DOES WAVE FUNCTION COLLAPSE CAUSE GRAVITY?

Lajos Diósi, Budapest

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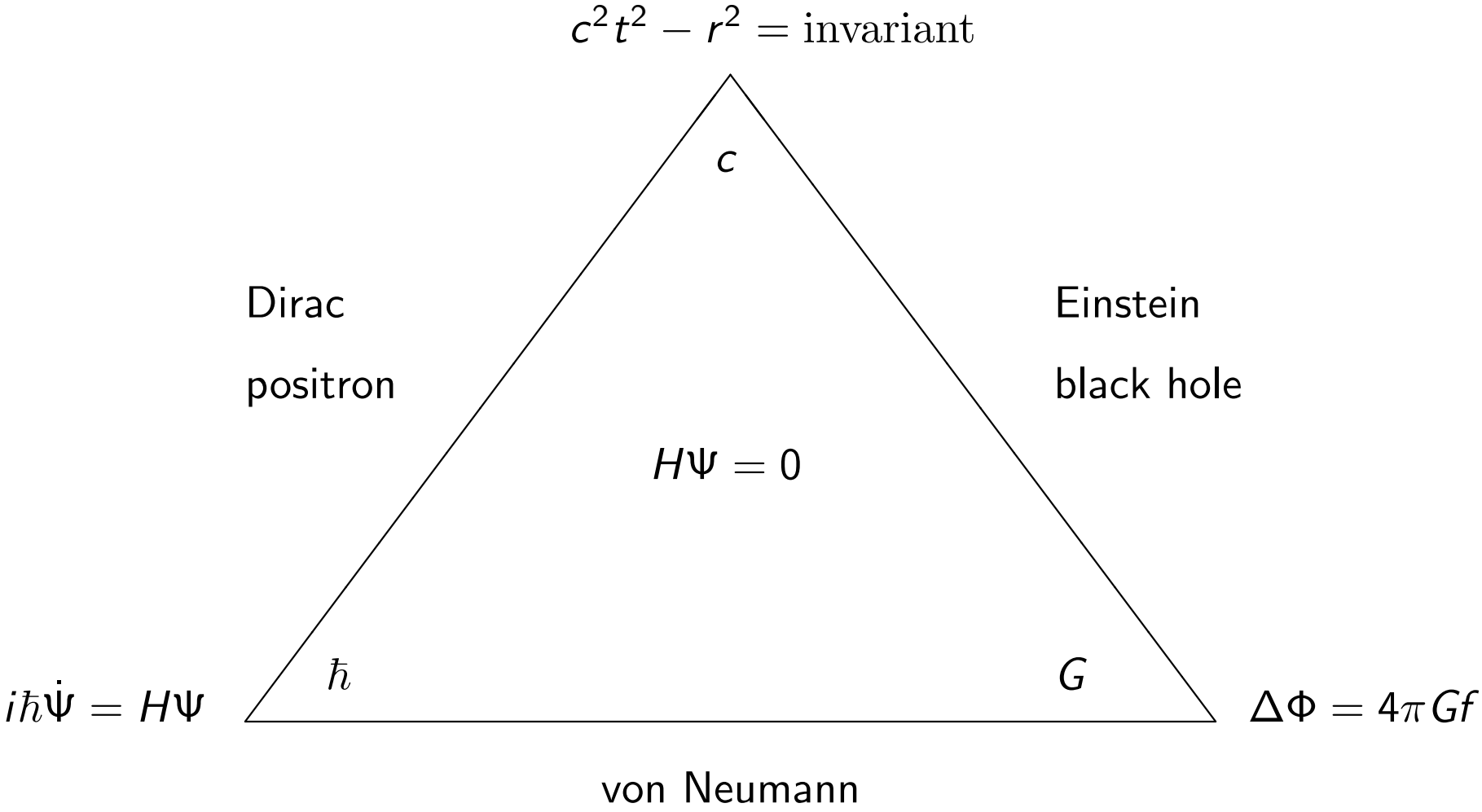
BOTTLE-NECK OF QUANTUM GRAVITY: Q OR G?

