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Wondering with physics: engage public and teachers in science communication

Wondering with physics: engage public and teachers in science communication

V Montalbano[1,2], A M D'Onghia[2], M Giambolini[2], R Montorzi[2], B Rossi[2] and M Sirigu[2]
[1] *Department of Physical Sciences, Earth and Environment, University of Siena, Siena, Italy*
[2] *Association for Teaching Physics (AIF), Siena, Italy*

montalbano@unisi.it

Abstract. The European Researchers' Night takes place every year simultaneously in many cities all over Europe and beyond. Researchers and teachers designed and implemented together a series of inquiry-based activities to bring people closer to physics. The enthusiast answer from participants suggests that these activities can be easily utilized with students for enhance their motivation. Moreover, the close collaboration between university and secondary school teachers is an opportunity for promoting the professional development on topics, like resonance or birefringence, sometimes very far from teaching practice.

1. Introduction

Science communication is becoming an expanding area for both research and outreach [1, 2]. All citizens should have the opportunity to acquire an adequate level of scientific literacy, to make informed decisions about the most critical aspects of contemporary society such as energy, consumer choices, their impact on the environment and their footprint on the planet. While high levels of scientific literacy are not currently feasible in modern society, it is still an important goal to be achieved.

It is easy to recognize that the relationship between science and the public is at a critical phase. During the next future the choices made, either deliberately or by inaction, will profoundly affect the future both of peoples and scientists. Since public awareness of science aims to stimulate awareness of and positive attitudes towards science, it is very important to carefully design and realize public events in order to increase the attention paid to science and to promote scientific literacy.

Learning about science can occur in either formal or informal settings. The European Commission is deeply committed to facilitating the dialogue between science and society and has taken numerous recent initiatives in this context. Promoting dialogue between science and culture or, more precisely, putting science back into society is one of the priorities of the European Union's policies.

The European Commission, as a part of the Marie Skłodowska-Curie actions, funded under the Horizon 2020 program, is supporting a series of events in informal settings aimed at the public called The European Researchers' Night. It is a Europe-wide public event dedicated to popular science and fun learning. It takes place each year on the last Friday in September. Around 30 countries and over 300 cities are involved.

The European Researchers' Nights have been organized every September since 2005. In 2015, the event celebrated its 10th anniversary. About 1.1 million citizens and 18,000 researchers took part, in the scientific events organized in over 300 cities within Europe and neighbouring countries.

In Tuscany, the event is called BRIGHT and involves the Universities of Siena, Pisa and Florence [3]. The acronym BRIGHT means "Brilliant Researchers Impact on Growth Health and Trust in research". The key objective of the event is to motivate and inspire people, especially the youth, to enjoy, understand and pursue science and technology by connecting them with outstanding scientists and innovations. During the event, researchers explain their activities and their research in a fun and interactive way, involving adults and children in experiments, performances, educational activities, guided visits to laboratories, scientific games and so on.

The Laboratory of Educational Research in Physics of the University of Siena together with the local section of the Association for Teaching Physics designed and implemented a series of inquiry-based activities entitled *Seeing the invisible* to bring people closer to physics.

2. Seeing the invisible

If one succeeds to obtain direct visualization of a phenomenon inaccessible to senses, it is possible to get a deeper understanding since an effective process of learning is involved. When the physical system utilized for visualization enables direct interaction with the phenomenon a broader and more profound result in learning can be obtained [4].

Every activity was centered on an initial observation followed by storytelling about the physics topic spacing from science history to a recent application in everyday life [5].

Six workshops were organized in the University's Magna Historical Hall (Figure 1):

- From the rectilinear propagation of light to the… DNA
- Polarization: a feature of the light invisible to our eyes
- Seeing the magnetic field
- A shape in the past of an alloy
- Seeing the resonance
- Seeing the heat.

Let us see some of the activities in more details.

Figure 1. Participants to workshops in the University's Magna Historical Hall are shown. In the foreground, they were exploring the magnetic field, while in the background it is possible to see other people taking part in the workshops on light.

2.1. From the rectilinear propagation of light to the… DNA

A pair of concave mirrors, shown in Figure 2, were used to generate an eye-catching 3D real image. In order to draw attention to the image, a laser pointer was used to create the perception of an object actually at the top of the hole in the upper mirror.

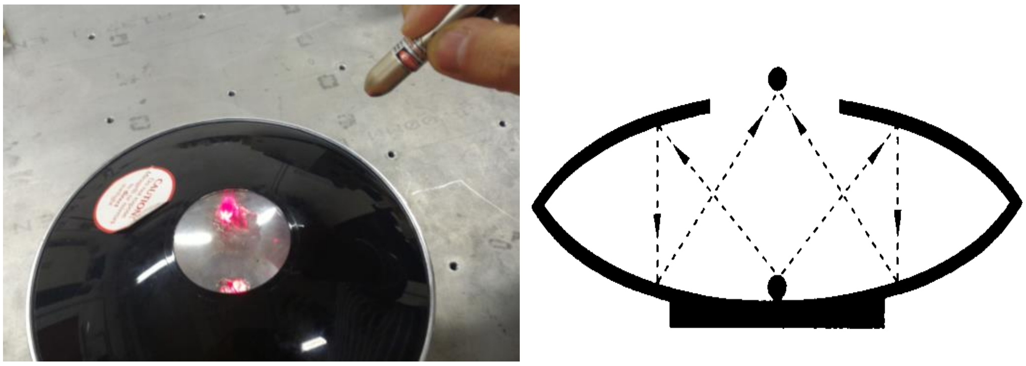

Figure 2. A laser pointer indicated the real image formed in the concave mirrors (on the left). A schematic drawing made it possible to understand how the image is formed (on the right).

