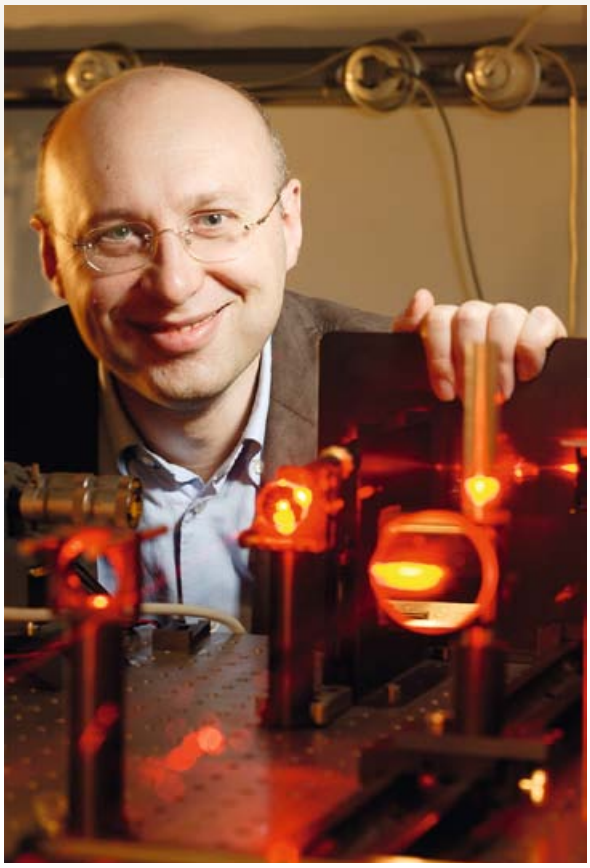
Nobel Prize in Chemistry 2014 for Stefan Hell



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Stefan Hell im Labor
Stefan Hell in his lab

Stefan W. Hell, Director at the Max Planck Institute for Biophysical Chemistry in Göttingen was awarded the Nobel Prize in Chemistry 2014. He shares the prize with Eric Betzig and William E. Moerner. With the award the Royal Swedish Academy of Sciences honours their pioneering work in the field of ultra-high resolution fluorescence microscopy. Stefan Hell succeeded in radically overcoming the resolution limit of conventional optical microscopes – a breakthrough that has enabled new ground-breaking discoveries in biological and medical research.

With the invention of the STED (Stimulated Emission Depletion) microscopy experimentally realized by Hell in 1999, he has revolutionized light microscopy. Conventional light microscopes reach their resolution limit when two similar objects are closer than 200 nanometers (millionth of a millimetre) to each other because the diffraction of light blurs them to a single image feature. This limit discovered by Ernst Abbe had been considered an insurmountable hurdle for nearly a century. The same limit by diffraction also applies to fluorescence microscopy which is frequently used in biology and medicine. In this technique, cell molecules are marked with fluorescent dyes and made to glow by using a laser beam with a particular wavelength. If the molecules are less than 200 nanometers apart, however, they also blur into a single, glowing image. For biologists and physicians, this meant a massive restriction because for them, the observation of much smaller structures in living cells is decisive.

The 52-year-old physicist Stefan Hell was the first to radically overcome the resolution limit of light microscopes – with an entirely new concept, In the case of the STED microscopy method that he developed, the resolution is no longer restricted by the wavelength of light. For the first time, it is now possible to observe intracellular structures in ten times greater detail compared to conventional fluorescence microscopy.

In order to overcome the phenomenon of light diffraction, Hell and his team applied a trick: a second light beam, the STED beam is sent after the beam that excites the fluorescent molecules. This, however, instantly quenches the molecules and thus keeps them dark. To ensure that the STED beam does not "switch off" all molecules, it is shaped like a circular ring. Thus, only the molecules at the spot periphery are switched off, whereas the molecules in the centre can continue to fluoresce freely. As the brightness of the STED beam is increased, the spot in which molecules can fluoresce is further reduced in size. As a consequence, the resolution of the system can be increased, in principle, to molecular dimensions. The specimen is scanned with a resolution that is typically improved by up to ten times compared with conventional microscopes, and an image is created.

By developing special fast recording techniques for the STED microscopy, Hell's team further succeeded in recording fast movements within living cells. They reduced the exposure time for single images in such a dramatic way that they could film in real-time the movements of small bubbles filled with neurotransmitters within living nerve cells, so-called vesicles, at 33 images per second, with a resolution of approx. 70 nanometers.