Newton force from spontaneous wave function collapse?

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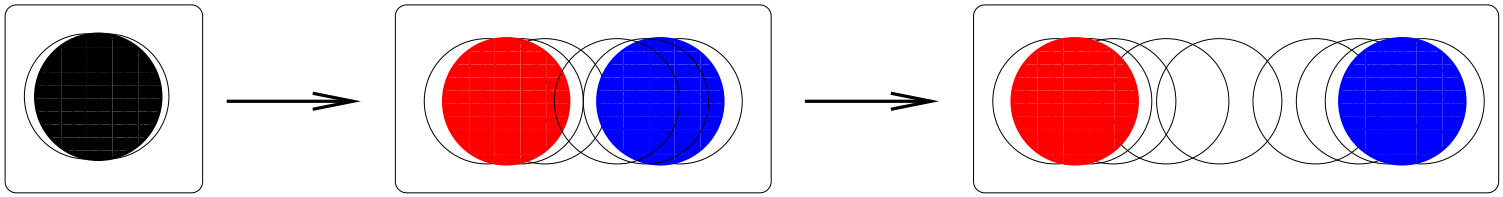
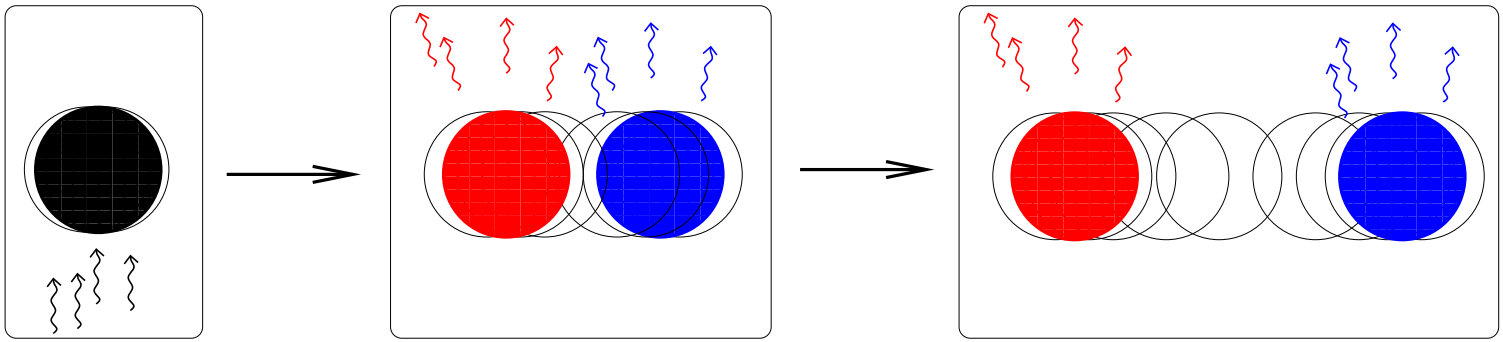
Q-C boundary: massive d.o.f.'s matter

Massive d.o.f.= hydrodynamic d.o.f.=c.o.m.
Free Schrödinger evolution of $\Psi(c.o.m.)$: Schrödinger Cat states



In light environment: "same" $\Psi(c.o.m., \textit{light d.o.f.})$ for c.o.m. just entangled with the light d.o.f.'s



Schrödinger Cats are problematic.
Schrödinger Cats can be suppressed by spontaneous collapse models.

G-related spontaneous decoherence

- Hawking (1983): unitarity is lost due to space-time fluctuations (instantons) on Planck scale

$$\rho \to \$\rho \neq S\rho S^\dagger$$

- Banks-Susskind-Peskin (1984): master equation, violation of conservations laws

$$\dot{\rho} = -i[H,\rho] - \int [Q(x),[Q(y),\rho]]h(x-y)d^3xd^3y$$

- D. (1986): unitarity is lost due to gravitational fluctations much before the Planck scale, nonrelativistically

