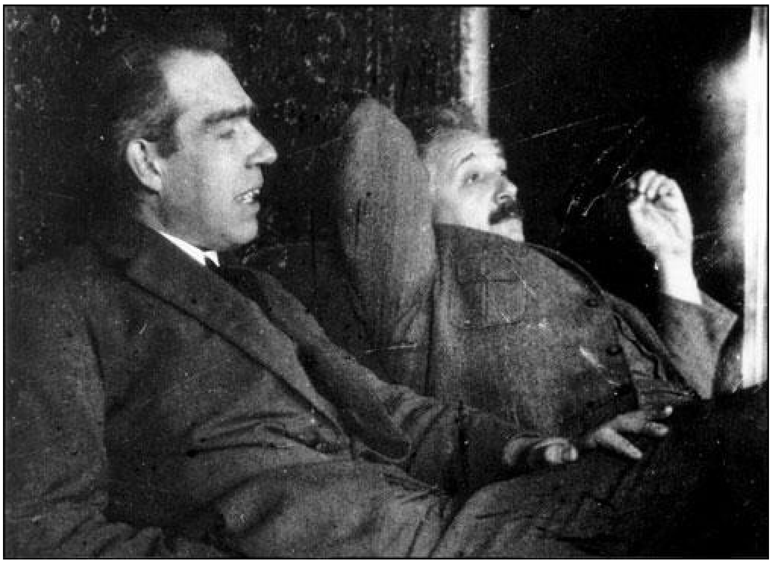
Article 240410

Einstein's mistake

Source: https://blogs.20minutos.es
Link: https://blogs.20minutos.es/ciencia-para-llevar-csic/2015/07/09/el-espeluzante-error-de-einstein/
Date of the original article: 2015-07-09
Published on web-ur.com: 2024-04-10
Date of last update: 2024-04-10
Author/Publisher: Mar Gulis / EL BLOG DEL CSIC
Translated by: JD Arimathea

By Mar Gulis (CSIC)*

One of the most puzzling ideas in **quantum mechanics**, the discipline that studies the behavior of matter at the microscopic scale, is the **superposition of states**. All small particles—such as electrons or atoms—can be in several states at once. It is the action of measuring some parameter (velocity, position, etc.) that breaks the superposition and leads to the manifestation of a particular state.



Einstein and Bohr photographed in 1925.

Albert Einstein (1879-1955) was never convinced by this unintuitive approach, but it was based on numerous evidences. The creator of the **theory of relativity** refused to accept, for example, that an electron could be at several points at the same time and that it was the attempt to measure its position that 'fixed' it at one of them. The electron had to be at a single point before measurement. Hence his famous phrase: "**God does not play dice with the universe**". And hence also the famous retort of his colleague **Niels Bohr** (1885-1962), one of the 'fathers' of quantum mechanics: "**Stop telling God what to do with his dice**".

Einstein did not doubt that the observations and formulation of this discipline were correct, but he thought that its indeterminism made it an incomplete theory. One of the most elaborate criticisms he devoted to it is known as the **EPR paradox**, named after its authors: Einstein himself, **Boris Podolsky** (1896-1966) and **Nathan Rosen** (1909-1995).

The paradox proposed an imaginary experiment in which, from a known and controlled phenomenon, two particles (A and B) were created correlated in such a way that if one had the **spin**—the 'direction' in which the particles spin on themselves—upwards (clockwise spin), the other should have it downwards (counterclockwise spin). However, according to the superposition principle, we have to assume that both A and B have their spin up and down until the moment of measurement. Therefore, by measuring A we would not only be 'forcing' its spin to assume a certain direction, but we would also be causing B's spin to adopt the opposite one. According to the laws of quantum mechanics, this **entanglement** or **correlation** (as the phenomenon was later called) should be maintained no matter how far apart A and B are.

Matthias Weinberger

This conclusion clashed with the **theory of relativity**, according to which **nothing can travel faster than light**. If A stays on Earth and B travels to Alpha Centauri, more than four light years away, how can a measurement on A affect B immediately? Either quantum mechanics was incomplete or one had to accept the existence of a "**spooky [or ghostly] action at a distance**"; an instantaneous communication between A and B.

The EPR paradox remained in the realm of the philosophy of science until 1964, when **John Bell** (1928-1990) proposed a mathematical way to solve it. However, it was not until the 1980s that **Alain Aspect** (1947) and his collaborators succeeded in transferring Bell's proposal to the laboratory in a satisfactory way. Experiments proved quantum mechanics right: entanglement and action at a distance are part of the microscopic world. And here we have one of the **differences between the theory of relativity and quantum theory** that makes it so difficult to unify them: if the former is a **local theory**, because the speed of light is finite and photons need time to go from one place to another, the latter is **non-local**, which means that the action of a perturbation can be transmitted instantaneously from one place to another very far away.

The brilliant **Einstein was wrong on this occasion**. However, **his mistake proved to be enormously fruitful**, as it led to the verification of the existence of a phenomenon with wide potential applications. Entanglement is the basis for the development of **quantum technologies** that are expected to transform the world as we know it today. **Quantum computers** much more powerful than the current ones, **new encryption methods** that are practically inviolable and even the **teleportation of microscopic particles** are just some of them. We will tell you about them in future posts.

* *If you want more science to take away on this topic, consult the book* **Mecánica cuántica** *(CSIC-Catarata), by CSIC researcher* ***Salvador Miret****.*

ABOUT THE BLOG:

ciencia-para-llevar-csic

At the Consejo Superior de Investigaciones Científicas (CSIC) we like to do science and also to share it. We have a lot to tell because we do research in all areas of knowledge and we work in 125 centers distributed in all the autonomous communities, which makes us the largest public research organization in Spain. In this collective blog, promoted by the Scientific Culture Area, we talk to you about the advances and curiosities of science. We do it with carefully prepared pills to take away and drink.

ABOUT MAR GULIS:

blogs_peque_ciencia-para-llevar-csic

Under the collective name of Mar Gulis (in homage to the great researcher and popularizer Lynn Margulis), we write several people who are part of the Scientific Culture Area of the CSIC. In alphabetical order: Eduardo Actis, Paloma Arroyo, Irene Cuesta, Cristina Delgado, Laura Ferrando, Carmen Guerrero, Irene Lapuerta, Mónica Lara, Laura Llera, Belén Macías and Violeta Vicente.