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Observation of the Talbot carpet for waves on the liquid surfac

A N Morozov[1], I V Moskvina[1], B G Skuibin[1,2] and E V Smirnov[1,3]

[1] Bauman Moscow State Technical University 105005, Moscow, 2nd Baumanskaya, 5

[2] E-mail: bgscuibin@yandex.ru
[3] E-mail: seva09@rambler.ru

Abstract. In this paper, the first observation of the Talbot effect for waves on the surface of a liquid is made. The diffraction of flat surface waves in a ditch with water on a diffraction grating containing 8 slits made it possible to obtain a clear image of the Talbot carpet on the surface of the water behind the grating. The Talbot length observed in the experiment coincides with the data of theoretical calculations.

1. Introduction

Currently, the study of Fresnel diffraction of different waves attracts much attention of researchers. This is primarily due to the study and wide practical application of the Talbot effect – the phenomenon of self-reproduction of a regular system of coherent wave sources (see, for example, [1]). The Talbot effect is observed for waves of different nature, in particular, electromagnetic, acoustic, de Broglie matter waves, etc. [2-4].

In the student experimental laboratory of physics (SELF) at the Department of physics Bauman Moscow State Technical University was first demonstrated the existence of the Talbot effect for ultrasonic waves [3] and obtained high-order harmonic patterns in the optical range of electromagnetic waves [4]. Common for these studies is the observation of the interference pattern of plane waves diffracted on the slits of the gratings in the planes parallel to the diffraction grating. In this paper, it became possible to observe the diffraction pattern – Talbot carpet – in the plane perpendicular to the diffraction grating.

2. Scheme of experimental setup

An experimental setup for observing the interference of surface waves in a liquid medium after a diffraction grating was created in SELF (Figure 1). The installation consisted of a water-filled horizontal cuvette 1m × 0.5 m in size, a wave generator exciting surface waves, and a diffraction grating with a period d = 14.1 mm having 8 slots. The wave generator consisted of a bar suspended on two springs above the surface of the water and a small motor with an eccentric that told the bar forward movement. The pattern of wave interference behind the diffraction grating was recorded with the help of a camera.

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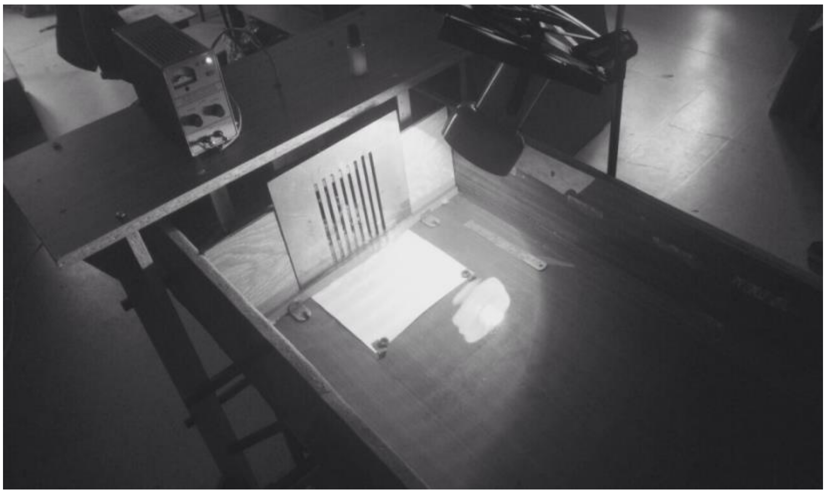

Figure 1. Scheme of experimental setup for observation of Talbot effect for waves on the liquid surface

3. Experimental result

The frequency of the generator was experimentally selected, at which the diffraction pattern behind the grating had the most distinct appearance. The wavelength on the surface of the liquid was λ= 9 mm. the Photo of the structure of the surface waves behind the lattice is shown in Figure 2. It demonstrates a clearly observed pattern of diffraction of surface waves in the liquid and allows visualization of the Talbot carpet.

Figure2. Talbot carpet for surface waves in liquid

In the experiment, waves are observed that reveal the Talbot carpet in the region between the lattice and its self-image observed at a distance from the lattice equal to the value of the Talbot length:

$$L_T = \frac{2d^2}{\lambda}.$$

The experimental value $L_T = 40\ mm$ is obtained, which is consistent with the results of theoretical calculations $L_T = 43{,}6\ mm$ with an error of less than 10%.

It follows from the theory that at a distance of half the length of the Talbot, the images of the lattice – the intensity maxima shifted in phase by π relative to the location of the slots of the original lattice should also be observed. Such images are clearly visible in Figure 2.

4. Conclusion

The results of the research show that the type of Talbot carpet significantly depends on the wavelength, the type of the wave front, the size of the sources, the period of their regular location. It should be noted that the observed pattern of the Talbot carpet for surface waves on water is similar to the similar pattern for surface de Broglie electron waves on the metal surface, calculated for diffraction on a lattice curved in the form of a circle segment (Figure 3) [5].

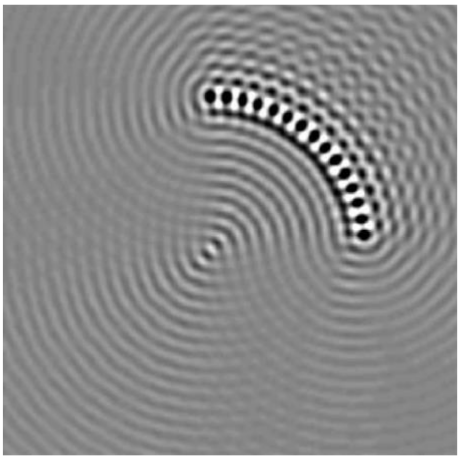

Figure 3. Calculation of de Broglie wave diffraction on a curved grating [5]

References

[1] Smirnov E V, Skuibin B G, Martinson L K 2014 Talbot effect I. Diffraction on one-dimensional gratings *Physics in Higher Education* **20** 2 p109–21.
[2] J Wen, Y Zhang, M Xiao 2013 The Talbot effect: recent advances in classical optics, nonlinear optics, and quantum optics. *Advances in optics and photonics* **5** p. 83–130.
[3] Morozov A N, Krikunova M P , Skuibin B G, Smirnov E V 2017 Observation of the Talbot effect for ultrasonic waves *JETP Letters* **106** 1 pp. 23–25.
[4] Morozov A N, Salbieva L R, Skuibin B G, Smirnov E V 2018 Observation of the high-order fractional Talbot effect in the optical range **JETP Letters 107** 6, pp. 355–357.
[5] G A Fiete, E J Heller 2003 Theory of quantum corrals and quantum mirages *Rev. Mod. Phys*. **75** 3 p.933-948.