Gravity-related spontaneous disentanglement: cause of Newton force?

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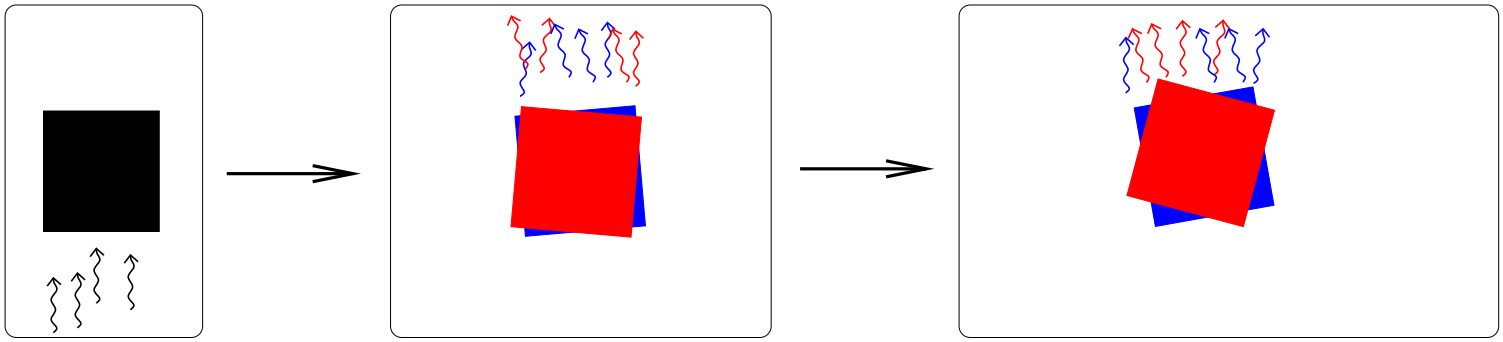
Theses on spontaneous collapse models

- Spontanoues collapse models: GRW, QMUPL, DP, CSL
- SN was not claimed to be collapse model (1984).
- Collapse models are standard monitoring theories (1989).
- The only difference: the detectors are hidden (2013).
- Spontaneous decoherence is testable, collapse is'nt (1989).
- ME for $\hat{\rho}$ is relevant, SSE for Ψ is redundant (1989).
- Both DP and CSL are monitoring the mass density $\hat{f}(\mathbf{r}, t)$.
- Both increase temperature of mechanical oscillators by $\Delta T_{sp} \sim$ring-down time[s]$\times(10^{-5} - 10^{-1})$[K] (2014).
- DP resolves atomic structure of $\hat{f}(\mathbf{r}, t)$, CSL does not.
- DP collapses acoustic modes; CSL: but surfaces (2013).
- DP shows up for large acoustic modes, CSL can't (2013).
- Post-D(P) speculation: collapse causes gravity (2009).

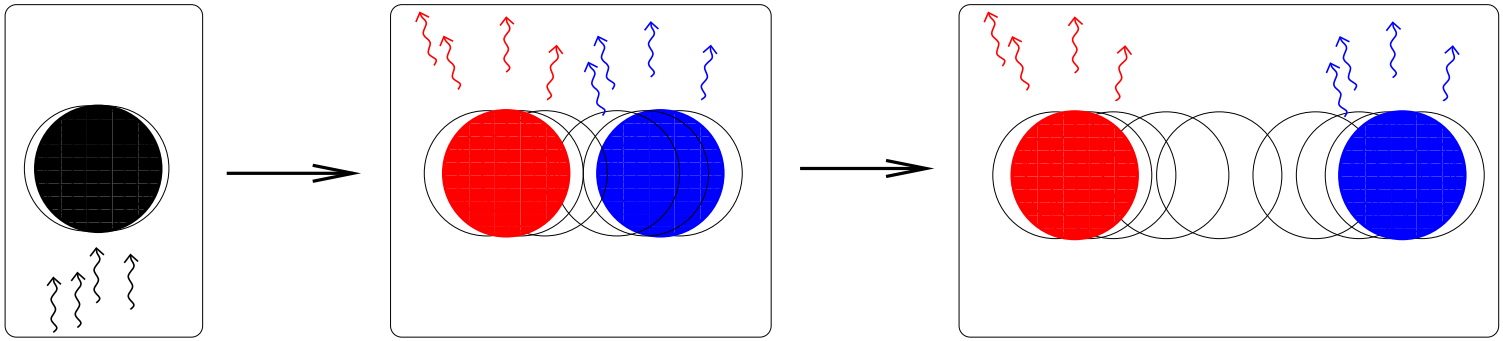
Wigner, to illustrate the inevitable influence of environmental noise on macroscopic quantum objects, estimated that even in intergalactic space a 1cm solid looses its wave function in about 1s due to cosmic background radiation. One of the hypothetic models of quantum-classical boundary is gravity-related spontaneous wave function collapse (Diosi-Penrose model). Recently I have extended the model and propose that collapses are responsible for the emergence of the Newton force between massive objects. I identify the collapse rate, possibly of the order of 1ms, with the rate of emergence of the Newton force. A simple heuristic emergence (delay) time is added to the Newton law of gravity. No available experimetal evidence exists against it. Confirmation or refutal can be done in feasible modern Cavendish experiments with the moving source and of better time-resolution w.r.t. to the old tests.

