Comparison with Bell's Theorem

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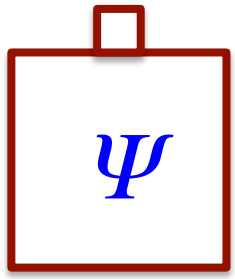
- Well, yes…

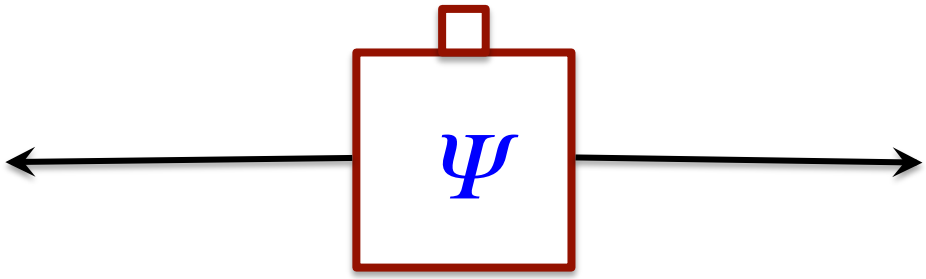
Comparison with Bell's Theorem

- Isn't pseudotelepathy just another form of Bell's theorem?
- Well, yes and no!

Three flavours of Bell's Theorem



Three flavours of Bell's Theorem



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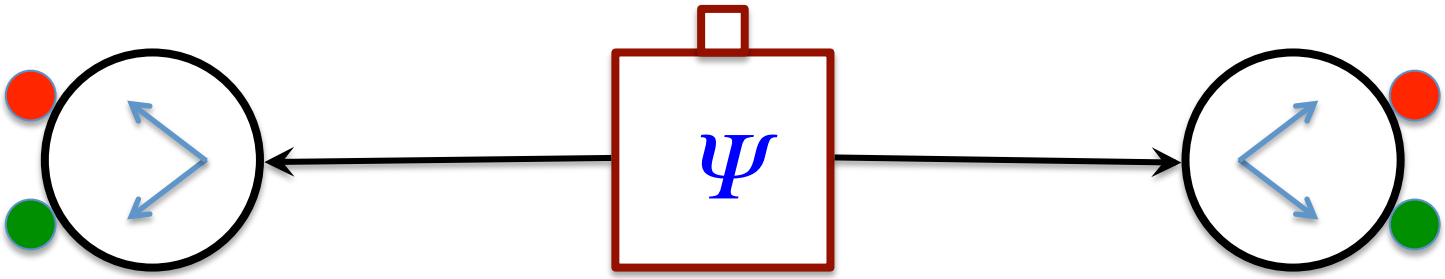

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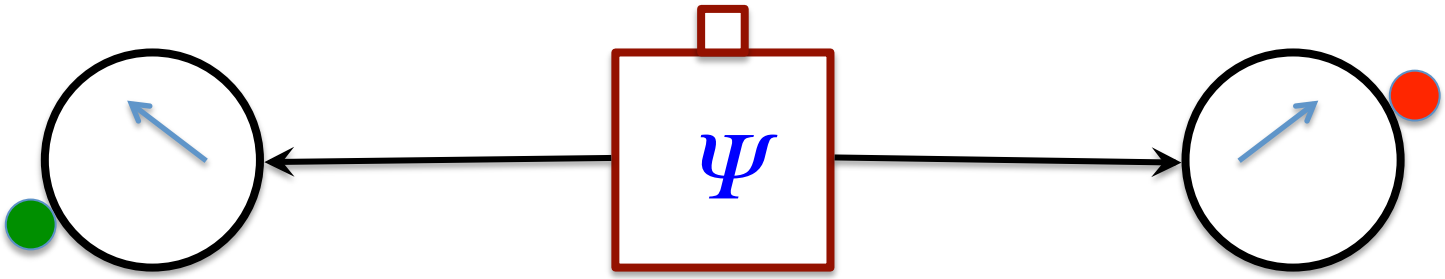

