Research on the Auxiliary Teaching of Classroom Demonstration Experiment in University Physics Class

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Abstract. In University physics class, classroom demonstration experiments play an important auxiliary role to help the student understand physics theories. Based on the classroom teaching of university physics, this paper analyzes the auxiliary role of classroom demonstration experiments in university physics teaching from the teaching process and students' performance. This paper also explores the auxiliary significance of classroom demonstration experiments in theory teaching. We selected two classes with the same number of students and similar mid-term exam results to take the same quiz three times. One class conducted classroom demonstration experiment, while the other class did not. The results show that the results of the students in the class who conducted the demonstration experiment is higher than that of the students who did not. It can be seen that the classroom demonstration experiment has a positive impact on the teaching results. At the same time, in the demonstration process, the actual problems encountered by teachers and the methods to solve and deal with the actual problems directly enable students to better understand the steps to solve the actual problems. It also helps the students understand the methods to eliminate interference and face the core of solving the actual problems. The efficiency of students' learning physics knowledge in the classroom is further raised.

Keywords: Teaching Reform · University physics teaching · Classroom demonstration experiments

1 Introduction

A University physics is one of the compulsory public basic courses for engineering students [1, 2]. Physics has been in contact with students since they were in junior high school. In the process of physics learning in middle schools, most of the basic physics concepts are introduced through experiments [1–13]. Students establish basic physical images with the most direct experimental phenomena. During the transition from high school physics learning to college physics learning, the biggest change is the transition of the problem to be handled from a special phenomenon to a general phenomenon, that is, the use of calculus and vector to handle problems. In this part of the transition period, most of the students still stay in the idea of dealing with problems in high school

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[14–18]. For the theories introduced in college physics classes [19–23], it is easier to find the correct physical images they think to understand new knowledge. Therefore, in the classroom teaching, helping students to establish an intuitive and appropriate physical map has become an important link between middle school physics teaching and college physics teaching.

Classroom demonstration experiment is a supporting experiment in physics class teaching [1–5]. In middle school physics teaching, such experiments are generally intended to better describe physical phenomena or physical concepts. This kind of experiment is simple and convenient. Compared with the process of university physics teaching, most of physical concepts have been touched in middle schools, and the establishment of concepts has been completed. However, when encountering practical problems, the method of handling is unknown and no system has been formed. In the course of college physics teaching, presentations or pictures are often used. The students had a rigid understanding of the content and did not change their thoughts. Therefore, a more intuitive approach is needed to help them understand the problem and practice the method of dealing with practical problems. The classroom demonstration experiment fills in the blank.

Based on the introduction of interference content in optics teaching, this paper analyzes the role of classroom demonstration experiment in theory teaching. The classroom demonstration experiment is integrated into the theoretical teaching part to help students understand the basic physical concepts, so that students can more intuitively understand the methods of practical problem analysis. Then improve the students' ability to solve practical problems, and lay a good foundation for the follow-up courses.

2 Theoretical Teaching of Optics

We take the part of Interference in Optics teaching as an example. Interference is a phenomenon in which two or more columns of waves meet in space and overlap or cancel to form a new waveform. The conditions for interference of two beams are the same frequency, constant phase difference and parallel vibration direction of light vector. The first two terms are necessary for interference of any wave. The interference effect can be realized as long as the vibration direction of the light vector is not vertical. In the classroom teaching, Yang's double slit interference is mainly introduced. The light path of Young's double slit interference experiment is simple and intuitive as shown in Fig. 1, which is easy to be accepted by students. In Young's double slit interference experiment, the incident light is required to be monochromatic and the wavelength of the incident light λ It should be less than the distance d between two seams, and d should be far less than the distance D between the seam and the receiving screen. Under such conditions, the optical path difference can be simply written as $\delta = d\sin\theta$ [15–17].

