

Increasing awareness of quantum science

by means of card magic

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Using magic for public understanding and awareness of science

- We have been involved in the use of magic games and tricks to teach and communicate complex concepts in everyday science - and in not-so-evident scientific concepts, like entropy, osmosis, gas mixtures, etc.
- Quantum Mechanics involved a further difficulty.
- Our purpose is not that people understand Quantum Mechanics (no one does!), but to have a glimpse at its basics.
- Quantum Mechanics appears in everyday talk in mass media and social networks - however, neither adults nor young students have an adequate perception or understanding.
- Awareness of its importance in the 21st Century would be enough!

Playing cards

A useful, fun analogy for bits and qubits

Red cards (hearts and diamonds) represent "0"

Black cards (spades and clubs) represent "1"



Randomness

Card shuffling

- A pack of 52 cards may be thoroughly shuffled. Then, selecting the top card is akin to generating a random number.
- If the selected card is spades or clubs, it represents a 1, otherwise it is a 0 (hearts or diamonds)
- Much better randomness if one uses a huge amount of card packs and shuffles them well



Classical card

To represent a bit

- After shuffling a pack of cards, the top card is selected but not seen.
- Before taking a look at it, the card is already either black or red (i.e., either 1 or 0)
- When the card is turned over, we see it black or red - like it was before turning it over



Quantum card

To represent a qubit

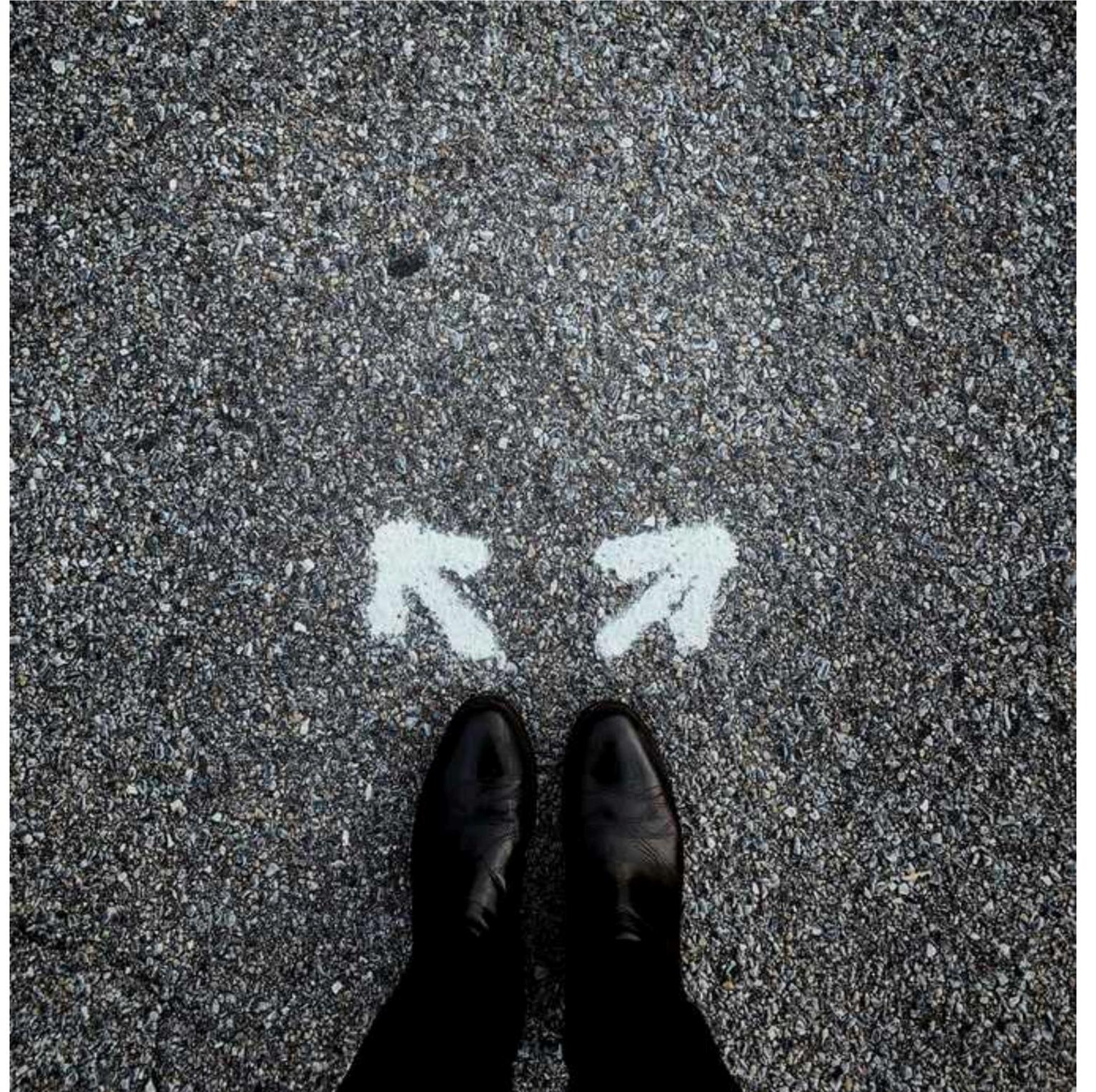
- After shuffling a pack of cards, the top card is selected but not seen.
- Before taking a look at it, the quantum card is black or red (i.e., 1 and 0) at the same time, unless we turn it over.
- When the card is turned over, we see it black or red - it has become either 1 or 0, despite being in superposition before the turn (we have observed it - the superposition has been destroyed, the wavefunction has collapsed).



