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Review Article

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The Driver for Innovation and Discovery in Physics

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ABSTRACT

Many breakthroughs in physics originate from raising scientific questions, which promotes the progresses of science and technology eventually. Great Scientists in physics have the courage to deal with difficulties and make innovations. Additionally, they have demonstrated the art of scientific discovery to the world.

Introduction

A scientific question refers to a problem or contradiction raised in the course of scientific exploration that has not been answered. It is usually associated with unrecognized natural phenomena or scientific mysteries. The big scientist Albert Einstein once said that it is often more important to ask a question than to solve it. Moreover, asking new questions or looking at old questions from a new perspective require creativity and imagination, which will promote the progress in science ultimately. A series of breakthroughs in the history of physics can not only give us knowledge, but also give us inspiration. Indeed, physicists' courage to innovate, as well as the spirit of overcoming difficulties have already impressed us a lot. In this article, we will have a look at the source of innovation and the art of discovery in physics.

The Problem in Physics is the Source of Innovation

Major Breakthroughs in Physics are Originated from Solving Problems in Science

Finding contradictions or asking questions is the starting point of scientific research. There are many concepts emerged and many laws discovered in the development of physics, which originated from asking scientific questions. After a series of achievements in classical mechanics, thermodynamics, statistical mechanics and electrodynamics, many people believe that the grand scientific building of physics has been completed. It seems that the younger generation of physicists could only do some patchy work in order to repair this building. However, two new problems appeared, which plagued the physics community at that time. The former is related to the Michelson-Morley experiment and the latter is the black-body radiation. These two problems looked like two dark clouds appearing in the clear sky of physics. It is the solution of these two problems that set off a profound revolution in the history of physics. Simply because the first problem resulted into the creation of relativity and the second problem led to the birth of quantum mechanics.

On the other hand, new problems will be induced with the solution of the original scientific problems in the process of physicist's exploration. This process has promoted the spiral rises and progresses of physics. In 1896, Zeeman discovered the phenomenon that the spectral line was split into three under the magnetic field, which was later called as normal Zeeman effect. Lorentz gave a correct theoretical explanation for Zeeman effect. Although old problems were solved, new problems appeared. In December 1897, Preston reported that the number of divisions may not be three, and the line intervals are not exactly the same. This discovery is called as the "abnormal" Zeeman effect. Although many people tried to explain it, none of them could succeed. Thirty years later, Dutch scholars Uhlenbeck and Goodzmit proposed the hypothesis of electron spin, which solved the problem of anomalous Zeeman effect at last.

Many discoveries in physics seem accidental on the surface. It looks as if some persons seized the opportunity and fortunately observed the laws of physics. But in fact, every researcher actively

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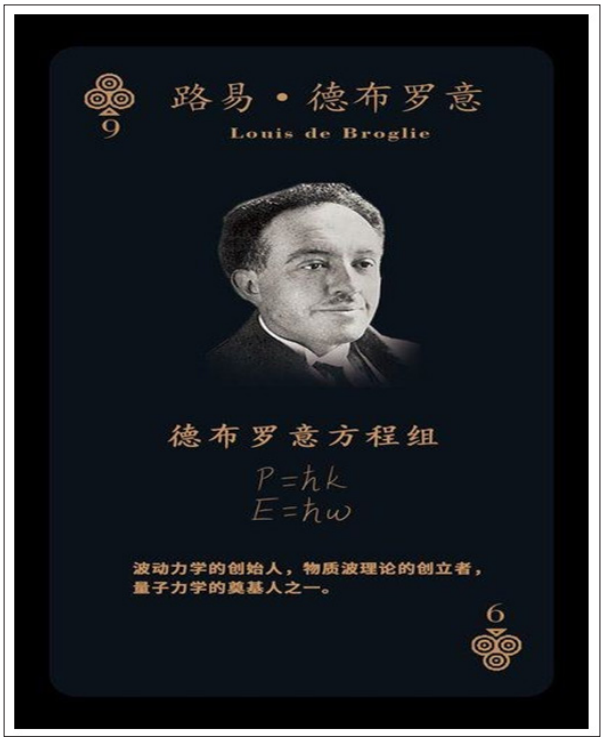
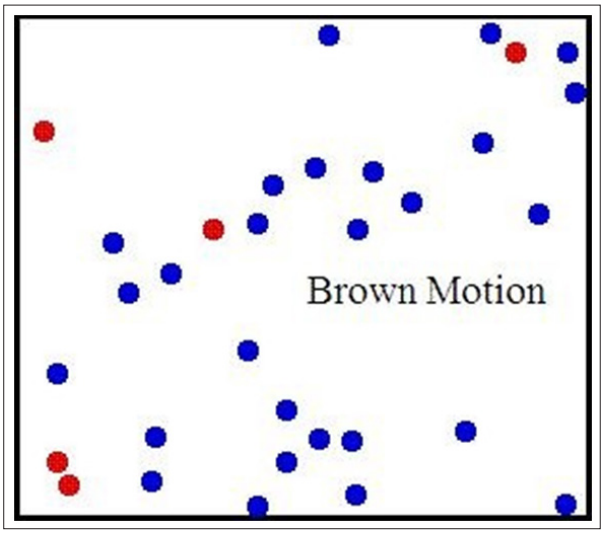
explores science according to certain problems, and finally makes major discoveries. As we know, light can show both the characteristics of wave and particle, which demonstrates wave-particle duality. However, a French young man De Broglie, who had just shifted from the study of history to the study of physics, extended wave-particle duality to all microscopic particles when some physicists were puzzled by the wave-particle duality of light in the early 20th century. De Broglie has made a landmark contribution to physics.



