

Title: Quantum Foundations Lecture - 230102

Speakers: Lucien Hardy

Collection: Quantum Foundations (2022/2023)

Date: February 01, 2023 - 9:00 AM

URL: <https://pirsa.org/23020015>

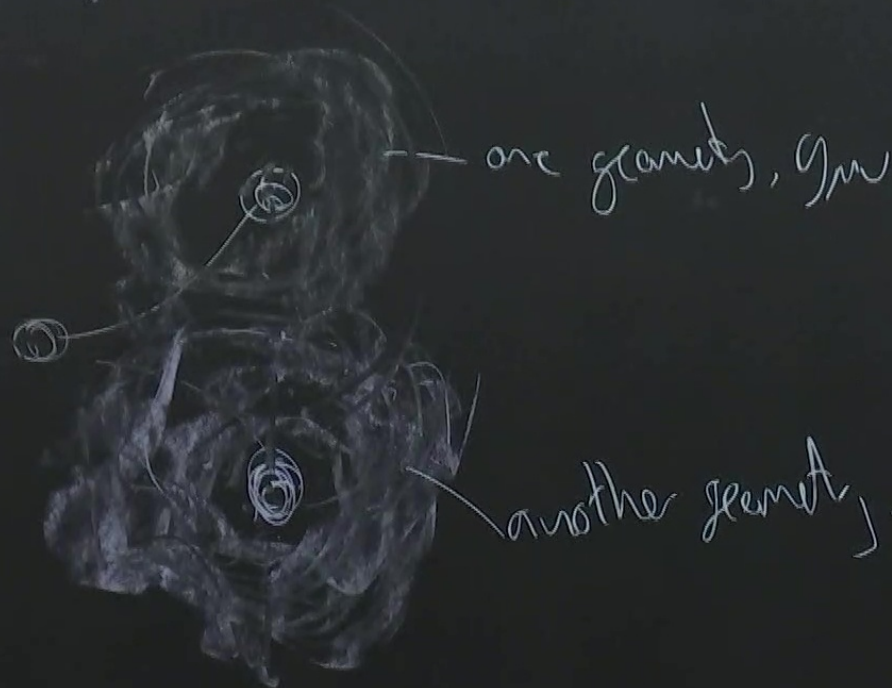
Collapse models - P. Pearle, GRW, J. Bell.

Motivation: To solve measurement problem by explicitly modifying the Schrodinger eqn

small object: hardly influenced at all by modification

big object: strongly influenced by the modification

Possible physical justification from QG - Diosi/Penrose



can't identify
points

$\Rightarrow$ can't set up
a "t" across
both terms

$\Rightarrow$ 'Something has "gotta give"

$$T = \frac{\hbar}{E_0}$$

E_0 is the gravitational self energy

$$E_0 = -4\pi G \iint \frac{(\rho(x) - \rho'(x))(\rho(y) - \rho'(y))}{|x-y|} d^3x d^3y$$

$$T = \frac{\hbar}{E_0} \quad \text{timescale for collapse}$$

E_0 is the gravitational self energy

$$E_0 = -4\pi G \iint \frac{(\rho(x) - \rho'(x))(\rho(y) - \rho'(y))}{|x-y|} d^3x d^3y$$

The Bell presentation of GRW.

① The ontology.

② wave fn $\psi(\vec{r}_1, \vec{r}_2, \dots, \vec{r}_N, t)$

③ A way to get local beables $\rightarrow$ Bell flash ontology

$\rightarrow$ Ghirardi mass density ontology

④ Dynamics. Schrödinger evolution except when a "jump" occurs.

Details on jump process.

(i) The prob per unit time per particle for a jump is

$$\frac{1}{\tau}$$

τ is a new fundamental constant of nature.

have a Poisson distribution

$$\text{prob}(m \text{ jumps in time } T) = \frac{e^{-\left(\frac{N}{\tau}\right)} \left(\frac{N}{\tau} T\right)^m}{m!}$$

(ii) The jump is

$$\psi \rightarrow \frac{j(\vec{x} - \vec{r}_n) \psi(\vec{r}_1, \dots, \vec{r}_n, t)}{R_n(\vec{x})}$$

Usual choice for $j(\vec{r})$ is

$$j(\vec{x}) = k \exp\left(\frac{-|\vec{x}|^2}{2a^2}\right)$$

a is another fundamental constant

$$|R_n(x)|^2 = \int d^3\vec{r}_1 \dots d^3\vec{r}_N |j(\vec{x} - \vec{r}_N) \psi(\vec{r}_1, \dots, \vec{r}_N, t)|^2$$

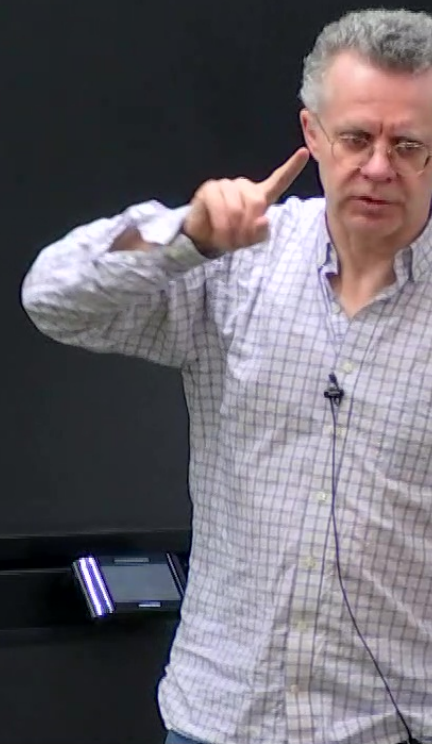
(iii) The collapse centre $\vec{x}$ is chosen with prob distribution

$$|R_n(\vec{x})|^2$$

$$|R_n(x)|^2 = \int d^3\vec{r}_1 \dots d^3\vec{r}_N |j(\vec{x} - \vec{r}_N) \psi(\vec{r}_1, \dots, \vec{r}_N, t)|^2$$

