

Experimental Test of qRule Theory

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Three qRules governing the collapse of a wave function are given in another paper. In most situations the predictions of the theory are identical with the predictions of other foundation theories. However, there is at least one experiment in which the qRules predict characteristically different results than other theories. These results are shown to be a function of temperature and pressure in an experiment proposed by Collett and Pearle. Wave reductions in other collapse theories are distinctly not a function of temperature and pressure.

Introduction

The most highly developed theory of quantum mechanical state reduction (i.e., wave collapse) is the GRW/CSL theory of Ghirardi et al. [1] and Pearle [2]. According to the theory, elementary particles occasionally (although rarely) 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.

In 2003 Collett and Pearle proposed an experiment intended to establish an empirical basis of the theory [3]. 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 with respect to the azimuth. A disk with a radius of 200 nm and a thickness of 50 nm is expected to diffuse through 2π radians in about 70 sec due to GRW/CSL effects. This diffusion results from energy induced into the system by the same stochastic process that collapses the wave function, so it should provide a measure of λ . The disk is held vertically by the trap with its normal lying along the horizontal, while laser photons are

directed horizontally toward the disk. The angular spread of their deflection is therefore a measure of the angular diffusion of the disk. The measurement must take place between collisions with atmospheric molecules.

If this experiment produces the expected results we would have to conclude that the qRule theory proposed by the author is incorrect, for the qRules posit no constant λ and they do not provide for the introduction of energy in connection with a stochastic choice [4]. However, if the experiment does not confirm the diffusion predicted by GRW/CSL, then other alternatives will remain on the table.

Experimental Set-up

The angular diffusion of the above disk that results from Heisenberg uncertainty alone would be considerably less than GRW/CSL diffusion. For this reason, an experiment that is intended to measure a purely Heisenberg angular diffusion would be more difficult, especially if the measurement must monitor the results of molecular collisions. According to the qRule theory, state reductions of the disk will occur only in connection with molecular collisions with the disk (Ref. 4), so an observation of collapse must span at least one collision in order to confirm the predictions of the theory. It might be necessary to optically squeeze the disk to as small a thickness as possible (thereby minimizing the initial angular uncertainty $\Delta\phi_0$ – and maximizing the initial angular momentum uncertainty ΔL_0) before releasing it for measurement. The assumption is that after a time the angular uncertainty will be much larger than $\Delta\phi_0$ because of ΔL_0 , and that a collapse will reduce the angle to the smallest value $\Delta\phi$ consistent with ΔL at that time (which might differ from the initial ΔL_0 because of collision dynamics). This is analogous to an atom with the smallest initial width Δx_0 consistent with Δp_0 that expands because of Δp_0 , and collapses under the right qRule conditions to the smallest width Δx consistent with the value of Δp at that time. See the rationale given in Ref. 4 in connection with Fig. 3 of that paper.

Temperature vs. Collision Rate

It should be possible in principle to measure the number of reductions per second experienced by the disk as a function of temperature and pressure. This relationship is shown qualitatively in Fig. 1.

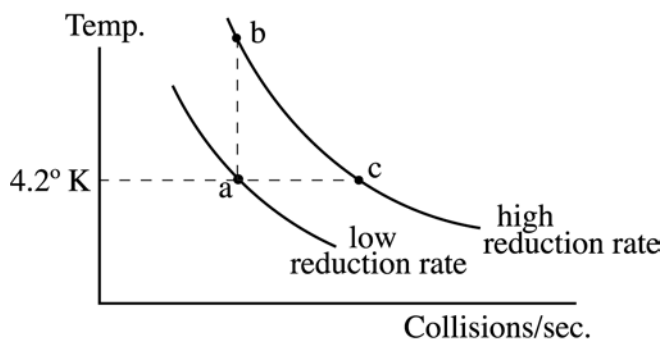


Figure 1: State reductions, temp. vs collision rate

State reduction depends on the possibility of a molecular collision with the disk according to the qRules (Ref. 4), so the reduction rate will generally increase with temperature and pressure. Specifically, it will increase when the temperature increases while keeping the collision rate constant (going from point 'a' to point 'b' in Fig. 1); and it will be *proportional* to the collision rate at constant temperature (going from point 'a' to point 'c' in Fig. 1). In the first case the increase occurs because rotational levels are more easily available to atmospheric molecules at high temperatures, and this availability is essential for the possibility of collapse (Ref. 4). Reductions should disappear as temperature goes to zero, for in that limit the rotational levels will be frozen out.

A plot of the reduction rate against the collision rate (values between points 'a' to 'c' in Fig. 1) is shown in Fig. 2. The slope of the curve is constant and is equal to or less than 1.0, inasmuch as it represents the total rotation transformation probability/collision at 4.2°K. It is likely that experimental ingenuity will be challenged just to show that a reduction occurs with the right probability following each collision. A collision will be known by its disruption of the disk, thereby making the measurement of the reduction all the more difficult. Nonetheless, Figs. 1 and 2 show what should happen in principle according the qRules, and therefore provide a guide to experimental strategy.

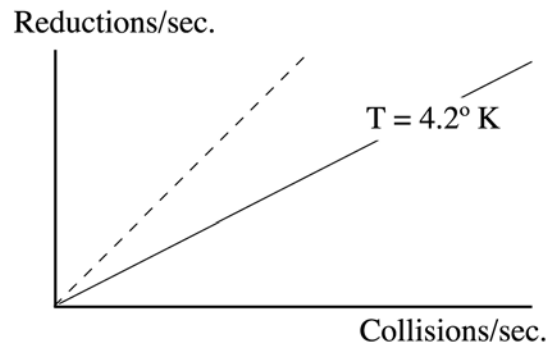


Figure 2: Reduction rate vs collision rate at constant temperature

Conclusion

The qRule theory of state reduction leads to a characteristic dependence of reduction rate as a function of temperature and pressure. No other foundation theory shows this kind of dependence.

References

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3. B. Collett, P. Pearle. “Wavefunction Collapse and Random Walk”. *Found. Phys.* **33**, No. 10 (2003)
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