The Importance of Light in our Lives[1]

An overview of the fascinating history and current relevance of Optics and Photonics

Lecture Notes

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[1]This subject is included in the University of Cantabria's Senior Program.

Figure 0. Sunglasses on a mobile phone. Source: pixabay. License: Creative Commons CC0. http://bit.ly/2ATF20a

The Importance of Light in our Lives

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Course Structure

This course is divided into 8 chapters and aims to provide an introduction to the main concepts of optics and photonics: from the use of the first magnifying glasses to the use of laser in a multitude of present-day devices and applications.

- **Chapter 1: The Historical Evolution of Optics and Photonics**
  With reference to the discoveries of key personalities such as Archimedes, Newton or Einstein, this chapter traces the fascinating history of the evolution of Optics through to Photonics, with the invention of the omnipresent laser and optical fiber.
- **Chapter 2: What is Light? Waves and Particles**
  This chapter aims to provide a clear and simple explanation of one of the "mysteries" that have most greatly concerned and occupied hundreds of scientists throughout the centuries: What is Light? Is it a wave or a particle?
- **Chapter 3: Sun, Light and Life: how the Sun and photosynthesis work**
  Life on our planet would not exist without the Sun and the energy it provides every second. Likewise, photosynthesis or the conversion of inorganic substances to organic compounds in plants, takes place thanks to the energy of light.
- **Chapter 4: The light that revolutionized the digital era: the laser and optical fiber**
  Today's society would not be the same if, back in 1958, the laser had not been invented and, thereafter, optical fiber. The Internet, the great communications phenomenon that has revolutionized our lives, is simply light (laser) travelling around the world through optical fiber. We will briefly review the invention of the laser, optical fiber and their fundamentals.
- **Chapter 5: Measuring the world using light: from biomedicine to civil work**
  Light not only serves for high speed communication via the Internet, but can also help us in a variety of applications: from precisely delimiting cancer cells to real-time monitoring of a bridge or dam. This chapter provides a brief explanation of some important examples that help us to better understand this "hidden" facet of light.
- **Chapter 6: The phenomenon of vision: how humans and animals see**
  This introduction to the world of light would not be complete if we were not to explain how one of the most incredible parts of our body works: the eye and the sense of sight. Furthermore, we will explore the differences between our sense of sight and that of other members of the animal kingdom.
- **Chapter 7: Photonics: current situation and future perspectives**
  This final chapter reviews some of the most recent advances in the world of optics and photonics and other possible future applications of this field of knowledge, which is fundamentally important today and will undoubtedly continue to be so in future decades.
- **Chapter 8: Experiments with light that you can do at home**
  Finally, we suggest a series of simple experiments that students can do to help assimilate the concepts explained during the course.

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Chapter 8
Experiments with light that you can do at home

Having finished the theoretical part of the course, it is now time to carry out some experiments to see some of the concepts studied. The simple experiments described below are intended to be carried out at home using everyday household objects and devices (or objects that can be easily obtained at a reasonable price).

8.1. Infrared Vision

In this course, we have seen that light is not just what we perceive with our eyes, but that it is also made up of wavelengths that we cannot see[1], like **ultraviolet (UV)** or **infrared (IR)**. Even though we may not know it, many of the cameras on our mobile phones are capable of detecting infrared[2].

Let's see if we are capable of "seeing" infrared light with our mobile phones:

1. **Take** the television remote control.
2. **Activate** the camera of your mobile telephone and set it to record video.
3. **Record** a video of the front end of your television's remote control (you will see that there is a small "bulb" or LED) whilst you are pressing some of the keys.
4. **Observe** the result: are you capable of seeing the remote control's "light"?
5. **Now observe** the remote control with your own eyes: are you capable of seeing the light?
6. **Explain and justify** the result of this experiment in your own words.

Figure 1. Picture of a television remote control. Source: Wikimedia. License: CC-BY-SA 4.0. http://bit.ly/2AVjCAv

[1] Although other animals like birds of prey or snakes can, as explained in the chapter on vision.
[2] Some high-end mobile phones include a filter to block a large part of the IR light that reaches the camera's sensor.

