A19.3. The Experimental Situation for Collapse.

Our summary of the experimental situation will rely primarily on the review by Pearle [1].

Interference experiments.

The most direct way to observe collapse would be to do an interference experiment, similar to the Mach-Zehnder (A5.2) or double slit (A5.1) interference experiments on photons. If the observed interference pattern does not follow that derived from standard quantum mechanics—if it disappears, for example—then this would imply that the wave function had collapsed to one branch or the other. This has been done with buckyballs having about ΔN =720 nucleons [2], and no deviation has been found from what is expected from standard quantum mechanics. Using Eq. (A19.2-7) in the form 10^{-3}sec$\leq t_{collapse} = 5/(\lambda\Delta N)^2$ implies $\lambda<5\text{x}10^{-3}$/sec so this experiment provides very little constraint on the theory (where the presumed value for λ is on the order of 10^{-16}/sec). A recent experiment has upped the value of ΔN to about 5,000, but that still puts no significant constraint on λ.

There have also been Superconducting QUantum Interference Device (SQUID) experiments in which approximately 10^9 electrons took part [3]. The interference between two states of the 10^9 electrons was just what quantum mechanics predicted, so there was no support for collapse. It is difficult to fit this into the GRWP scheme because there is no satisfactory way to define ΔN. But still, when a state with 10^9 particles shows no signs of collapse in an interference experiment, that weakens one's confidence in the possibility that there is collapse.

Decays and mass constraints.

The proposed GRWP form for the theory (A19.2) adds terms to the Hamiltonian (Eq. (1) in A19.2) and so it can affect certain processes. In particular, it can lead to energy fluctuations that occasionally (*very* occasionally) cause the ejection of an electron from an otherwise stable atom. In one experiment [4], a chunk of germanium was monitored for a year to see if there were decays at a particular energy. The matrix element for the decay is substantial if electrons and nucleons couple equally to the collapse-producing fields, but it is essentially zero if the coupling is proportional to the mass. The negative results (no decays) are *consistent with no collapse*. If collapse is assumed, the results lead to the constraint

$$0 \leq \frac{\alpha_{elec}}{\alpha_{nuc}} \leq \frac{13m_{elec}}{m_{nuc}} \qquad (1)$$

where the α's are the coupling constants to collapse (and m_{elec}/m_{nuc} is about 1/2,000). That is, the results are consistent with the coupling being proportional to the mass, but completely inconsistent with an equal coupling for electrons and nucleons.

In another experiment that yields information on the possibility of collapse, the smallness of the disagreement between theory and observation in the Sudbury experiment on solar neutrinos [5] is *consistent with no collapse*. But if we assume collapse, it gives a constraint on coupling constants for neutrons and protons;

$$\frac{\alpha_n}{\alpha_p} = \frac{m_n}{m_p} \pm 4x10^{-3} \tag{2}$$

This, too, is consistent with a coupling proportional to the mass.

To date, the mass constraints are the only serious constraints on GRWP theories, but they are significant. It apparently implies either that the coupling is proportional to mass (so there would be no coupling to photons and very little to electrons) or that the coupling is only to nucleons (in which case the random field would have internal symmetry group properties).

References.

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[3] A. J. Leggett, Journal of Physics: Condensed Matter (2002).
[4] E. Garcia, Phys. Rev. D**51**, 1458 (1995).
[5] SNO collaboration, Phys. Rev. Lett. **92**, 181301 (2004).