

Philosophical Thoughts in the Teaching of Electrodynamics

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Abstract

As the important part of the theoretical physics, the electrodynamics is a theoretical basic course of the physics and relative subjects. To adapt the demands for cultivating the target of highly-quality talents in the 21st century, to properly add relative philosophical thoughts can not only deepen students' cognition about the electromagnetic law, but can further cultivate students' scientific thinking ability, which is very important for cultivating innovative talents with high quality. Combining with teaching experiences, the philosophical thoughts in the teaching of electrodynamics are analyzed in this article from five aspects including the general and the special, the abstract and the concrete, the local and the whole, the matter and the movement, and the time and the space.

Keywords: Electrodynamics, Philosophical thoughts

The electrodynamics is a complete and accurate classical physics theory. The basic law of the electromagnetic movement is presented dialectically and scientifically by beautiful, harmonious, simple and symmetrical equation and profound electromagnetic concepts, and its physical contents not only have higher quantification degree, but contain abundant philosophical thoughts. In the electrodynamics materials compiling and the classroom teaching, the transfer and understanding of the scientific knowledge are generally emphasized, but the necessary and complete discussion about the philosophical thoughts are deficient. In fact, to add relative philosophical thoughts education properly in the teaching of electrodynamics could not only deepen students' cognition about the electromagnetic law, but can further cultivate students' scientific thinking ability, which is very important for cultivating innovative talents with high quality. The philosophical category in the electrodynamics is wide, and classical philosophical problems include following aspects.

1. The general and the special

Ascending to the historical skeleton of the electrodynamics knowledge system, it is not difficult to find that the production, formation and development of the electromagnetic theory are the dialectic cognition process from the special to the general and then from the general to the special. Scientists' initial researches about the electrics, magnetism and photics were to conclude the Coulomb Law applying in the general static field from the rules among special point charges, obtain the Ampere Law in the general constant magnetic field from the special abstract electric current element, conclude the general electromagnetic induction law from the special electromagnetic induction phenomena, and obtain general photic laws such as intervention, diffraction, refraction and reflection from some special photic phenomena. Relative to the whole electromagnetic movement rules, above various laws about static electrics, magnetism and photics still are some special concrete electromagnetic rules. By understanding these special electromagnetic rules, Maxwell gave reasonable scientific hypothesis and used mathematical wonderful method to obtain the general law which can more generally reflect the characteristics of the electromagnetic movements, i.e. the Maxwell's equations. By these two scientific cognition processes from the special to the general on different layers, the electromagnetic theory was sublimed epically, so the uniform rule could be describe the general electromagnetic phenomena. On the new theoretical layer, Maxwell's equations could be reversely utilized to profoundly and theoretically analyze many relatively special electromagnetic problems such as electrics, magnetism and photics. According to the diffusions of the static electric field, the constant magnetic field and the electromagnetic wave, the electromagnetic radiation and various corresponding conditions of concrete electromagnetic problems, the second-level theoretical equation from the Maxwell electromagnetic theory could be used to solve corresponding special problems. For example, as the theoretical references, the Poisson equation and the Laplace Equation applying in the static electric field obtained from the Maxwell's equations could solve more concrete static field problems. By the scientific

evolution from the special to the general and from the general to the special, the electrodynamics made the electromagnetic theory system more systematic and perfect, the contents more abundant and colorful, and the essential of the electromagnetic phenomena more profound.

2. The abstract and the concrete

To accurately describe the electromagnetic movement rules, the electrodynamics adopts many physical models such as point electric charge, electric current element, electric doublet, magnetic doublet, electric multi-pole, magnetic multi-pole, and plane wave. They all have their own corresponding concrete physical ante-types, and they are a group of ideal objects by ignoring subordinate factors and giving prominence to main factors though scientific abstract. For example, the charged body with tiny size can be abstracted as the point charge, and two point charges with equal quantity and different symbols and close distance can be abstracted as the electric doublet, and the magnetic doublet is the abstract of the electric current loop, and the plane wave is the abstract of the large spherical wave in the local range. The physical model established from the concrete to the abstract can also complete the scientific cognition process from the abstract to the concrete, i.e. the abstracted physical model can be utilized to discuss and analyze the concrete electromagnetic problems. For example, general charged bodies can be divided into numerous charge elements (point charges), and the field formed by the former can be regarded as the iterative of the fields produced by the latter. The electric media and the magnetic media can respectively equal to corresponding combinations of point charges and electric doublets under certain conditions. The electromagnetic wave can be divided into the iterative of the plane waves with various frequencies. The charged bodies can equal to corresponding physical combinations of point charge, electric doublet, magnetic doublet, electric multi-pole and magnetic multi-pole on different levels, and the force stimulated by the former is the iterative of the forces induced by the latter. And spread of the magnetic multi-pole and the multi-pole spread of the radiated force are also similar with above phenomena.

The physical model processing method of the electrodynamics concretely embodies the philosophical thoughts from the concrete to the abstract to the concrete. To obtain the ideal model of scientific thinking from the abstract of the concrete electromagnetic object and ascend to the concrete subjective electromagnetic phenomena from the abstract model will continually enhance the layer of the scientific cognition, and the scientific cognition will be continually deepened, so the electromagnetic phenomena will more and more present their own abundant contents and profound connotations.

