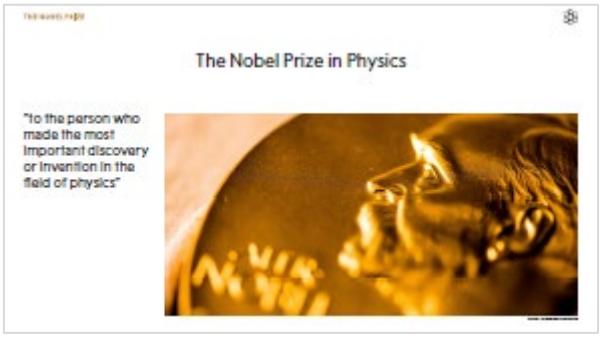
THE NOBEL PRIZE

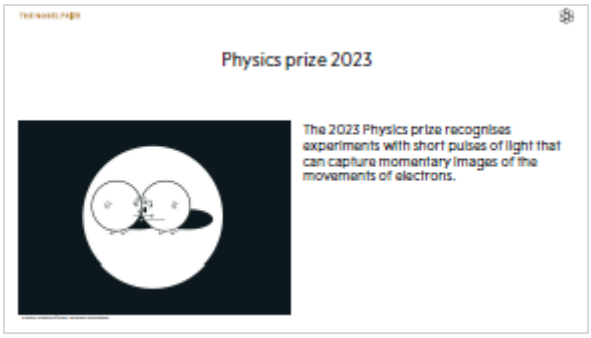
Speaker's manuscript – Physics prize 2023
Electrons in pulses of light

The Nobel Prize in Physics



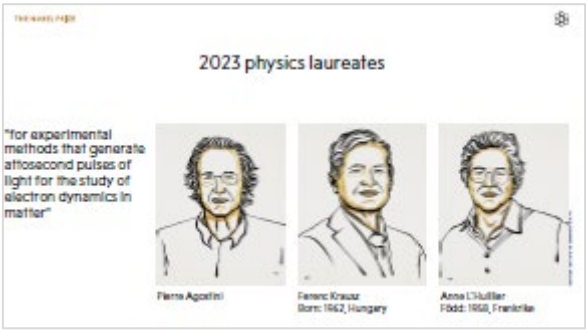
- The Nobel Prize in Physics is one of the five prizes founded by Alfred Nobel and awarded on 10 December every year.
- Before Alfred Nobel died on 10 December, 1896, he wrote in his will that the largest part of his fortune should be placed in a fund. The yearly interest on this fund would pay for a prize given to "those who, during the preceding year, shall have conferred the greatest benefit to humankind."
- The interest would be divided into five equal parts, with one part awarded to those who "shall have made the most important discovery or invention within the field of physics".
- This prize rewards important discoveries or inventions in the field of physics.

2023 physics prize



- The 2023 Nobel Prize in Physics is about experiments that create pulses of light that are short enough to capture momentary images of electrons' extremely rapid movements.

2023 physics laureates



- The prize is awarded to three researchers. Anne L'Huillier found a new effect of laser light that interacts with the atoms in a gas. Pierre Agostini and Ferenc Krausz demonstrated that this effect could be used to create shorter pulses of light than had previously been possible. That means that researchers today can

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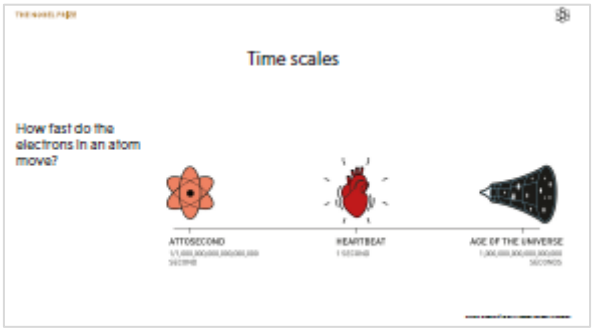
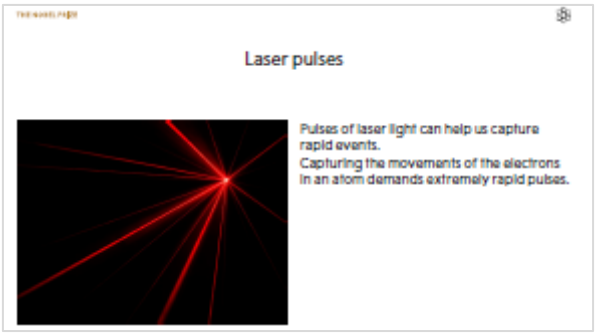
register the movements of electrons in an atom.
- Anne L'Huillier works at Lund University in Sweden.
- Pierre Agostini works at Ohio State University in USA.
- Ferenc Krausz works at the Max Planck Institute for Quantum Optics in Garching and at the Ludwig Maximilian University of Munich in Germany.

