Interference Experiment with Two Coherent Acoustic Sources

When it comes to the "Interference Experiment", the first sight comes up in our minds is the classical Young's Double-slit Interference Experiment. Comparing with light waves, sound waves are similarly equipped with the fluctuant property. Therefore, we design and conduct a specific experiment by means of the sound wave to demonstrate the interference of wave. However, if we depend on the general Double-slit Interference theory, as the most *University Physics* textbooks[1-3] required, the experimental result will hold approximately 16% inaccuracy. Thus, we designed the second experiment which is based on an amelioration of analysis. The result shows the error was controlled within 4%, which may indicate that the amelioration on analysis could arise the accuracy of the experiment. Thus, we designed the second experiment which based on an amelioration of analysis. The result shows the error was controlled within 4%, which may indicate that the amelioration on analysis could arise the accuracy of the experiment. Moreover, it may be helpful for teachers and students to comprehend the essence of the interference phenomenon.

What's more, in the study of wave propagation, the usual demonstration or approach to these subjects in elementary courses is mainly by way of optics[4] rather than acoustics. Although few elementary textbooks do more than pointing out the existence of this phenomenon in acoustics, some former teachers are still processing plenty of excellent attempts: for example, Harold K. Schilling[5] proposes several acoustic models analogy of optics, which's helpful for students' comprehension on wave property; Haywood Blum[6] points out that by walking around the room, especially in a path parallel to a line joining the speakers, one can easily hear and feel the maxima and minima of the interference pattern; Joshua Allen[7] makes use of inexpensive audio activities similarly grasp the existence of acoustic interference. Even though the above pedagogies are practical and feasible, it is because of qualitative demonstrations instead of quantitative demonstrations that their persuasive competence is impaired a bit. From this perspective, our work could be supplement for the revered pioneers.

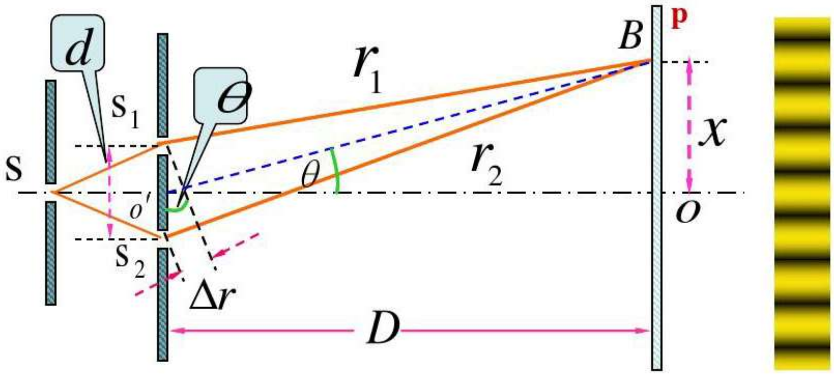

Figure 1 Young's Double-slit Interference Experiment. It is familiar with us that bright strips rise up

when $\Delta r = d\frac{x}{D} = \pm k\lambda, k = 0,1,2,\cdots$; dark strips rise up when

