13

Experimental test

The most highly developed theory of quantum mechanical state reduction is the GRW/CSL theory of Ghirardi and Pearle [Ghirardi 1990, 1990]. According to that theory, elementary particles undergo a spontaneous collapse that spreads to the macroscopic level through correlations. The rate of collapse is governed by a small hypothetical constant λ that has not as yet been observed.

Collett and Pearle proposed an experiment intended to establish an empirical basis of that theory [Collett 2003]. A micro-disk of aluminum or gold is suspended in a Paul trap at 4.2°K and very low pressure ($5 \cdot 10^{-17}$ Torr), and the disk's angular diffusion rate is observed. The disk with a radius of 200 nm and a thickness of 50 nm is held vertically with its normal lying along the horizontal, while laser photons are directed horizontally toward it. The angular deflection of the photons is therefore a measure of the disk's angular diffusion. The claimed spontaneous reduction of the angular state can then be observed, so the reduction rate λ can be measured. The measurement must take place during a time *between* collisions with atmospheric molecules.

If this experiment produces the expected results we would have to conclude that the q-rule theory proposed by the author is incorrect, for these rules posit no constant λ. However, if the experiment does not confirm the diffusion predicted by GRW/CSL, then other alternatives such as the q-rule proposal will remain on the table.

Collision reduction with sphere

It is simpler to visualize the author's proposed collapse mechanism with a small sphere. Consider a sphere of radius $r_0 \approx 10^{-5}$ cm that is solid aluminum or gold. Imagine that it has expanded to five times that radius as a result of the uncertainty of its momentum. This is shown in Fig. 13.1a where a number of small dashed spheres, representing the minimum volume sphere, are circumscribed by a large dashed sphere representing its uncertainty of the sphere's position. An incoming molecule shown as a black dot in Fig. 13.1b penetrates the extended radius, engaging the sphere at various possible locations in this sphere of uncertain locations. The first encounter shown in Fig. 13.1b is a continuous scattering of the incoming molecule at one of the possible sphere locations. The second possibility is a faux collision involving a quantum jump of some kind that does not result in a collapse of the wave. The third encounter in Fig. 13.1b represents a collapse of the wave resulting in a *realized* collision. There is a continuum of possible locations of the sphere inside its extended volume, so there will be a continuum of possible collisions before there is a stochastic hit on one of them. Only three encounters are shown in the figure.

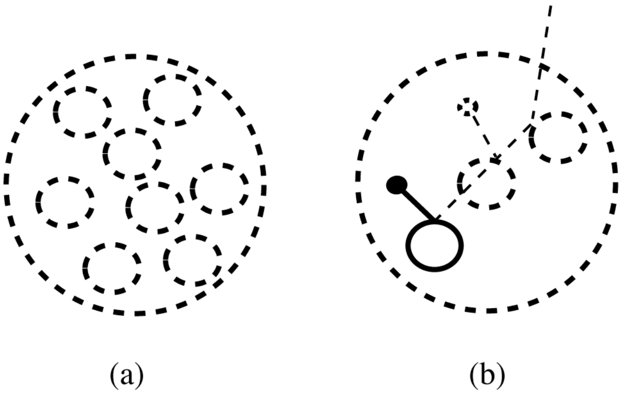
(a) (b)

Figure 13.1: Uncertainty of position of sphere

If the collisions in Fig. 13.1b are all continuous like a Compton scattering, there will be no collapse of the wave. For a diatomic molecule at 4.2°K these collisions will no doubt cause many jumps to higher of lower rotational levels, but these alone will not qualify as wave collapses. For a collapse to occur there must be a quantum jump in which a *new particle is created or an old one is annihilated* as explained in Chap. 9. An allowed process is a collision in which the molecule falls to a lower rotational orbit emitting a photon. The assumption is that of the many collision that occur inside the extended spherical volume, one of them will create a new photon in this way, and that this will satisfy the requirement of Chap. 9. At that point a collapse will localize the sphere and its recoiling molecule as required by the q-rules. The sphere will then have its minimum volume consistent with its uncertainty of momentum.

The experiment

The proposed experiment involves a disk rather than a sphere. The reduction principle is the same in both, but a disk has a measurable angular displacement and diffusion rate. According to the q-rule theory, state reductions of the disk will occur only in connection with molecular collisions with the disk, so an observation of a collapse must cover the time before and after a collision in order to confirm the predictions of the theory. The assumption is that between collisions the angular uncertainty $\Delta\phi$ will become much larger than the initial uncertainty $\Delta\phi_0$ (its value right after a collision) because of the uncertainty ΔL_0 in angular momentum; and furthermore, that a subsequent collapse-producing-collision will reduce the angle to the smallest value $\Delta\phi_c$ consistent with ΔL_c at that time (i.e., the angular momentum after the collapse-producing-collision). It will be difficult to measure the state reduction following a collision because of its disruptive influence; but assuming that this can be done, a collision reduction will provide a unique test of the q-rule theory inasmuch as no other foundation theory shows that kind of dependence.

I regard the predictions of the q-rules as being well substantiated. This is based on the exhaustive examples of their application in Chaps. 9-11 that seem to me ‘correct' beyond doubt. This is why I include them with the dynamic principle as part of the mechanics of quantum mechanics. It is nonetheless possible that they are not fundamental in the same way that the laws of spectroscopy are empirically correct but not fundamental. It is possible that these rules might be integrated into the dynamic principle in the same way that Ghirardi and Pearle have included the stochastic term into the Hamiltonian. An integrated theory of that kind seems to me desirable, but to be correct it would have to predict the same experimental results as the q-rules as they appear in Chap. 9. The theory of Ghirardi and Pearle does not do that. It predicts a spontaneous collapse between collisions rather one that occurs *at* a collision with an associated photon emission.