Quan...-class... boundary: Massive DOF's matter

Wigner 1983: 1 cm cubic object in intergalactic space
Ψ(angular) becomes meaningless in cca 1 s:



Same for Ψ(c.o.m.), it spreads and entangles with the environment:



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

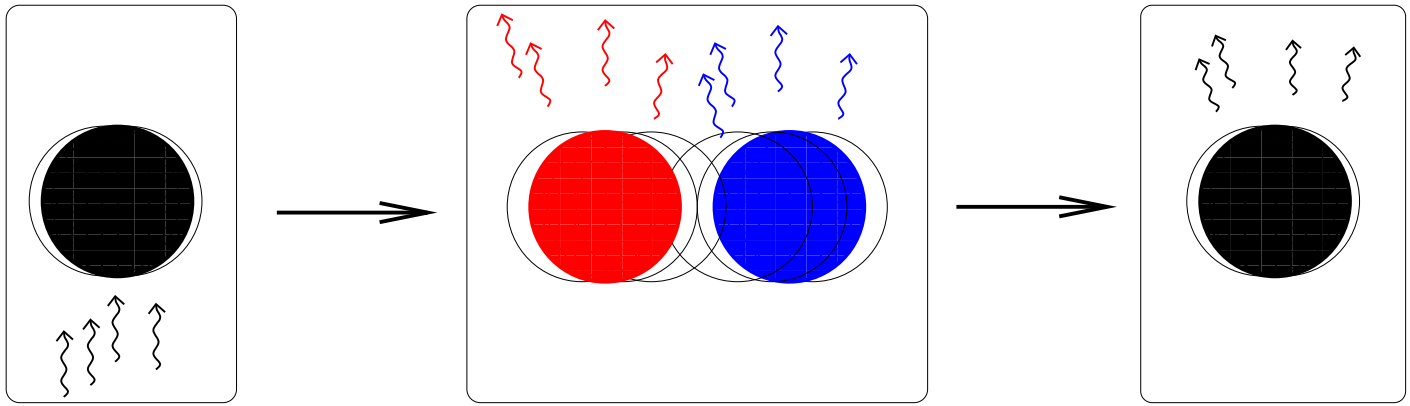
G-related spontaneous collapse (DP)

Spontaneous collapses (GRW,DP,CSL): von Neumann measurements.

- Devices are present everywhere and everytime.
- Devices are hidden.

DP collapses:

