Omnipresent physics in technologies and other scientific fields

from the physics knowledge in secondary/high schools

by

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Chapter 5: X-Physics or Physics-X shaping other scientific fields

V.1. Introduction

"All science is either physics or stamp collecting". So said Ernest Rutherford, the father of nuclear physics. All of our modern sciences take their names from ancient Greek. In the case of physics, that word is "physik" which means "knowledge of nature". Physics, then, means studying nature at its most base level: matter, behavior and motion, energy types, time and space, and their actions and interactions. Physics impacts on the evolution of other scientific disciplines and has led to new fields such as Biological physics, Medical physics, Chemical physics, Astrophysics, Sociophysics, Econophysics, etc.

This chapter presents some concepts of physics, learned in secondary education, which are used in chemistry, medicine, biology, astronomy and astrophysics, economy, and sociology. We mention that it will just be a sample of what physics laws are used to describe phenomena in these different fields. Indeed, after obtaining a bachelor in Physics or a Master in physics, students will be able to see more details on how physics laws are used in different fields of sciences. Some students could eventually choose to continue their studies in some of the fields created by physics (biological physics, medical physics, socio-physics, astrophysics, econophysics, and so on).

V.2. Chemical physics

From Wikipedia, Chemical physics is the branch of physics that studies chemical processes from the point of view of physics. It is a sub discipline of chemistry and physics that investigates physicochemical phenomena using techniques from atomic and molecular physics and condensed matter physics. It is a discipline which is developed in universities in terms of education and research. And major scientific discoveries with high impact in technological applications come from that discipline.

In secondary/high schools, there is an introduction into chemical physics even if it is not indicated explicitly. It is the use of the principle of classical mechanics, Coulomb law and the quantization of energy levels to come out with the expression of energy levels given by the following expression:

$$E_n = -\frac{me^4}{8n^2\varepsilon_0{}^2h^2}$$

(5.1)

This expression is obtained when we consider an electron orbiting around the nucleus of the hydrogen with the concept of uniform rotation and centrifugal force.

Coulomb law learned in secondary/high schools is used not only to determine the electron orbit round the nucleus, but also to explain the forces holding the chemical molecules. This eventually explains the structure of materials. Indeed, the structural distribution of atoms and molecules inside a material is explained by the electrical and magnetic forces between atoms and molecules and the fact that the total potential energy should be at its minimum.

V.3. Medical physics

In chapter 3, we presented some applications of modern physics laws in medicine. This was the premises of an interesting physics discipline called medical physics. It is a discipline or branch of applied physics which uses physics laws and principles and methods to come out with technological devices for the prevention, diagnosis and treatment of human diseases.

Even here, there are divisions or specialties such as Medical Imaging Physics, Nuclear Medicine Physics, Medical Health Physics (Radiation Protection in Medicine).

. Medical Physicists can work in clinical, academic or research institutions.

V.4. Biological physics

Biological Physics, also known as biophysics, applies the principles and techniques of physics to study living things in order to understand how they function. For instance, our heart works as a mechanical pump.

At the macroscopic level, a biological physicist uses physics laws presented in this books and other physics laws (Newton laws, Ohm's laws, Faraday's or Lenz's laws, optics laws, etc.) to explain how our biological organs work: brain, heart, ear, eye, brain, arms, feet, muscles, bones, kidney, lungs, blood circulation tree, nervous system, etc. At the atomic and molecular levels, the principles of physics are used to understand the functioning of several biological entities: cells, DNA and other biological molecules.

From the investigation of biological word using physical laws, one comes out with technological devices which imitate the functioning of the natural biological organs. This is bioinsipiration or biomimetism which leads to the creation of artificial biological organs: artificial pacemaker, artificial heart, artificial eye, artificial pancreas, artificial lung, artificial kidney, artificial arms, etc.

V.5. Astronomy and astrophysics

Astronomy is the science which studies extraterrestrial objects and phenomena (Universe as a whole). Astronomers use the physics principles to learn about the fundamental nature of the universe and its components, including the sun, moon, planets, stars, and galaxies (based on Universal gravitation law and Newton's laws, but also on optical laws).

Astrophysics applies physics laws and chemistry laws to explain the nature and structure of astronomical objects (stars, planets, galaxies, nebulae).

While astronomy is concerned with the motions and luminosities of the planets and stars in the universe, astrophysics is interested in the chemical and physical composition of the objects in the universe, rather than study their position or motions in space. A part of the astrophysics is the cosmology which studies the birth, the life and death of celestial objects.

Let us mention that these three space disciplines are very close and sometimes it is difficult to make a clear difference between them.

V.6. Sociophysics and econophysics

The French social thinker Henri de Saint-Simon in one of his book written in 1803 (Letters of a Geneva resident) introduced the idea of describing the societal phenomena using laws similar to those found in physics and biology. In 1819, Auguste Comte (one of the collaborators of Saint-Simon), who as a young man dreamed of studying political and social phenomena as if they were natural forces, conceived a new science, called "social physics". Social physics or sociophysics uses mathematical models based on physics to study the behavior of phenomena involving humans such as human crowds, in order to discover natural and invariable laws.

Econophysics is a discipline which applies methods developed by physicists in order to solve problems in economics, usually problems where stochastic and nonlinear dynamics are involved. It is a recent discipline whose name was given in 1995 by the American physicist, Eugene Stanley (Boston University), to describe the large number of scientific articles published by physicsists in the problems of markets. This term was pronounced during a conference on statistical physics in Kolkata (Calcuta, India). The proceeding of that conference was published in 1996 by Physica A, a physics journals owned by Elsevier.

Econophysics considers that the economic world behaves in the same manner as ensembles of electrons or molecules interacting with each other as what happens in the context of statistical physics. It can lead to complex behavior such as chaos (economic chaos) which is a state of general confusion in which it becomes difficult or impossible to make previsions.

V.7. Conclusion

As it appears in this chapter, physics is shaping the scientific idea in several fields and is gaining more disciplines, more than any other scientific discipline. There is no doubt that physics will continue to do so as it is the discipline at the heart of science and technology. Thus, a good student in physics can later specialize or work in a domain which, in the past, was considered far from physics. During the university education, they will see that those new physics disciplines are taking space in education and research, but also in technology and other applications.

General conclusion

Physics is the essence of scientific knowledge and technology. From some concepts taught in secondary/high schools physics textbooks, this book has presented some interesting technological applications in a general context and a chapter has been devoted to the telecommunication technology. The last chapter has shown that physics is still growing in extension by creating new fields from scientific disciplines which seem far from physics.

The message presented in this book has been limited to some physics laws taught in secondary/high schools. When going further in university studies, students registered in physics will be able to receive more knowledge in both fundamental and applied physics. They will see that physics is omnipresent in all other scientific disciplines even if it is not seen at first glance. They will thus have a large door open for physics studies and physics applications either by going into engineering schools which are mainly based on physics laws or going into several specialized fields of physics including the X-physics or physics X fields. They will see that a good knowledge in physics can lead to job opportunities, not only in physics and engineering, but also in biology, chemistry, economics and social sciences.

And thus, they will come to the conclusion that Physics is omnipresent in technologies and other scientific fields.