$$\Delta r = d\frac{x}{D} = \pm(2k+1)\frac{\lambda}{2}, k = 0,1,2,\cdots.$$

Introductory to the Experiment

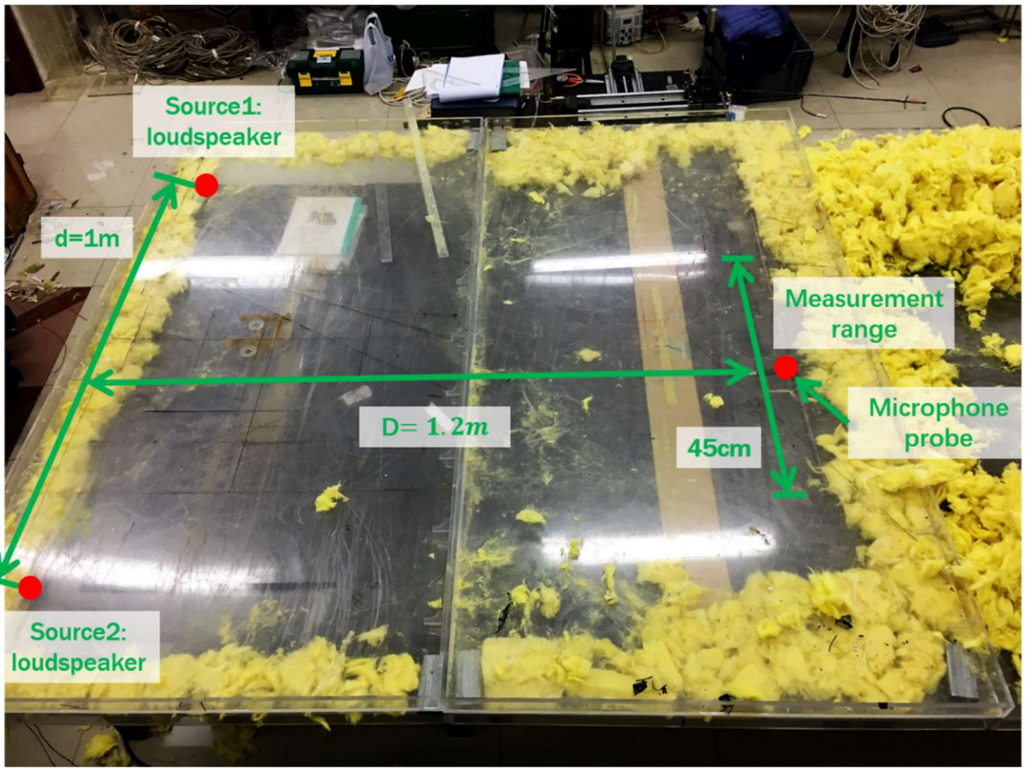

Figure 2 The layout of Interference with Two Coherent Acoustic Sources[8]. Sound velocity is about 344m/s, when we suppose acoustic frequency is 5,000Hz, the corresponding wavelength is 6.88

centimeters.

In our experiment, two big organic glass plates (the transparent plates on figure2) are used for construct a testing environment between which two loudspeakers produce singular frequency sound microphone probe would measure the amplitude of acoustic pressure along with the measurement range (line). At the margin of the above plates, we plugged in sound-absorbing cotton, the yellow substance in Figure 2, to avoid the influence of wave reflected.

Having measured 180 points equally-distributed along with the measurement range, we got the result of interference. (Figure 3)

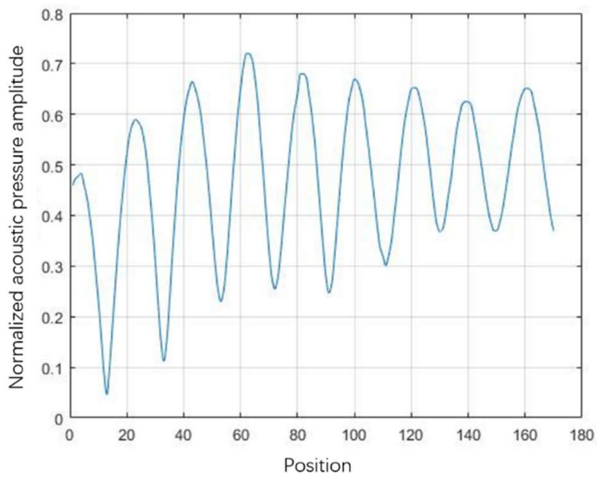

Figure 3 result of acoustic interference

the First Data Processing Method

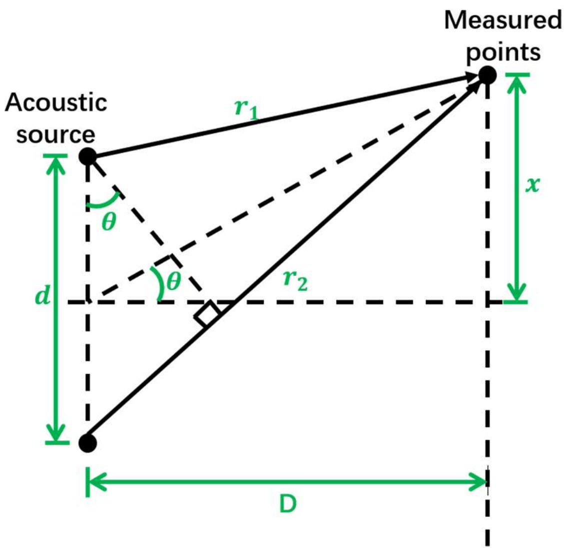

Figure 4 sketch map of interference analysis

According to the textbook[2], we could get the position of the bright strip.

