

# Physics and some social phenomena

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## Abstract

It is well-known that, in science, several concepts that apply to an specific area of knowledge, may be borrowed by other areas of knowledge. Namely, resilience, reservoirs, evolution, etc. are concepts that may be used in social sciences, physics, biology and other sciences with complete sense. In this contribution I want to give some insights about some topics of quantum physics that could be used in social sciences.

## 1. Introduction

Nowadays the world is so connected that things that happen in a part of the planet affect many other parts. As good examples one can give the common ones: global warming, companies moving to lower wage places in order to increase their earnings and very recent, covid. In the case of businesses, it should imperative for our owners to count with means of control such that they may keep their bonanza flourishing while keeping the world a secure place to live. As an example of this, I may mention the recent case of the disappearing of 43 students in Ayotzinapa, a town in the Mexican state of Guerrero. Some miles away a Canadian mining company is investing little money in order to obtain obscene earnings by gold extraction. One of the purposes of this manuscript is to propose some concepts, useful in (quantum) physics, that may be used to understand the means used by the companies in order to keep their status quo. These concepts could have some value to sociologists.

There exist, amongst diverse science fields, analogies that may be used to make some concepts clearer, for instance, one may think of evolution, a common concept in biology that has crossed some scientific barriers, and in social sciences one can read about social Darwinism or in quantum physics about quantum Darwinism [1-4] or quantum cloning [3-7]. Furthermore, as stated by Feynman [8], because similar equations have similar solutions, paraxial wave equations in classical optics have as

quantum mechanical counterpart the Schrödinger equation for a free particle, and therefore many solutions and effects may be translated from one topic to the other [9-10].

First, let us note that we, as individuals, are not disconnected from quantum physics and use it commonly in our lives probably without noting it. For this, let us think of a very common apparatus: a laser. We use this technology in our everyday lives, for example in eye surgery. A laser, like us, is composed by atoms, atoms that have energy levels. Among its many levels, we have to choose two of them to select the color of the laser beam. By giving energy to the laser, we can excite the atoms to put them in a state of higher energy, let us say,  $|e\rangle$ , and, when this level decays to a less energetic level, the ground level  $|g\rangle$ , it delivers a photon, a quantum of energy, a piece of light, that, by kicking other excited atoms, produces a cascade effect that will produce a laser beam.

The energy levels of the atom are explained by quantum theory. As we are composed by atoms that entangle with other atoms to form molecules, which form cells, which in turn form us: we are, in fact, quantum beings.

In the next sections I will show some analogies of some social events with quantum physical phenomena. In particular I focus in the so-called quantum Zeno effect and journalism (section II), system-reservoir dynamics and wage control (section III), entropy and media control (section IV) and finally on some non-classical states of the harmonic oscillator, namely squeezed states and the concentration of wealth (section V). Section VI is left for conclusions.

## 2. Quantum Zeno effect and journalism

In Zeno's paradox of Achilles and the tortoise, Achilles is in a footrace with the tortoise. Let us say that Achilles allowed the tortoise a head start of 100 meters. If we suppose that each of them starts running at some constant speed but one fast and the other very slow, then after some finite time, Achilles will have run 100 meters, bringing him to the tortoise's starting point. During this time, the tortoise has run a much shorter distance, say, 15 meters. It will then take Achilles some time to reach that distance, by which time the tortoise will have advanced further; and then more time still to run to this third point, while the tortoise again moves ahead. Thus, whenever Achilles reaches a position where the tortoise was, he still has to run an extra distance. Therefore, because there is an infinite number of points Achilles has to reach, where the tortoise has passed, he is never able to overtake the tortoise.

It is translated into the quantum realm as the quantum Zeno effect [11-13], which is a situation in which an unstable particle, if observed continuously, never decays to a lower state. Therefore, one may "freeze" the evolution of a given system by measuring it frequently enough in its initial state. It means that continuous monitoring of the state forbids it to move to a different state (just as Achilles is unable to reach the tortoise).

For instance, if we were able to continuously observe the atoms in the laser in their excited state, they would never decay and thus a laser beam would not be produced.

