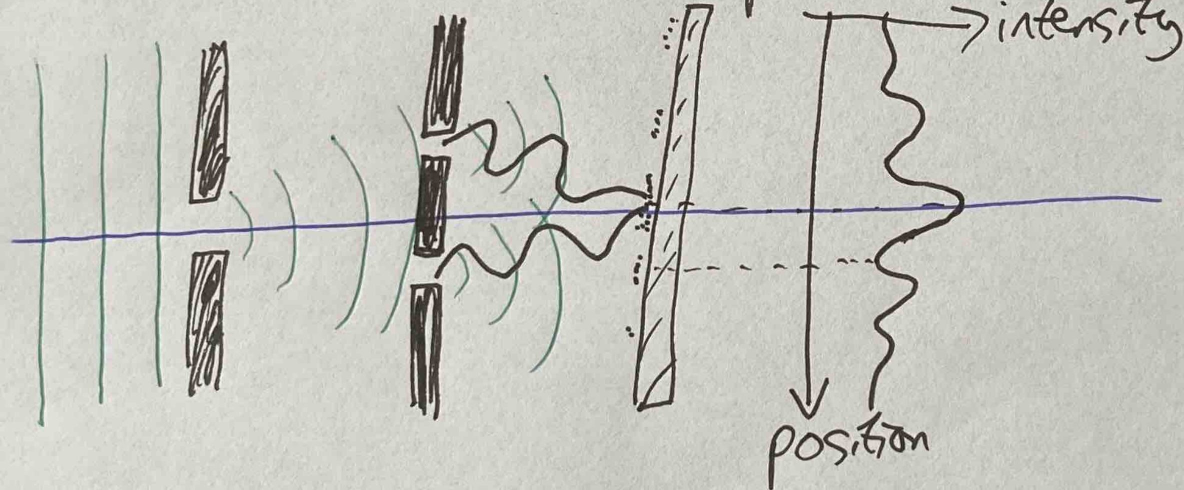
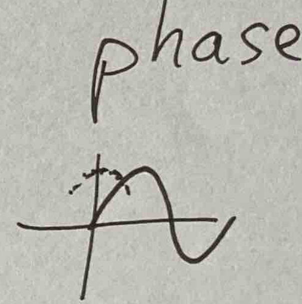
CAN WE TEST THE GRAVITATIONAL EFFECT OF A MASS IN A SUPERPOSITION?

MACROSCOPIC QUANTUM SUPERPOSITIONS TO TEST QUANTUM GRAVITY

QUANTUM MECHANICS

- INTERFEROMETRY
  - Quantum 2-slit experiment





- WAVEFUNCTION

↓

SPATIAL SUPERPOSITION

$$|\psi\rangle = \frac{1}{\sqrt{2}}\left(|L\rangle + |R\rangle\right)$$

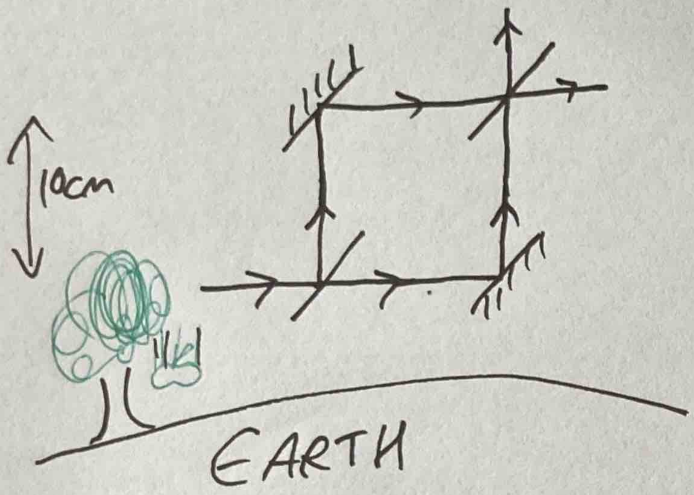
↓

INTERFERENCE

$(p = h/\lambda)$

☆ MOLECULES MADE UP OF 2000 ATOMS [1]

S.E.: $\left[\frac{\hat{p}^2}{2m} + \hat{V}\right]|\psi\rangle = i\hbar\frac{\partial}{\partial t}|\psi\rangle$



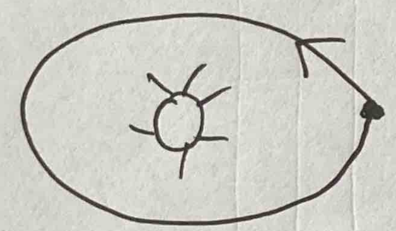
Interferometer

1975

COW [2]