De Broglie's success is not by accident, because people who investigate history are inclined to consider problems by analogy. He thought that all microscopic particles may have common characteristics, including wave-particle duality. On this revolutionary basis, scientists keep on moving towards the creation of quantum mechanics at last.

Putting forward scientific problems and solving them are the excellent character of a good physicist

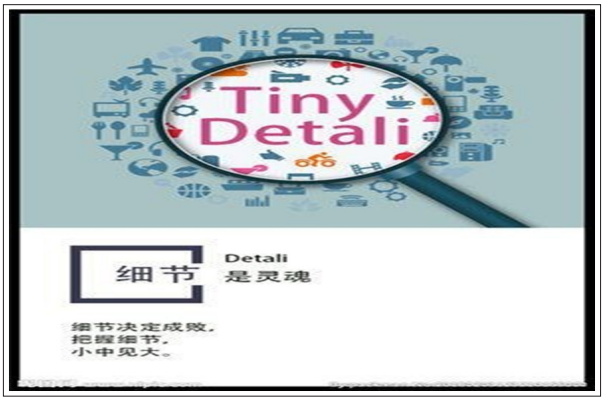
Scientific innovation is reflected in scientists' abilities of putting forward scientific problems. In 1930, when physicist Bot investigated Beryllium's interaction with alpha particles, he found that beryllium emitted a very penetrating ray, which cannot deflect in electric field and magnetic field. The intensity of this ray is only reduced by 13% after penetrating the thickness of 2 cm. The academic community believed that this penetrating ray could only be gamma ray at that time. However, Chadwick realized a very valuable scientific problem. The energy of gamma photon will be much greater than the energy of this unknown neutral particle. Therefore, this unknown neutral particle cannot be gamma rays. So, what exactly is it? Chadwick finally discovered neutrons through careful experimental research. With the ability of putting forward scientific problems, people can explore and make innovative discoveries eventually. To a large extent, an outstanding scientist's creative talents mean the excellence of putting forward scientific problems and solving them. In 1827, a botanist named Brown discovered that pollen particles' motion is irregular. People at that time did not know the reason for this phenomenon called as Brownian mystery. For more than half a century, this scientific problem has not been explained properly until Delso pointed out that Brownian motion was caused by the imbalance of the collisions between the medium's molecules and pollen particles. At the beginning of the 20th century, Albert Einstein gives a clear explanation regarding the Brownian motion. In summary, putting forward scientific problems is the starting point of innovation in physics. A good skill of putting forward scientific problems is necessary for the real scientific innovation.