Uncertainty Principle

$$\Delta x \Delta p \geq \frac{\hbar}{2}$$

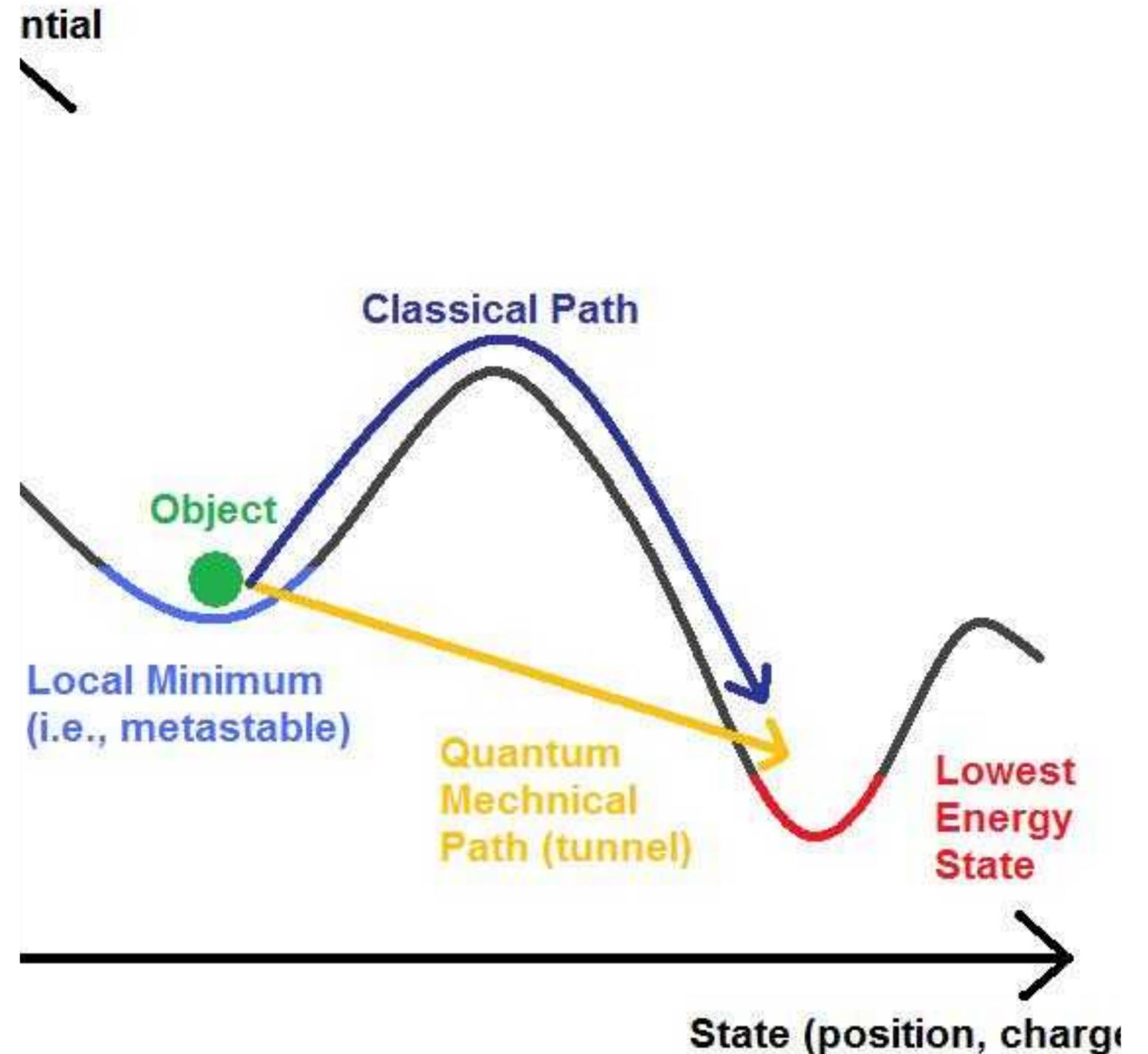
- A special card may quantum in its back (green or blue) and its face (red or black).
- For such a card, either its back may be known, or its face, but not both simultaneously