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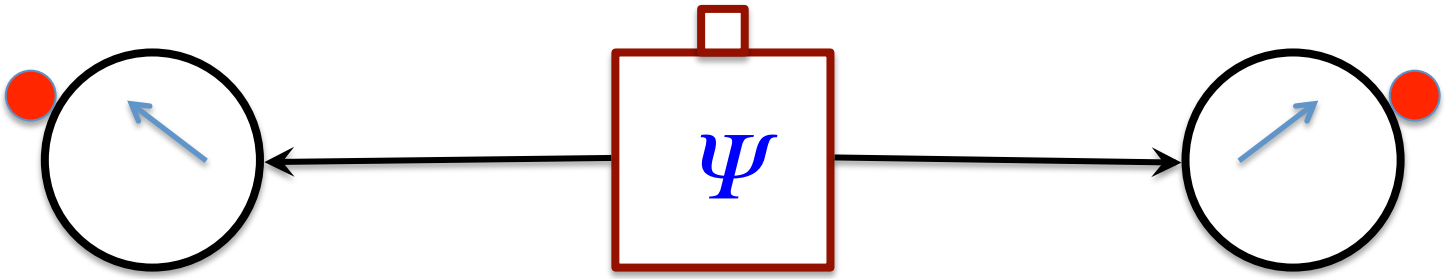

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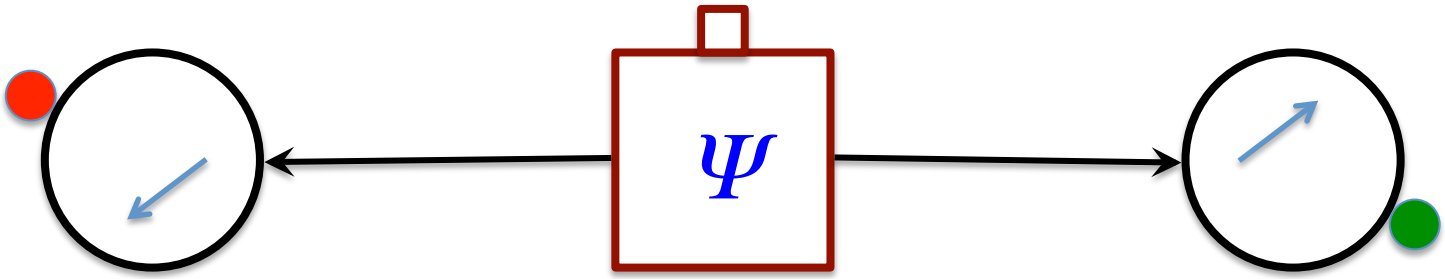

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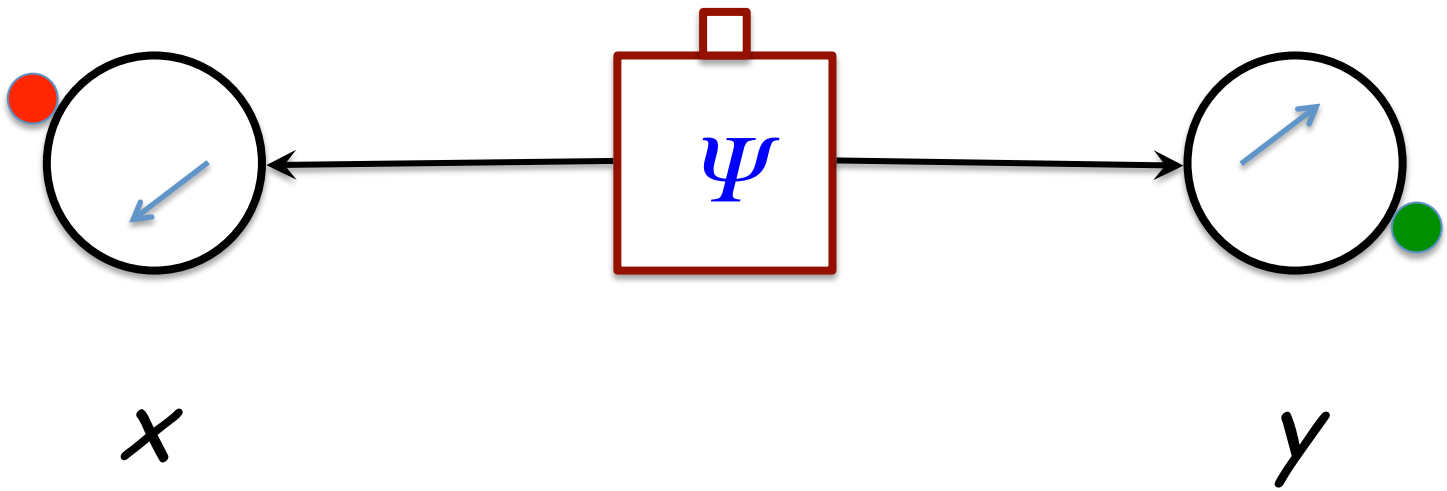