GRAVITY

NEWTON



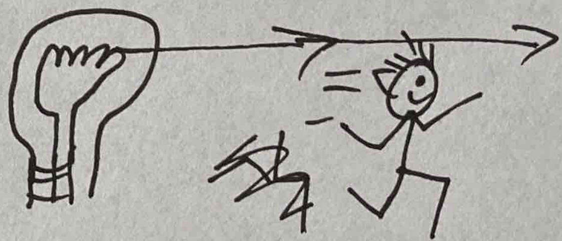
$$F = \frac{GMm}{r^2} \approx mg$$

$$V = \frac{-GMm}{r} \leftarrow \text{GRAVITATIONAL POTENTIAL ENERGY}$$

$$V_{\text{Earth}} \approx mgh$$

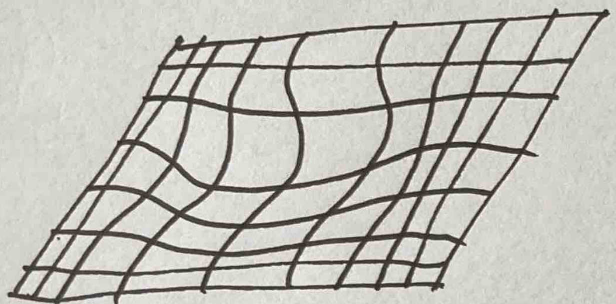
PROBLEMS

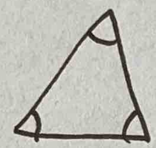
- mediator? x
- instantaneous? x



GENERAL RELATIVITY

MASS CURVES SPACETIME



 180°? ×

1936

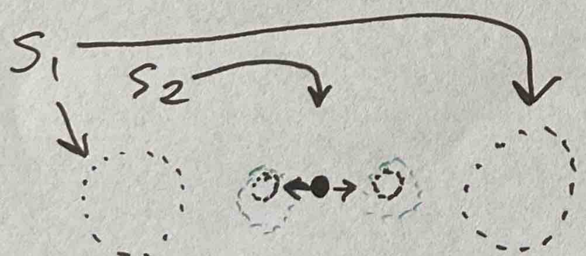
BRONSTEIN

[3, 4, 5]

1957 CHAPEL HILL

FEYNMAN [6]

NANOPARTICLE: $10^8 - 10^{12}$ atoms



$$|\psi_1\rangle = \frac{1}{\sqrt{2}}\left(|L\rangle + |R\rangle\right)$$

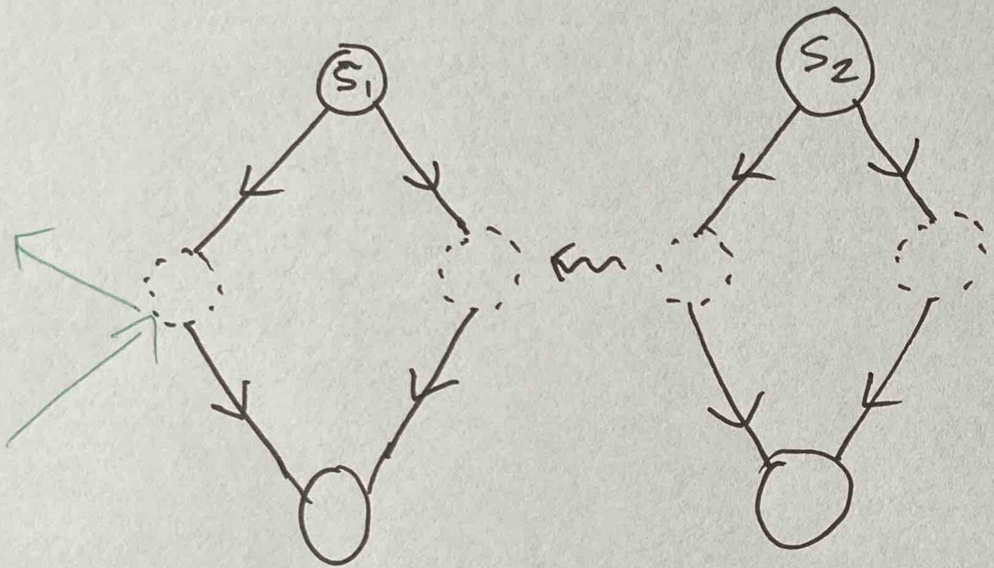
$$|\psi_1\rangle|\psi_2\rangle = \frac{1}{\sqrt{2}}\left(|L\rangle + |R\rangle\right)|\psi_2\rangle$$

$$\Downarrow$$

IF WE HAVE QUANTUM GRAVITY: $|\psi_{\text{entangled}}\rangle = \frac{1}{\sqrt{2}}\left(|L,L\rangle + |R,R\rangle\right)$

2017 [7, 8]

DECOHERENCE



- $2 \mu m$ across
- 10^{-14} kg
- 10^{12} atoms

☆ ONLY A QUANTUM THING CAN ENTANGLE THINGS