THE NOBEL PRIZE

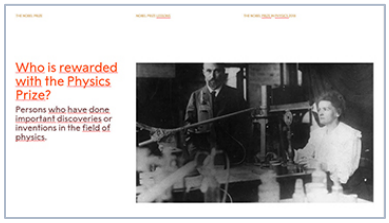
Nobel Prize Lessons 2018

Teacher's manuscript – the 2018 Physics Prize

The Nobel Prize in Physics

- The Nobel Prize in Physics is one of the five prizes founded by Alfred Nobel and awarded on December 10 every year. Before Alfred Nobel died on December 10, 1896, he wrote in his will that the largest part of his fortune should be placed in a fund. The yearly interest on this fund would pay for a prize given to "those who, during the preceding year, shall have conferred the greatest benefit to humankind." '

Who is rewarded with the Physics Prize?



- This Prize rewards important discoveries or inventions in the field of physics. The development of "wireless telegraphy" (radio) is one example. Another is discoveries about how stars behave.
- Guglielmo Marconi and Karl Ferdinand Braun received the Physics Prize in 1909 for the development of radio ("wireless telegraphy"). Subramanyan Chandrasekhar received the 1983 Prize for studying processes of importance to the structure and evolution of the stars.
- Three women have been awarded the Physics Prize:
- Maria Goeppert Mayer who made the first advanced model of nuclear structure, Marie Curie for pioneering research on radiation and the discovery of the elements radium and polonium and Donna Strickland, awarded with the 2018 Nobel Prize in Physics "for groundbreaking inventions in the field of laser physics".

Physics Prize 2018

- The 2018 Nobel Prize in Physics is all about laser technology. One half of the Prize is being awarded for a tool for capturing and manipulating various particles. The other half rewards a technique for intensifying and speeding up pulsing laser light, beyond what was previously believed possible.

The Nobel Laureates

- Arthur Ashkin, aged 96, is the oldest Nobel Laureate ever. He has worked with his idea since the first laser was built in 1960.
- Donna Strickland and Gérard Mourou published a joint article in 1985. It was Strickland's first scientific article and paved the way for many new applications for pulsing laser lights. Strickland is the third women to receive a Nobel Prize in Physics, 55 years after Maria Goeppert-Mayer.

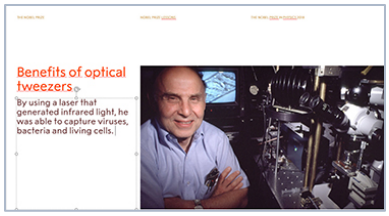
Laser

- A laser produces a very special kind of light. Ordinary light is a mixture of wavelengths (colours) that move at different intensities and in different directions. A laser generates a light that has exactly the same wavelength (colour), intensity and direction.

Optical tweezers

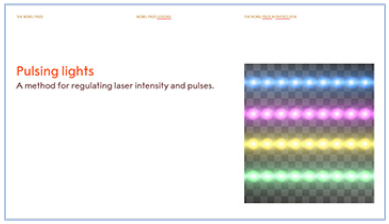
- As early as the 17th century, Johannes Kepler understood that light can exert pressure on objects that it illuminates, similar to the way a powerful stream of water can move objects that get in its way. This was verified experimentally in the early 20th century, but was of no practical use at that time. When the laser was invented, Arthur Ashkin understood that such a device could generate light that was intense and directional enough to actually move objects.
- By aiming a laser beam at small particles, he was able to show that they moved along the beam at precisely the predicted speed. To his surprise, it also turned out that particles seemed to move towards the centre of the laser beam. Eventually he was also able to do this using small transparent plastic beads.
- Ashkin understood that because the outer part of the laser beam had a lower intensity (strength) than the central part, a so-called gradient force pushed the object towards the centre of the beam, but in order to keep the object still, one more force was needed. To begin with, Ashkin also used gravity to keep the object entirely still. The method worked, but was of limited practical use. Then he realised he could use a lens to focus the laser beam into a point where the object would be trapped, since at this focal point, powerful opposing forces are generated that keep the object motionless.

Benefits of optical tweezers



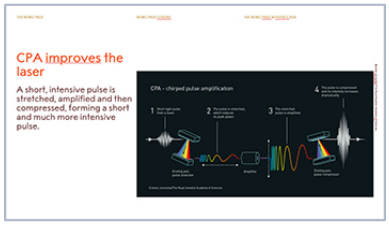
- Optical tweezers are used in many ways. At first, a number of researchers used this technique to capture atoms and molecules so they could be studied. Ashkin himself became more interested in how the technique could be used to understand various processes in living organisms. By using a laser that generated infrared light, he was able to capture viruses, bacteria and living cells. Today this method is used in many fields where researchers wish to examine small objects – from atoms and DNA molecules to viruses and bacteria.

Pulsing lights



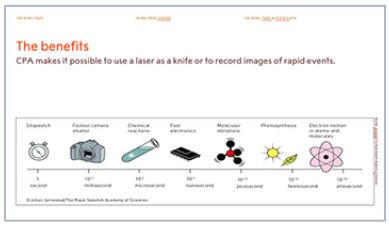
- Another application for lasers is to generate optical pulses: short, intensive flashes of light with much shorter time intervals than other light sources can achieve.
- By the mid-1980s it was no longer possible to create more intensive or faster lasers. The lasers simply became overheated and were destroyed. To solve this problem, Donna Strickland and Gérard Mourou developed a technique called chirped pulse amplification, or CPA.

CPA improves the laser



- CPA occurs in several steps. First a laser pulse is stretched so it takes more time. This also makes its intensity (strength) lower.
- The next step is to amplify the pulse so that its intensity increases, but without destroying the amplifier.
- Finally the pulse is compressed again, increasing its intensity and making it much bigger than the amplifier could have handled.
- Besides generating a much more intensive laser beam, the method can also be used to make the pulses much shorter.

The benefits



- There are many ways to use pulsing lasers. They can cut and drill with great precision in sensitive materials. By adjusting the pulses, a laser can be used as an extremely sharp knife for eye surgery.
- Another application is creating images of very rapid events, such as chemical reactions and how electrons move.