Mainstream blames G, sidestream blames Q.



What's wrong with Wheeler-DeWitt Eq. $H\Psi = 0$?

WHAT'S WRONG WITH WHEELER-DEWITT EQ. $H\Psi = 0$?

$$H\left(g, \frac{\partial}{\partial g}, q, \frac{\partial}{\partial q}\right)\Psi(g,q) \;=\; 0$$

g = 3-geometry, q =matter fields

- Generic solution $\Psi(g,q)$ implies no 4-geometry
- No room for von Neumann measurement theory

A remedy would be a certain (hypothetic) universal decoherence to forbid "Schrödinger Cat" states, to enforce wave function collapse into "pointer states" localized in g. The technical key-element is our smart choice for:

- Distance $\ell(g,g')$ between two 3-geometries, to measure "catness"
- Modification of WDW Eq. to decohere Ψ for large ℓ

Full relativistic option is largely unexplored.
Go Newtonian! Decent theoretical results, experimental proposals.

NEWTONIAN DECOHERENCE DISTANCE AND DYNAMICS

Choice for the distance (to measure "catness"):

$$\ell(g, g') = \frac{1}{4\pi G} \int |g - g'|^2 dV$$

g, g' are two Newtonian acceleration fields.
Expressing g, g' through mass densities f, f':

$$\ell(g, g') = G \int \int [f(r) - f'(r)][f(s) - f'(s)] \frac{drds}{|r - s|}$$

Note: mCSL chooses distance directly for f, f', γ is unrelated to G:

$$\ell_{mCSL}(f, f') = \gamma \int [f(r) - f'(r)]^2 dr$$

Interrelated options for non-unitary dynamics:

- Minimalist's model: decay time of catness $= \hbar/\ell(g, g')$ [Penrose]
- Master equation for the density matrix [D.]
- SNE: $\hbar\dot{\Psi} = -i\hat{H}\Psi - i\langle \ell(\hat{g}, .)\rangle_\Psi \Psi$ [Penrose, D.]
- frSNE: $\hbar\dot{\Psi} = -i\hat{H}\Psi - \langle \ell(\hat{g}, .)\rangle_\Psi \Psi$ [vanWezel & vandenBrink, D.]
- jump/diffusive stochastic SNE [D.]

DO WE HAVE TESTABLE PREDICTIONS?

PROPOSED TESTS

Detecting Newton-G-related loss of coherence in:

- nucleon decay [Pearle & Squires]
- flavor oscillations of neutrinos from distant cosmic sources [Christian]
- light propagation from distant stars [Christiansen & Ng & vanDam]
- gravity wave interferometer LIGO/VIRGO [Amelino-Camelia]
- nano-mechanical oscillator [Marshall & Simon & Penrose & Bouwmeester]

Are there more characteristic effects than excess noise?
Well, there would be — in a more radical theory.

GRAVITY CAUSED BY COLLAPSE?

In the above Newtonian-G-related models

- ambiguity/blurredness/noise of g implies decoherence/collapse
- interaction via Newtonian potential is included by hand

CAN'T WE TURN IT AROUND:
WHAT IF COLLAPSE IMPLIES THE NEWTONIAN FIELD?
Example: For a single free mass M, one might like to derive the presence of an average attractive Newtonian field $\overline{g} = -GM/r^2$ *from* the features of the random path of the c.o.m. broken by the repeated collapses.
Exercise: For a classical free spherical Brownian Mass, suppose ideal collisions of short duration compared to intercollision time. Imagine you sit inside the BM and experience the sequence $\Delta v_1, \Delta v_2, \ldots, \Delta v_k, \ldots$ of velocity jumps. Then you shall conclude that *there must be* and average compressing force acting on the surface of the BM (a hydrodamic pressure, this time):

$$P \;=\; \frac{M}{\text{surface x time}} \sum_{k=1}^{n} |\Delta v_k| \qquad (n \to \infty)$$