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13:00: Lab tour (if interested). Meet here.

Lecture Notes: Probabilistic Theories and Reconstructions of Quantum Theory, arXiv: 2011.01286.

PART 1

Today: 1. Perfectly distinguishable states in a GPT

2. A slightly different reconstruction of QT (sketch)

[redacted]

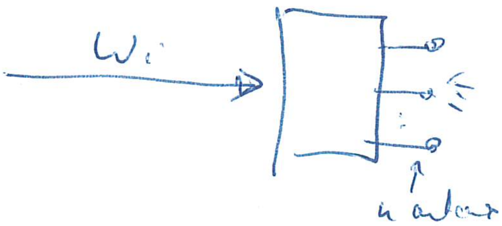
3. Why has the qubit a ball state space?
(Super-brief sketch: why $d=3$?)

4. The qubit and relativity of simultaneity

1. [redacted] Ω: state space of a GPT.

You obtain unknown state $\omega \in \Omega$, but are promised that it's one of [redacted] n states $\omega_1, \omega_2, \ldots, \omega_n$.

Can you have a device where



i'th outcome obtained with certainty

Mathematically: $e_1, e_2, \ldots, e_n$ linear functionals with

[redacted] $0 \leq (e_i, \omega) \leq 1$ for all $\omega \in \Omega$

$$\sum_i (e_i, \omega) = 1 \text{ for all } \omega$$

and $(e_i, \omega_j) = \delta_{ij}$?

① QT: [redacted] For pure states: $\omega_1 = |\psi_1\rangle\langle\psi_1|, \ldots, \omega_n = |\psi_n\rangle\langle\psi_n|$

If a measurement can do it, then a <u>projective</u> measurement can.

<u>Wlog</u>: $(e_i, \omega_j) = \mathrm{tr}(P_i |\psi_j\rangle\langle\psi_j|) = \langle\psi_j|P_i|\psi_j\rangle = \delta_{ij}$

The P_i project onto mutually $\perp$ subspaces S_i

Need that $|\psi_j\rangle \in S_j \Rightarrow \langle\psi_i|\psi_j\rangle = \delta_{ij}$

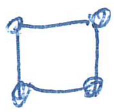
states are mutually orthogonal. $\boxed{\text{DISCUSS!}}$

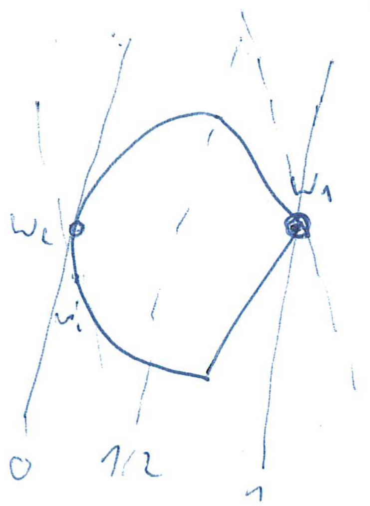
For mixed states: $\rho_i \rho_j = 0$ for $i \neq j$, i.e. mutually $\perp$ supports.

$N :=$ maximal number of perf. dist. states of a GPT system

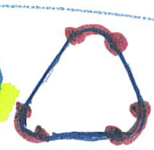
qubit: $N=2$. N-level quantum system: N [redacted] $= \dim \mathcal{H}$.

classical k-outcome GPT: $\Omega = \{(p_1, \ldots, p_k) \mid p_i \geq 0, \sum_i p_i = 1\}$ $N = k$

Gbit:  $N=2$. Can distinguish all pure states perfectly, but not jointly from each other.

<u>GPT</u>: 

which states ω_2 can be perf. dist. from ω_1?
$(e_1, \omega_1) = 1$, $(e_1, \omega_2) = 0$

[redacted] old slides 2370  

[redacted]

ω is a <u>pure</u> state, if it cannot be written in the form
$\omega = \lambda \cdot \omega_1 + (1-\lambda)\omega_2$, $\omega_1 \neq \omega_2$, $0 < \lambda < 1$. <u>QT</u>: $\omega = |\psi\rangle\langle\psi|$