LIGHT

An easy method to show the diffraction of light

When we talk about diffraction we usually emphasize this phenomenon as typical for all kinds of waves. Waves normally travel in straight lines, but if they encounter an obstacle or a barrier they bend around the edge and spread into a region behind the barrier with an intensity that decreases with bending angle. This is easily demonstrated with water waves. Our experience with light is quite different. Shadows are evidence that light propagates almost linearly near obstacles. This made Isaac Newton convinced that light is not a wave. If we want to show the wave nature of light

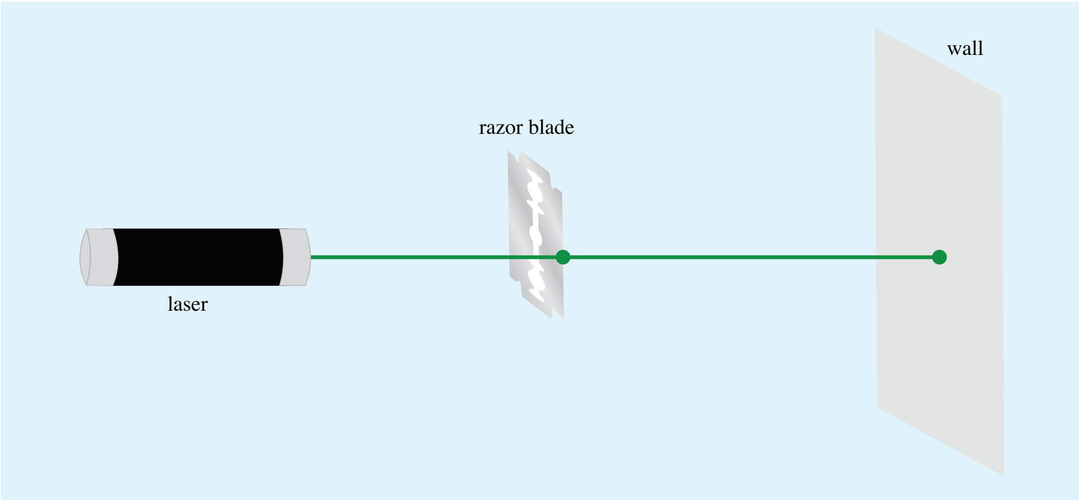

Figure 1. *The set-up for diffraction of light by a sharp edge.*

then a comparison with the behaviour of water waves is welcomed. However, diffraction of light by a sharp edge is difficult to demonstrate because the bending angle depends on wavelength, and is very small for light. That is why we usually show diffraction of light on a slit. But students are often confused with the obtained diffraction pattern exhibiting strong fringes characteristic for interference and usually do not relate the phenomena to diffraction itself.

Diffraction of light by a sharp edge is a well known demonstration [1–3]. A simple experimental set-up is shown schematically in figure 1. The problem with this demonstration is that the diffraction pattern is not easy to see, even in a dark room, if you use a common red laser. The pattern is pale because the source doesn't have enough light power. That's why it does not show in the classroom. Today, the situation has changed significantly. Green laser pointers have become cheap and easily found. With a green laser pointer, even in daylight there will be no doubt that light spreads beyond the barrier.

A stable diffraction pattern obtained with a 532 nm green laser pointer and the experimental set-up is shown in figure 2. The result is amusing. For a demonstration in a classroom it is enough to hold a laser pointer with one hand and a blade, or other sharp object, with the other. First we steer a laser beam onto the wall to obtain a bright circle spot (figure 2a) and ask students what will happen if we cover half of the beam. They usually answer that we should obtain half of the spot due to a linear propagation of light. Then we cover half of the beam with a vertical sharp edge of a blade. Instead of halving the spot, a huge diffraction pattern appears. Light bends on both sides of the edge forming long bright stripes left and right of the spot (figure 2b). There are some interference patterns as well, but the diffraction effect is dominant and clearly visible, as seen in figure 2c. This can be explained in one of the following ways.

- If light waves pass by a sharp edge they bend behind a barrier. However, this doesn't explain deflection of light on the outer side of a barrier.
- According to Huygens's principle the laser beam wave front emits light in all directions, but because of phase shifts and the Gaussian-like beam intensity profile the emitted light cancels out in all directions, except in the direction of the beam itself with a very weak divergence. If we remove part of the front we break the symmetry of the beam and light radiation emerges in other directions [3].
- The sharp illuminated edge becomes a bright line light source emitting light in all directions. This explanation in terms of edge waves is due to Young and Sommerfeld's theory [4]. Fringes that appear in the diffraction pattern on the illuminated side are the result of the interference between incident and edge waves.

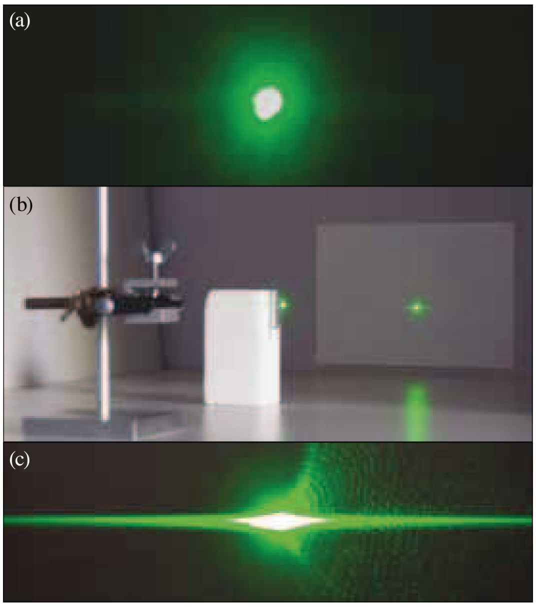

Figure 2. *(a) A laser pointer spot close up. (b) The experimental set-up with a green laser pointer, razor blade and white paper sheet on the wall. (c) The diffraction pattern close up.*

This demonstration clearly shows the wave nature of light.

Please note the following safety rules when working with lasers:

- Never look directly into a laser beam. Permanent eye damage may result.
- Pay attention to the beam reflected from the razor blade. A reflected beam can be dangerous as well.

References

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Ivica Aviani and Berti Erjavec *Institute of Physics, Zagreb, Croatia (e-mail aviani@ifs.hr)*