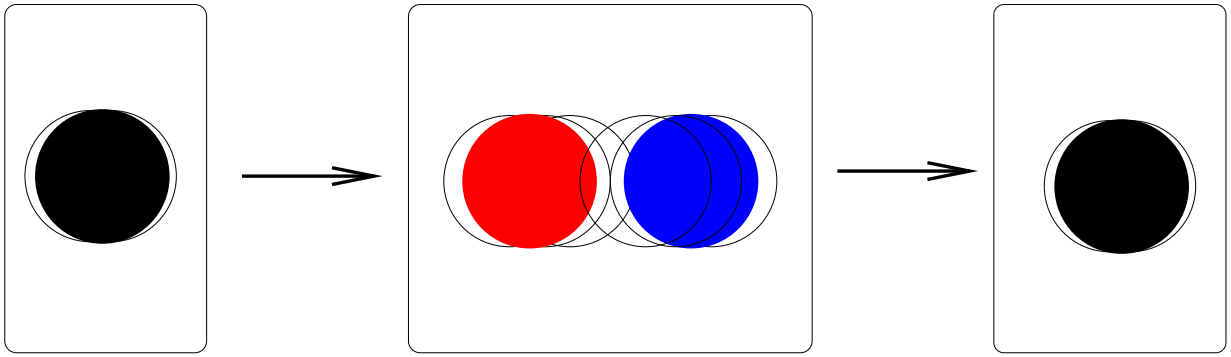
- Hidden devices weakly ($\sim G$) measure the mass distribution.
- Hidden devices collapse (i.e.: disentangle) the massive DOF's.



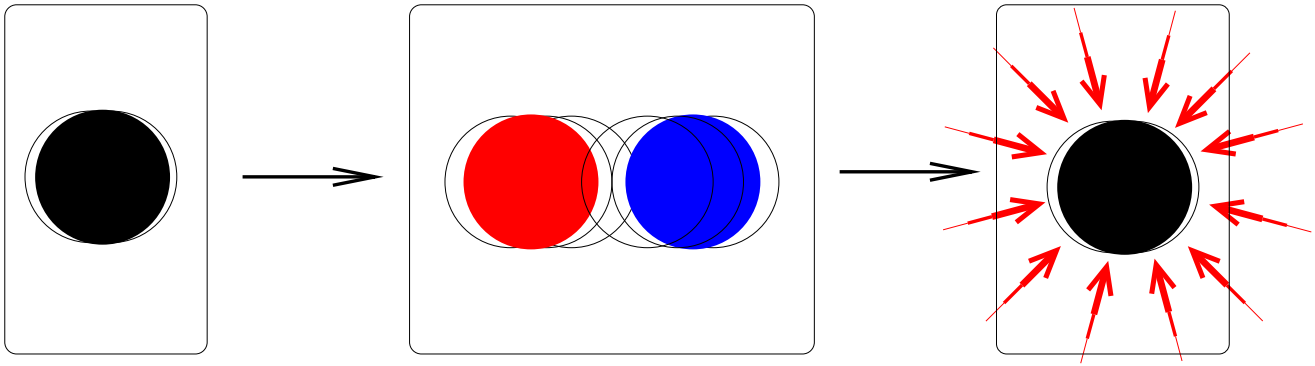
When Schrödinger "spread" of c.o.m. and DP-collapses are balanced:

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

DP Collapse: Cause of Newton Force?



Spontaneous collapses are never detectable.
Only their decoherence effects are detectable...
Experiments: Bouwmeester (Leiden), Aspelmeyer (Vienna), ...
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

Assumption:
Newton forces emerge from collapse at rate $1/\tau_G \sim 1/\mathrm{ms}$.
Consequence:
Newton field has the same emergence time scale $\tau_G \sim 1\mathrm{ms}$.

Minimum heuristic extension of Newton equation (2013):