The art of discovery in physics

There are many historical discoveries in the development of physics. These discoveries not only involve the joy of physicists' success and the pain of failure, but also include the art of exploring mysteries in nature. The art of discovery by physicists can be manifested in the following aspects:

Pay attention to tiny details and See the big world through small one

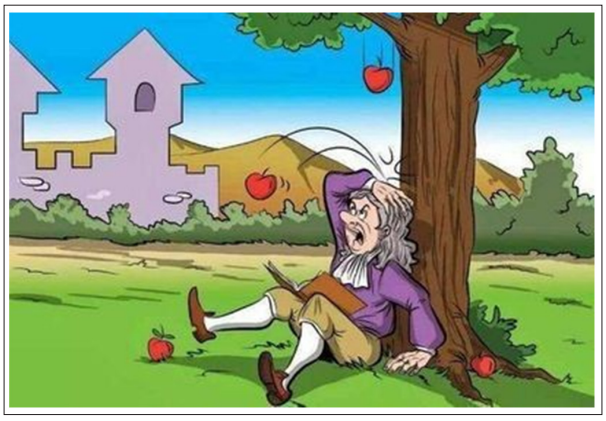


Physicists could sometimes encounter results that differ slightly from expected results in their scientific research. You will often make unexpected discoveries if you keep on paying attention to these tiny details. There is a famous saying that details determine success or failure. Great Physicists can perform well with their keen insight and rigorous scientific attitude. As early as 1890, the British physics professor Schuster had studied the deflection of cathode rays in hydrogen discharge tubes. He calculated the charge-to-mass ratio of these particles constituting the cathode ray and found that the charge-to-mass ratio was more than a

thousand times the charge-to-mass ratio of hydrogen ion. He can't believe in his results because he feels that this conclusion is ridiculous. In 1897, a German scholar named Kaufman conducted a similar experiment, however, he was not willing to admit that the cathode rays are particles. Lately, Thomson bravely proposed that there exist particles which are much smaller than the atom. After a series of intricate experiments, he confirmed that the cathode rays are composed of electrons. For the first time, humans have experimentally proved the existence of the most basic particle-electron. Thomson grasped the details of previous experiments, then, saw a big world through the small one. He proved not only the existence of the electron, but also measured the charge-mass ratio of this basic particle, which caused a great sensation in the physics community at that time.

Breaking the Routine

Great physicists are good at digging out scientific rules from ordinary events, which are very common in daily life. They can expect something unexpected. This kind of curiosity towards nature often leads to major discoveries. Newton is a well-known British scientist,who often stared at the stars at night when he was young. Many questions often flicker in his mind, for example, why does the moon and the stars always hang in the sky and never fall? A ripe apple fell from the tree suddenly while he was reading under an apple tree, which make him feel surprised and raise some problems as follows: Why does an apple fall vertically on the land, rather than float in the air? Does the earth have an attraction for the apple? Subsequently, Newton delved into such phenomena carefully.



Finally, He discovered that there is mutual attraction between all objects in the universe, which we call it gravity today. Additionally, Newton explained the tidal phenomenon caused by the gravitation between Moon and Sun. In 1687, Newton published the law of gravity in his famous book "The Mathematical Principles of Natural Philosophy". It not only illustrates the functional law of all objects on the earth, but also reveals the functional law of celestial bodies, which has a profound impact on the development of physics and astronomy.

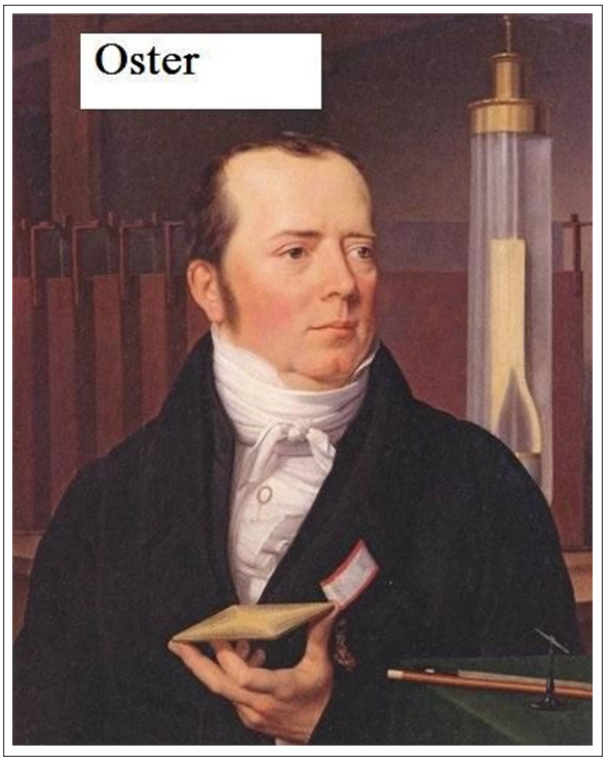
The phenomenon of apple landing is a common place, and there are many natural phenomena everywhere in our daily life, however, Newton was able to discover the law of universal gravity from these ordinary things. Therefore, Newton deserves to be an outstanding physicist who promotes human progress.