Tunnelling effect

Overcoming energy barriers...
with not enough kinetic energy

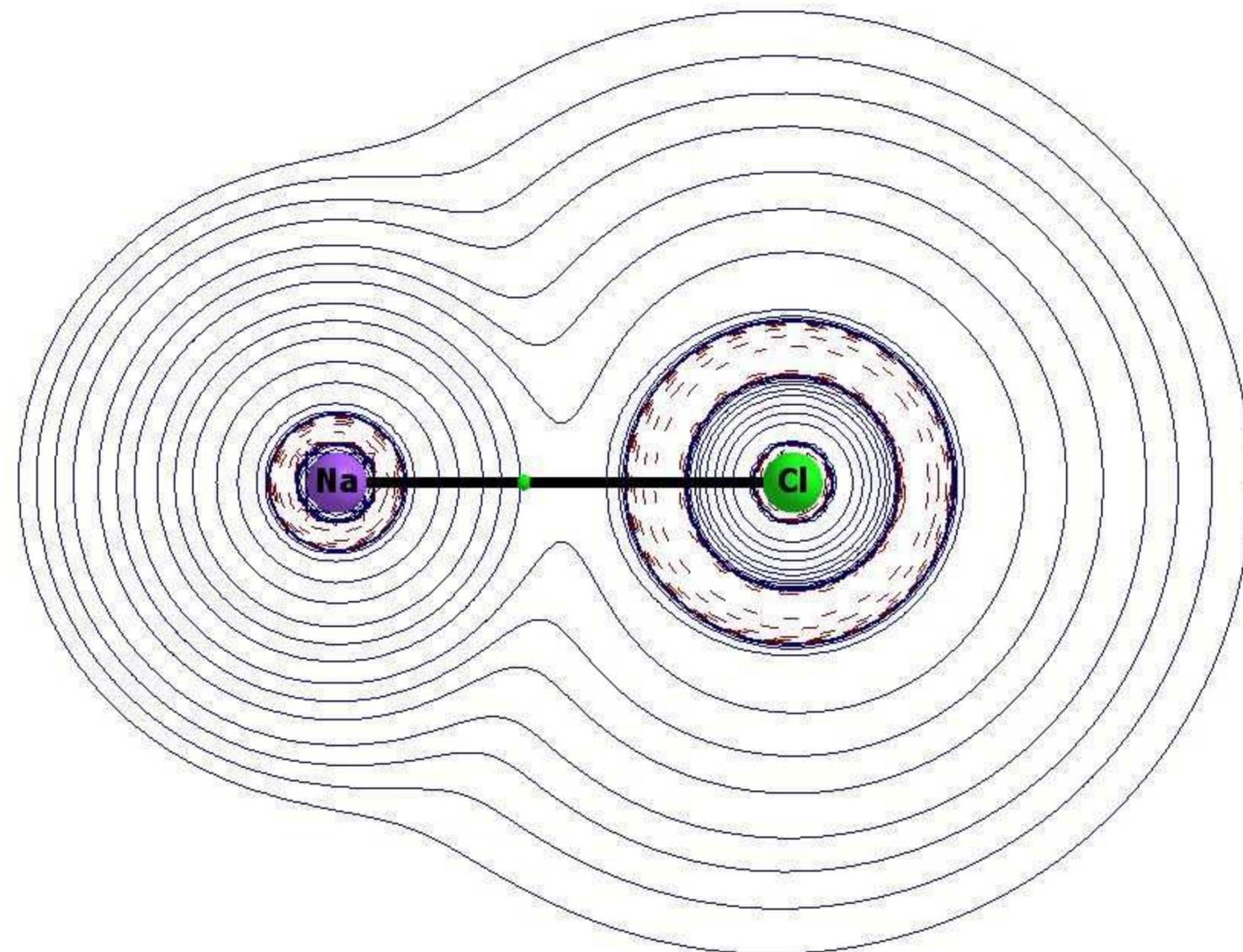
- Several card magic tricks involve inserting a selected card in the middle of a pack.
- A magician is able to make it jump to the top position through a magical tunnel crossing other cards (the so-called Ambitious Card, for instance)