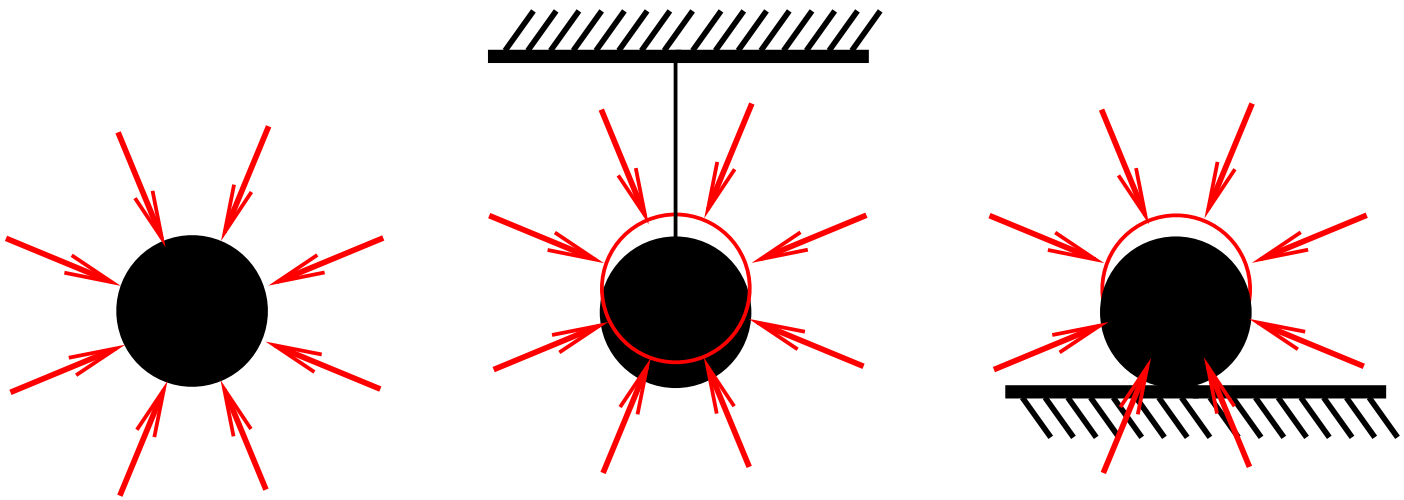
$$\Phi(r,t) = \int_0^\infty \frac{-GM}{|r - x_{t-\tau}|} \mathrm{e}^{-\tau/\tau_G} \frac{d\tau}{\tau_G}$$

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.
Modifications only show up under non-gravitational accelerations.

Testable predictions of gravity's laziness I.

Universal effect in Earth field

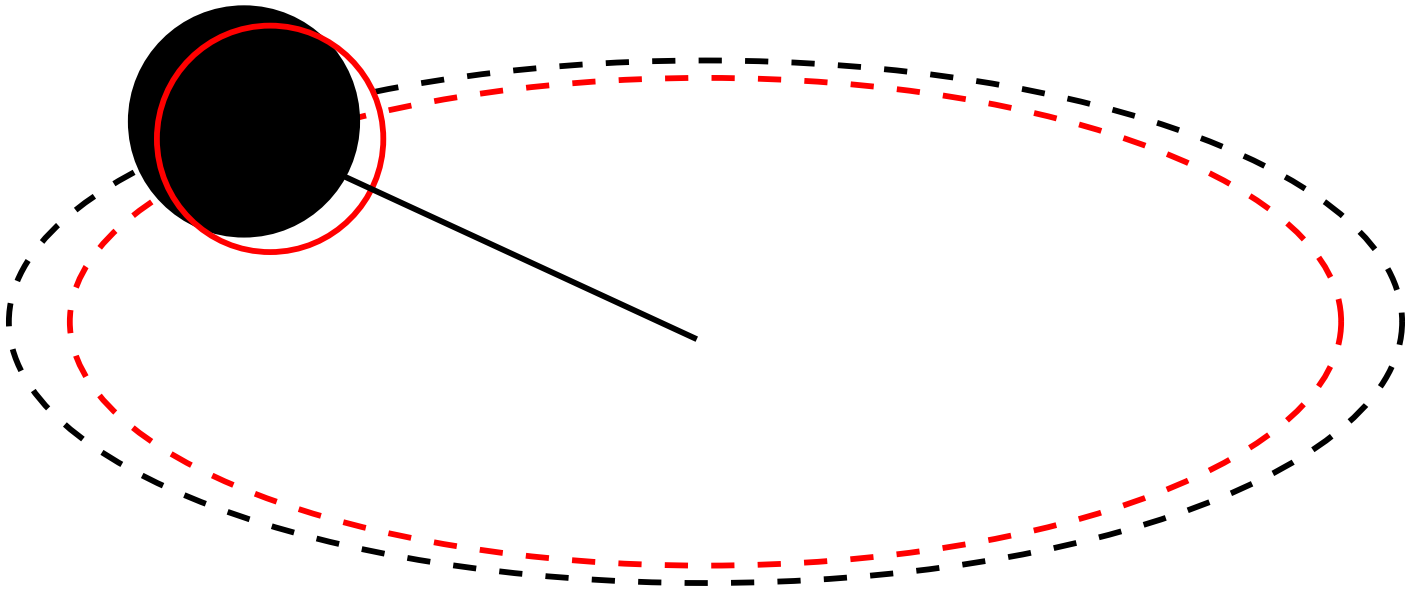


Free falling objects create standard instantaneous Newton forces.
All static objects create Newton forces as if they were higher than their static position, by

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

Testable predictions of gravity's laziness II.