Theoretical explanation is easy to understand from the mathematical expression. There is no actual physical image for comparison of students. It is not easy for students to understand the relationship between theory and experiment and they don't know why they set the experiments. In order to better understand the interference phenomenon and master the basis for judging the interference phenomenon in the experiment, the corresponding classroom demonstration experiment is essential. In the Young's double

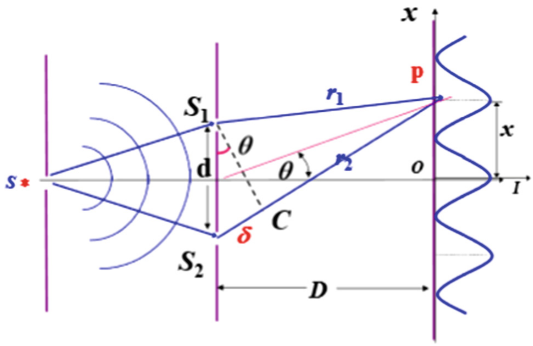

Fig. 1. The sketch of Young's interference experiment.

slit interference experiment, the preparation of the experimental original is required to be high, and the area required in the demonstration experiment process is quite large, which is difficult to be realized simply and quickly in the classroom. Other interference phenomena are easier to find in real life than Young's double slit interference. Therefore, other interference effects are used instead of Young's double slit interference experiment to demonstrate.

In our class, we use some pictures of the interference patterns to show the results of Young's double slits experiments as shown in Fig. 2. These pictures lie in the screen, and show some characteristics of the fringes. There are several straight bright and dark fringes are in the screens. The space between two adjacent bright (or dark) fringes are the same. In these pictures, although there is a picture marked the order of the fringes, we cannot know the axis along the fringes. Students are used to taking the abscissa of such pictures as distance. In fact, the horizontal ordinate in these pictures is mainly as the sinusoid of the angle θ in Fig. 1. These pictures are difficult for students to understand how long of the interference patterns. And it is also difficult for students to understand the conditions of Young's double slits experiments. Hence, it is necessary to do the experiment in the classroom teaching to show the real pattens in classroom teaching. It will provide a great help in understanding the interference pattens.

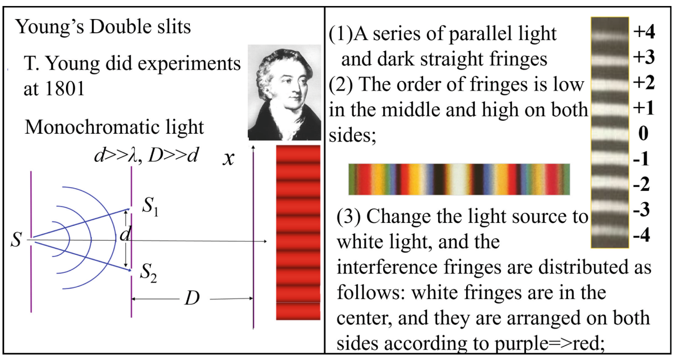

Fig. 2. The images of interference patterns in the powerpoints in the classroom teaching.

3 Classroom Demostration Experiments of Interference Teaching

We use Lloyd's mirror experiment to show the interference effect. The interference methods of these two experiment systems are the same as the ones of the Young's double slit interference experiment, which is called the split wavefront interference. The basic components of the experiment are shown in Fig. 3. An optical sliding mirror frame, a green round laser extended light source, and a receiving screen are needed. As shown in Fig. 3(b), a circular light spot can be observed in the screen.

First place the Lloyd's mirror on the empty shelf in Fig. 3(b). We adjust the distance between the light source and the mirror and make the mirror closer to the source as shown in Fig. 3(d). The purpose are below: 1. In order to better adjust the incident direction of the light source, the distance between the light source and the mirror surface should be very small; 2. It lays a foundation for further adjusting the position of the light source to maximize the overlapping area between the reflected light and the incident light.

Secondly, in order to present the interference effect, the position of Lloyd's mirror needs to be adjusted back and forth. In the process of adjustment, students can experience the path of light and observe the conditions under which interference fringes are generated. We use the wall in the classroom as the screen to show the patten of the interference. By tuning the distance between the instruments and the wall, we change the space between two adjacent fringes and find a clear interference patten as shown in Fig. 4.