Electron density

A physical observable

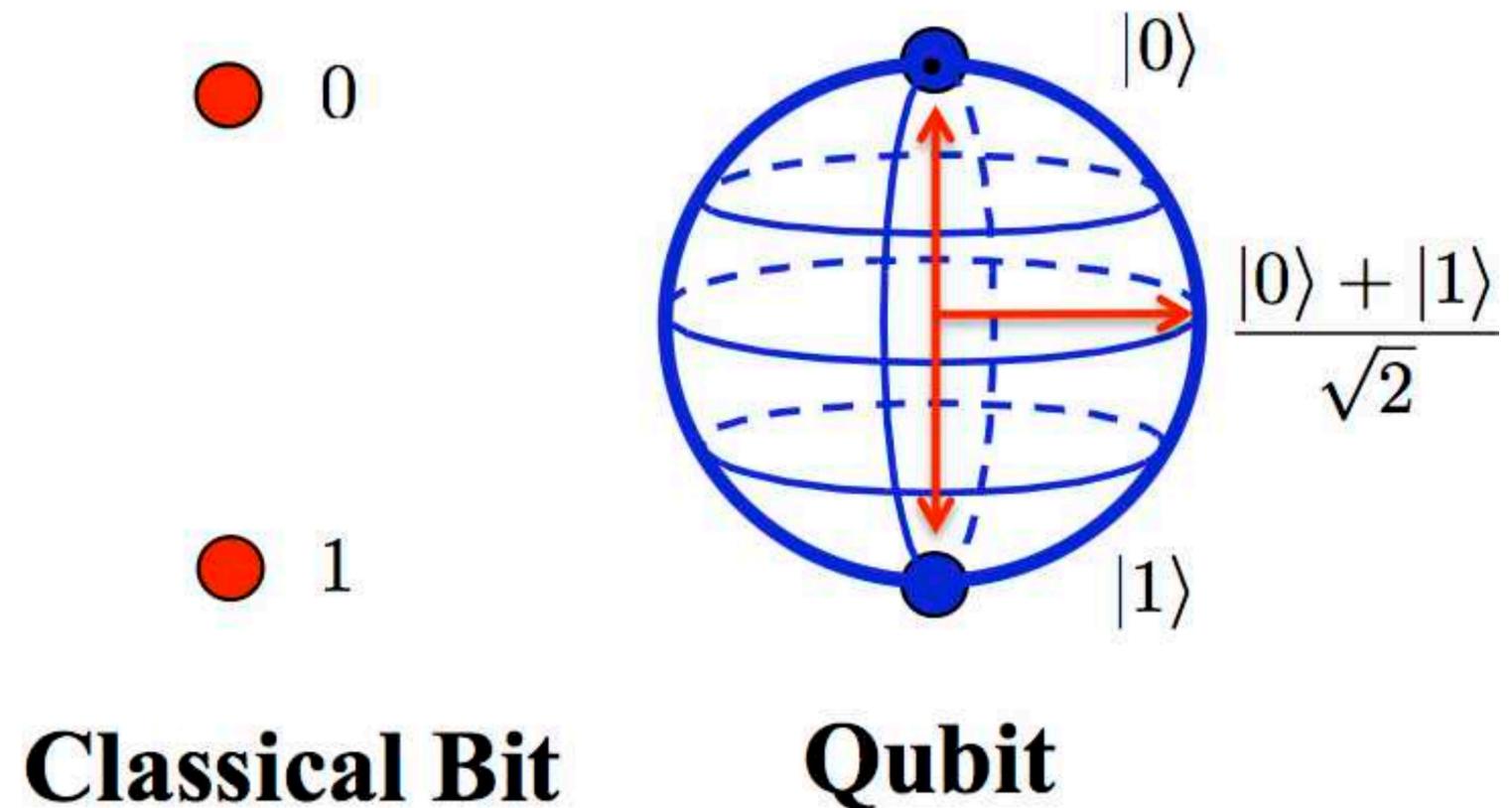
- Electron density is one of the key aspects of quantum reality
- The decrease and increase (with a minimum value in between) may be simulated by a collection of 13 cards of a given suit, e.g.
- K-J-9-7-5-3-1-2-4-6-8-10-Q
- 1 is the so-called bond critical point. K and Q are located at atomic nuclei and this suite of cards is an analogy for a chemical bond.



