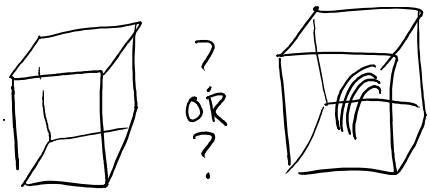
S. KIMMEL

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.

What to Do!?

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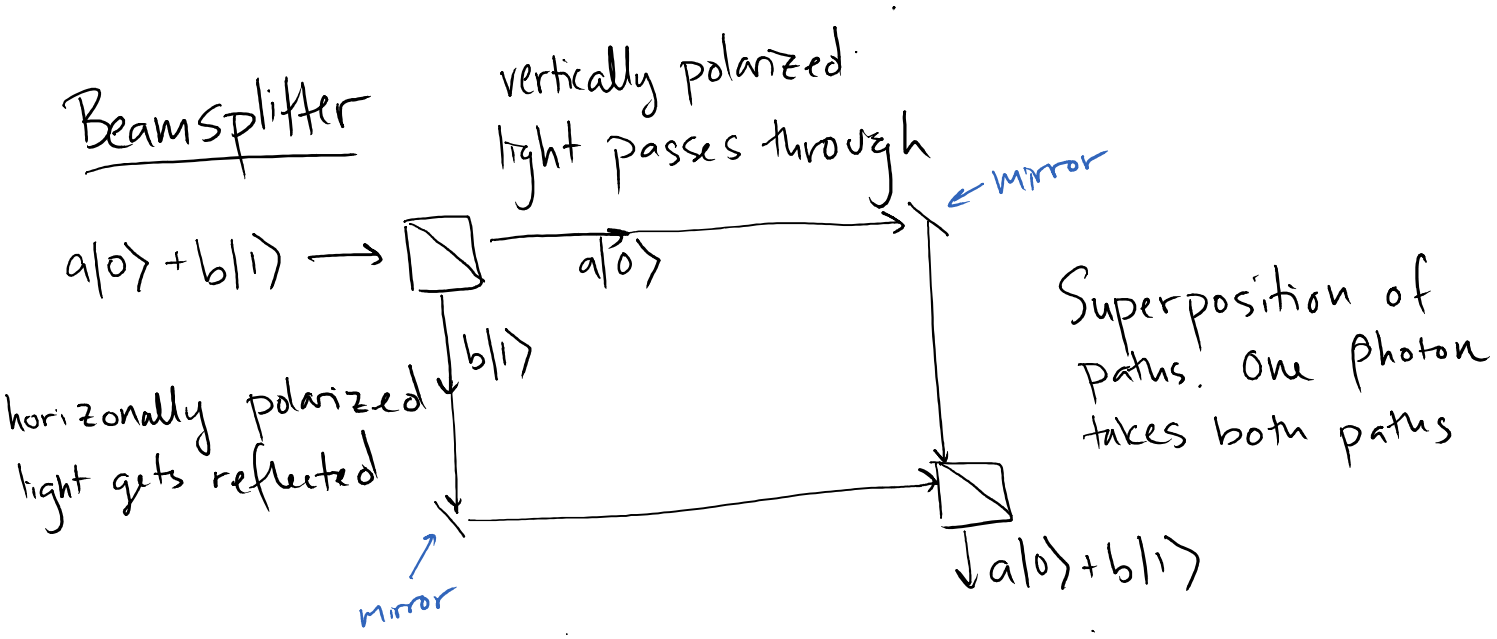
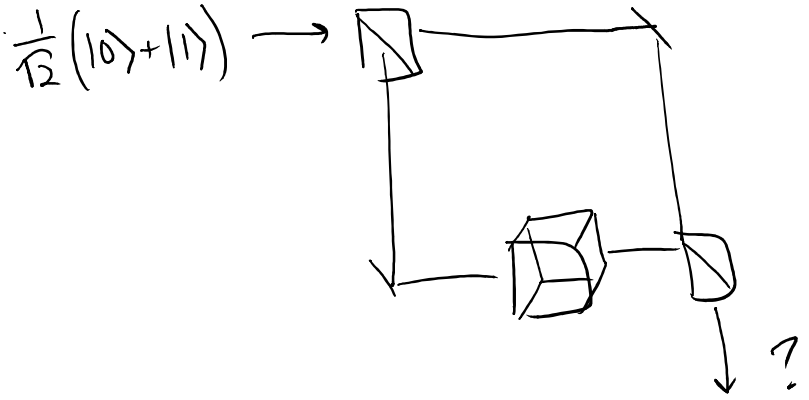
Beamsplitter



Superposition of paths. One photon takes both paths

Beamsplitter doesn't measure!
Reversible $\leftrightarrow$ no collapse
} Quantum operation