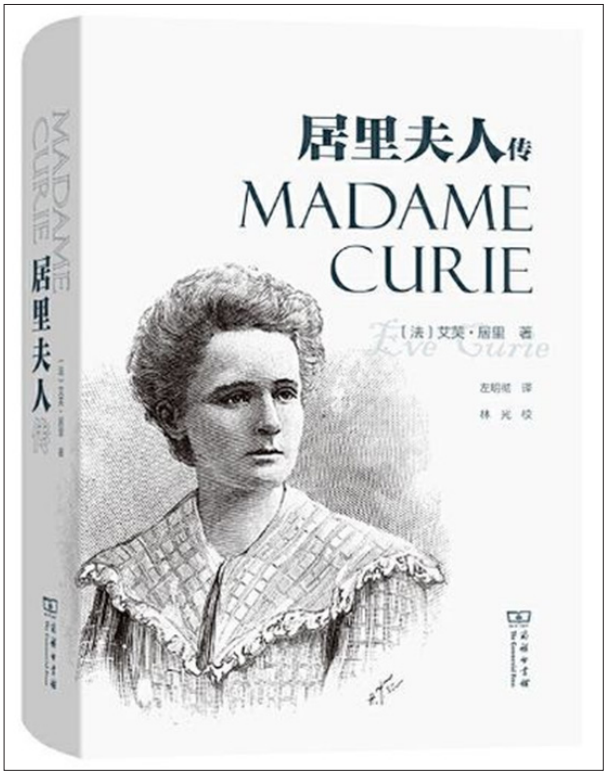
Unexpected, Reasonable

Scientists usually pay attention to observing new things and analyzing these unexpected results in the course of scientific research. There will be new scientific discoveries in physics if new results deviate from the original assumptions or expectations. Oster is a Danish teacher, who once said that I don't prefer the boring course without experiments because all scientific research starts from experiments. In April 1820, he discovered the magnetic effect of current when he was demonstrating an experiment to the students in the classroom. He found that the magnetic needle suddenly moved when the wire with electric current was moved over the magnetic needle. This phenomenon did not attract the attention of the audience, but this unexpected phenomenon did not escape from Oster's eyes. He performed many experiments and confirmed the magnetic effect of electric current later on. Oster's discovery seems accidental, but it is not necessarily the case, because he always believed that there might be some connections between electricity and magnetism. Oster's story tells us that you can obtain the truth if you observe carefully and think correctly.

This is because opportunities belong to those who have preparations. "Watch out for accidental events" is the motto of scientific researchers. It is reasonable that some unexpected results can be captured by scientists and analyzed in scientific research. New breakthroughs can happen if there are enough preparations. Madame Curie is a world-famous scientist, who separated radioisotopes and discovered two new elements, namely, thorium and radium.

At the times when Mrs. Curie was studying the separation and purification of metallic radium, she always reduced sleep and forgot to eat. Not only did she suffer the loss of her husband, but she also developed leukemia due to excessive exposure to radioactive material.





Conclusion

The problem in physics is the source of scientific innovation. The process of physics discovery involves both asking questions and solving them. Exploring certain problems and making major discoveries are the most excellent quality of a great physicist, who promotes the continuous development of physics. The art of scientific research can be summarized as follows:

1. Great scientists in physics have keen insight and rigorous scientific attitude. They know that "details determine success or failure."
2. Great scientists in physics are good at digging out unusual truths from ordinary events.
3. Opportunities belong to people who have preparations. Good physicists can not only seize opportunities, but also create opportunities and make innovations.