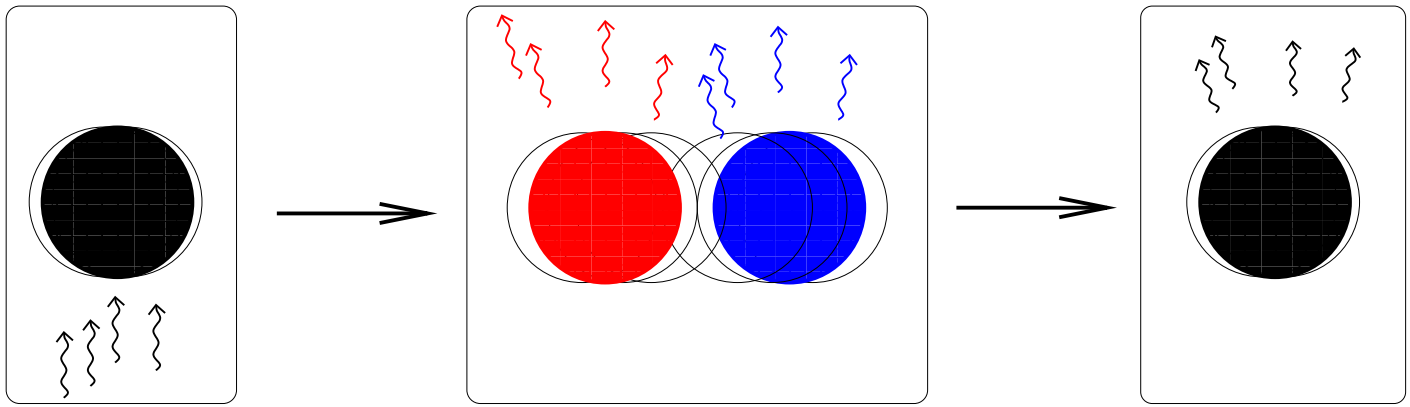
$$\dot{\rho} = -i[H,\rho] - G\int [f(x),[f(y),\rho]]\frac{1}{|x-y|}d^3xd^3y$$

G-related spontaneous collapse (DP)

Spontaneous collapses (GRW,DP,CSL) = v. Neumann measurements

- Devices are present everywhere and everytime
- Devices are hidden

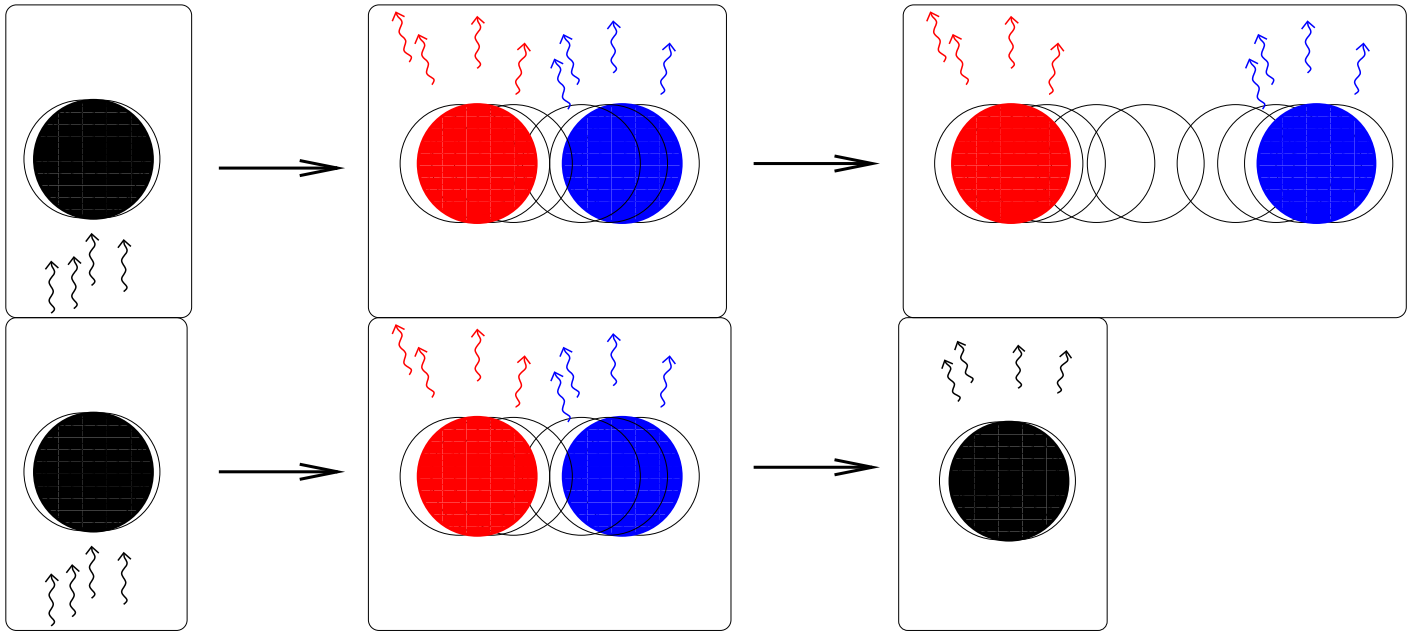
DP: Hidden devices weakly ($\sim G$) measure the mass distribution $\Rightarrow$ collapse (i.e.: disentangle) massive d.o.f.



