

Conservation Laws in Physics. Emmy Noether's Theorem

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ABSTRACT

The study is explanatory-interpretative and argues the practical character of Physics. It starts from premise that formation of a correct conception of the world begins with the understanding of physics. It is one of the earliest chapters of human knowledge, studying the material world from the microscopic level of the particles to the macroscopic level of the celestial body. As an example for the practical importance of applying the laws of physics take the set of physical laws of conservation, in particular, it explains the practical impact of Emmy Noether's Theorem.

Keywords: practical character of Physics ; conservation laws ; Emmy Noether's Theorem

1. INTRODUCTION

By physics the students can find out answers to the most natural questions such as: Why is the rainbow? How is formed the solar eclipse and lunar eclipse? Why we see the lightning first and then the thunder? What is an echo? Why is not the snow transparent? Why wet wood when are put on fire crackle? How is explained the people walking? Why water does not pass through the umbrella or tent sheet? Why illuminate a light bulb? Why water from a deep well is cold even in summer? Why are shaken the laundry before being stretched? (Bărbulescu, Țățu & Țățu, 2007).

Physics is the science that studies the structure and properties of matter and its transformations which do not affect the microscopic structure (Constantinescu, 2001; Stoenescu & Florian, 2009; Pluta & Hryniewicz, 2013). But is not strictly related of matter, representing a discernible pattern, of the reality that can be an imaginary model, imperceptible, in this case referring to fields associated to interactions between particles, the quarks, to the concept of "ether", etc.. Physics studies physical phenomena, discovers and defines the properties and physical quantities that characterize and establish the laws which govern these phenomena. Therefore physics helps to explain physical phenomena observed at every step and thus to perceive and understand reality.

2. SOME TAXONOMIS OF LAWS. CONSERVATION LAWS

In the philosophy of physics the knowledge issue is related to the report between objective factor and subjective factor in the perception of the world (Budan, 1995). The question is: are physical laws, "pragmatic expressions" independent of any reference to cognitive subjects, or they are outcomes of the "mental states" of observers? M. Bunge suggests four possible theses:

- the realistic thesis (Boltzman, Planck, Einstein) – physical facts have an autonomous existence, objective;
- the subjective thesis (Mach, Schrodinger) – physical theories are related to perceptions or ideas of a subject engaged in a cognition process;
- the thesis of the school of Copenhagen (released by N. Bohr and collaborators) - in quantum theories cannot be established a strict boundary between subjective and objective;
- the dualist thesis (Peirce, Dingler, Dewey) – the physical theories contain both physical objects and mental, outcomes of the people "trades" with the environment.

The law expresses a necessary relation generally relatively stable and repeatable between systems (or processes) between the internal sides of the same object or phenomenon, between different objects or phenomena, or between successive stages of a certain process. The law is one of the most important forms of universal interaction of the phenomena. Every law of physics can be expressed both qualitatively (in a sentence) and quantitatively (by one or more mathematical relationships) (Vlăduțescu, 2004; Vlăduțescu, 2006). Centuries ago, the laws are discovered accidentally, and the mathematical formulas that represented them were determined empirically based on the correlation of observations, of the results of repeated experiments. Further, the theory became an integral part of scientific research, many of these empirical formulas have been found as limit or specific cases of a general relationship (Spoială, 1998).

The laws have different degrees of generality, depending on the width of their sphere of action. There are such laws specific, to a particular field of reality and general laws that act in whole nature, for example the law of conservation of energy - as universal laws – the dialectical laws acting around reality, both in nature and in society and thought (Pluta & Hryniewicz, 2014; Borowski, 2013, 2014).

From the point of view of the logical-deductive structure of physics, the laws can be empirical laws, deduced laws and experimentally verified or theoretical laws, deduced laws in a precise axiomatic context.

A physical law expresses a dependence between the physical quantities relating to one and the same physical phenomenon. The law can be expressed verbal, algebraic or graphic.

The most known laws of physics are: universal law of attraction, the Archimedes's law, the Ohm's law, the Kirchhoff's laws, the friction laws, the Kepler's laws, the Coulomb's law, the Pascal's law, the Bernoulli's law, the conservation laws, the ideal gas laws.

There are attempts to make a classification of physical laws.

A first classification would be:

- laws of state (example : thermic equation of state) ;
- laws of evolution – of motion (example : the law of motion of the material point , the law of velocity ...).

First expresses simultaneous relationships between state quantities, the other express relationships between simultaneous events, non-simultaneous, constituting partial expressions of the causality (Spitzer, 2013).

