Applications of discoveries range from leveling rice fields to anti-terrorism defenses

BY ALDEMARO ROMERO
AND SUSAN D. ALLEN
SPECIAL TO THE SUN

JONESBORO — One of Albert Einstein's major breakthroughs was to indicate that the speed of light in empty space is constant. The potential practical implications of this discovery were enormous. It meant that light could be used to measure time with virtually absolute precision. However, there were many barriers that had to be overcome to take full advantage of all of the potential practical applications of this finding.

One problem was that since the 19th century light was viewed as an electromagnetic phenomenon, that light was seen as transmitted in the form of waves. However, when analyzing the radiation emitted by a glowing source such as the sun or a light bulb, the results were inconsistent with the idea that light behaved as an electromagnetic wave.

Thus, in the 1900s Max Planck and Einstein developed the fundamental ideas that considered light as individual energy packets or photons and that when the light hits the surface of a metal its energy is transferred to an electron, which is released and leaves the material. Einstein proved that a single photon gives all its energy to just one electron and generated an electric current that was measurable.

Today almost all light detectors are based on this effect, known as the photoelectric effect, for which Einstein won a Nobel Prize (not for his Theory of Relativity). After World War II a better mathematical understanding of this phenomenon and practical applications were developed.

One practical application was the invention of laser in 1960. Laser is an acronym for Light Amplification by Stimulated Emission of Radiation. A laser is light emitted in a single wavelength (one color) in which all of the photons are launched in unison and the light is very directional and concentrated, i.e., coherent. Lasing requires both stimulated emission and the feedback provided by partially transmitting mirrors on the end of the lasing cavity. Unlike a flashlight that releases photons in a disorganized manner, the laser emits photons in a very organized, controlled way.

Lasers are being used today in CD and DVD players, laser pointers for presentations, dental drills, high-speed metal cutting machines and precision instruments such as those that are used to level agricultural fields.

This year's Nobel Prize in Physics, and its financial prize of about $1.3 million, was awarded to Roy J. Glauber of Harvard University for his theoretical description of the behavior of photons, while John Hall of University of Colorado and Theodor Häensch, Max-Plank Institute, Germany, share one half of the prize for the development of laser-based precision spectroscopy, that is the determination of the color of the light absorbed or emitted by atoms and molecules with virtually absolute precision.

Glauber was able to develop the theoretical foundation of Quantum Optics that established the mathematical basis for differentiating between the light produced by a laser and that of a hot source such as a light bulb or the sun, while Hall and Häensch made it possible to measure frequencies, i.e., colors, with an accuracy of 15 digits.

These frequency measurement techniques have provided a critical tool not only for precise measurements of time but also for more everyday technologies such as GPS (Geographic Positioning System) used by the military, geographers, field scientists and in many vehicles to determine the precise position of an object on earth by using information provided by a network of satellites that orbit our planet.

'Lasers are being used today in CD and DVD players ... high-speed metal cutting machines and precision instruments.'

Aldemaro Romero and Susan D. Allen
professors of biology, chemistry and physics, Arkansas State University

Other potential applications of these discoveries range from improving communication across the globe and with spacecrafts as well as developing better digital animation leading to 3-dimensional images without the need to use special glasses.

High resolution spectroscopy is being used in a new program just starting at Arkansas State University involving five professors in chemistry, physics and engineering to measure potential terrorist threat agents in the atmosphere.

For more information contact the ASU Dept. of Biological Sciences at biology @astate.edu.

Dr. Romero is chairman and professor of biology and Dr. Allen is vice-chancellor for research and academic affairs and professor of chemistry and physics at Arkansas State University.