Now, let us imagine two possible states of a government: an honest state denoted by  $|h\rangle$  and a corrupt state, denoted by  $|c\rangle$ . In the best interest of people, if the government is in a state  $|h\rangle$  it should remain in such state. Therefore it should be imperative to watch it continuously in order to avoid its decay to a corrupt state  $|c\rangle$ . Honest journalism, if that were possible, would serve people, as it is in charge of monitoring government activities so that corrupt states are not developed.

In case that the initial state is the corrupt one, the frequency of the observation should be varied in order to achieve a change of state, to the honest one.

### 3. Salary control and reservoirs

Now we turn our attention on a similarity between the way salaries may be controlled and quantum decay. Systems in quantum mechanics are usually not isolated: they have an environment, that not only interacts with them, but that affects them severely. The environment, being so large, gets not affected by the small system. For instance, a quantized field inside a cavity will decay to the vacuum because of its interaction with a reservoir of quantized fields outside the cavity: If we start with  $N$  photons in the cavity and the outside fields in vacuum states, the most probable events are that single photons in the cavity will be annihilated while photons (quanta of the electromagnetic field) in the outside modes will appear. This process will eventually empty the cavity leaving us with the vacuum state  $|0\rangle$ . In the case that the reservoir is at finite temperature, photons will exist outside and will be able to enter the cavity generating a so-called thermal state in it.

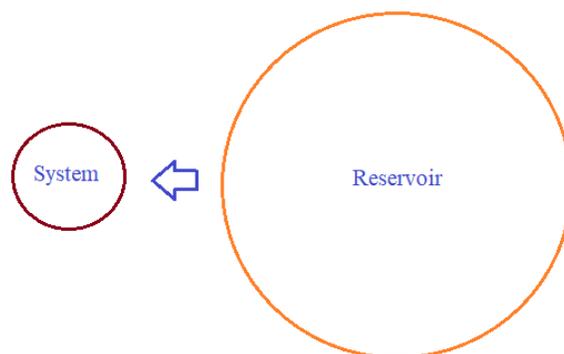


Fig. 1. A system-environment interaction that, because of their size, only the system is affected.

Companies can count with a reservoir of workers that may lead the salary to a minimum wage that they decide. Workers may be dismissed, as the reservoir outside (the many unemployed workers that look for a job, even though may be a very low paid job), has so many individuals trying to find a job that the desired state: Low salaries may be easily achieved.

Finally it is worth to mention that system-reservoir interactions lead to stochastic differential equations very similar to the ones studied by large banks in order to see where they should invest. It is not strange then that in some countries there are university careers like Econophysics.

#### 4. Entropy and media control

In physics, entropy is a concept that is usually related to information. Let us think that a quantum state may be described by a wave function  $|F\rangle$ . In this case we have a deterministic system in the sense that we know which is its state. With the wave function we may define the so-called density matrix

$$R=|F\rangle\langle F|$$

and note that, as states are usually normalized,

$$R^n = R,$$

therefore we may find the von Neumann entropy, which is a function of the density matrix  $S=-\text{Tr}(R\ln R)$ , has the value of zero. Here  $\text{Tr}$  means the trace over the system's

degrees of freedom. The fact that the entropy is zero means that we have complete knowledge about the system.

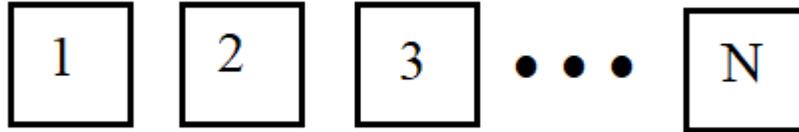


Fig. 2. If a system may be in any of the boxes with probability  $P_j$ , we do not have much information about it. As the number of boxes increases, we have less and less information while, in the limiting case of only one box, we have complete information.

Now consider a different density matrix

$$R_N = P_1|F_1\rangle\langle F_1| + P_2|F_2\rangle\langle F_2| + \dots + P_N|F_N\rangle\langle F_N|$$

where  $P_j$ , for  $j=1, \dots, N$ , are the probabilities that the system is in the state  $F_j$  ( $P_j$  greater or equal to zero). In this case the von Neumann entropy is different from zero and will depend on the probabilities  $P_j$ . Consider that all the probabilities are equal:  $P_j=1/N$ , in that case  $S=\ln N$ , and as we increase  $N$ , we increase the entropy and therefore the lack of information we have of the system.

