# Introduction to the VI fundamental principles of Quantum Physic —

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# Chapter I

# Duality principle
# Wave-particle

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Every quantum object is both a particle, like a tennis ball, and some sort of wave, like a wave in the ocean. Imagine a tennis ball that would be in several different places at the same time. But when you try to locate it with measuring instruments, the quantum object is suddenly reduced to one spot. This means that electrons, atoms, molecules, and even photons (light particles), are small particles and waves, both at the same time!

*Using electrons to observe matter*

In order to overcome the limitations of optical microscopes, physicists use quantum mechanics. Since electrons are — like light — waves, why not use them to light up objects? This is what lies behind the electron microscope, which has an amazing magnifying power.
It is one of the most popular microscopes amongst physicists, who want to observe atoms and molecules, and amongst biologists, who want to observe microbes and viruses.

*Quantum mechanics and CCD display*

All our digital cameras are manufactured with CCD image sensors that work using quantum mechanics. Light is made up of photons, which behave as particles and waves at the same time. When light falls upon a CCD sensor, each photon — when it has enough energy — pulls out one electron. These electrons are thus detected and converted into a digital image.
This technology has enabled us to develop ultra-sensitive cameras.

*Any ping - pong ball would be, at same time, a ball itself and a wave.*
*In this way, the ball will react to the racket as a particle and as a wave at the same time.*

# Chapter 2

# Quantization Principle

# Quantization Principle

In the quantum world, particles can only assume certain energies. Imagine a car that could only run at certain specific speeds and would directly accelerate from 30 to 50 mph! Why? Because particles are waves and do not assume just any shape: for each shape there is a corresponding energy, and that is what quantization is.

These energy levels help us to understand the atomic structure and to create new technological devices.

*Quantum gems*

We can see the quantization of energies in our daily lives, in the colour of gems for instance. Thus, rubies are red because they contain a few atoms of chromium, whose energy levels are separated in such a way that we see rubies reflect a red light.
Thanks to ingenious physicists who have manipulated these energy levels, we now have lasers and LEDs.

*On the right, the slope is showing the classic physic, in which any gradient of red or blue are possible.*

*Electron boxes*

In the clean rooms of our labs, physicists have been able to carve patterns to within one ten-billionth of a metre accuracy, with the help of new devices !
For instance they have designed nanoboxes a few atoms wide in order to imprison electrons. They use these boxes to study matter on a nanometre scale and to control its colour and its electric and magnetic properties.

*On the left, the stairs represent quantum physic, in which the evolution occurs by hop, and just specific colours are possible.*

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# Chapter 3

# Uncertainty Principle

# Uncertainty Principle

In quantum physics, some properties can not be simultaneously measured with high precision. For example, it is impossible to accurately measure both the position and velocity of a quantum object, onewe  must choose in between the two. This mathematical principle does not prevent the quantum physics to be very accurateprecise, one just haswe just have to decide properly what should be determined or measuredmake sure we choose right what is to be measured.

*Un principe utile*

The uncertainty principle might seem limiting but yet it allows physicists to better understand some of the properties of matter. For example, with this principle, the material may not be perfectly still. Even at a temperature of absolute zero where everything should freeze the atoms continue to vibrate a little. An amazing result for a particular gas, helium: when it is cooled, it becomes a liquid, but not solid, even at absolute zero. The uncertainty principle also explains why the electrons in the atoms are forced to occupy a certain space and can not crashing into a small volume. Otherwise, we know where they are and then they would have too high velocities. In other words, the atoms exist with the uncertainty principle!

*In the first picture we can understand the position of the metronome's needle, but it is impossible to calculate the speed of it.*
*On the other hand, the second picture shows the speed of the needle but it is impossible to decode the position.*

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# Chapter 4

# Measurement in Quantum Physics

*In this airtight container is visible a light bulb. when the box is closed, the light bulb is on. But whenever somebody opens the door, we realise that the light bulb is off. The observation affects the light behaviours.*

# Measurement in Quantum Physics

In classical physic, it is possible to measure an object without it being affected. This is not the case in quantum physics, where the measurement changes the nature of the object being measured ! For example, an electron behavesacts as a matter wave and stands in several positions at once. But when onewe tryies to measure it, the electron-wave suddenly reduces itself in a specific point. Another example : a quantum object can be in two states at once, but when you measure it, it randomly selects one of these two states.

*Understanding the mesurement*

Recently, researchers have been able to better understand what happens during the measure which is the sudden reduction. To do this, they measured with a light atom in two states at once. They discovered that the atom chooses one of the two states as soon as light has been injected. More importantly, it does not happen instantly, and the time it takes for the atom to choose a state depends on the amount of light. So depending on the size of the measurement tool or on the amount of light that is used, the quantum object reduces more or less quickly in a single state. More measurement tool, the larger the quantum object is reduced quickly.

# Chapter 5

# Non - locality and Entanglement Principle

# Non - locality and Entanglement Principle

Any quantum object is both a particle and a wave. Sometimes we are able to “mix” two of these quantum objects, such as two grains of light. We say they are entangled. We can then separate them as much as we want, they remain attached, and the properties of each stays dependent of the other. If an experimenter interacts with behave on o one of these objects, the other object is immediately affected, as if there was an instantaneous action at a distance. This violates the notion of locality : the double-object is indeed extended in space and not in one place, yet behaves as a single composite object. This is oOne of the most strange properties of the quantum world.

*Consider two seeds of the same orange and dispose them in two separete universes. If these two seeds are entangled, by affecting one of the seeds we will be able to see instantly the effects on the other one as well.*


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*Entanglement as a fundamental topic*

Entanglement and measurement are central to many research laboratories. We now know entangle and measure two particles of light, photons, up to 100 miles away! Entanglement has opened new fields of research such as quantum information theory and quantum teleportation. Understanding how finely entangle and measure two particles will also be a crucial issue if one day you want to build quantum computers to replace our current computers.

*Perfect secret codes*

In this new field of quantum cryptography, entanglement has been used to manufacture devices to create coded messages perfect. These devices use entangled photons to communicate messages to each side of an optical fiber. The information is encoded through the properties of these photons. If a spy tries to intercept the encrypted message, it inevitably changes the photons and users will see it too. These processes are used for example in the field of banking.


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# Chapter 6

# Superposition of states Principle

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A quantum object can only exist in certain specific energy states. Nevertheless, it is sometimes able to existoverlap in two of those states at once ! For example, in some molecule-schemicals or specific, magnets can be in two configurations simultaneously. This is called a We say that there is superposition of states.

*How Big ?*

Researchers have recently arrived to create a superposition state for some kind of small metal swing. Visible to the naked eye, this little piece of metal was cooled and placed in a black empty box. The researchers then observed at very low temperatures, the metal was able to both vibrate and not vibrate. Like a swing could be both still and moving! This is the largest quantum object we have seen to date overlap in two states.

*Computers of the future*

In today's computers, electronic components used to carry out calculations on 0 and 1. Physicists seek to use the superposition state to invent computers of the future. The calculations would then on quantum numbers, both 0 and 1. The power of such computers would be much greater for some calculations. At the heart of current research, this new kind of electronic still poses many technical problems but could revolutionize computing in the future.

*Experience the Cat Schrödinger conceived in 1935 by Erwin Schrödinger, represents and highlights the complexity of conceptualization of physics. A cat, locked in an opaque box, a chance of dying.*

*Quantum physic says that as long as the observation is not made, the cat is both dead and alive, and it will be until the box will be close.*

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june 2013

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Emilio Patuzzo

Thank to
François Azambourg
à l'ENSCI

and to
Julien Bobroff
Véronique Huyghe