Entanglement

Action at a distance between two particles

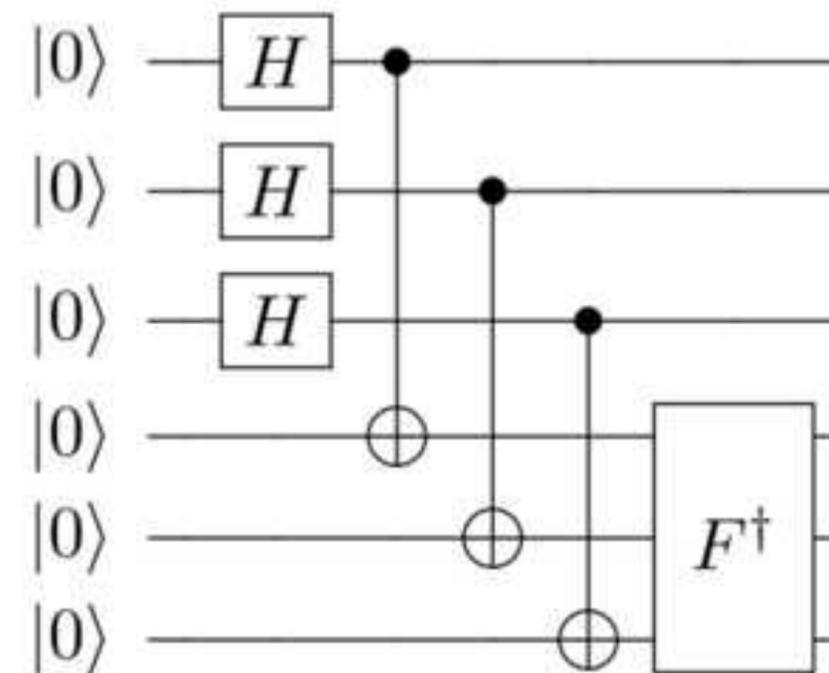
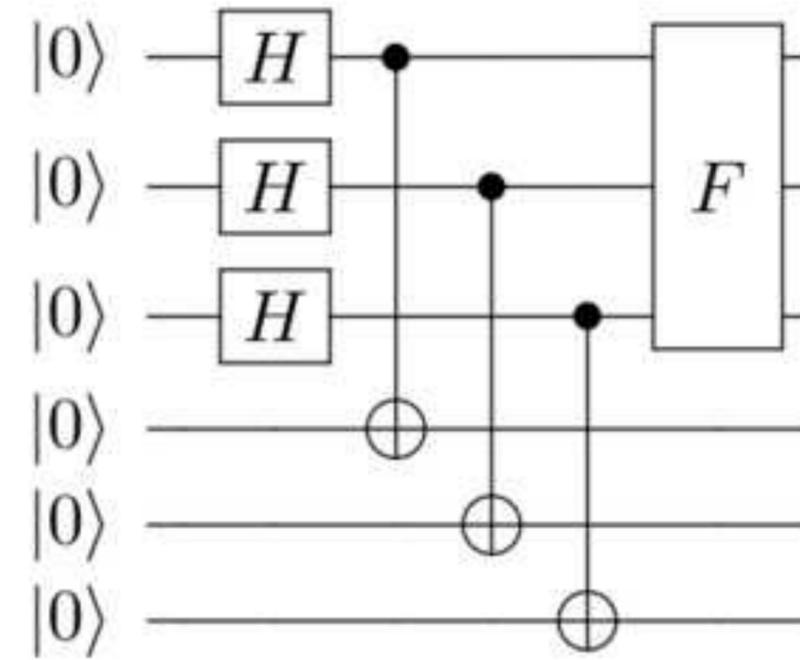
- The so-called Gilbreath Principle allow to create pairs of red/black or black/red cards (i.e., entangled qubits: simplified to 0/1 or 1/0 pairs of bits).
- Unentangled pairs of bits might be 0-0 or 1-1. However, entangled pairs are either 0-1 or 1-0, even though one does not know which until one of the qubits of the pair is observed



