

Application of Science Aesthetics 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, the aesthetic principle can be used in the teaching to stimulate students' learning desire and cultivate students' scientific thinking ability. Combining with research experiences, the aesthetic characteristics of the electrodynamics and the application of science aesthetics in the teaching of electrodynamics are analyzed in this article.

Keywords: Electrodynamics, Science aesthetics

The development of modern science and technology more and more clearly indicates that various subjects are not only highly different but highly agreeable. As one branch of the science, the science aesthetics has played more and more important function in the development of various subjects. On the one hand, the science aesthetics guides and encourages people to open out the beauty of the nature. On the other hand, the beauty of the nature cognized by people would further approve and enrich the ideas and contents of the science aesthetics. In the teaching, the principles of aesthetics can be utilized to dig the factor of beauty, stimulate students' learning desire, and cultivate students' ability to cognize problems, analyze problems and solve problems, and their scientific percipient ability.

1. Aesthetic characteristics of electrodynamics

The characteristics of science beauty are different with the characteristics of the common art beauty. The beauty of art can predominantly present its formation of figurativeness, emotionality and aesthetic feeling, and gives priority to the imagery thinking. The characteristics of the science beauty are rational beauties, and the truth of the content combines with the beauty of the form, and its aesthetic feeling is based on the knowledge, and mainly depends on the imagery thinking. Long-term teaching and research make us realize that Maxwell's electromagnetic theory (electromagnetic theory) and Einstein's special theory of relativity (theory of relativity) all are imperishable science artworks.

1.1 Characteristic of oneness

The nature is uniform, and the science which reflects the electromagnetic movement regulation of the nature is also uniform. The oneness of the electrodynamics is presented in the oneness of the mathematical forms, the oneness of physical concepts, and the oneness of the basic physics thoughts. The electrostatic field, the magnetic static field and the stable current field all satisfy the Laplace's Equation, $\nabla^2\phi = 0$, and their green's functions all are $1/r$, which is the oneness of the mathematical forms. The electromagnetic theory realizes the oneness of original independent electricity, magnetics and optics, and the relativity theory associates the conversation of energy with the conservation of momentum, and it opens out the oneness of quality and energy, and makes the electromagnetics and the mechanics to achieve the oneness based on new space-time view. That is the oneness of physical concepts, and both two times of oneness are the landmarks in the development history of the physics. The oneness of the mathematical form and the physical concept reflects the oneness of the physical world. The basic physical ideal of the traditional expression of the electrodynamics is the oneness, and this ideal requires one or one group of equation to uniformly describe all phenomena in this domain to form the logical rigid theory system. This idea was guiding the road of the advanced science "as the important orientation with infinite ability (Einstein)", which actually has acquired abundant result. So many people even thought that "the oneness of the classical theory endowed by physical scientists has exceeded the practical oneness".

The oneness of the science shows a kind of beauty of elevation, just as Einstein said, "If people can realize the electromagnetic oneness of various complex phenomena which looks very visual, it will be a kind of gallant feeling".

1.2 Characteristic of harmony

Harmony is the necessary factor to perfect the theory, and one of important characteristics of the nature. Therefore, the science theories reflecting the nature should be harmonious. The harmony of the electrodynamics

is represented by the interior maturity and autonomy of two theories including the electromagnetic theory and the relativity theory, and the harmony between two theories should be consistent.

Einstein thought that if one theory was nature or mature, this theory certainly was autonomous, and the conflict which could not be eliminated should not exist in various basic concepts or opinions of the theory. Whether for the electromagnetic theory or for the relativity theory, even today, people still are convinced for their maturity, system and rigor. The electromagnetic theory is also consistent with the relativity theory. Taking the study of the electromagnetic field with the constant moving charged particles as the example, there are two ways. The first way is obtaining the Maxwell equation group by the experiment rule, and establishing the electromagnetic theory based on that, and utilizing the theory of four dimensions of the relativity theory to seek the electromagnetic field with the constant moving charged particles. The second way is establishing the mechanics of the relativity theory based on the Lorentz Transformation, and utilizing the Coulomb's Law to seek the electromagnetic field with the constant moving charged particles, which can also prove that this electromagnetic field could also satisfy the Maxwell equation group. The results of two ways are completely same, which shows that the electromagnetic theory and the relativity theory are harmonious and consistent. Both harmony means the interior profound association between them, and they all contain the space and time characteristics and the movement rules, and are all dominated by this rule.