3. The local and the whole

The physical prospect of the electrodynamics is described by a group of strict physical concepts and a set of accurate relations with them. Both the electrical field strength and the magnetic induction intensity are the local attributes to describe the field, and the charge density and the electric current density are respectively to denote the local distribution characteristics of charge and electric current. These electromagnetic concepts are all used to describe the point characteristics of corresponding physical quantities, and belong to local physical concepts, and their property is a local physical property. The concepts including the electric flux, the magnetic flux, the charge intensity, and the electric current intensity are used to describe the total physical attribute of corresponding objects, and belong to the total concepts, and their property is the total physical property. The local associations in physics exist among local physical quantities. For example, the Gauss Law was to describe the total relation between the electric flux and the charge, and the Ampere Loop Law was to describe the total relation between the magnetic field circulation and the electric current intensity. The integer equation of the electromagnetic theory could actually reflect the comprehensive behaviors of the electromagnetic movement point according to special mode. For example, the electric flux on certain curve surface is the integer result of the scalar product of the point surface element and the electric field intensity, and the magnetic flux has the similar corresponding comprehensive relation with the magnetic induction intensity, and the charge of the system is the integer result of the scalar product of the point volume element with the charge intensity.

The local and the whole are a kind of opposite and uniform. The review of the local electromagnetic flux can help us to cognize the total electromagnetic attribute of the system, and the total electromagnetic attribute of the system can help us to analyze the local characteristics of the electromagnetic phenomena. Properly using the local electromagnetic relation, the whole relation and the relation between the local and the whole to discuss various concrete electromagnetic problems can help us to understand the laws of the electromagnetic movement.

4. The matter and the movement

Energy and momentum are the representations and scales of the matter's movement, and both the matter and the movement depend on each other for existence. The theory and the experiment of the electrodynamics all indicate that the electromagnetic field has energy and momentum, i.e. the electromagnetic field has abundant movement connotation, and the electromagnetic movement and the electromagnetic matters can not leave each other, so the electromagnetic field is a moving matter. The field and the matter compose two basic formations of the matter, and the field and the matter can convert each other, and the disappearing of the matter will certainly company with the production of the field matter. On the contrary, the disappearing of the field matter will certainly company with the production of the matter,

that is not only the disappearing of the matter, not the virtual production of the matter, and it is the mutual conversion of the matter movement form and the existence state, and its energy scale of the conversion process is dominated by the Einstein mass-energy relation, and still follow the conversation of energy and the conversation of momentum laws at the same time. For example, the positive charges and the negative charges can disappear and turn into photons, and here, though the electron as the matter form has disappeared, but the photons as the field formation also generate with that, and the moving matter still exists, and the energy and the momentum which could measure the movement of the matter are still equal, only the concrete form of the matter changes. In fact, the conversion form of the form between the field and the matter is very similar with the physical connotation of the phase change of gas, liquid and solid on the molecule layer, and the conversion between the field and the matter is a kind of phase change of the matter on the deeper layer. Therefore, to utilize the philosophical matter view to further consider the characteristics of the electromagnetic field can deepen the understanding of the matter attribute connotation of the electromagnetic field.

5. The time and the space

Space is the spreading representation of the matter movement, and time is the sustainable representation of the matter movement. This philosophical opinion is hard to exactly be opened out in the static electrodynamics. Newton thought that time and space liked a big box, and time liked a flowing river, and relation didn't exist among time, space and movement. Facing the conflict between the old theory and the new experimental fact, Einstein established the narrow relativity based on original experiences at the beginning of the twenty century, and proposed the new time-space view. The core problem of the narrow relativity is the problem of simultaneity and relativity, and there is not the absolute simultaneity in the world, and the simultaneity is related to the special movement frame of reference. The simultaneity is closely related with the time-space scale, and the relativity of the simultaneity will certainly induce the relativity of space and time. The scientific conclusion of the relativity shows that the moving scale will shrink, and the moving clock will delay, and the size of the shrinking and delaying is always related with the concrete movement frame of reference, and this time-space effect is the result of the change of the space spreading and the time durative with the change of the matter movement state, and it indicates that the time-space attribute is related with the movement, and the time, space and matter movement are closely associated.

In the teaching of electrodynamics, not only the scientific knowledge should be transferred accurately, but the philosophical thoughts in the electromagnetic theory should be analyzed properly. The philosophical spirit can be opened out in the interaction of scientific knowledge, and the essence of the scientific knowledge could be further understood profoundly under the instruction of philosophical thoughts.

References

- Guo, Shuhong. (1997). *Electrodynamics*. Beijing: China Higher Education Press.
- Li, Guangzhou & Zhou, Xiaoming. (1997). The Modernization of Modern Science and Technology and Basic Physics Teaching. *College Physics*, No. 16.
- Yin, Zhen. (1999). *Electrodynamics*. Nanjing: Nanjing University Press.
- Yu, Yunqiang. (1999). *Concise Course in Electrodynamics*. Beijing: Beijing University Press.
- Zhao, Kaihua. (1992). Modernization of the General Physical Courses. *College Physics*, No. 11.