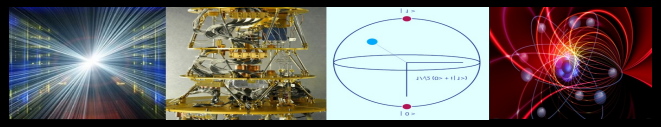
EECS 4141



QUANTUM COMPUTING

THE ASTRONAUTS GEDANKEN

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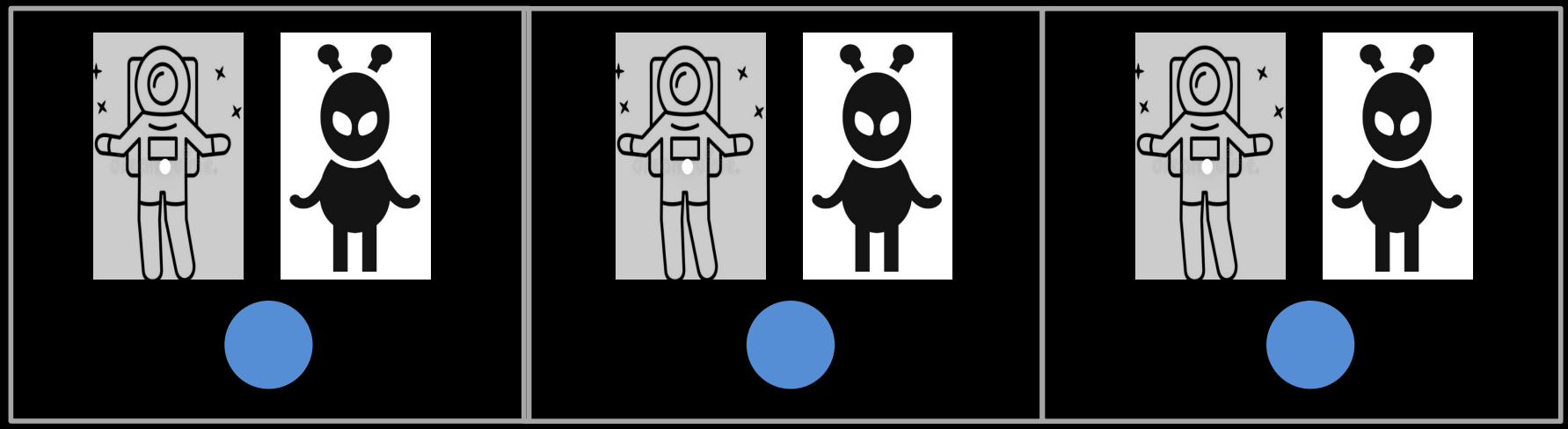
Planet BBB

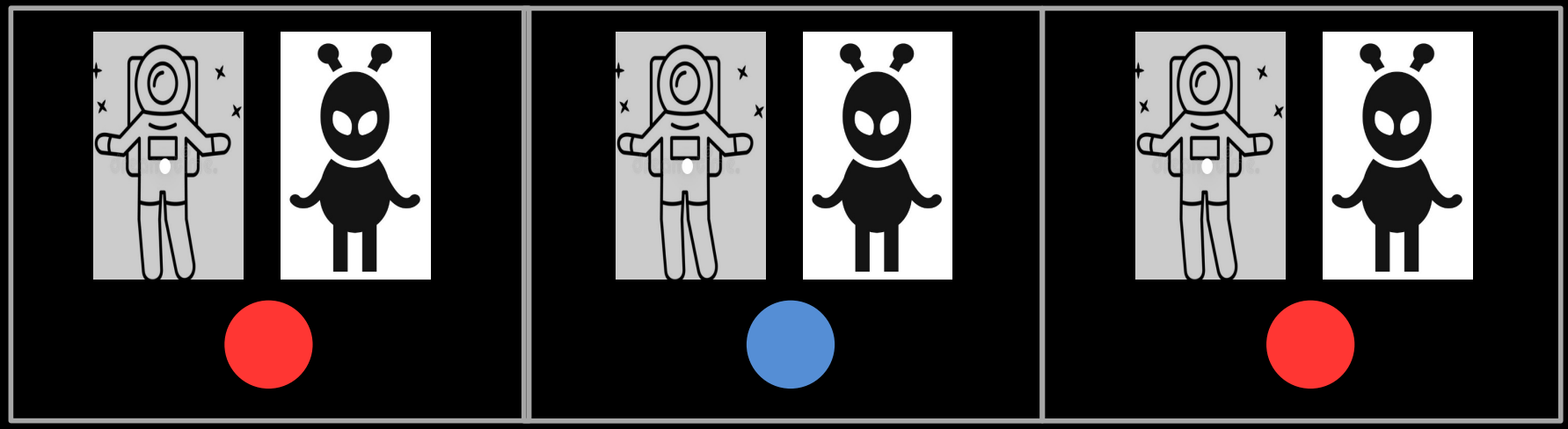
- 3 astronauts travel to BBB to mine. They get caught and end up imprisoned in separate rooms—*no way to communicate.*
- Three aliens offer each a blue ball to take or leave.



- If the number of balls they keep in total is odd, they are set free; else all three are executed.
- *Knowing this, what strategy should they adopt before landing on this planet?*

PLANET BRR

- 3 astronauts travel to BRR to mine. They get caught and end up imprisoned in separate rooms—*no way to communicate.*
- 3 aliens offer each a ball to take or leave, 1 blue and 2 red.



- If the number of balls they keep in total is even (regardless of colour), they are set free; else all three are executed.
- *Knowing this, what strategy should they adopt before landing on this planet?*

PLANET BBB or BRR

- Due to errors, their *teleporting* engine sometimes puts them in BBB instead of BRR, or in BRR instead of BBB.
- When this happens, they can't be sure whether they landed on BBB or BRR.
- They can tell which planet they are on *if* they can see what they were *all* offered, but alas, they can't communicate.
- *Knowing this what strategy should they adopt before landing so that it would work on both planets?*

Reminder:

- *BBB: must keep an odd number.*
- *BRR: must keep an even number.*

Quantum Telepathy

- Before landing, each has a qubit, and the 3 qubits are entangled:

$$|\psi> = \frac{1}{\sqrt{2}}(|000> + |111>)$$

- If offered a blue ball, the astronaut transforms it using the BLUE gate, else the RED gate, and then measures it in 0/1.

$$BLUE = \frac{1}{\sqrt{2}}\begin{pmatrix} -1 & 1 \\ 1 & 1 \end{pmatrix}, \quad RED = \frac{1}{\sqrt{2}}\begin{pmatrix} -i & 1 \\ i & 1 \end{pmatrix}$$

- If the outcome is 0, the ball is returned, else it is taken.
- *Show that this works in both planets.*
- It is as if they communicated … instantly!
- This works regardless of physical separation and temporal ordering of the transformations and measurements.