

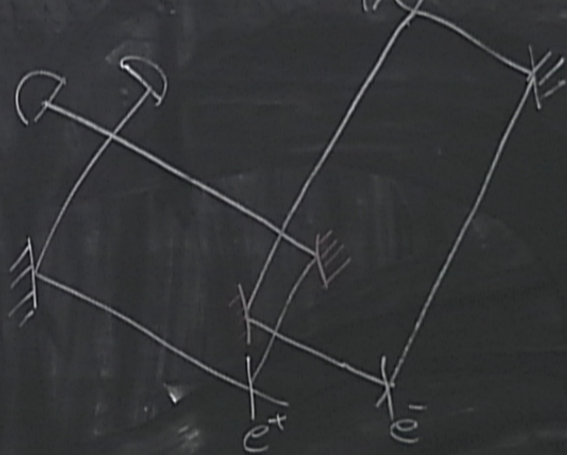
Title: 13/14 PSI - Foundations of Quantum Mechanics - Lecture 7

Date: Jan 15, 2014 11:30 AM

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Abstract:

Correction to Home



The many worlds interpretation (Everett 1957)

The axioms.

- ① The ontic state at time t is given by a wave function $|\psi(t)\rangle$

The many worlds interpretation (Everett 1957)

The axioms.

① The ontic state at time t is given by a wavefunction $|\psi(t)\rangle$

② The wavefunction evolves according to the Schrödinger eqn

$$i\hbar \frac{d|\psi\rangle}{dt} = \hat{H} |\psi\rangle$$

Everett (1957)

represented by a wave function $|\psi(t)\rangle$

to the Schrödinger eqn

And
that's
it!

The claim is that these actions are sufficient

(a) to recover appearances (definite worlds)

(b) to recover the Born rule
($\text{prob} = |\text{amplitude}|^2$)

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will follow David Wallace's

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Born rule
amplitude²)

will follow David Wallace's treatment

} influenced by Simon Saunders.

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see David W's book.

At fundamental level we have a ψ defined on the fundamental particle

At fundamental level we have a ψ defined on the fundamental particles and fields
Wallace uses decoherence to argue that at the macroscopic level

At fundamental level we have a ψ defined on the fundamental particles and fields

Wallace uses decoherence to argue that at the macroscopic level we have the emergence of quasiclassical worlds in a branching structure.

$$|\psi\rangle = \alpha|a_1\rangle + \beta|a_2\rangle$$

$$|\psi\rangle|A_0\rangle|B_0\rangle \rightarrow \underbrace{\alpha|a_1\rangle|A_1\rangle|B_0\rangle}_{\gamma|b_1\rangle + \delta|b_2\rangle} + \underbrace{\beta|a_2\rangle|A_2\rangle|B_0\rangle}_{\mu|b_1\rangle + \nu|b_2\rangle}$$