Only light source figure is shown in Fig. 4(a). The shape of the extended light source is a circular. Due to the expansion of the laser, the light source pattern is concentric rings. After Lloyd's mirror is added and the relative position between the mirror and the light

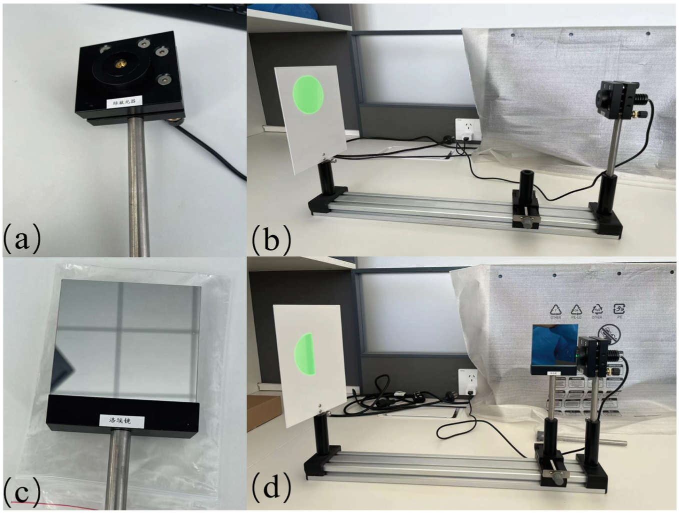

Fig. 3. The components of Lloyd's mirror experiments. (a) The source in the experiment. (b) The system without the Lloyd's mirror. (c) The Lloyd's mirror. (d) The demonstration experiment of Lloyd's mirror interference.

source is adjusted, the students will observe the appearance of bright and dark straight bands on the screen. The cause of straight fringes is interference, as shown in Fig. 4(b).

Figure 4(b) not only show the phenomenon of the interference, but also show some details for the interference. We may find that in the middle of the pattern, adjacent stripes are equally spaced. Because of the boundary effect, the fringe at one end of the pattern will become different from others.

By adjusting the distance between the experimental instrument and the wall, the fringe spacing can be changed. By measuring the distance between the instrument and the pattern and the distance between the fringes, the tangent value of the angle between the fringes of the corresponding order and the line between the center of the pattern and the instrument can be obtained. Comparing these tangent values, it can be found that changing the distance between the instrument and the observation screen and changing the angle of the observation screen can change the distance between the fringes and the width of the fringes. However, the included angle between the position of these fringes and the connecting line from the instrument to the center of the pattern cannot be changed.

After generating stable images, turn on the classroom lights gradually. With the lighting in the classroom being turned on, the intensity of the interference pattern gradually weakened. Here, we will illuminate the influence of changes in the external environment on the interference pattern. For a simple interference fringe, the contrast factor is defined as (Imax -Imin)/ (Imax + Imin), where Imax is the maximum light intensity in the fringe and Imin is the minimum light intensity in the fringe. This formula only discusses the contrast factor from the interference fringe itself. However, during the demonstration experiment, the surrounding light still affects the clarity of the interference fringes. The surrounding light source is introduced into the classroom demonstration experiment as a noise source. These light intensities are directly superimposed incoherently on the maximum and minimum light intensities, so the contrast of the above formula decreases.

It can also make students understand the contrast factor better, and also make students understand how to create experimental conditions, how to explore the influence of other conditions on the experimental results and analyze the causes.

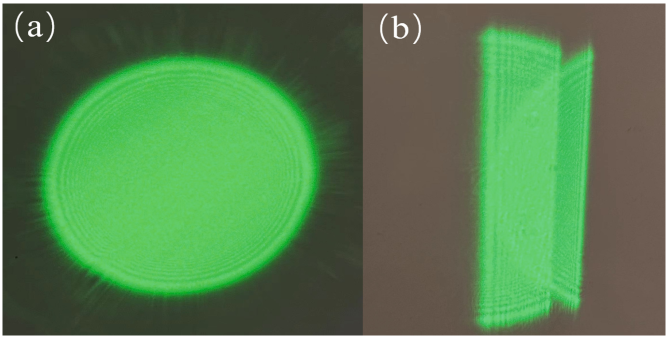

Fig. 4. The images of the classroom demonstration experiment: (a) The spot of light source. (b) The pattern of the interference of Lloyd's mirror.

Finally, another classroom demonstration experiment of fractional amplitude interference is also presented. The optical element in the classroom demonstration experiment is to use two right angle triangular prisms to form a biprism, as shown in Fig. 5(a). When light hits the junction of the two prisms, the amplitude is divided into two parts. These two parts of light meet the basic condition of coherence and come from the same wave train. They can form interference patterns on the screen at certain conditions.

By adjusting the distance between the biprism and the light source, the transformation between the interference pattern and the shadow formed by the biprism can be realized. In order to better achieve the effect of classroom demonstration experiment, it is necessary to place the biprism close to the light source as shown in Fig. 5(b). The purpose is to make the light spot emitted by the extended light source pass through the biprism to the maximum extent to form the best interference pattern as shown in Fig. 6. For comparison, the light spot of the light source is still placed in Fig. 6.