When Schrödinger "spread" of c.o.m. and DP-collapses are balanced:

$$\text{equilibrium collapse rate} := \frac{1}{\tau_G} \sim \sqrt{G\rho^{\text{nucl}}} \sim \frac{1}{ms}$$

Decoherence vs Collapse



Spontaneous (GRW,DP,CSL) collapses are never detectable.
Only their decoherence effects on c.o.m. are detectable...
...if not masked by the environment.
Experiments are under way to suppress natural environment.
Extend DP theory to associate collapse with something detectable!
Suppose (speculate) Newton force is generated by DP-collapses.

Lazy Newton forces generated by DP-collapses

[Why so? — see various highly heuristic arguments (2008-)]
Newton forces emerge from disentanglement at rate $1/\tau_G \sim 1/\mathrm{ms}$.
Newton field has the same emergence time scale $\tau_G \sim 1\mathrm{ms}$.
No details (despite longstanding efforts).
Minimum heuristic extension of Newton equation (2013):

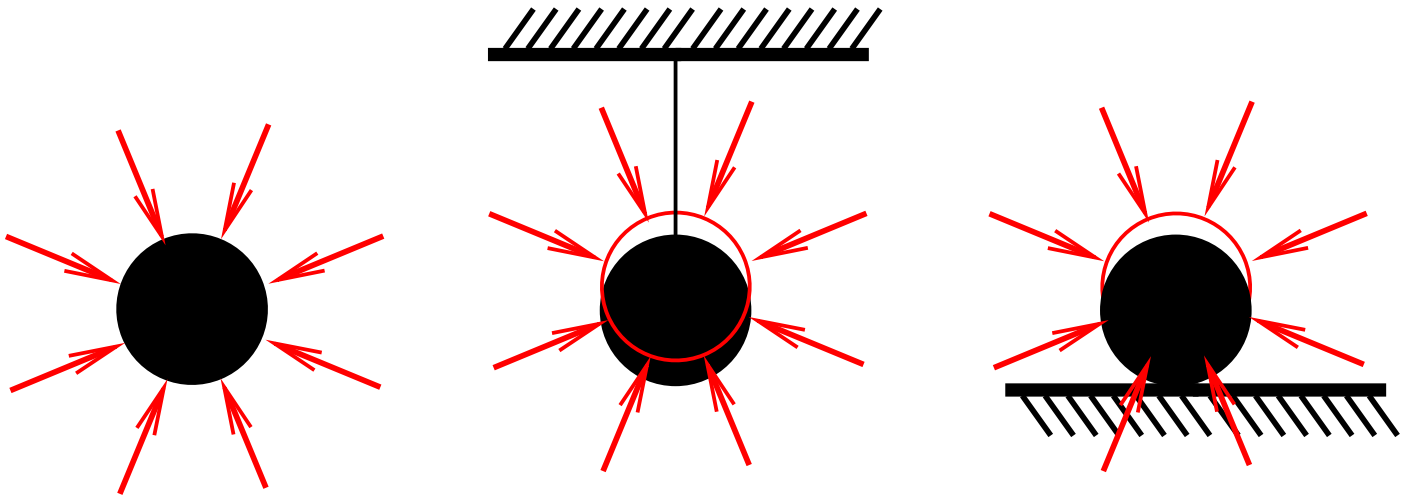
$$\Phi(r,t) = \int_0^\infty \frac{-GM}{|r - x_{t-\tau}|} \mathrm{e}^{-\tau/\tau_G} d\tau/\tau_G$$

valid in the co-moving free falling reference frame (i.e.: where $\dot{x}_t = 0$ and $M\ddot{x}_t$ is equal to the non-gravitational forces.