$$\gamma^* \mu + \delta^* \nu = 0$$

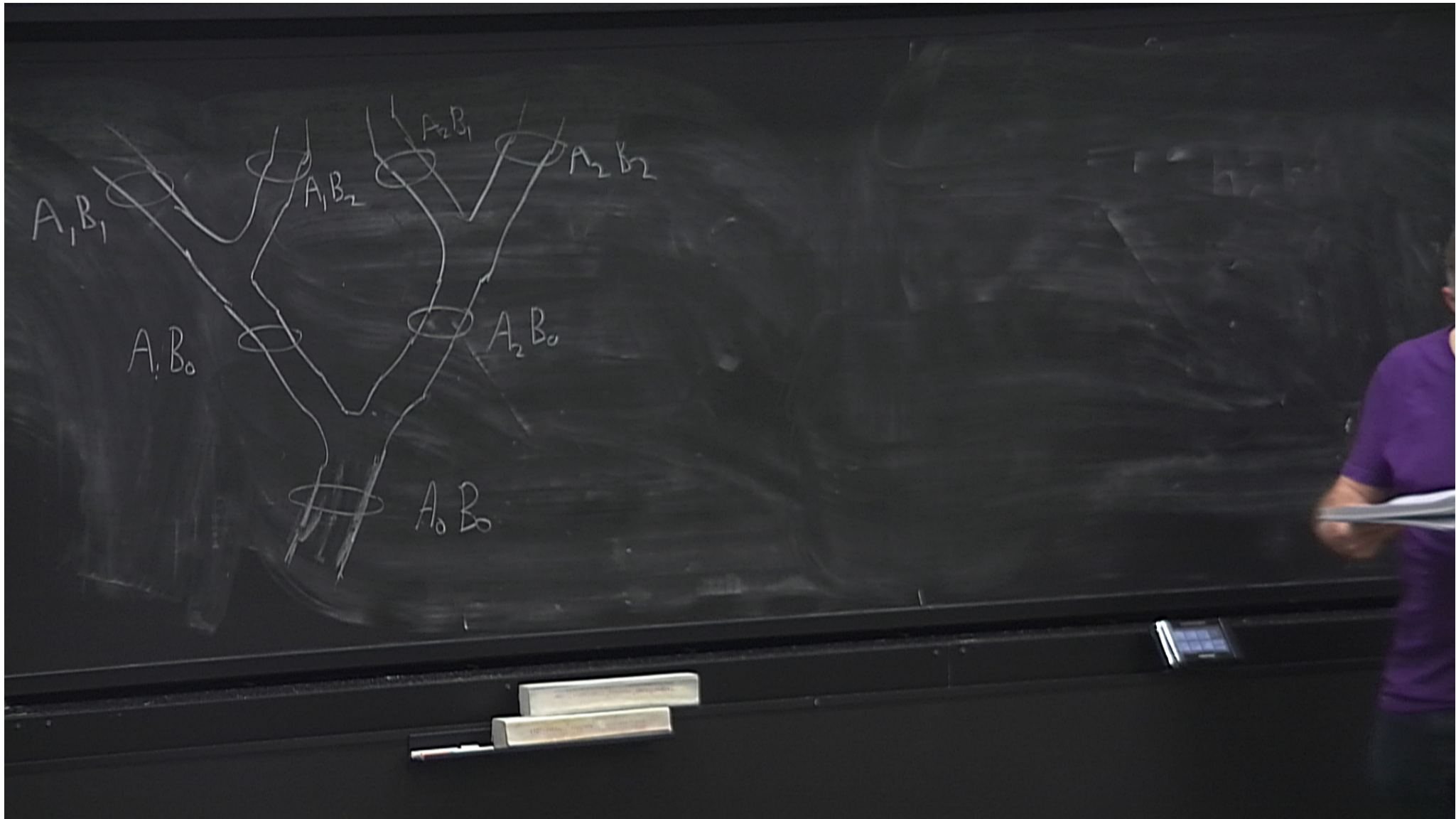
$$\rightarrow \alpha\gamma|b_1\rangle|A_1\rangle|B_1\rangle + \alpha\delta|A_1\rangle|B_2\rangle + \beta\mu|b_1\rangle|A_2\rangle|B_1\rangle + \beta\nu|A_2\rangle|B_2\rangle$$

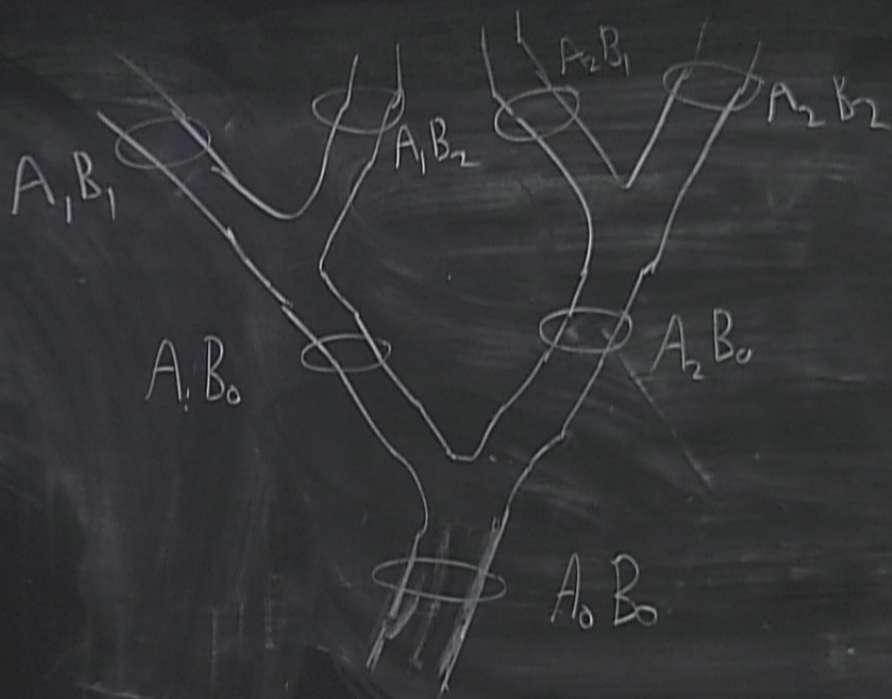
$$|\psi\rangle_S = \alpha|a_1\rangle + \beta|a_2\rangle$$

$$|\psi\rangle_S |A_0\rangle |B_0\rangle \rightarrow \underbrace{\alpha|a_1\rangle |A_1\rangle}_{\gamma|b_1\rangle + \delta|b_2\rangle} \underbrace{|B_2\rangle + \beta|a_2\rangle |A_2\rangle}_{\mu|b_1\rangle + \nu|b_2\rangle} |B_0\rangle$$

$$\gamma^* \mu + \delta^* \nu = 0$$

$$\rightarrow \alpha \gamma |b_1\rangle |A_1\rangle |B_1\rangle + \alpha \delta |A_1\rangle |B_2\rangle + \beta \mu |b_1\rangle |A_2\rangle |B_1\rangle + \beta \nu |b_2\rangle |A_2\rangle |B_1\rangle$$





What pick out the $\{|A_i\rangle|B_j\rangle\}$ basis?