8.2. Creating a rainbow at home

In this course we have explained some fundamental concepts concerning light, like reflection and refraction. This is precisely the concept tested in the experiment described below. To create a rainbow at home, you must follow the steps below:

1. **You will need** a CD or DVD.
2. **Use** the back of the CD/DVD (the side on which data has been "recorded") and face it towards the sunlight, for example the light coming through a window.
3. **Observe** the result: can you see different colors?
4. **Try to find an explanation** for this color formation effect. If necessary, search for information on the Internet.
5. **Repeat** the experiment with sources of light other than the sun, like an incandescent bulb, a fluorescent lamp, a LED, etc.

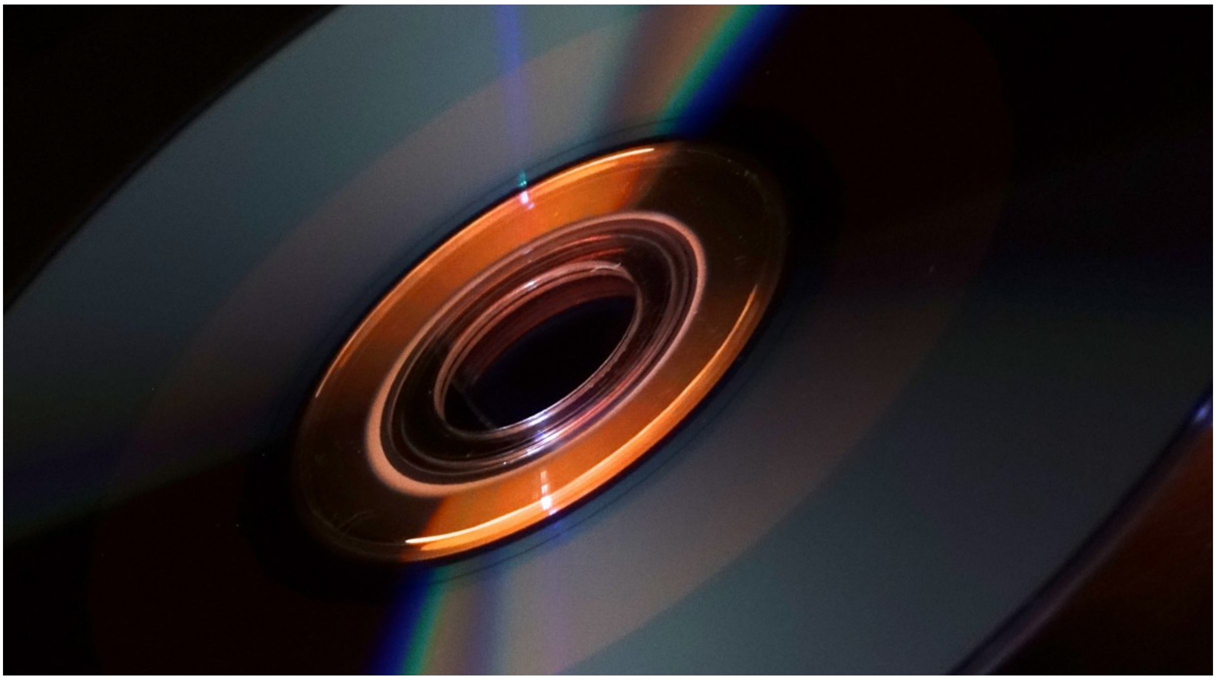

Figure 2. Image showing the formation of colors on the surface of a CD. Source: pxhere. License: Creative Commons CC0. `http://bit.ly/2A4o2Vp`

8.3. Are my sunglasses polarized?

Many models of sunglasses are polarized, which means that they “filter” the incoming light, leaving only light polarized (or light which vibrates) in a certain direction. To test whether or not your sunglasses are polarized, you can do the following simple experiment:

1. **You will need** your sunglasses and a mobile telephone.

2. **Switch on** the mobile telephone on so that the screen is turned on.

3. **Look at** the telephone through the sunglasses and, checking that the screen is still turned on, rotate the phone, moving it from vertical position to horizontal position.