Newton law is restored in absence of non-gravitational forces.

Testable predictions of gravity's laziness I.

Universal effect in Earth field

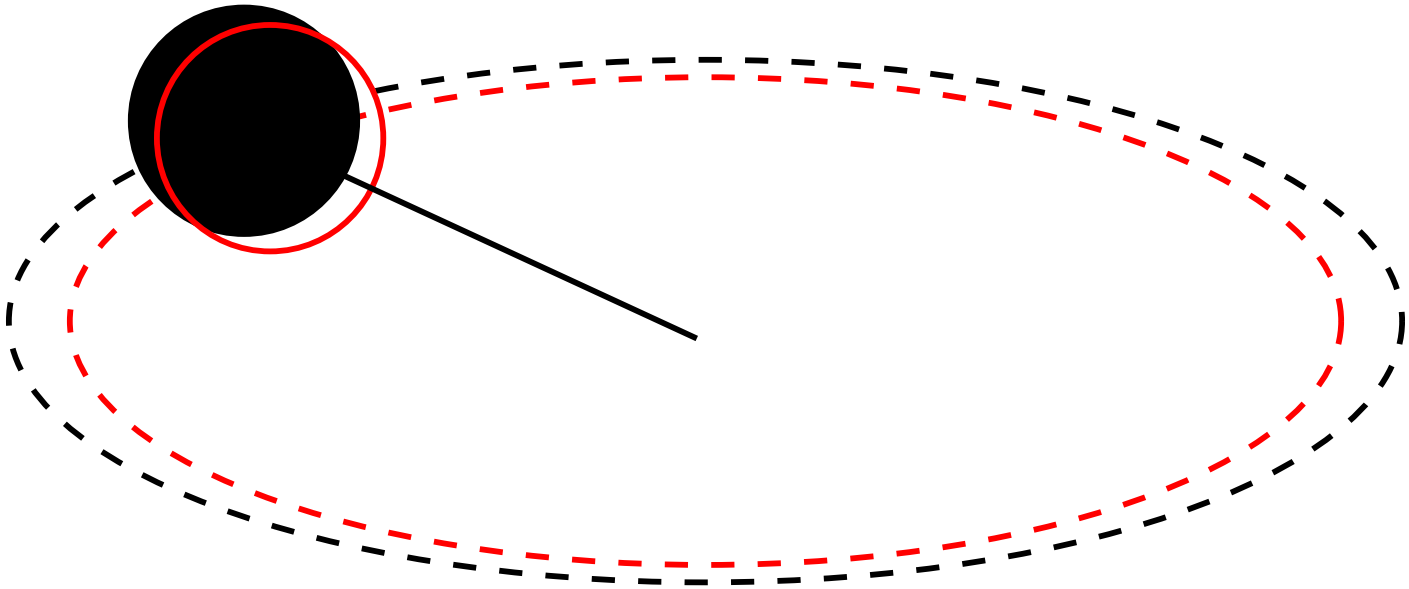


Free falling objects create standard instantaneous Newton forces.
All static objects create Newton forces as if they were higher than their static position, by

$$g\tau_G^2 \sim 10^{-3}\mathrm{cm}$$

Testable predictions of gravity's laziness II.

