The simple Balmer spectrum of atomic hydrogen has provided the Rosetta stone for deciphering the strange laws of quantum physics during the early 20th century. Four decades ago, Doppler-free laser spectroscopy opened a new chapter in the exploration of hydrogen. The pursuit of ever higher resolution and measurement accuracy has inspired many experimental advances, from laser cooling of atomic gases to the laser frequency comb technique for measuring the frequency of light. Today, precision spectroscopy of hydrogen is reaching a precision of 15 decimal digits. However, the determination of fundamental constants and experimental tests of fundamental physics laws are now hindered by our insufficient knowledge of the rms charge radius of the proton. Recently, a laser measurement of the 2S-2P Lamb shift of muonic hydrogen has yielded an independent precise new value of the proton radius which differs by five old standard deviations from the official CODATA value. This discrepancy is subject of intense current discussions. It may be caused by a mistake, or it may indicate a dent in the armor of quantum electrodynamic theory.

The discovery of X-rays in 1885 by Wilhelm Conrad Röntgen on 8 of November 1885 has added a new dimension to image our world. Since then, a tremendous scientific and technological progress took place, which allowed X-rays to let us understand where atoms are and how they move in condensed matter, materials and living matter. The observation of synchrotron radiation, and its use since the 1970s as the prime tool for deciphering the strange laws of quantum physics, has inspired many experimental advances, from laser cooling of atomic gases to the laser frequency comb technique for measuring the frequency of light. Today, precision spectroscopy of hydrogen is reaching a precision of 15 decimal digits. However, the determination of fundamental constants and experimental tests of fundamental physics laws are now hindered by our insufficient knowledge of the rms charge radius of the proton. Recently, a laser measurement of the 2S-2P Lamb shift of muonic hydrogen has yielded an independent precise new value of the proton radius which differs by five old standard deviations from the official CODATA value. This discrepancy is subject of intense current discussions. It may be caused by a mistake, or it may indicate a dent in the armor of quantum electrodynamic theory.
light fantastic.

Diederik Wiersma

Trapping light fantastic

INO-CNR, Firenze, Italy

Sun light contains an enormous amount of energy and is provided to us freely every day. One square meter illuminated by the sun corresponds to about a kilowatt of energy. To harness this energy, at current state-of-the-art efficiencies, would already allow to us freely every day. One square meter illuminated by the sun corresponds to about a kilowatt of energy. To harness this energy, at current state-of-the-art efficiencies, would already allow to supply the entire world with all its energy need, using a total surface equal to only one fourth of the size of the Sahara. Several strategies are being followed to improve the efficiency and reduce the cost of solar cells, applying sometimes surprisingly deep physical concepts like that of Anderson localization of light and trapping in plasmonic nano structures. I will give an overview of the current state-of-the-art, and discuss recent developments in this exciting field of research.

Attempts to understand the nature of light have been central to the historical development of physics. Although understanding the duality of wave and particle challenges our classical intuition, one cannot escape asking hard questions on this issue, and indeed this subject was at the heart of Bohr-Einstein debate in the early years of the 20th century. The emergence of quantum optics and especially studies of the nature of nonclassical light and its exploitation in quantum computing and quantum cryptography have put this back at the heart of current physics. This talk will review the historical development of wave particle duality, discuss its central place in the modern theory of quantum optics, and consider implications of the subject for current and future research in quantum information science.

Modern multi-messenger astronomy - the observation in particular of high-energy phenomena in the Universe using a variety of messenger particles - has made rapid strides in the last decade, with detectors “imaging” very high energy gamma rays, neutrinos, and cosmic rays from cosmic sources. In many of the detection techniques, particle tracks are imaged using their Cherenkov light emission, providing large detection areas at (relatively) modest cost. The talk will address the history, the highlights, and the future challenges of this field.

The once and future Cosmic Microwave Background

Andrew Jaffe

Imperial College, London, UK

Measurements of the Cosmic Microwave Background (CMB) have proven to be the best way of determining cosmological parameters from observations combined with simple physical principles. I will discuss the formation of the CMB, the oldest light we observe, and how the pattern of its fluctuations is determined by those cosmological parameters. The Planck Surveyor has, for the past two years, been measuring the CMB over the whole sky with the highest sensitivity and the widest frequency coverage yet achieved. Although the Planck team will not be releasing its cosmological results until early 2013, the Planck data have already provided a wealth of information about the microwave sky, from observations of the structure of our galaxy to the properties of dusty galaxies in the nearby Universe, as well as the discovery of some of the most massive galaxy clusters yet observed. I will discuss these results and prospects for Planck’s cosmological measurements as well as planned and proposed observations at still higher sensitivity from the ground, balloons and satellites.

Light and art: an indivisible relationship

Alessandro Farini

INO-CNR, Firenze, Italy

This talk is devoted to the close relationship between light and art. It is actually impossible to separate light from art and especially from painting and sculpture. First of all, light is intrinsic to a painting: one can think for example of Caravaggio’s works of art, where light creates the scene also when it is painted in a non-realistic way, as in “The Calling of St Matthew”. But light is also the instrument that permits to us to see artworks. Colors, but also volumes and spaces depend on the lighting degree. The recent introduction of Light Emitting Diodes (LEDs) in the lighting market is an important step forward, because it offers the opportunity to obtain different color temperatures and to change the dominant color in a very short amount of time. Some examples, using real contemporary artworks, are shown during the talk. Speaking about light and art offers also the opportunity to address a major topic: the relationship among light, an object and a human being seeing the object: this interrelation reveals the subjectivity and objectivity of our perception of light and colors.

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