But when people tried to touch it, they were surprised to discover that there was only air because we do not have light sensors on our fingers. A schematic drawing made it possible to understand how the image is formed and to compare it with the real image in a flat mirror. The explanation of the rectilinear propagation of light was naturally used.

The next step was to foresee and explore what happens if you pass a ray of light through an increasingly narrow slit. The discovery of diffraction patterns allows introducing the concept of light as a tool for measuring lengths comparable to the wavelength of light. As an example, the case of a hair was examined.

The final step was to examine the diffraction pattern of a spring and show an analogy in visible light of how the DNA structure was discovered by using X-rays (see Figure 3).

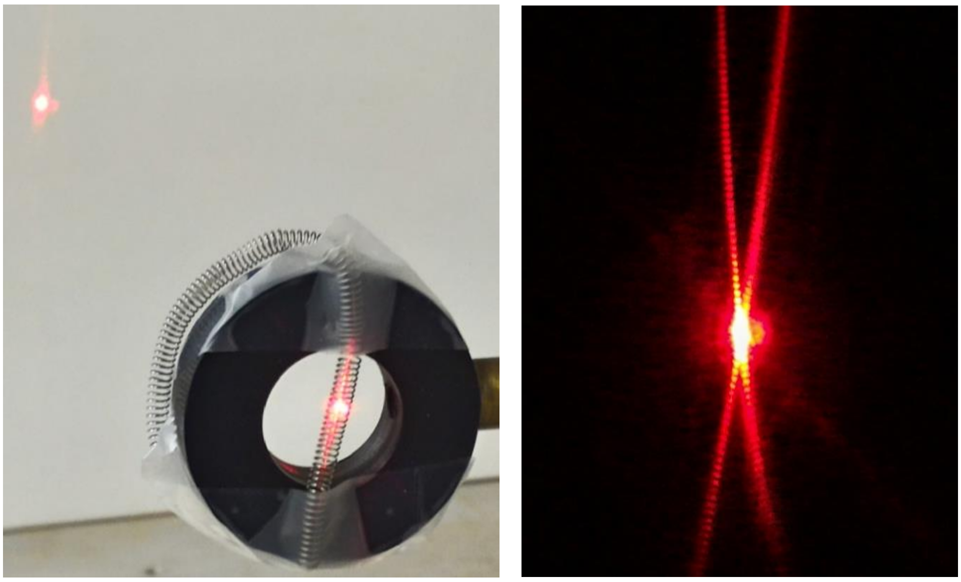

Figure 3. An analogy in visible light of how the DNA structure was discovered by using X-rays. On the left, it is shown the spring with is diffraction pattern on a screen. The diffraction pattern is shown in more detail on the right.

2.2. Polarization: a feature of the light invisible to eyes

The starting point was storytelling of the discovery of the Iceland spar (calcite) as the first material that shows the phenomenon of birefringence and how Malus, an officer of the Napoleonic French army, discovered a way to explain the phenomenon. His discovery of the polarization of light by reflection

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was essential to develop the theory of double refraction of light in crystals, in 1810. From here to understanding how sunglasses work, the step is short. In Figure 4 an Iceland spar is showed together with a linear polarizer. People were invited to explore for themselves how the image can vary by rotating a linear polarizer.

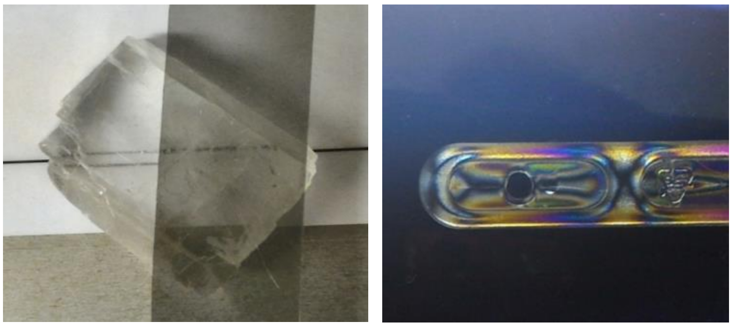

Figure 4. An Iceland spar showing birefringence with a linear polarizer on it (on the left) and a coffee stripper observed with polarized light on the right. The birefringence, in this case, depends by the wavelength too.