Why not, instead,

$$\frac{1}{\sqrt{2}}(|A_1\rangle \pm |A_2\rangle)$$

Answer - decoherence.

(can show

$$|A_i\rangle|E_{\text{before}}\rangle \rightarrow |A_i\rangle|E_i\rangle$$

This picks out a basis.

$$\text{Eg } (|A_1\rangle \pm |A_2\rangle)$$

This picks out a basis.

$$\text{Eg } \frac{1}{\sqrt{2}}(|A_1\rangle \pm |A_2\rangle) |E_{\text{before}}\rangle \rightarrow \frac{1}{\sqrt{2}}(|A_1\rangle |E_1\rangle \pm |A_2\rangle |E_2\rangle)$$

This picks out a basis.

$$\text{Eg } \frac{1}{\sqrt{2}}(|A_1\rangle \pm |A_2\rangle) |E_{\text{before}}\rangle \rightarrow \frac{1}{\sqrt{2}}(|A_1\rangle |E_1\rangle + |A_2\rangle |E_2\rangle)$$

gets correlated with environment

whereas

$$|A_i\rangle |E_{\text{before}}\rangle \rightarrow |A_i\rangle |E_{\text{before}}\rangle$$

the states in this basis persist:

This picks out a basis.

$$\text{Eg } \frac{1}{\sqrt{2}}(|A_1\rangle \pm |A_2\rangle) |E_{\text{before}}\rangle \rightarrow \frac{1}{\sqrt{2}}(|A_1\rangle |E_1\rangle + |A_2\rangle |E_2\rangle)$$

gets correlated with environment

whereas

$$|A_i\rangle |E_{\text{before}}\rangle \rightarrow |A_i\rangle |E_i\rangle \rightarrow |A_i\rangle |E_c\rangle$$

the states in this basis persist:

⑤. The problem

Every branch that has non zero amplitude in

see David V. Book.

on zero amplitude in $|\psi\rangle$ certainly happens.

see David V. Book.

very much that has non zero amplitude in $|\psi\rangle$ certainly happens

Eg

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

$$\alpha|a_1\rangle + \beta|a_2\rangle$$

what if $\beta = 10^{-100}$ but the $|A_2\rangle$ branch
definitely happens.

see David V. Book.

very much that has non zero amplitude in $|\psi\rangle$ certainly happens

Eg

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

$$\alpha|a_1\rangle + \beta|a_2\rangle$$

what if

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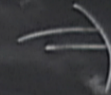
why not

$$P(A_2) =$$

or why not

$$|\psi\rangle^{\otimes N} |A_0\rangle^{\otimes N} \rightarrow \alpha^N |a\rangle^{\otimes N} |A_1\rangle^{\otimes N} + \dots$$

probabilities are a measure of agents subjective beliefs.



Decision theory

$R^b(s)$

States s $\xrightarrow[b]{\text{acts}}$ Rewards r

$b_1 > b_2$ (I prefer b_1 to b_2) & $b_2 > b_3 \Rightarrow b_1 > b_3$

beliefs.

$\Rightarrow$ A representation theorem.

① $\exists$ unique $P_r(s)$ such that $\sum_{s \in S} P_r(s) = 1$

and if we have $b_1 > b_2$

$b_1 > b_2$

e beliefs.

$\Rightarrow$ A representation theorem.

① $\exists$ unique $P_r(s)$ such that $\sum_{s \in S} P_r(s) = 1$

and if we have $b_1 > b_2$

then

$$\sum_{s \in S} P_r(s) U(b_1(s)) > \sum_{s \in S} P_r(s) U(b_2(s))$$

$\Rightarrow b_1 > b_2$

e beliefs.

⇒ A representation theorem.

- ① $\exists$ unique $P_r(s)$ such that $\sum_{s \in S} P_r(s) = 1$
 - ② $\exists$ a function $U[b(s)] \rightarrow$ rewards.
- and if we have $b_1 > b_2$

⇒ $b_1 > b_2$

$$\sum_{s \in S} P_r(s) U[b_1(s)] > \sum_{s \in S} P_r(s) U[b_2(s)]$$

$U[\cdot]$ is unique upto affine transformations.

$$U' \rightarrow aU + b$$

Wallace's axioms.

$\Rightarrow$ equal amplitude branches $\Rightarrow$ equal probabilities

$$\# \text{ prob} = |\text{amplitude}|^2$$