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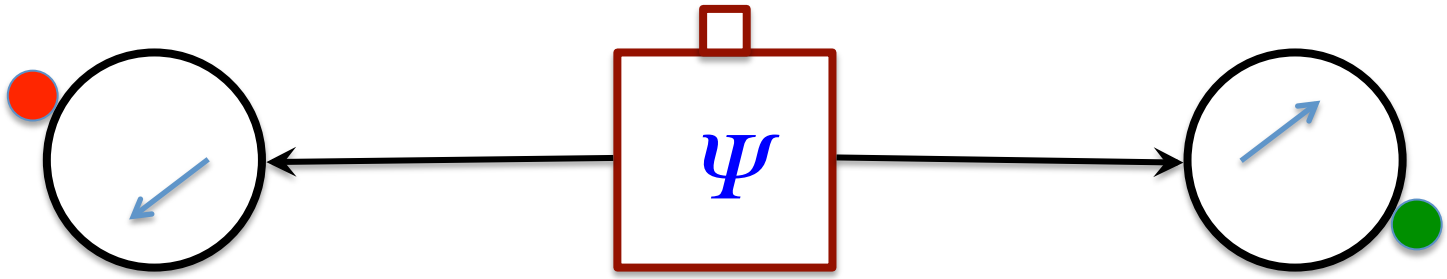

$a \leftarrow x$

$y \rightarrow b$

Three flavours of Bell's Theorem

- The box defines conditional probabilities

$$prob_{QM}(a, b \mid x, y).$$

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- Can these probabilities be reproduced classically without communication, allowing classical correlation (hidden variables)?

Three flavours of Bell's Theorem

- The box defines conditional probabilities

$$prob_{QM}(a, b \mid x, y).$$

- Let

$$prob_{C}(a, b \mid x, y)$$

denote some classical probability.

Bell's Theorem

With some Ψ and measurements, there cannot exist a classical $prob_C$ such that

$$prob_{QM} = prob_C$$

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For instance, the singlet:
as in Bell's original theorem.

Bell's Theorem

With some Ψ and measurements, there cannot exist a classical $prob_C$ such that

$$prob_{QM}(a, b \mid x, y) = prob_C(a, b \mid x, y)$$

for all a, b, x and y.

Bell's Theorem
Without Inequalities

With some Ψ and measurements, there cannot exist a classical $prob_C$ such that

$$prob_{QM}(a, b \mid x, y) = 0 \text{ if and only if } prob_C(a, b \mid x, y) = 0$$

for all a, b, x and y.

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For instance the GHZ and Hardy's state.

Pseudotelepathy

With some Ψ and measurements, there cannot exist a classical $prob_C$ such that

$$prob_{QM}(a, b \mid x, y) = 0 \text{ implies that}$$
$$prob_C(a, b \mid x, y) = 0$$

for all a, b, x and y.

Theorems

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- It is not possible to exhibit pseudo-telepathy with any 2x2 entangled state.

Theorems

- It is not possible to exhibit a Bell Theorem Without Inequalities (BTWI) with a maximally entangled 2x2 state. (but of course they can be used to exhibit Bell's Theorem).
- It is not possible to exhibit pseudo-telepathy with any 2x2 entangled state (but Hardy's state can exhibit BTWIs).

Hierarchy Theorem

- Any quantum state that can exhibit a BTWI can exhibit a Bell's Theorem.

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- Any quantum state that can exhibit a BTWI can exhibit a Bell's Theorem.

- Any quantum state that can exhibit pseudotelepathy can exhibit a BTWI.

Hierarchy Theorem

- Any quantum state that can exhibit a BTWI can exhibit a Bell's Theorem.
- But not vice versa.
- Any quantum state that can exhibit pseudotelepathy can exhibit a BTWI.
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