



BIG PARTY

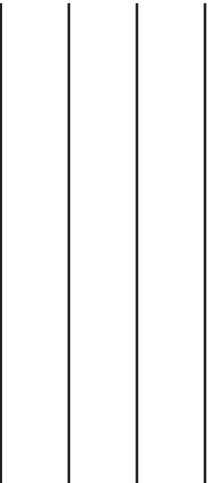


BOSE-EINSTEIN PARTY



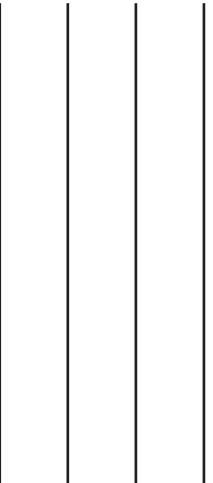
ESAKI EXPERIMENTS WITH THE TUNNEL EFFECT AT HOME

Sometimes quantum particles can go through walls, as if an invisible tunnel opened up before them. In 1958, Leo Esaki demonstrated this tunneling in semiconductor devices.



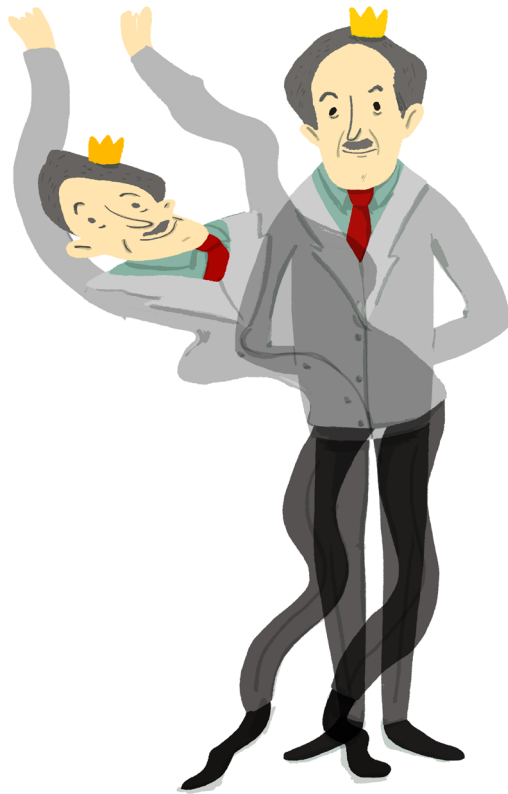
« Physicists at Play », Margaux Khalil & Janet Rafner, Physics Reimagined (LPS) CNRS et Université Paris-Sud, 2014, [www.vulgarisation.fr](http://www.vulgarisation.fr).

In 1995, Wolfgang Ketterle, with other physicists, discovered that at really cold temperatures some atoms in a gas can behave like one collective quantum wave, a state of matter called a Bose-Einstein condensate.



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## WAVE PARTICLE DUALITY



DISCOVERED IN 1924  
BY PRINCE LOUIS DE BROGLIE

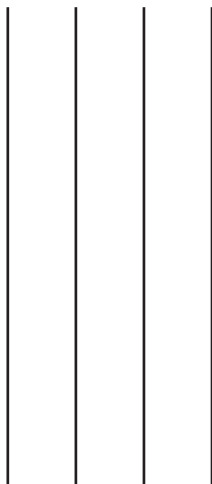
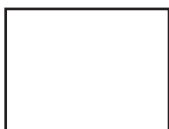
## QUANTUM LEVITATION CRISIS:



HIGH COOLING COSTS FOR SUPERCONDUCTORS  
FORCES ONNES TO SEEK NEW AUDIENCE

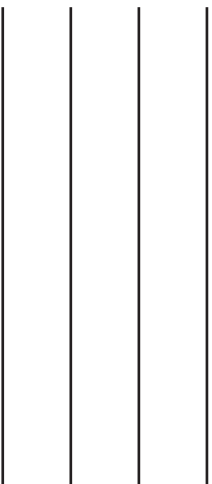
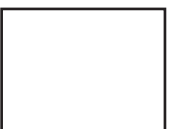
In 1911, Kammerlingh Onnes discovered that when some materials are cooled to very low temperatures, their electrons become like one huge quantum wave. This wave expels all magnetic fields and repels magnets, allowing for levitation.

