https://doi.org/10.1038/s41566-023-01328-4

Photonics celebrates double Nobel Prize achievement

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The 2023 Nobel prizes in physics and chemistry have been awarded to important discoveries and developments in photonics-related research.

Photonics research is back in the limelight with the news that achievements in attosecond science and quantum dots have both been recognized in this year's physics and chemistry Nobel prizes announced in early October.

The Nobel Prize in Chemistry has been awarded to Moungi Bawendi, Louis Brus and Alexei Ekimov, from the Massachusetts Institute of Technology, Columbia University and Nanocrystals Technology Inc., respectively, for "the discovery and synthesis of quantum dots".

The prize recognizes the pioneering efforts of the three recipients, who contributed to bringing to life the predictions of quantum mechanics. It was known since the early days of quantum mechanics that quantum dots – semiconductor particles just a few nanometres in size – could be a platform for demonstrating and harnessing size-dependent light absorption and emission. However, fabricating and utilizing them remained out of reach.

In the 1980s, Ekimov and Brus fabricated small nanocrystals embedded in coloured glass and floating in solution, respectively. But it wasn't until Bawendi pioneered chemical synthesis techniques in the early 90s that quantum dots could be manufactured with precisely controlled size and emissive characteristics suitable for applications.

Following these pioneering contributions, interest in quantum dots surged, leading to new synthesis approaches, characterization methods, and practical applications. This was also made possible by an expanded library of materials, spanning from inorganic semiconductors to organic compounds and perovskites. Today, quantum dots have found their way into LEDs and consumer products such as TVs where they are attractive due to their tunabilty of emission wavelength, high brightness, colour purity and stability. Quantum dots are also being deployed in other classes of optoelectronic devices, such as photodetectors and solar cells, where they enhance charge transport and light harvesting efficiencies. They are also finding applications in biology and medicine, where they can be used as light-emitting probes for guided surgery, targeted imaging, diagnosis and localized treatment.

Moving on to this year's Physics prize, almost ten years ago we discussed the exciting potential of attosecond photonics in a Focus issue on the topic in 2014 (www.nature.com/collections/fshnzztpfc). Since that time, the field has progressed at an extremely rapid pace, culminating in recognition by the Wolf Prize in Physics last year[1,2] and now this year's Nobel news.

The 2023 Nobel Prize in Physics has been awarded to Pierre Agostini at The Ohio State University, Ferenc Krausz at the Max Planck Institute of Quantum Optics and the Ludwig-Maximilians-Universität München, and Anne L'Huillier at Lund University in Sweden "for experimental methods that generate attosecond pulses of light for the study of electron dynamics in matter".

A brief recall of the history of the development of attosecond light pulses tells us that attosecond science began as far back as 1987, when the 33rd harmonic in the extreme ultraviolet (XUV) range (32.2 nm) was generated in argon gas at an intensity of about 10^{13} W cm^{-2}. In 1993, the theory behind such high-harmonic generation was developed. In 2001, the first experimental proof of attosecond pulse trains with a duration of 250 as was reported, and a few months later, isolated attosecond pulses with a pulse width of 650 as were produced by a streaking technique. High-harmonic generation was also discovered in transparent solids in the early 2010s, allowing the study of the band structure, bonding networks and topology of solids.

Because both the timescale and the energy of the attosecond pulses match those of light–matter interaction, attosecond science has now been applied to the study of electron dynamics, opening up the 'attoworld' of science. Applications include the localized control of electrons in molecules and ultrafast switching of an insulator to a conductor, as highlighted by Mats Larsson, a member of the Nobel Committee for Physics.

What started as a fundamental study of multiphoton processes in atomic physics has now broadened to impact molecular physics, physical chemistry, condensed-matter physics and even bioimaging. "This is a typical example of research which is very fundamental. We have been working in this field for 30 years. Only now, you begin to have applications in science," commented L'Huillier. "Basic research is very important and has to be funded by different institutions or agencies because it takes time to arrive at a point where we start to see applications for medicine, semiconductor industry and chemistry."

The acknowledgment of these groundbreaking discoveries is certainly well-deserved and serves as a testimony to the broad impact that both quantum dots and attosecond physics have had and will continue to have across numerous fundamental research fields and technological applications.

Impressively, it's not the first time that photonics can claim a double celebration, scooping both awards in the same year. A similar situation occurred in 2014 when the Physics prize went to the development of GaN blue light emitters while the Chemistry prize went to the demonstration of super-resolution fluorescence microscopy. The 2023 news means that photonics research has been directly or indirectly recognized in 11 Nobel Prizes in the past 16 years. Collections of relevant content published in Nature Portfolio journals related to the 2023 Nobel prizes can be found at https://www.nature.com/collections/gdiedachgb and https://www.nature.com/collections/hhbaafijej.

Published online: 31 October 2023

References

1. Pitruzzello, G. *Nat. Photon.* **16**, 550–552 (2022).
2. *Nat. Photon.* **16**, 549 (2022).