$$x = \pm \frac{D}{d}\lambda, k = 0, 1, 2, 3, \cdots \tag{1}$$

Due to that, the difference between two adjacent bright strips is one constant.

$$\Delta x = x_{k+1} - x_k = \frac{D}{d}\lambda \tag{2}$$

Thus, we got the measured fluctuations of acoustic pressure (Figure 3) and able to calculate wavelength. The Figure 3 indicated nine maximal value of acoustic pressure, which leads to eight calculated wavelengths (λ). After calculating the average λ and comparing experimental calculated λ with veritable wavelength, we rationally gain error percent.

$$\frac{8_{experimental} - 6.88_{true}}{6.88_{true}} = 16.27\% \tag{3}$$

the Second Data Processing Method

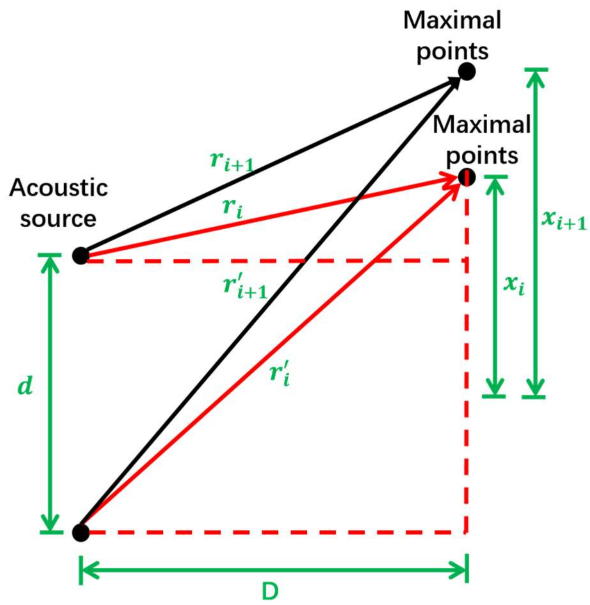

Figure 5 sketch map of interference analysis

From the above content, we calculate to the wavelength via experimental data, but the error rate might beyond our expectations. On the basis of the essence of wave interference, we precisely obtain acoustic path difference at every maximal point. Sequentially, the calculated experimental value of wavelength is floating.

Depending on the Pythagorean Theorem, we could get the following equations.

$$\left.\begin{aligned} r_i &= \sqrt{(x_i - \frac{d}{2})^2 + D^2} \\ r_i' &= \sqrt{(x_i + \frac{d}{2})^2 + D^2} \end{aligned}\right\} \tag{4}$$

And then acoustic path differences are corresponding to acoustic pressure maximal points (bright strips).

$$\left.\begin{array}{c} \Delta_i = r_i - r_i' = k\lambda \\ \Delta_{i+1} = r_{i+1} - r_{i+1}' = (k+1)\lambda \\ k = \pm 0, 1, 2, \cdots \end{array}\right\} \tag{5}$$

Thus, we could get the value of λ.

$$\Delta_{i+1} - \Delta_i = \lambda \tag{6}$$

Similarly, after taking average and comparison, we gain the result of experimental wavelength λ and error percent.

$$\frac{7.22_{experimental} - 6.88_{true}}{6.88_{true}} = 4.94\% \tag{7}$$

Reflection and Suggestions

According to the previous analysis, it is evident that the second method is more accurate than the first. The reason can be explained by the "boundary" between near and far measured locus, which might be seen in some advanced physical textbooks[3].

$$D\lambda \approx d^2 \tag{8}$$

Thus, we can make a rough criterion that far-field approximations are justified for measured points much farther from the sources than a distance ***D***. Generally, optical experiments are satisfied with the condition, so there is less inaccuracy via the equation of $\Delta x = \frac{D}{d}\lambda$. For most time, acoustic experiments scarcely attain the far-field criterion, therefore, we cannot simply apply $\Delta x = \frac{D}{d}\lambda$.

Anyway, we encourage introductory physics learners to apply the second Data Processing Method, which is indeed helpful for them to comprehend the core of wave interference. Given if they haven't a knowledge of the Criterion on Far and Near Field, they are more likely to be confused by the first methods. Meanwhile, for the students with good foundation in physics, we advise that some advanced and complex demonstration for acoustic interference could be explored which combine with optical techniques to observe[9, 10]. In addition, they are also encouraged to apply knowledge of acoustic interference to illustrate some bio-nature phenomenon[11].

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