Small effect under moderate non-gravitational force

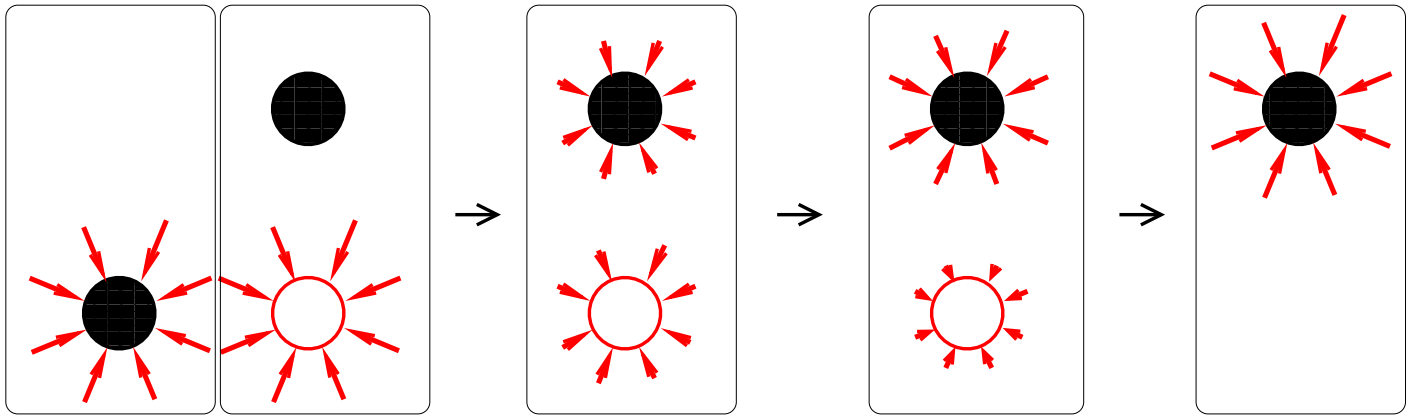


Revolving at (small) angular frequency Ω under non-gravitational force (e.g. of a rope), the accelerated source yields an enhanced Newton force in the center, by the factor

$$1+\Omega^2\tau_G^2 \qquad (\Omega \ll 1/\tau_G \sim 1\mathrm{kHz})$$

Testable predictions of gravity's laziness III.

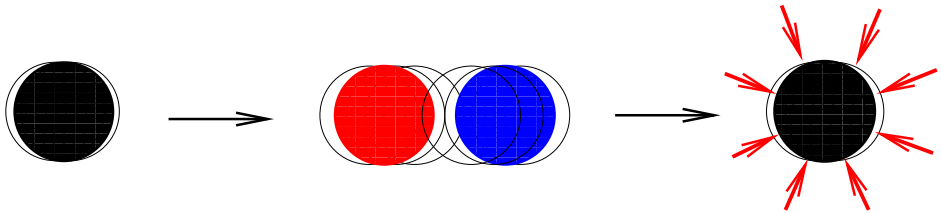
Large delay effect after sudden displacement



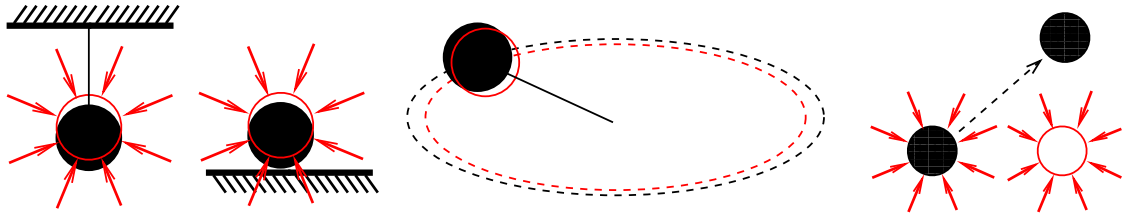
If the source is sudddenly displaced by a non-gravitational force, it's Newton field follows it with the time-delay $\tau_G \sim 1$ms.

Summary

- DP theory: 1 ms is the equilibrium collapse time scale.
- Extension of DP: collapses cause Newton force:



- Newton equation for lazy Newton force, with emergence time τ_G
- No experimetal evidence exists against $\tau_G \sim 1$ ms.
- There are various detectable predictions:



There must be feasible tests of $\tau_G \sim 1ms$!

L.D.: Note on Possible Emergence Time of Newtonian Gravity [PLA377, 1782 (2013)]