By comparing the two pictures in Fig. 6, students can clearly see the interference pattern. The light spot of the light source presents Bessel type distribution, and from this kind of fractional amplitude interference mode, the interference pattern obtained should be straight fringes, as shown in Fig. 6(b). It is clear from Fig. 6(b) that the straight fringes are in the middle. Without considering the fringes at both sides of the interference pattern,

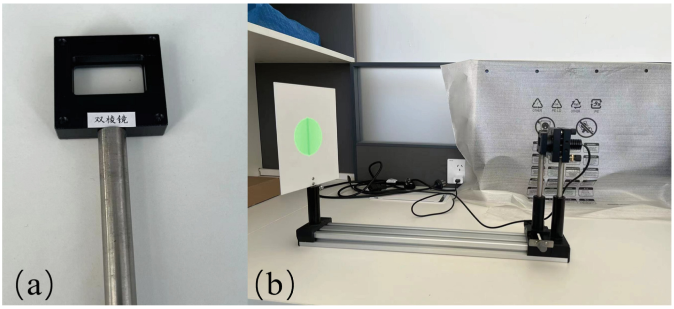

Fig. 5. The components of biprism experiments. (a) The biprism. (d) The demonstration experiment of the biprism interference.

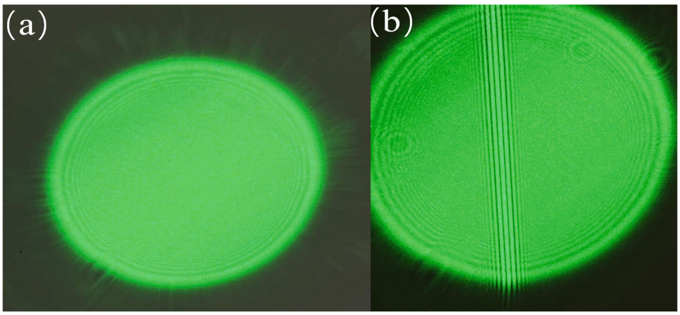

Fig. 6. The images of the classroom demonstration experiment: (a) The spot of light source. (b) The pattern of the interference of the biprism.

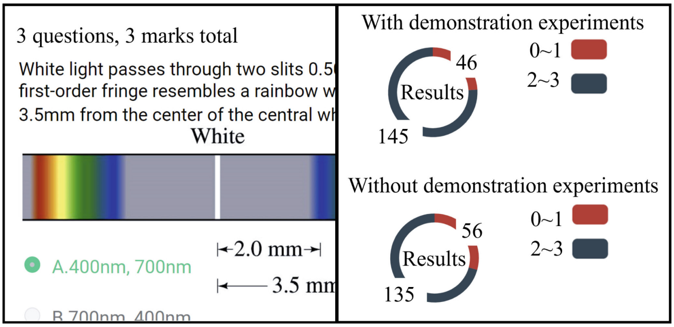

Fig. 7. The average results of quizzes of the students with and without demonstration experiments.

it can be seen that the spacing of fringes in the middle of the picture is equal. The fringe width is also equal. By changing the distance between the instrument and the wall, the fringe space and the fringe width can be adjusted. It can also be explained that the included angle formed by the fringe position and the connecting line between the fringe center and the instrument is always a fixed value.

We selected two classes with the same number of students and similar mid-term exam results to take the same quiz three times. One class conducted classroom demonstration experiment, while the other class did not. The score results are shown in Fig. 7. It can be seen from the figure that the overall performance of the students in the class who conducted the demonstration experiment is higher than that of the students who did not. It can be seen that the classroom demonstration experiment has a positive impact on the teaching results, that is, students' test scores.

4 Conclusions

Classroom demonstration experiment is an important assistant prop in university physics teaching. It can not only add interest to classroom teaching, but also attract students' attention. It also adds interactivity to boring theoretical teaching. The explanation of the theoretical content during the demonstration can help students deepen their understanding of the theory. At the same time, it can also tell students that they will encounter many practical problems in the process of theory and practice. Peel the cocoon from the actual problems encountered, and go straight to the core of the problem. Classroom demonstration not only allows students to grasp theoretical knowledge more easily and intuitively, but also guides the steps and methods in dealing with practical problems.

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