4. **Can you still see the screen?** If the screen “turns off” with the sunglasses on, but then you take them off and see that the screen is still turned on... what has happened?

5. **Explain** this phenomenon using the explanation given in this course on polarization. Search for more information on the Internet if you need to.

5. **Repeat** the experiment, but this time observe the sun’s reflection on a window or metallic surface, with and without the glasses. The “ordinary” light from the sun is not polarized, but its reflections are: are your glasses polarized? Justify your answer.

Important 3.1: Screen with polarizing filter?

BEAR IN MIND that not all screens on mobile telephones or similar devices have a polarizing filter (used to remove glare from their surface). If the experiment does not work, try to look for another mobile telephone or tablet and repeat it.

Figure 3. Sunglasses on a mobile telephone. Source: pixabay. License: Creative Commons CC0. `http://bit.ly/2ATF20a`

8.4. Total internal reflection at home: emulating optical fiber (I)

We already know that light is guided through an optical fiber by means of total internal reflection. We are now going to see if we can emulate this process in our own kitchen.

1. You will need a glass, water, milk and a laser pointer.

2. Fill the glass with water and then add a few drops of milk and mix them together, so that the water becomes a whitish color.

3. Place the laser pointer next to the glass, below the level of water, pointing towards the interface between air and water (inside the glass, look at Figure 4 as a reference).