The harmony of the science indicates the harmonious beauty of the science.

1.3 Characteristic of innovation

The innovation of the science theory means whether the theory has new, special and adventurous imagines, which is the life force of the science theory, and the aesthetic value of the science theory.

At Dec 8, 1864, Maxwell issued the thesis of "A Dynamical Theory of the Electromagnetic Field". And based on that, he predicted the existence of the electromagnetic field in 1865, and he thought that the electromagnetic wave was only the transverse wave, and the propagation velocity of the electromagnetic wave equaled to the velocity of light, and the light was one form of the electromagnetic wave. These conclusions are all very adventurous, special and innovational then and there. Up to 1888, Hertz had proved the existence of the electromagnetic wave.

In June of 1905, Einstein wrote the long thesis of "On the Electrodynamics of Moving Bodies". Out of everyman's expectation, the basic hypothesis of the relativity theory and the conclusion of the relativity theory amazed the whole science academy. One thus theory was proved by the experiment, people would taste a kind of pleasure feeling after amazement.

The innovation of the science possesses the new beauty of the science.

1.4 Characteristic of briefness

Both the electromagnetic theory and the relativity theory show the briefness of the science, especially for the relativity theory, the briefness of the science is embodied in (1) there are only two basic hypotheses, (2) there are a few independent concepts and basic equations, and the vector forces and the scalar forces all four-dimensional vectors, and the both the electric field and the magnetic field are thinking tensors, and four equations in the Maxwell equation group can be combined into two equation, (3) whether the Maxwell equation group or the Lorentz Covariance equation in the relativity theory are all briefly denoted, for example, $E = mc^2$ shows the equality of the quality and the energy.

The briefness indicates the unvarnished beauty of the science.

1.5 Characteristic of symmetry

The importance of the symmetry theory in the modern physics is more and more cognized by people. The symmetry of the electrodynamics is represented by the space symmetry of the research objects, the form symmetry of the mathematical equation and the constant symmetry of the physical concepts. The space symmetry of the research objects includes the spherical symmetries of electric charges, electric currents and electric fields, the plane symmetry and the axial symmetry. The wave equation of the electromagnetic wave in the vacuum can present the beauty of the mathematical form and the electromagnetic symmetry in physics. To explore the symmetry beauty of the magnetics and electrics, Dirac predicted the monopole, and if it actually exists, the Maxwell equation group would have higher symmetry. The symmetry is closely associated with the conservation law, and the symmetry is the based of the conservation law, and the conservation law is the symbol to show the symmetry. The conservation law of the electric charges shows the axial symmetry of the interior space, and the symmetric form of the Lorentz Transformation opens out the symmetry of space and time, and the

invariance property of physical equation in the Lorentz Transformation indicates the isotropy of space and time.

The symmetry of the science shows the symmetric beauty of the science.

2. Application of science aesthetics in teaching

In the teaching of electrodynamics, the association between truth and beauty can be obvious everywhere. The harmonious uniform of physical laws, the briefness and symmetry of formulas and the artifice and extract of experiments all make students to feel beautiful. In the teaching, teachers should create the atmosphere of the beauty, cultivate students' taste emotion, promote students' understanding and grasp of the knowledge, and instruct students to study in a creationary way. According to the aesthetic characteristics of the electrodynamics, following approached can be used to utilize the science aesthetics in the teaching.

2.1 Integrated teaching

Yang Zhenning Said that studying physics liked looking a large picture, and each part of this picture had its profoundness. The observation with near distance can know the details of each part, but the observation from the far distance can know the whole picture and grasp the structure of this picture and taste the beauty of this picture. According to the oneness of the electrodynamics, the aesthetic principle of the variety in unity can be applied in the integrated teaching to observe the associated structure among various parts as a whole, which can help students to grasp the knowledge and cultivation their ability. The teaching materials of electrodynamics using at present are generally to summarize the general law of the electromagnetic phenomena by analyzing and summarizing the experiment laws of electromagnetic phenomena, and then respectively discuss the electrostatic field, the steady electromagnetic field, the diffusion of electromagnetic wave, and the radiation and scattering of the electromagnetic wave, and finally summarize and extend to be the four-dimensional form of the relativity theory, which is a multiform and uniform process. For the teaching material system, the lines are clear, the structure is rigid, the interior logic is strong, and various parts have their own structured characteristics in system, content and method.