Time scales



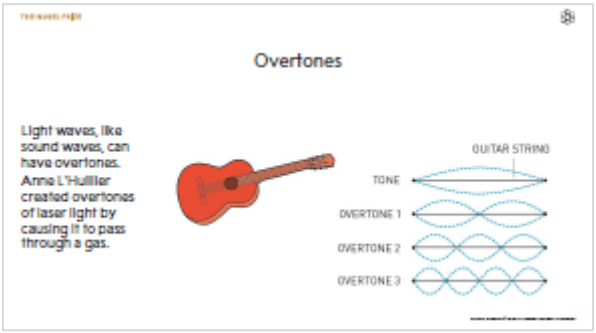
- The events in the world around us happen at different scales of time. There is about a second between the beats of a human heart. The movement of the electrons in an atom take about a billionth of a billionth of a second – an attosecond.
- An attosecond is so short that that the number of them in one second is the same as the number of seconds that have elapsed since the universe came into existence, 13.8 billion years ago.

Laser pulses



- Our minds cannot perceive the individual beats of a hummingbird's wings. Registering such rapid events requires technology. One such technology is pulses of laser light. Laser light is concentrated light waves of a particular wavelength. However, common lasers cannot create light pulses that are shorter than about a femtosecond – a millionth of a billionth of a second. That's fast enough to record the sequence of events in the chemical reactions between atoms and molecules. But capturing the movements of electrons required new technology to create even shorter pulses of light.

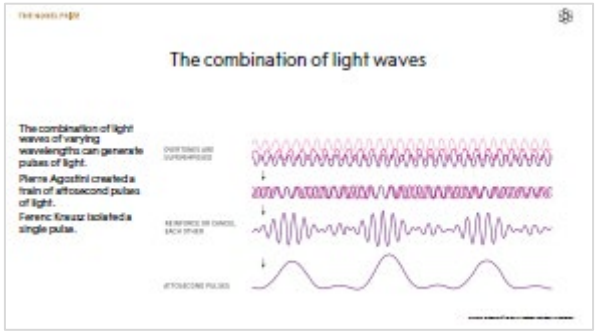
Overtones



- One step along the way toward shorter pulses was to create overtones of light waves. Light's overtones can be compared with the overtones in the sound emitted by a vibrating guitar string.
- Anne L'Huillier and her co-workers succeeded in creating overtones of infrared laser light by causing it to pass through various noble gases. Overtones are created when this light interacts with the electrons in the gas. The light's electrical field distorts the electrical field that holds the electrons in place within their atoms, thus allowing

them to escape from those atoms. When the light's electrical field changes, the electrons fall back, emitting light pulses that are overtones of the original laser light.

The combination of light waves



- One way of creating shorter pulses is to combine light waves of differing wavelengths. When waves of different wavelength are superimposed, they reinforce one another at regular intervals to create a single pulse.
- Pierre Agostini and his research group succeeded in producing and studying a train of light pulses that were about 250 attoseconds long.
- Ferenc Krausz and his research group developed a technique for isolating a single pulse.

Applications

- Attosecond pulses make it possible to explore the details of what happens inside of atoms and molecules. There are also potential practical applications in a variety of fields from electronics to medicine. For example, attosecond pulses can be used to push molecules, which then emit a measurable signal. The signal from these molecules has a particular structure, like a kind of fingerprint, that reveals what kind of molecule is emitting it. This may perhaps be used in medical diagnostics, for example.

"Even now, 30 years afterwards, we are still learning new things."

- In an interview given in conjunction with the announcement of the 2023 physics Prize, Anne L'Huillier talks about how her research on light's overtones continues to engage her.
- She first learned that she had been awarded the Nobel Prize in the middle of giving a lecture. After receiving the news, she returned to the topic at hand and went on with her lecture.