True/untrue explanations in Physics: the Bohr's atom model

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Abstract

In this note, and inspired by an article appeared recently in this journal, we discuss an example related to the theory of the Bohr's atom, who illustrates the fact that erroneous expositions in the learning of Physics exist, considering that this concept includes the use of well internationally recognized and commonly used educational text books.

Keywords: Physics Education, History of Science, Text Books.

Resumen

En esta nota, e inspirados en un artículo aparecido recientemente en esta revista, se discute un ejemplo relacionado con la teoría del átomo de Bohr, que ilustra el hecho de que existen planteamientos erróneos en el aprendizaje de la Física, considerando que este concepto incluye el uso de libros de texto reconocidos internacionalmente y comúnmente utilizados en la practica docente.

Palabras clave: Educación en Física, Historia de la Ciencia, Libros de Texto.

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In a recent published paper in this Journal, Wörner [1] presented some examples of erroneous common facts that often appear in physics learning. In one of them (quoted as F in the mentioned article) the author shows that when Franck and Hertz performed their well known experiment about the ionization of atoms they did not know Bohr's theory, as it is often assumed because the most physics text books present this experiment as a consequent confirmation of the quantum hypothesis proposed by Bohr. We will show in this brief article why the Bohr model of the atom, in the way that it is described in the most used text books [2, 3, 4, 5, 6, 7, 8], is an example of another untrue explanation.

As it is well known Bohr postulated that the classical radiation theory does not hold for atomic systems. He overcomes the Rutherford's model problem of an unstable atom that continuously losses energy, by applying Plank's idea of quantized energy levels to orbiting atom electrons. In the above mentioned books the authors state that in order to calculate the electrons energy in their orbits in a one electron (better say, Hydrogen) atom, Bohr have made some basic assumptions that have been resumed in three postulates, namely:

i- The electron can moves only in certain and stable circular orbits about the nucleus (proton) where does not emit energy in the form of radiation.

ii- Radiation is emitted by the atom when the electron "jumps" from a more energetic initial orbit (energy state) to a lower orbit, or it is absorbed when an electron transition from a lower to a higher energy state takes place.

iii- The allowed orbits are those for which the electron's orbital angular momentum, L, about the nucleus is an integral multiple of $h/2\pi$, where h is the Plank's constant, *i.e.* $L_n = mv_nr_n = n\ h/2\pi$, where m is the electron mass, v_n its velocity in the n-orbit of radius r_n and n an integer number ($n = 0, 1, 2,\ldots$)

One can easy see that while the first two assumptions can be justifying using the above mentioned Bohr´s previous knowledge of ancient atom models, including the planetary Rutherford's model, and of Plank's work on the laws of Black Body radiation (both date from the first years of the past century), the third assumption, although it can be interpreted on the basis of the wave-particle duality postulate of Louis De Broglie[1], does not have a preceding historical foundation at the moment at which Bohr developed his model, which sometimes makes difficult its acceptance: Note that the work of Bohr was developed

[1] Louis De Broglie proposed towards 1924 the relation $\lambda=h/mv$ for the wavelength of a wave associated to a particle of mass m moving with speed v. If the wave associated to the particle must "enter" one circular orbit of radio r, then the length of the orbit must agree with a multiple of an integer number of wavelengths, that is, $2\pi r_n=n\lambda_n=nh/mv_n$ from which the condition of angular momentum quantization is straightforward obtained.