In the teaching, especially in the stage of review, teachers should enlighten students to summarize the knowledge, and compare and classify relative knowledge, and make clear the ordered structure of the knowledge formed by the interior association, and summarize the solution methods, and form the method system, and grasp the knowledge structure as a whole. Students should study to taste the "lingering charm" of the interior association among various parts, and form the perfect knowledge structure with crossing knowledge groups.

2.2 Compared teaching

The comparison and adaptability are important contents of the harmonious beauty, and the "symmetry and broken" is the important aesthetic principle of the modern physics, and the analogy is the important method of the teaching. So the method of the compared teaching can be adopted to seek differences in similarities, and seek unity in diversity, and make strange physical phenomena and laws to achieve higher harmony, and make the harmonious laws to show strange, and accordingly make the teaching enter the atmosphere with harmonious beauty and strange beauty. The duality principle can obtain the boundary conditions of one type of problem from another type of problem, and accordingly give the solution of one type of problem by the exchange of the duality quantities of the solution of another type of problem. For example, comparing the equation of the exterior steady electrical fields with the electrostatic field without the charge distributed area, the method to solve the boundary value problem of the electrostatic field Laplace's equation can be used to solve the problem of the steady electrical fields. By comparing the electric field and the magnetic field in the vacuum with the electric field and the magnetic field in the mediums, the closed interior association can be found, so the disposal methods are similar and harmonious. By the comparison, the strange can be found in the harmony, and new harmonies will be sought in the strange, which can not only make students to more deeply understand the property of the electromagnetic problems, but give them the enjoying of beauty. The solution of same one electromagnetic problem can be based on different principles. Even for one principle, there are different methods, and when students complete a topic with multiple solutions, they will feel the strange and harmonious beauties because arriving at the same end by different means. The symmetric analysis is more predominant in the teaching of electrodynamics, and the symmetric analysis of the problem will make students to taste the symmetric beauty and the harmonious beauty.

2.3 Innovation teaching

The innovation of the science theory is the aesthetic value of the science theory, and it is the difference of the science theory with general arts. In the teaching, teachers can drive students' enthusiasm and creation by scientific methods, and let students to take the process of grasping knowledge as the process of "discovering"

truth. When students “find” this truth which is their interest and target, and when students have not satisfied the method used in the teaching materials or by teachers, but solved certain problem by another way, and when students use their knowledge to analyze practical problem and realize original opinion and new view and smart method, the inexpressible pleasure and satisfied feeling will occur. Just as Holland scientist Beigun said, “even inappreciable discover will bring people large pleasure”. For example, when instructing the theory of relativity, teachers can first review old relative-absolute space-time theory which could form a harmonious theory system without conflicts, and accord with people’s daily life experiences. Second, teachers could introduce that the electromagnetic theory was completely conflict with the relative-absolute space-time theory, and people thought that the electromagnetic theory could not exist generally, and it could only exist in one special frame of reference. However, what is this special frame of reference? When people failed to find this special frame of reference many times, the theory of relativity occurred. Here, by introducing the history of physics, physical scientists’ creative logic thinking is abstracted and recurs in the teaching, and students can realize physical scientists’ method and thinking when analyzing problems, and feel the pleasure and excitement for exploring knowledge.

References

- Guo, Shuohong. (1997). *Electrodynamics*. Eeijing: China Higher Education Press.
- Li, Guangzhou & Zhou, Xiaoming. (1997). The Modernization of Modern Science and Technology and Basic Physics Teaching. *College Physics*. No.16(5). P.35-37.
- Wu, Hong. (2008). Appreciating Charms of the Electrodynamics Theory in Physics Teaching. *Hournal of Jimei University*. No.9(3). P.66-69.
- Yin, Zhen. (1999). *Electrodynamics*. Nanjing: Nanjing University Press.
- Yu, Yunqiang. (1999). *Concise Course in Electrodynamics*. Eeijing: Beijing University Press.