Physics News Update
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Physics And Progress

Why do science? To learn more about the universe and to improve the material and intellectual conditions of people. The recently concluded APS March meeting was a great arena for showcasing new fundamental ideas in physics and also for seeing how these ideas can be marshaled for producing practical commercial benefits. Here are three examples:

1. Metamaterials. The architecture of these artificial nanoscale-engineered materials made of tiny ring-, strip-, and rod-shaped components serves to enhance the magnetic interaction between light and matter. This results in the material having a negative index of refraction and consequentially various novel optical properties.

One practical goal of negative-index optical research is superlensing, a process in which a thin flat panel of the metamaterial would be able to image an object at a spatial resolution better than the wavelength of the illuminating light. Since metamaterials were first realized in the lab for microwave light, physicists have been pushing negative-index behavior to shorter and shorter wavelengths.

To bring about a negative-index condition, the material's electric permittivity (a measure of a material's response to an applied electric field) must be negative, and in some cases also its magnetic permeability (a measure of the material's response to an applied magnetic field (to read more about these parameters and early reports of metamaterials, see http://www.aip.org/pnu/2000/split/pnu476-1.htm).

At last week's APS meeting Vladimir Shalaev (Purdue University, shalaev@purdue.edu) reported a negative-index material operating at a wavelength of 770 nm (at the end of the visible spectrum), the shortest wavelength observed for a single-negative (negative permittivity) and the same material (but with a different light polarization) operating at a wavelength of 815 nm, the shortest wavelength observed for a double-negative material (both negative permittivity and permeability). See Shalaev's review article at Nature Photonics, January 2007.

2. Graphene, essentially one-atom-thin carbon sheets, were presented at last year's meeting by no more than a few groups. Now there are dozens. The reasons for this are graphene's adaptable mechanical and electrical properties and the very unusual behavior of electrons moving through a graphene landscape: you increase the electron's energy but you don't increase their velocity.

It's as if the electrons were acting like slow-moving light waves. Pablo Jarillo-Herrero (Columbia Univ, pj2168@columbia.edu) reported the latest developments in this rapidly moving research area, including the useful development of graphene ribbons; the resistivity of the material changes according to the width of the ribbons, meaning that the semiconducting properties of graphene could be tailored to suit the application.

He also summarized out recent progress in the field, including the observation of superconducting graphene transistors (Delft), freely suspended graphene sheets, a room-temperature Hall effect, and room temperature single-electron transistors with graphene (Manchester).

3. Light-emitting diodes. Moving from two new topics-metamaterials and graphene-to a more mature field-the production of light by combining holes and electrons inside a semiconductor junction-we see that considerable forward strides are still possible. George Craford (Lumileds/Philips) described a new record-setting white-light high-power LED, with an input current of 350 mA, the one-square-millimeter device produced light at a rate of 115 lumens per watt, representing the first time a high-power LED exceeded the 100 Lm/W mark.

LEDs, because of their energy efficiency and their concentration, are already frequently used in traffic lights, brake lights, and in building lighting. Craford predicted that some LEDs were to be used in cellphone flashes, in daytime automobile running lights, and (later this year) for auto headlights.

Wireless Transmission of Quantum Code

Wireless transmission of quantum code over a distance of 144 kilometers (89 miles) between two Canary Islands has been demonstrated by a team of researchers in Europe. At the APS March Meeting, Anton Zeilinger of the University of Vienna (**anton.zeilinger@univie.ac.at**) described how he and his colleagues transmitted single photons from an astronomical observatory in La Palma Island to another one in Tenerife.

The transmitted photons' polarization states (representing 0s and 1s) formed the basis of a "quantum key," a stream of information that could be used to decipher a longer encrypted message. The researchers used single photons because they are more secure than groups of photons, from which an eavesdropper could pluck information about the key.

To detect potential eavesdroppers even better, the researchers entangled the outgoing particles of light with photons kept at the transmitting station. They used astronomy stations because their telescopes are sensitive enough to detect individual photons. The data transmission rate was low, only 178 photons in 75 seconds, but the photons are able to travel longer distances in free space (potentially thousands of kilometers or more) than they are in fiber optic cables (100 km) before they become undetectable.

In a proposed experiment to be coordinated by the European Space Agency (ESA, which operates the Tenerife telescope and which participated in the Canary Islands experiment) the International Space Station can transmit entangled key to two earthbound stations separated by distances ten times greater or more. (For a preprint, see Ursin *et al.*, **quant-ph/0607182**)

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