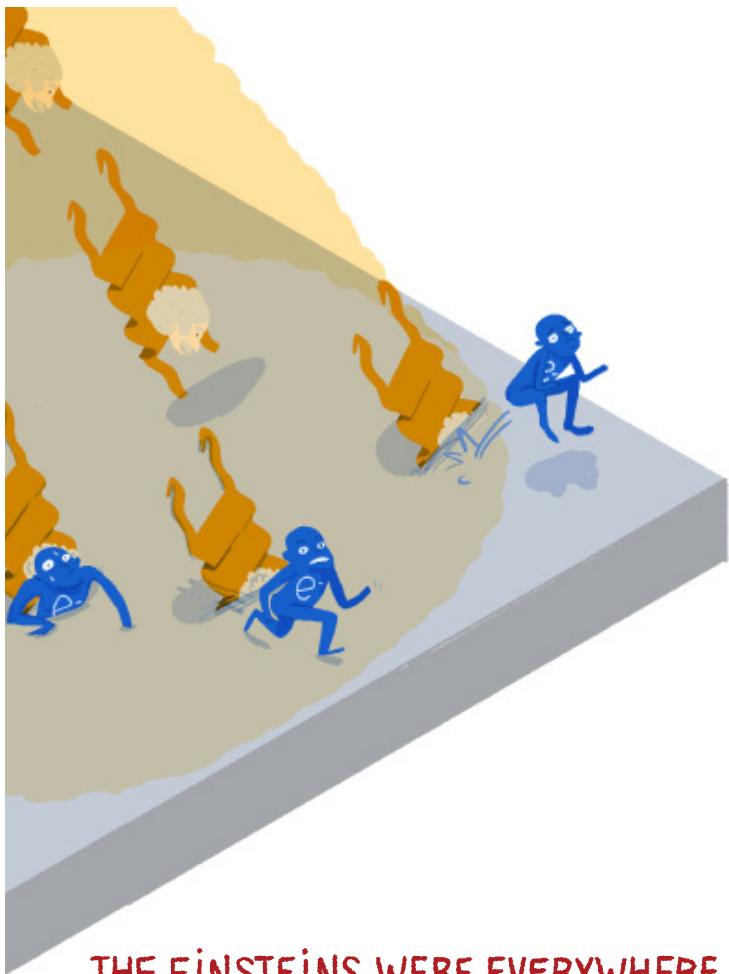
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In 1924, Prince Louis de Broglie discovered that any quantum object, such as an electron or an atom, behaves both as a particle and as a wave.

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THE EINSTEINS WERE EVERYWHERE...  
WE HAD NO PLACE TO HIDE  
- EVICTED ELECTRONS

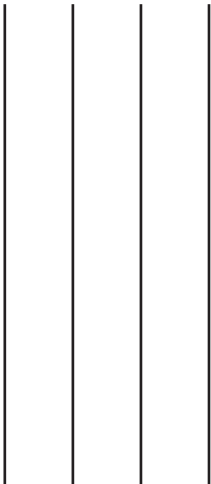
TONIGHT, QUANTUM MAGIC!



THE ANTIMATTER TRICK OF MR. DIRAC

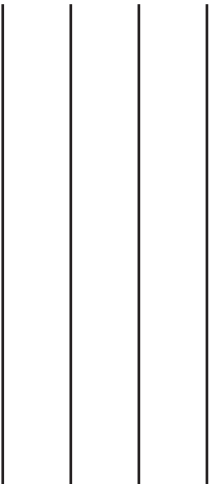
In 1928, Paul Dirac proposed that for every type of particle there is an antiparticle that has the same mass but opposite electric charge. If they interact with each other, they are annihilated and produce light.

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In 1905, Albert Einstein proposed that light consists of lots of little waves called photons that have energies linked to their frequencies. This allowed him to explain how light ejects electrons from metal, a process called the photoelectric effect.

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# UNCERTAINTY PRINCIPLE



RUINED EVERY  
HEINSENBERG FAMILY PHOTO

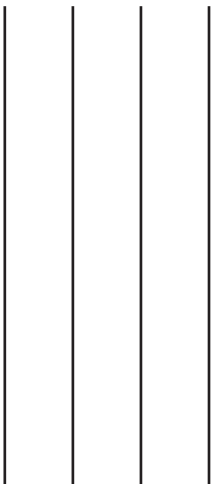
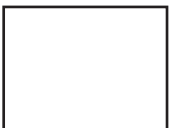
# PAULI EXCLUSION PRINCIPLE



THERE CAN BE  
ONLY ONE

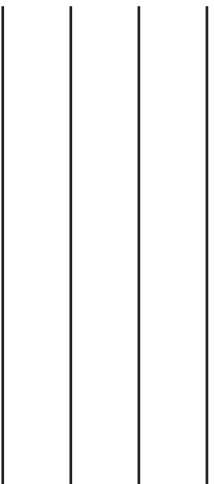
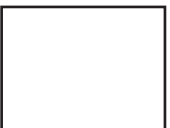
In 1925, Wolfgang Pauli proposed that in an atom, two electrons with the same characteristics cannot be in the same space at the same time.

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In 1927, Werner Heisenberg proposed that you cannot simultaneously know a quantum particle's position and speed. The more accurately you know one, the less accurately you know the other.

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KAPITSA'S ADVICE :



NEVER DRINK  
SUPERFLUID COFFEE

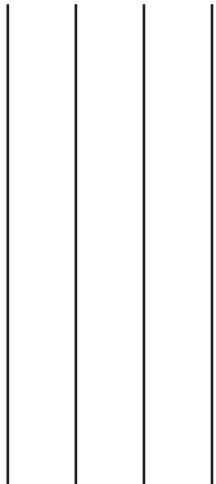
SCHRÖDINGER'S QUANTUM LIFE



SUDDENLY JUMPING  
FROM ONE MOOD TO ANOTHER

In 1925, Erwin Schrödinger designed an equation that enabled him to find the energies of any quantum particle. Such particles display a "quantized" behavior: they can only have certain energies and they jump suddenly from one energy level to another.

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Pyotr Kapitsa discovered in 1937 that some liquids, called superfluids, behave like giant quantum waves at very cold temperatures. They have no friction and therefore pass through the bottom of most ceramic containers, including your coffee cup.

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