Then they used two crossed polarizers and explored what was happening by putting one in the middle and rotating it. Finally, they placed a coffee stripper between the two polarizers and discovered the birefringence induced by mechanical stress in a transparent media (see Figure 4).

2.3. Seeing the Magnetic Field

We do not have sensors in our body that allow us to perceive the magnetic field. Therefore it is always a discovery to visualize the magnetic field lines, even with simple iron filings. For the workshop, filings were initially used in a flat screen diluted in an oil. However, the lines of the magnetic field always appear projected in a plane, so the three-dimensional perception of the field lines is lost.

Figure 5. A multipolar magnet displays minimum and maximum values of the magnetic field when it is observed by using a ferrofluid.

Conversely, by using a ferrofluid, a nanostructured material, the correct distribution of the field lines in space can be obtained. As an unusual example, we observed a multipolar field with regions of maximum and minimum (Figure 5) and an electromagnet (Figure 6) which allowed direct manipulation of the magnetic field by the participants.

Figure 6. A solenoid, on the right, shows no magnetic field if it is not powered (as shown on the left). When a current flows in the wire, the ferrofluid allows to observe a dipolar magnetic field whose intensity depends on the intensity of current in the wire (in the middle).

Finally, the participants could explore Faraday's induction by moving ceramic magnets of different strengths into an aluminium tube. The viscous friction induced by eddy currents was perceived very well.

Figure 7. Seeing a magnet falling in a metal tube.

A magnetic field viewer was utilized for allowing to see a magnet falling in the aluminium tube as shown in Figure 7.

2.4. Seeing the Resonance

The nodal lines of a vibrating elastic plate can be highlighted by sprinkling salt on it: the salt is thrown off the moving regions and piles up at the nodes. By discovering Chladni figures in a vibrating plate, it is possible to visualize and understand the resonance.

The unexpected behaviour of the salt wondered the participants who initially thought that the salt should move at any frequency of oscillation of the plate. Instead, the transfer of mechanical energy between the plate and the vibrating system is almost negligible when the frequency is not resonant with one of the normal modes of the plate.

Figure 8. Two different normal modes of a vibrating disk are shown at the top. At the bottom, an image is displayed taken from the applet [6] that allowed to understand the movements of the vibrating disk concerning the nodal lines in which salt accumulated.

When the frequency reaches the value of a normal mode of the vibrating system, the salt which remained stationary outside resonance begins to jump furiously and quickly accumulates on the nodal lines.

Figure 9. Two different normal modes of the plate.

In order to suggest what was happening, an applet was showed on the screen of a notebook (see Figure 8). Participants could search new resonances by varying the forcing frequency, but it is usually very narrow so it is necessary a little experience to find them. In Figure 9 two different normal modes are shown.

2.5. Seeing the Heat

In order to visualize the heat in an unusual physical situation, participants were invited to explore Seebeck and Peltier effects. The Seebeck effect was caused by the participants and was displayed by measuring the potential difference in a Peltier cell with a side in thermal contact with a metallic mass at room temperature while the hand of a participant heated the other side.

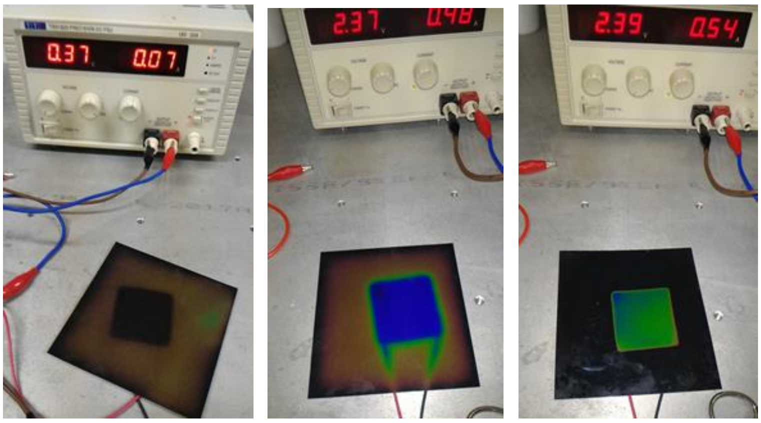

Figure 10. Different thermocolour films allow showing the rapid temperature decreasing on one side of the Peltier cell and the corresponding heating of the other side.

Thermocolour films were used for seeing the Peltier effect when the cell was powered by a voltage and a continue current flows (Figure 10). Also in this case, an applet can be useful to facilitating the comprehension of both phenomena.

3. Remarks and conclusions

The enthusiast response from participants convinced us that these activities could be easily utilized with students to enhance their motivation and engagement in a classroom [7-10]. Moreover, the close collaboration between university and secondary school teachers was an opportunity for promoting the professional development on topics sometimes very far from teaching practice.

In last months, many of the activities proposed in the European Researchers' Night have been used to interest and engage high school students in the physics laboratory. Recently, the workshops have been redesigned to be offered to physics teachers as a moment of reflection on an engaging laboratory teaching in a course for professional development.

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