(iii) The collapse centre $\vec{x}$ is chosen with prob distribution

$$|R_n(\vec{x})|^2$$



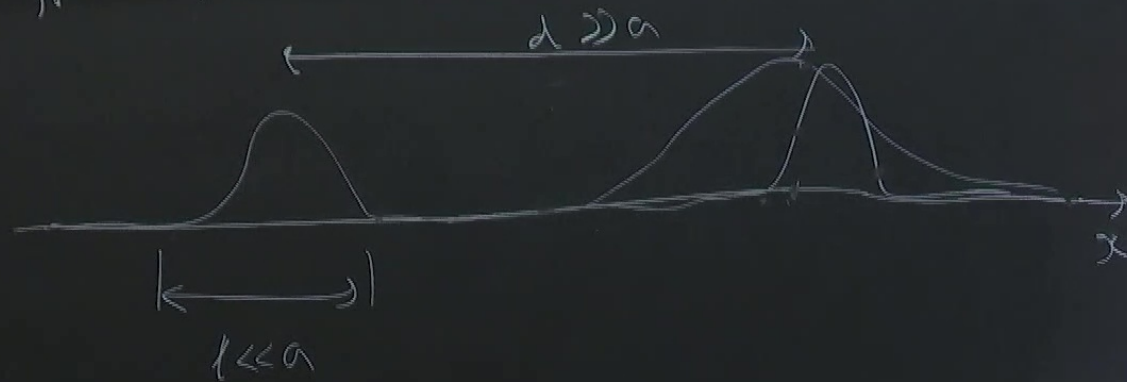
$$|R_n(x)|^2 = \int d\vec{r}_1 \dots d\vec{r}_N |j(\vec{x} - \vec{r}_N) \chi(\vec{r}_1, \dots, \vec{r}_N, t)|^2$$

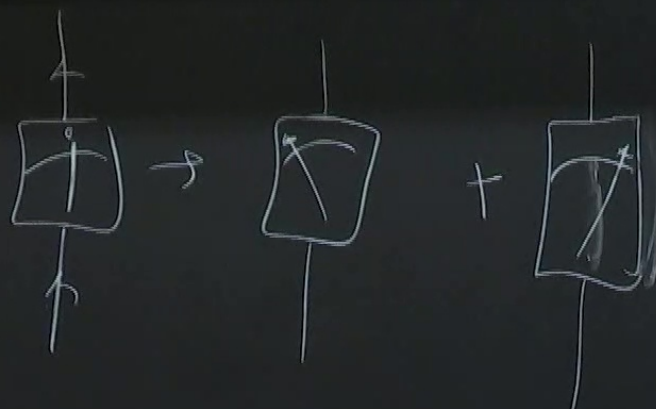
(iii) The collapse centre $\vec{x}$ is chosen with prob distribution

$$|R_n(\vec{x})|^2$$

(iv) GRW suggested $\tau = 10^{15} \text{ sec} \simeq 10^8 \text{ years}$

A typical quantum experiment.





$$|\psi\rangle|A_0\rangle \rightarrow \alpha|a_1\rangle|A_1\rangle + \alpha|a_2\rangle|A_2\rangle$$

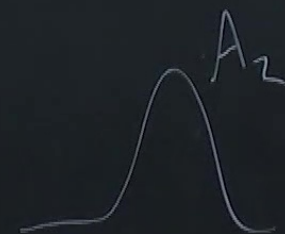
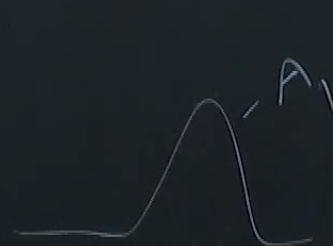
$\alpha|a_1\rangle|A_1\rangle$

$$\alpha a(r_1) \prod_{n=2}^N A_1(r_n) + \beta a_2(r_1) \prod_{n=2}^N A_2(r_n)$$

where $|A_1(r_n)|/|A_2(r_n)| \simeq 0$

$$\alpha a(r_1) \prod_{n=2}^N A_1(r_n) + \beta a_2(r_1) \prod_{n=2}^N A_2(r_n)$$

where $|A_1(r_n)|/|A_2(r_n)| \simeq 0$



jump $\rightarrow \simeq a_1(r_1) \prod_{n=2}^N A_1(r_n)$

$$|\psi\rangle|A_0\rangle \rightarrow \alpha|a_1\rangle|A_1\rangle + \alpha|a_2\rangle|A_2\rangle$$

1 is system, 2 is N are pointer

where $|A_1(r_n)|/|A_2(r_n)| \approx 0$

jump $\rightarrow \approx \alpha_1(r) \prod_{n=1}^N A_1(r_n)$



A typical quantum experiment.