Quantum gates

The CPUs of Quantum Computers

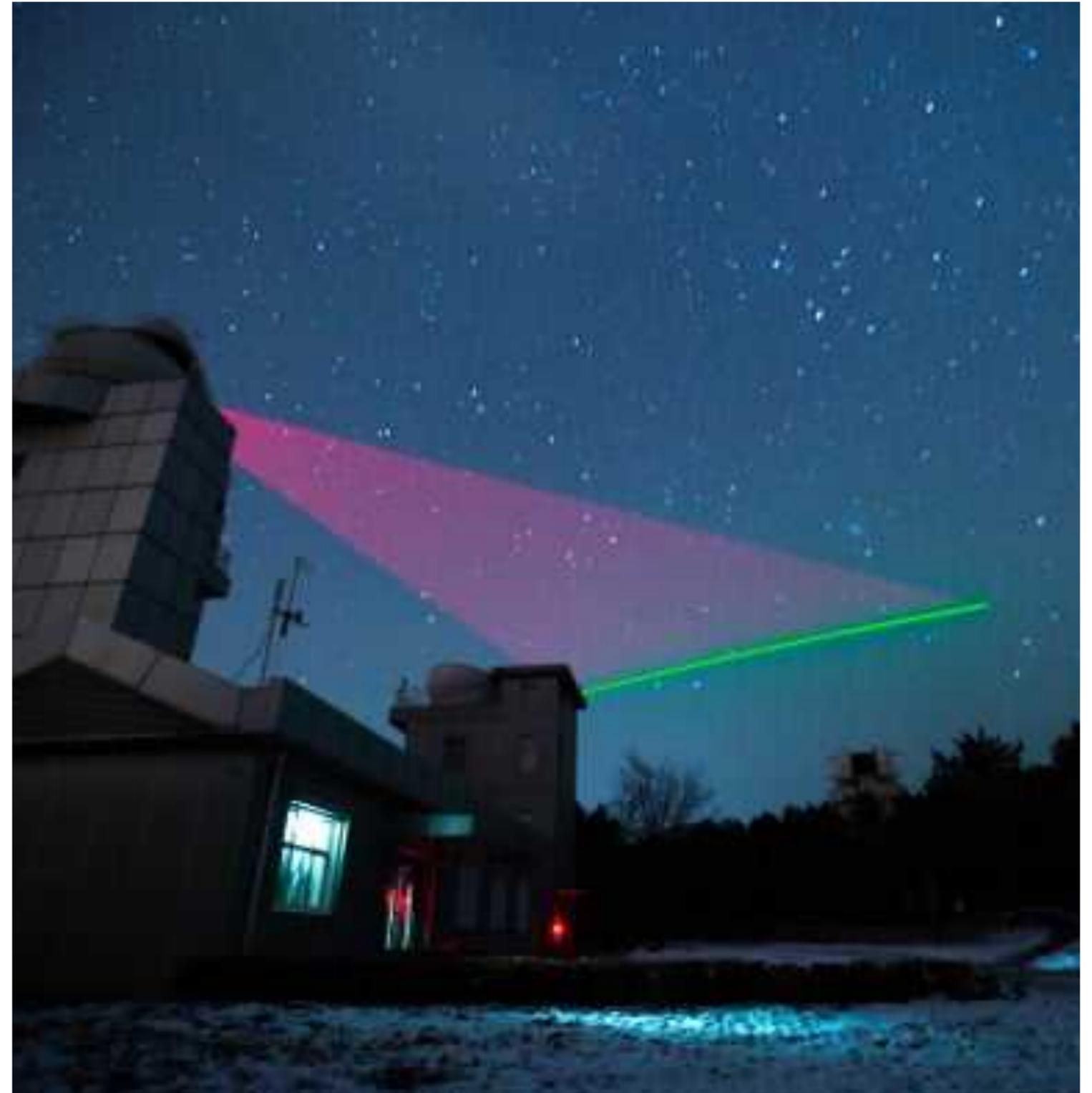
- Quantum computers use qubits, some of which may be entangled.
- Operations on such collections of qubits are made by Quantum Gates.
- Our group is researching the simplest way to create an analogy using playing cards.



Quantum Cryptography

Entangled pairs are used to create one-time pads that lead to completely uncrackable, secure messages

- In a recent Chinese experiment, an artificial satellite sent entangled pairs to two ground stations (one particle each), which were used to transmit absolute secure messages
- Moreover, any attempt to crack or spy messages is detected.
- Playing cards may simulate this process, even though a more complex procedure must be established



More Information:

From websites to social networks

- Project on magic and science, by @fblascoxyz and @miquelduran, at magsci.eu
- See also our website on the International Year of the Periodic Table 2019, with 52 games, quite a few of them on magic, but other classic adaptations: 52gamespt.wordpress.com
- Our Youtube channel: <https://www.youtube.com/channel/UCwbfQKqQhAsh4POOMNtcBUw>
- Twitter: @magsci - Instagram @magsci.eu