Small effect under moderate non-gravitational force

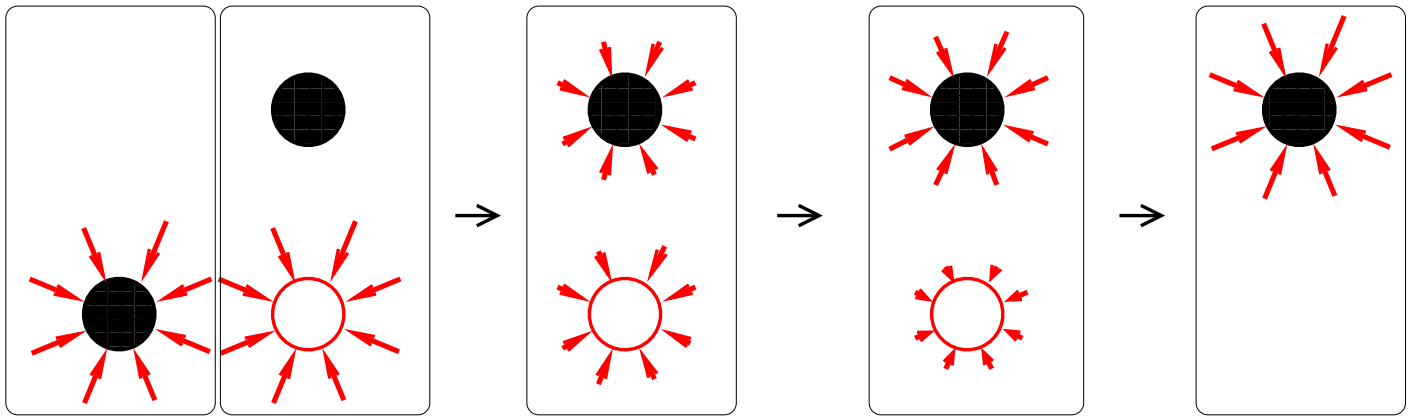


Revolving at (small) angular frequency Ω under non-gravitational force (e.g. of a rope), the accelerated source yields an enhanced Newton force in the center, by the factor

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

Testable predictions of gravity's laziness III.

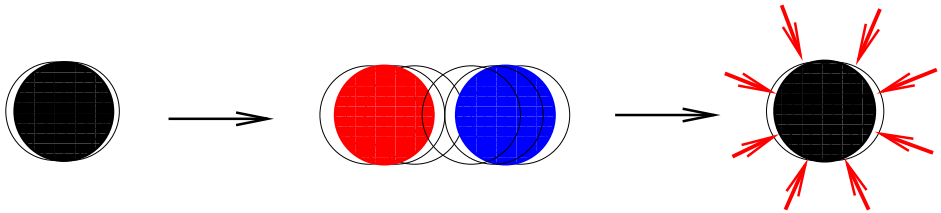
Large delay effect after sudden displacement



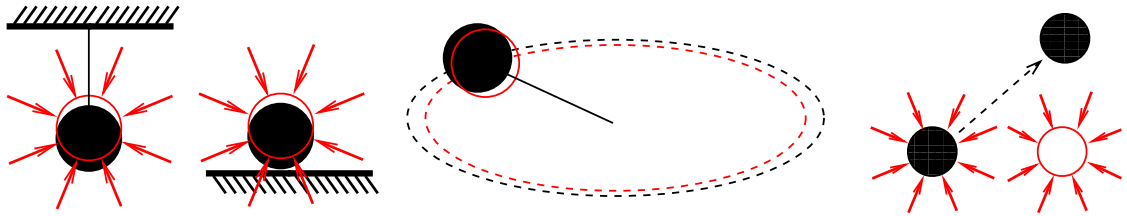
If the source is sudddenly displaced by a non-gravitational force, it's Newton field follows it with the time-delay $\tau_G \sim 1$ms.

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)]; Equation and test of possible delay time of Newton force [EPJ Web of Conf. 78, 02001-(4) (2014)]