Gravity-related spontaneous disentaglement: cause of Newton force?

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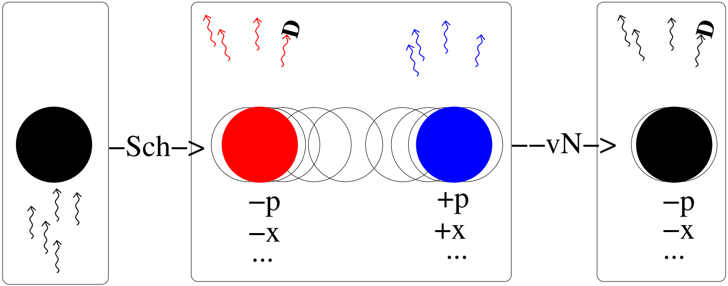
Cat Problem: more than a paradox

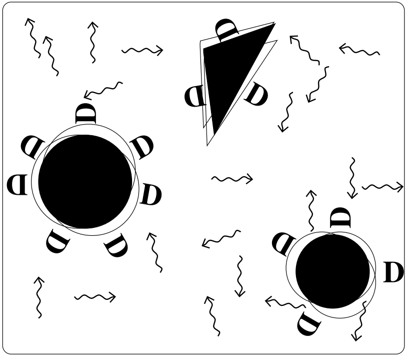
QM = Sch-equation (dynamics) + vN-measurements (predictions)
Measurements violate conservation laws, device compensates.
Macroscopic extension of QM = Schrödinger Cat (SC)
Measurements violate conservation laws, device cannot compensate.



Macroscopic non-concervation of c.o.m. x,p,..., of local density, ...
Let's disclose SCs before they arise!

G-related spontaneous disentanglement

Universal weak ($\sim G$) monitoring of mass distribution $f(r,t)$.
"Devices" act everywhere like real devices, but remain unseen.
Massive d.o.f. are disentangled (localized, collapsed, also decohered).



Shall we construct the modified Schrödinger equation?

Key equation: rate of disentanglement

SC: radius R, density ρ, mass $M=(4/3)\pi R^3\rho$, c.o.m. x
Just notation, with no dynamic role:

$$U(|x-x'|)=-G\rho^2\int_{|r-x|\leq R} d^3r \int_{|r'-x'|\leq R} d^3r' \; \frac{1}{|r-r'|}$$

The proposed disentanglement rate:

$$\frac{1}{\tau_G}=\frac{2}{\hbar}\left[U(x-x')-U(0)\right]$$

For $\Delta x=|x-x'|\ll R$ (i.e., for small coherent spread):

$$\frac{1}{\tau_G}=\mathrm{const}\times\frac{M\omega_G^2}{\hbar}(\Delta x)^2$$

where $\omega_G=\sqrt{4\pi G\rho/3}$ is the "Newton oscillator" frequency.

Equilibrium rate of disentanglement

Modified QM:

$$d\psi(x,q)/dt = \text{Sch. lin. term} + G \times \text{stoch. nonlin. term.}$$

q : SC internal d.o.f. plus light environmental d.o.f.
Sch. increases Δx — G-term decreases Δx.
Equilibrium condition:

$$\frac{\hbar}{M(\Delta x)^2} \sim \frac{M\omega_G^2(\Delta x)^2}{\hbar}$$

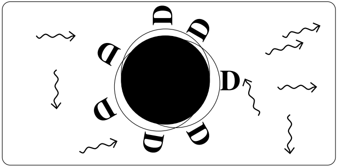
Equilibrium rate:

$$\frac{1}{\tau_G^{\mathrm{eq}}} \sim \omega_G \sim \frac{1}{hour}$$

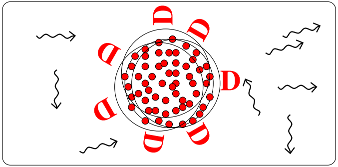
That's too slow, would be irrelevant in Nature. Loophole?

Mass density spatial resolution

Issue: low equilibrium disentanglement rate $\omega_G = \sqrt{4\pi G\rho/3}$.
Loophole: resolve microscopic structure, $\rho \Rightarrow \rho^{\mathrm{nucl}}$.



$$\frac{1}{\tau_G} = \omega_G \sim \frac{1}{hour}$$



$$\frac{1}{\tau_G} = \omega_G^{\mathrm{nucl}} \sim \frac{1}{ms}$$

Bad news: Nuclear mass distribution is vaguely defined!
Good news: High(er) disent. rate (1/ms) can be relavant for Nature.
Bad news: Local environmental decoherence is always faster.
Experimental prediction?

If G-related disentanglement is cause of gravity?

Why should it be?

Consider free massive object, ignore environment (don't need to):

- C.o.m. $p \neq \mathrm{const}$ under G-related spontaneous disentanglement.
- We prefer to restore p-conservation, at least on average.
- In equilibrium, c.o.m. world-line is wiggling.
- Wiggle is universal.
- Wiggly world-line *is the* geodetic one.
- This assumes gravitational forces along the world-line.
- These forces might restore p-conservation.
- These forces emerge from disentanglement at rate $1/\tau_G \sim 1/\mathrm{ms}$.
- Mean of these forces constitute the object's Newton field.
- Newton field has the emergence time scale $\tau_G \sim 1\mathrm{ms}$.

Testing gravity's laziness

A fully classical proposal to test the "delay" $\tau_?$ of the Newton field of a mass M moving along the path x_t:

$$\Phi(r,t)=\int_0^\infty \frac{-GM}{|r-x_{t-\tau}|}\mathrm{e}^{-\tau/\tau_?}d\tau/\tau_?$$

valid (i) in the free falling reference frame where $M\ddot{x}_t$ is equal to the non-gravitational forces; (ii) in the t-dependent co-moving system where $\dot{x}_t=0$.

(ii) guarantees boost-invariance. (i-ii) say Newton law is restored in absence of non-gravitational forces.

Example: Revolving at angular frequency Ω under non-gravitational force, the accelerated source yields in the center $(1+\Omega^2\tau_?^2/2)\times$ the standard Newtonian force.

There must be feasible tests of $\tau_?=\tau_G=1ms$!