4. Change the angle of the laser light entering the glass, always pointing towards the air/water interface.

5. Explain the results of the experiment in your own words, referring to the concepts seen during the course.

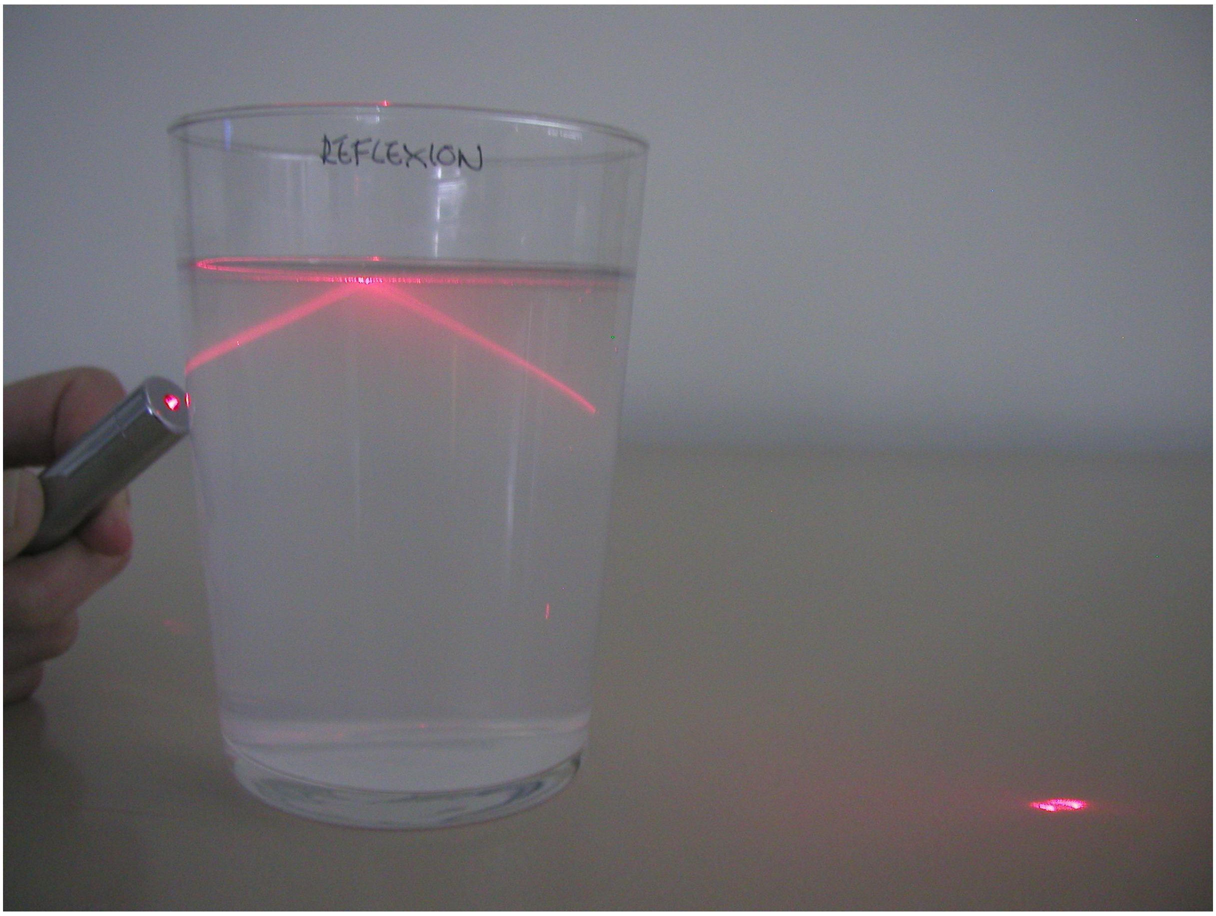

Figure 4. Total internal reflection with a laser pointer and a glass of water with milk. Source: (c) Universidad de Oviedo. `http://bit.ly/2ANOVfK`

8.5. Total internal reflection at home: emulating optical fiber (II)

We are now going to see if we are capable of emulating light being guided through optical fiber with a water jet.

1. You will need a transparent plastic water bottle or similar container, water and a laser pointer.

2. Fill the bottle with water and then make a small hole in one side for the water to come out of (block it until we reach point 4).

3. Place the laser pointer next to the bottle, on the side opposite the hole so that the light is pointing roughly at it.

4. Unblock the hole and move the laser until you can see that the water jet guides the light along its path.

5. Explain the results of this experiment in your own words, referring to the concepts seen during the course.

Important 5.1: Water as optical fiber

In order to see the effect clearly, it is advisable to carry out the experiment in a dimly lit room. You should also make sure that you have a container to catch the water coming out of the bottle's hole.

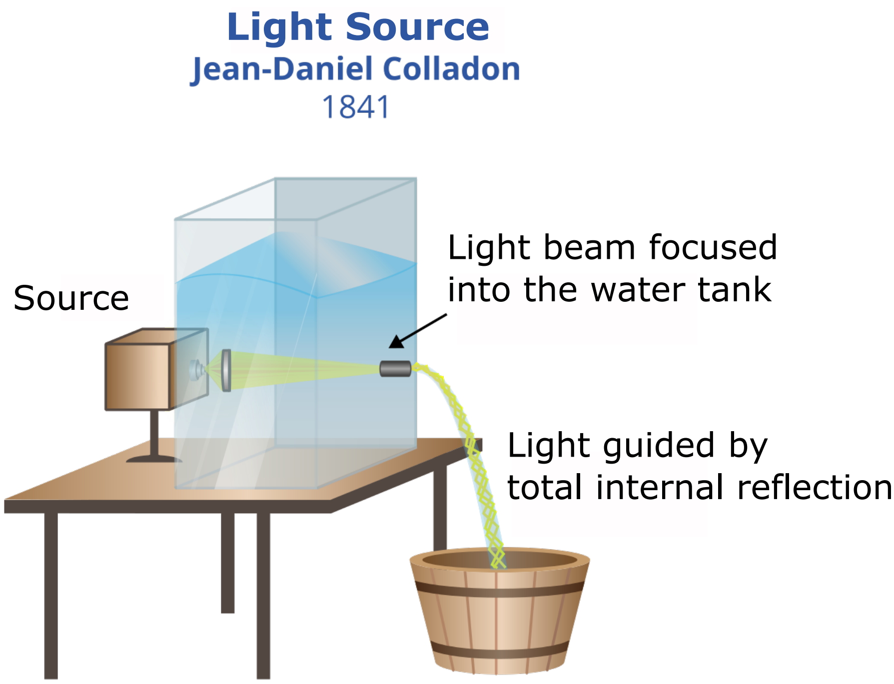

Figure 5. Source of light (Collandon's experiment). Source: Wikimedia. License: CC-BY-SA 3.0. `http://bit.ly/2AROLpD`

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