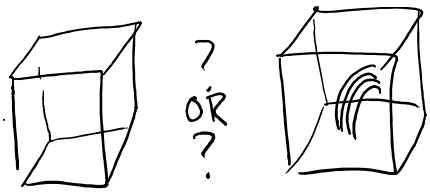
S. KIMMEL

Quantum Bomb Detection (Elitzur Vaidman Bomb Test)

(Rainbow)

You have a clear box. Nothing is in box, or a very sensitive rainbow bomb is in box, which will detonate a rainbow if a photon hits it.



Shoot photon at box:

- No Bomb → photon comes out other side of box
- Bomb → photon triggers bomb

This is the only way you can interact with box.

You would like to give a rainbow bomb to your parent, but you are worried you have a dud. What to do?

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Beamsplitter

- Transmits $|0\rangle$ ($\updownarrow$)
- Reflects $|1\rangle$ ($\leftrightarrow$)

Use ⧅ symbol for beamsplitter

ex: $|0\rangle \rightarrow$ ⧅ $\rightarrow |0\rangle$ (transmission)

$|1\rangle \rightarrow$ ⧅ $\downarrow |1\rangle$ (reflection)

ex: $|+\rangle = \frac{1}{\sqrt{2}}(|0\rangle + |1\rangle) \rightarrow$ ⧅ $\frac{1}{\sqrt{2}}|0\rangle$ → mirror, $\frac{1}{\sqrt{2}}|1\rangle$ → ⧅ → ?, ↓ ?

Single photon is in a superposition of 2 paths. One photon was both transmitted + reflected. It is in a superposition of two locations.

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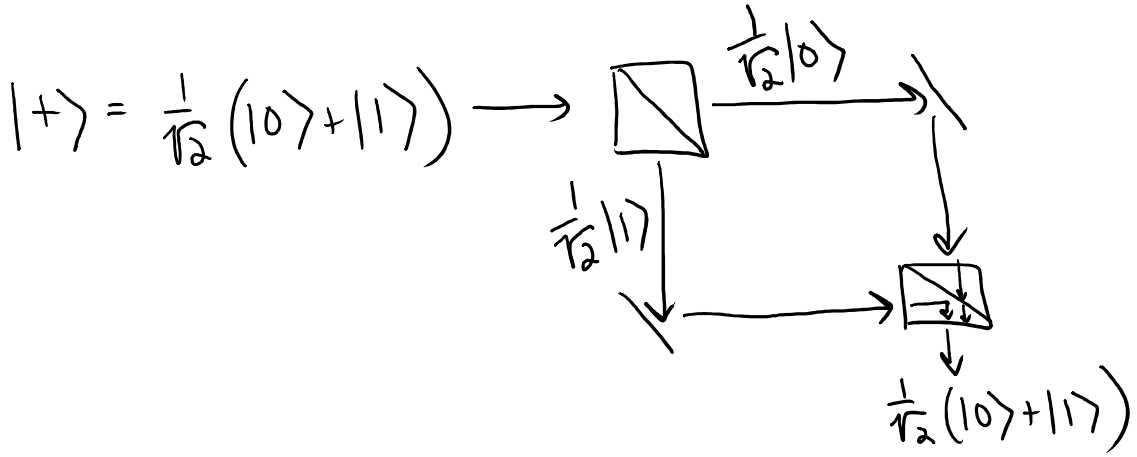
Q: What emerges from the second beamsplitter?

A) Nothing

B) $|+\rangle$ going down

C) $|+\rangle$ going right

D) 2 photons



Big Idea: Put bomb in one path. Less likely to explode, and maybe can learn something without exploding

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Mathematically, 1 photon described by polarization and path: 2 qubits!

$$|\psi_R\rangle_P |\psi_P\rangle_A$$

$|\psi_R\rangle_P$: polarization

$|\psi_P\rangle_A$: path (A for "arm")