Another classification would be (Huțanu, 1983):

- fundamental laws (example: the principles of classical mechanics);
- laws of material (example: the Hook's law, the second law of electrolysis...);
- laws of causality (the Boyle- Mariotte's law, the Gay-Lussac's law, the Charles's law, the Ohm's law);
- laws of conservation – dynamic laws (example: the law of conservation of energy , the law of conservation of momentum, the law of conservation of kinetic momentum, the law of conservation of mass, the law of conservation of nucleon number, the law of conservation of electric charge)
- statistical laws (the Ohm's law for semiconductors, the fundamental formula of kinetic-molecular theory, the law of radioactive disintegration)

Mathematical form of physical laws must remain independent of the different conventions that are made regarding measuring the physical quantities involved in their mathematical expression, because physical laws have an objective character. So the form of physical laws must remain invariant when is switching from one group of conventions to another, i.e. when is performing a transformation (Vlăduțescu & Ciupercă, 2014).

The invariance of physical laws besides various systems of measure units is ensured by the homogeneity of mathematical relations that express these physical laws. The homogeneity of a relationship consists in the both members of the relationship must have the same dimensions.

Laws which express the additive nature - conservative of some physical quantities during a transformation, are called conservation laws (Schlick, 2010; Stavre, 2012; Persinger, 2014).

The conservation laws are general laws of the nature. Some of them, for example the law of conservation of total energy of a system, the law of conservation of the total momentum of a system are applied to all phenomena. Others have a smaller applicability. So are: the law of conservation of baryon number, the law of conservation of parity, the law of conservation of strangeness and others in the field of elementary particles. Each of these conservation laws represents a particular form of conservation laws of matter and its motion.

3. EMMY NOETHER'S THEOREM

The conservation laws are an expression of the philosophical fundamental principle of the indestructibility of matter and movement. In the twentieth century, Emmy Noether established a relationship between certain laws of conservation and some symmetry properties of the space, thus revealing a deeper sense of the laws of conservation. It is known that the mechanical state of a system is determined by equations of motion (Lagrange, Hamilton). In some cases these equations can be integrated, but it may encounter also situations where this is not possible. However, even in this case it can get some information regarding the physical motion board. Thus although the $2s$ size q_1, \dots, \dot{q}_i ($i = 1, 2, \dots, s$) q_i and \dot{q}_i being the coordinates respective the generalized velocities) which determine the state of the system varies in time, it may also constituted other quantities, depending on them, to maintain unchanged the value during the motion. This kind functions are for example the

energy, the momentum, angular momentum, etc.. The invariance of these quantities is related to the fundamental properties of the space and time: homogeneity and isotropy of space and the uniformity of the time. These properties are defined by symmetry operations that leave invariant the laws of motion of the physical systems in space and time.

The circumstance that the translation in time represents a symmetry operation, means that an experiment that in well defined conditions, at a time gives some results must give at any time later, the same results. As well the fact that translations and spatial rotations are operations of symmetry means that an experiment which in well defined conditions at a time gives some results, it must give at any time later, the same results. As well the fact that translations and spatial rotations are operations of symmetry means that the physical laws do not depend on the choice of the origin of the reference system and respective of its orientation.

Noether's theorem enunciation: "In case of an isolated system (closed system) to each operation of symmetry corresponds a conservation law of a physical quantity". This theorem is one of the most important theorems of contemporary physics. Interdependence between conservation laws and properties of the space and time does not mean that the conservation laws are simple consequences of spatial-time symmetry properties in that the time and space would generate laws of conservation.

They are forms of existence of matter, space and time are closely related to it. This connection is manifested also by the dependence of laws of conservation of symmetry properties of the space and time.

On the philosophical the content of the Noether's theorem is reduced to the statement that of the known properties of space and time, as forms of existence of matter can be derived laws of conservation which govern the movement of these matters.

3. CONCLUSIONS

Physics is the most comprehensive of natural sciences, studying the deployment mode of phenomena and establishing the laws that govern them. At each step a physical phenomenon accompanies us, in every moment we feel the impact of a physical law. By means of this science, through calculation and experience, the human came out from the surreal influence, penetrating the secrets of the nature.

Physics is the first discipline that asks the student to observe the phenomena of nature, to perform experiments and to explain them scientifically, develops the investigative capacity, assimilation, interpretation and application in practice. By physical are decoded the mysteries of nature. By training as sport develops muscles, physics develops the intuition.

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