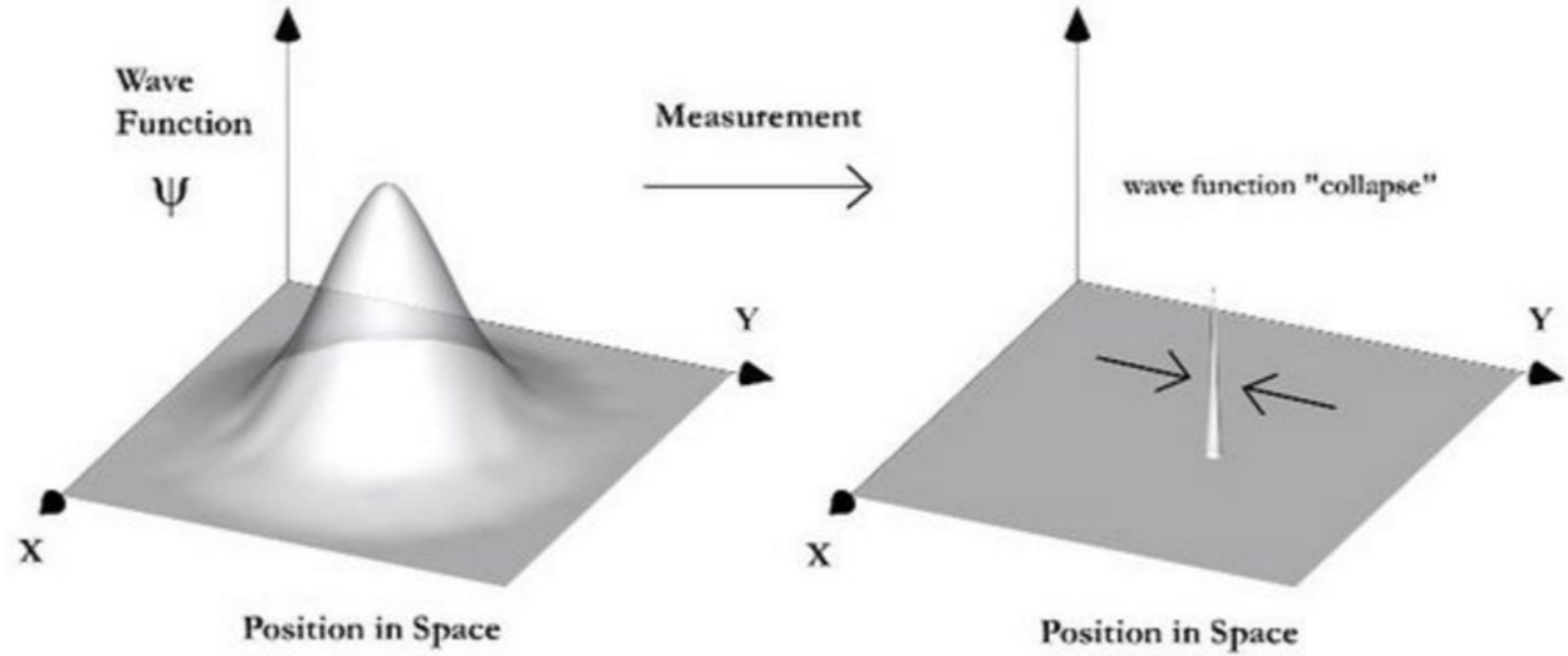
11. Interpretations of quantum mechanics

Measurements in quantum mechanics



Why is measurement such a special process?

Interpretations of quantum mechanics

1. Realist
2. Copenhagen
3. Agnostic
4. Many-worlds
5. Decoherence

1. Realist

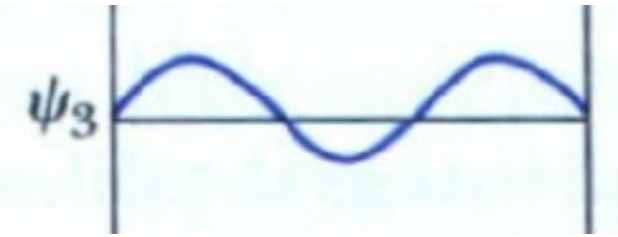
- The wavefunction reflects our lack of knowledge of the system

Einstein: “God does not play dice”

“Actually” the particle was there all along, we just didn’t know about it. There is a “hidden variable”.

2. Copenhagen

- The particle before the measurement **really** was in the state Psi. The measurement "forced" the particle to take the position, and changed the state.

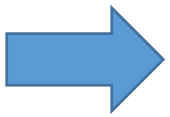


Bohr

"particles do not have definite properties prior to being measured, and quantum mechanics can only predict the probabilities that measurements will produce certain results"

Problems with Copenhagen

- Discontinuous jumps in the wavefunction
- Probability cannot be eliminated
- Subjectiveness of requiring observer
- How to define measuring device?
- Classical physics is still required to described the laboratory.



Nevertheless is the most popular interpretation.

3. Agnostic

- Render the question meaningless by saying that science is based on measurements, and what happens before a measurement is irrelevant and not the realm of science.
- “How can you know something before you make a measurement?”

