Reality*, (Vintage Books, New York, 2007).
[3] Philip Pearle, arXiv, quant-ph/0611212v3 (2007).
[4] Pearle, arXiv, quant-ph/9503019v1.