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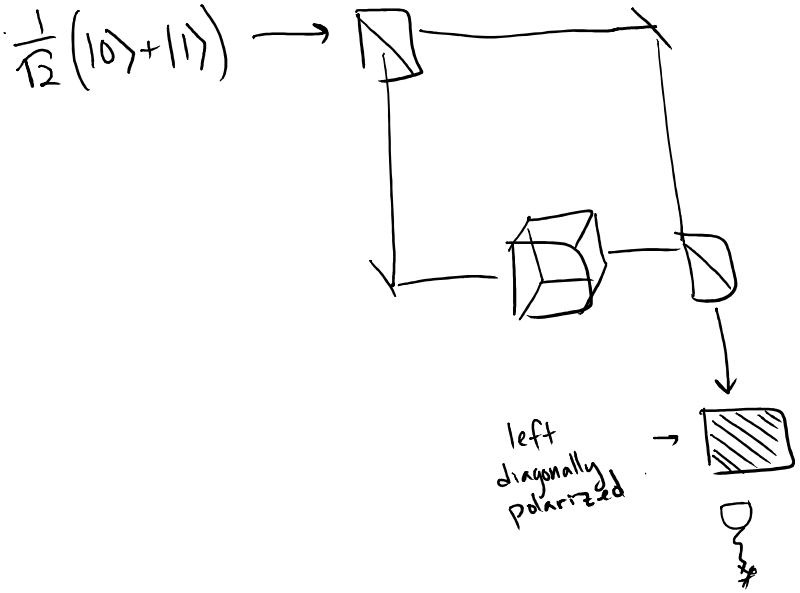
What happens?

- If no bomb → $\frac{1}{\sqrt{2}}(|0\rangle + |1\rangle)$ comes out
- If bomb. Bomb acts like measurement in $\{|0\rangle, |1\rangle\}$ basis. Collapses to one path or other.
  - $|1\rangle$ → explosion (prob 1/2)
  - $|0\rangle$ → photon takes upper path. (prob 1/2)

  Q. What happens if photon takes upper path?
  A. $|0\rangle$ emerges



- No bomb: 100% no detection
- Bomb: 50% bomb explodes
  - 25% detect photon
  - 25% no detection

There is a bomb, but you didn't blow it up! You can save it for a rainy day ☺

Can detect an object without shining light on it!

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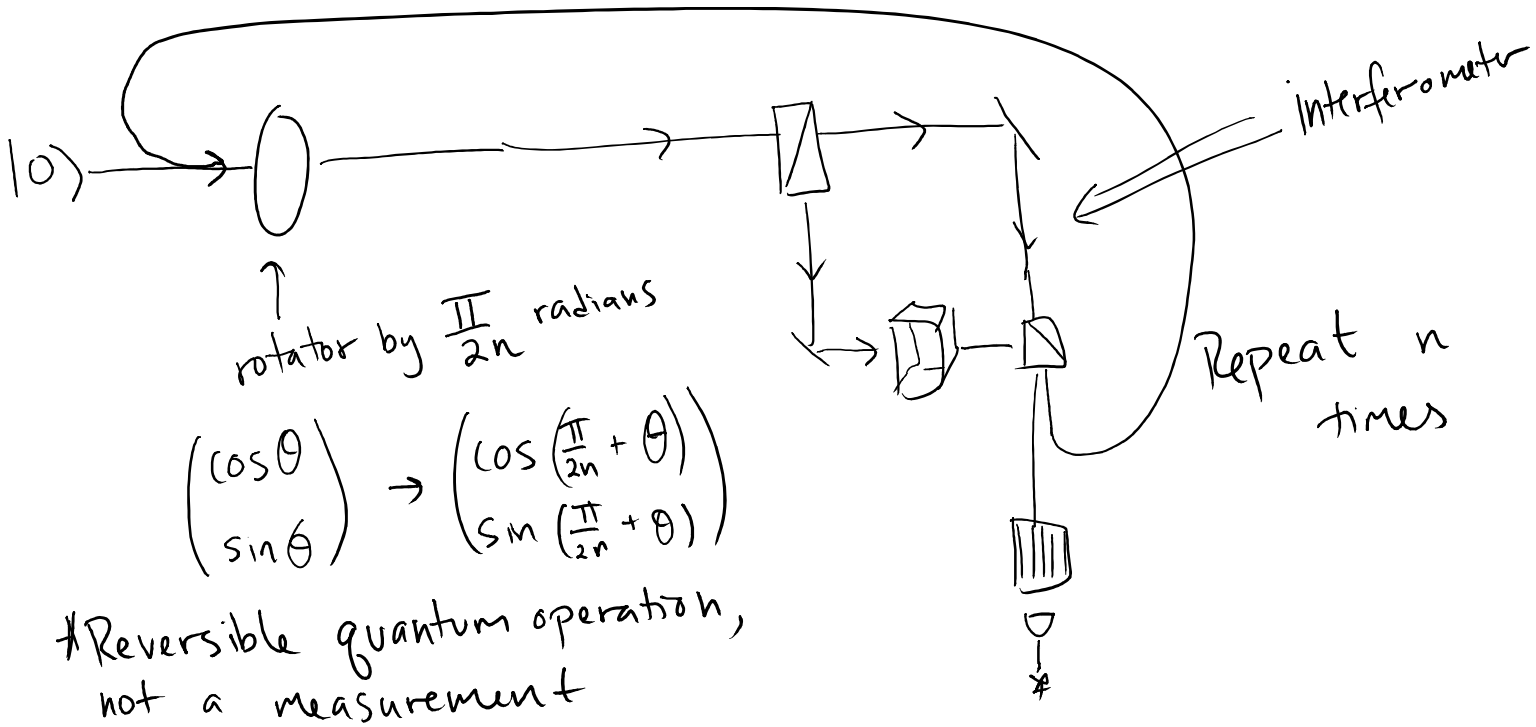

1) If no bomb, what is prob. of photon detection?

2) If bomb, what is prob of No explosion

3) If bomb but no explosion, what is the probability of photon detection?