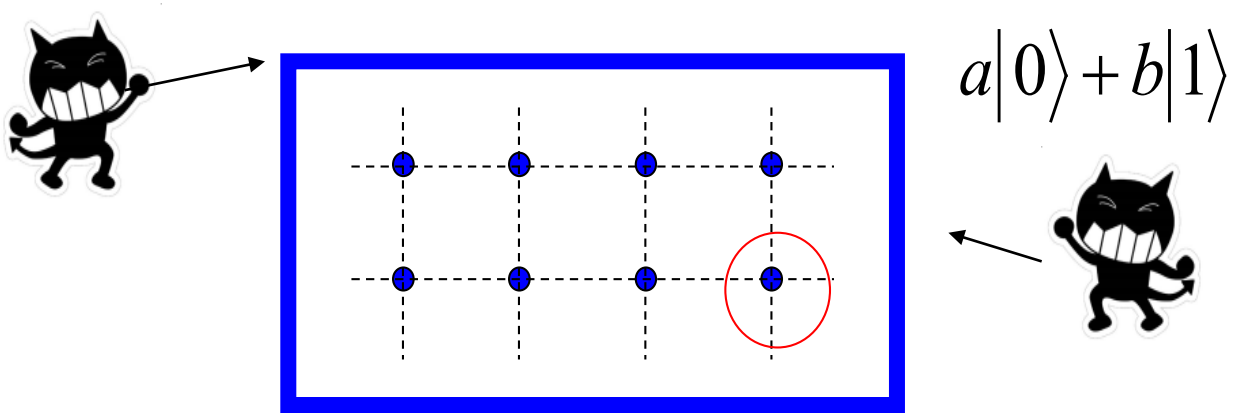
4. Many worlds

- There is a very large—perhaps infinite—number of universes, and everything that could possibly have happened in our past, but did not, has occurred in the past of some other universe or universes.

David Deutsch

5. Decoherence

- Derives the collapse of the wavefunction as resulting from external noise, which destroys the coherence (quantumness) in a system.

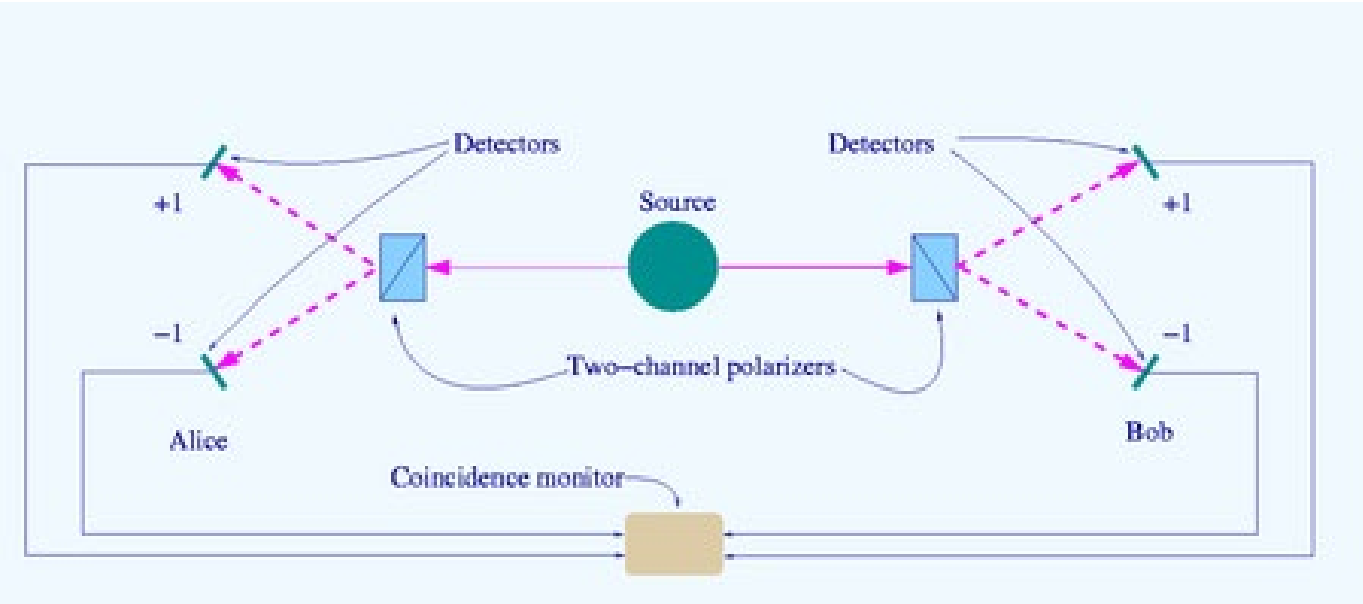


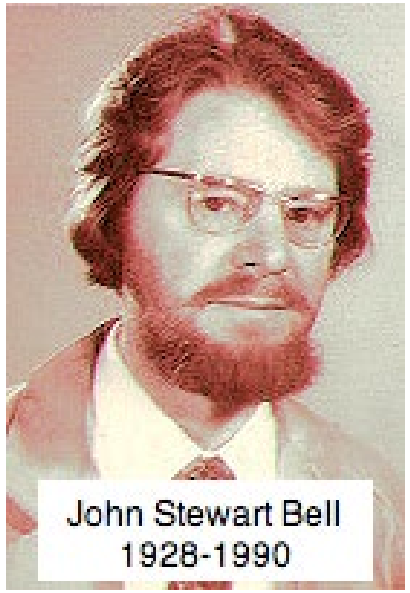
We can obtain consistency with probability of measurement $p(x) = |\psi(x)|^2$

But still cannot derive an explicit “collapse of the wavefunction”

Bell's theorem

- In 1964, invented a way of testing whether 1. is correct or not.





Quantum correlations are stronger than classical correlations

Einstein was WRONG! God plays dice! (well, according to Copenhagen)