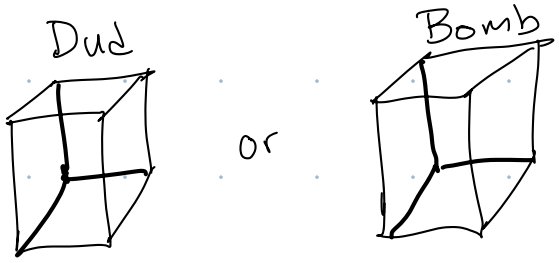
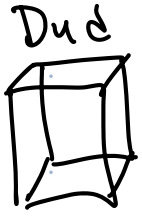
Problem: Quantum Bomb Detection (Elitzur-Vaidman)

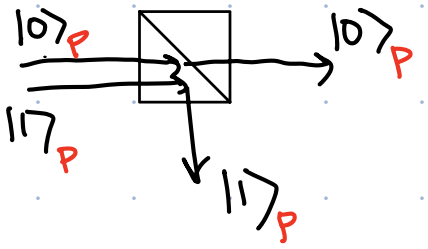


Dud: photon ⇝  ⇝ (passes through

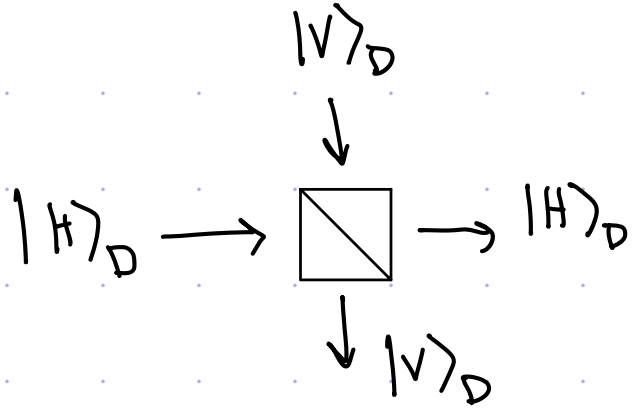
Bomb: photon ⇝  ∅

Want to give friend a rainbow bomb not a dud. How??

New Tool: Beamsplitter



∴ Transmist if photon $|0\rangle_P$
• Reflects if $|1\rangle_P$



"P" for polarization
"D" for direction

$\{|V\rangle_D, |H\rangle_D\}$ standard basis states

Behavior:

$|0\rangle_P|H\rangle_D \rightarrow |0\rangle_P|H\rangle_D$ ↕ → ▱ → ↕

$|1\rangle_P|H\rangle_D \rightarrow |1\rangle_P|V\rangle_D$ ↔ → ▱ ↓ ↔

$|0\rangle_P|V\rangle_D \rightarrow \boxed{|0\rangle_P|V\rangle_D}$ ↕ ▰

$|1\rangle_P|V\rangle_D \rightarrow |1\rangle_P|H\rangle_D$ ↔ ▱ → ↔

A) $|0\rangle_P|H\rangle_D$ B) $|0\rangle_P|V\rangle_D$ C) $|1\rangle_P|H\rangle_D$ D) $|1\rangle_P|V\rangle_D$

Quantum Gate

Operation that changes a quantum state without collapse.

We will describe gates using their effect on s.b. states

$|0\rangle$, $|1\rangle$

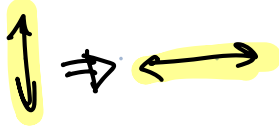
$|00\rangle$, $|01\rangle$ ...

Beam-Splitter

$$|0\rangle_P|H\rangle_D \rightarrow |0\rangle_P|H\rangle_D$$
$$|1\rangle_P|H\rangle_D \rightarrow |1\rangle_P|V\rangle_D$$
$$|0\rangle_P|V\rangle_D \rightarrow |0\rangle_P|V\rangle_D$$
$$|1\rangle_P|V\rangle_D \rightarrow |1\rangle_P|H\rangle_D$$

Mirror \

$$|H\rangle_D \rightarrow |V\rangle_D$$
$$|V\rangle_D \rightarrow |H\rangle_D$$



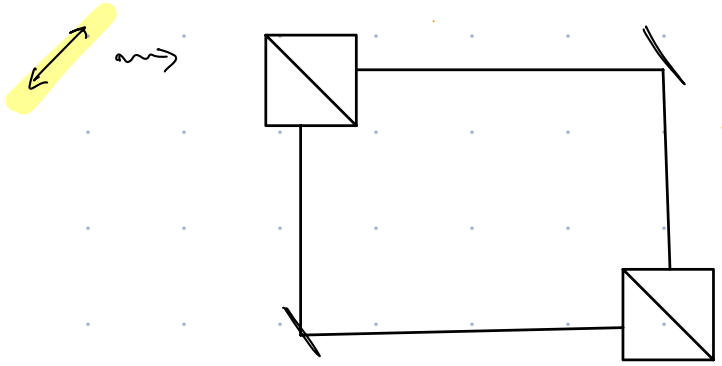
Wave plate

(0) Only affects polarization

(45°)
$$|0\rangle_P \rightarrow |+\rangle_P$$
$$|1\rangle_P \rightarrow |-\rangle_P$$

(90°)
$$|0\rangle_P \rightarrow |1\rangle_P$$
$$|1\rangle_P \rightarrow |0\rangle_P$$

Interferometer



$|0\rangle_P|H\rangle_D \rightarrow |0\rangle_P|H\rangle_D$

$|1\rangle_P|H\rangle_D \rightarrow |1\rangle_P|V\rangle_D$

$|0\rangle_P|V\rangle_D \rightarrow |0\rangle_P|V\rangle_D$

$|1\rangle_P|V\rangle_D \rightarrow |1\rangle_P|H\rangle_D$

$|H\rangle_D \rightarrow |V\rangle_D$

$|V\rangle_D \rightarrow |H\rangle_D$

$|\psi_1\rangle =$

$|\psi_2\rangle =$

$|\psi_3\rangle =$

$|\psi_4\rangle =$