Media, mainly TV and internet resources, use this fact, knowing it or not, to produce some control on people. Mass media is generally owned by the most reach people of the planet, therefore by people whose main interest is not to deliver real news to an audience, but instead in making up such news in order to avoid the common person to know his/her reality and in this way protecting themselves and other rich people with whom they do business (advertisements among other things).

The amount of TV channels and news programs available in different countries allows that, if there is a single channel or news program that for any strange reason is advocated to deliver truth, it is effectively unreached by ordinary people, as the amount of lack of information, or entropy, is increased continuously. Besides this, media, as a factual power, can even spread fake news in order to load the dice in favour of their own interests. I believe that this fact may be observed everywhere on the planet.

## 5. Squeezed states and wealth concentration

Coherent states of the harmonic oscillator are also known as minimum uncertainty states (MUS). They are the most classical states as the averages for the energy, momentum and position follow the classical trajectories. They minimize the Heisenberg uncertainty principle but not only that, their uncertainties for position and momentum are equal. Because of these features, they serve as a reference to know when arbitrary states behave non-classically. Another kind of MUS are the so-called squeezed states. Although they also minimize the Heisenberg uncertainty principle, their uncertainties are not equal.

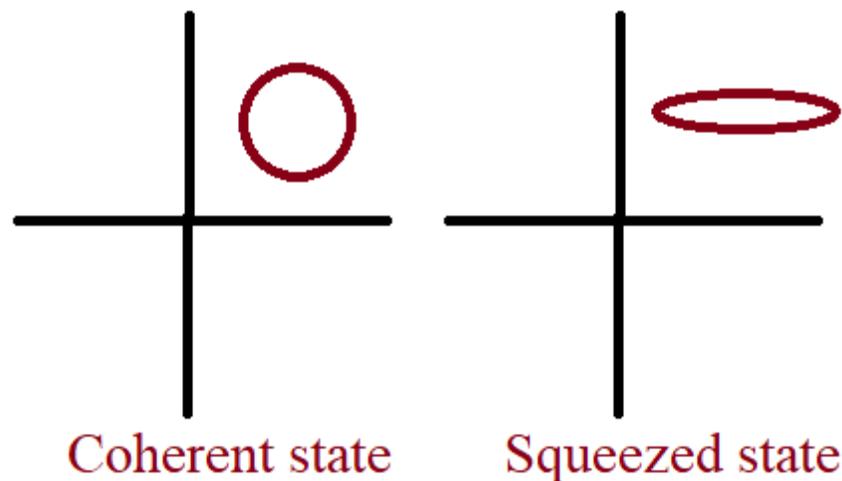


Fig. 3. How coherent and squeezed states look like in phase space. The axes in quantum mechanics are usually (generalized) position and momentum, or, in general canonical conjugate variables.

The analogy I would like to put forward here, is that the amount of resources of the planet are limited. Therefore, the concentration of wealth in some hands directly implies that many will have quasi-nothing. The process of some acquiring so much wealth, squeezes the amount of wealth for the others, leaving them almost with nothing. In words of Gandhi: “The world has enough for everyone's need (here we are in the coherent state regime), but not enough for everyone's greed (here we are in the squeezed state regime).”

## 6. Conclusions

I have tried to draw some connections between some cases of study in physics and some social phenomena. In particular, I have mentioned concepts like entropy, system-environment interaction, squeezed states and the quantum Zeno effect. As a conclusion it should be mentioned that, as events in a part of the world may affect all the world (for instance, the concept of reservoir of workers may be easily extended to other countries, as companies usually go to countries with lower salaries) we should be more aware of the things that happen around us and to be more critical about what we read or listen when it comes from media. As mentioned by Malcolm X: "The media's the most powerful entity on earth. They have the power to make the innocent guilty and to make the guilty innocent, and that's power. Because they control the minds of the masses." We should also study in detail where science money should be put, as we are arriving at times where it should not be wasted foolishly. In the words of one of the 2019 physics Nobel prize winners for finding exoplanets on humans travelling to them: "We are talking about hundreds of millions of days using the means we have available today. We must take care of our planet, it is very beautiful and still absolutely liveable [14]." To add that he felt the need to "kill all the statements that say 'OK, we will go to a livable planet if one day life is not possible on earth'." My view on these statements is, however, that human beings should spend a lot of money looking for these planets.

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