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Physics news on the Internet (based on electronic preprints)

1. Perfect mirror

The 'perfect mirror,' a device combining the best properties of metallic and dielectric mirrors, has been designed by an MIT team. Traditional metallic mirrors, while reflecting light from all angles, have a disadvantage of absorbing some portion of the incident light energy. More recent dielectric mirrors do not conduct electricity and therefore can reflect light more efficiently, but are limited to a prescribed range of light frequencies coming from within a certain set of angles. The perfect mirror consists of 9 alternating, micron-thick layers of the element tellurium and the polymer polystyrene, two materials having widely different refractive indices. Owing to its special light interference properties, the device is extremely low-loss and capable of reflecting light of any polarizations and from all angles possible. The working prototype operates at infrared wavelengths and, the authors claim, opens up many technological and research possibilities. For example, a cavity lined with such mirrors can confine light for a very long period of time. Among other possible uses, optical waveguides and efficient heat barriers are pointed out.

Source: http://web.mit.edu/news.html

2. Light-induced ice crystallization

When irradiated with ultraviolet light, a thin layer of amorphous ice deposited on graphite transforms into a crystal structure without changing the temperature, researchers from two Swedish universities report. According to the theoretical model the researchers propose, photons do not affect the ice structure directly but rather excite graphite electrons which subsequently tunnel quantum mechanically into the ice layer to supply energy to individual water molecules. The indirect nature of the light- ice interaction is corroborated by the fact that, if thick enough, ice only crystallizes in the immediate vicinity of the graphite. Amorphous ice was obtained in the lab by depositing water vapour on a surface colder than about 100 K, at which temperature molecules lack the energy to rearrange into a crystal. It is only on heating above 140 K that the ice crystallizes. The experiment shows that, in the present context, UV irradiation is in fact equivalent to heating. The effect may occur in the tails of comets, which consist of ice and dust particles, and is expected to be involved in the chemistry of Earth's ozone layer.

Source: http://publish.aps.org/FOCUS/

3. Casimir effect

According to quantum mechanics, so-called zero-point vibrations, i.e., the incessant creation and annihilation of virtual particles, take place in the vacuum. These processes, among other things, may cause interaction between two macroscopic bodies, as, e.g., in the so-called Casimir effect, in which two parallel metal places a small distance (say, l) apart attract each other. The explanation is that in the space between the plates, only zero-point electromagnetic vibration modes of wavelength no longer than $2l$ may exist, with the result that the zero-point energy density in-between is less than that outside. U Mohideen and A Roy, both of the University of California at Riverside, have made the most precise measurement ever of the Casimir force, using an atomic force microscope to study the attraction between a metal sphere and a surface. Importantly, corrections for undesirable effects such as electrostatic charges, surface roughness, non-perfectly reflecting surfaces, etc., were made. Also, the predicted temperature dependence of the effect was observed. The experiment is important as presenting an independent and more precise confirmation of earlier results.

Source: http://ojps.aip.org/prlo/top.html

4. Supernovae at cosmological distances

We have already published (see the February, 1996 issue of *Phys. Usp.*) the preliminary results of the study of supernovas at cosmological distances in the framework of the Supernova Cosmology Project headed by S. Perlmutter. The study, aimed at determining the universe extension parameters, is carried out with the help of the world's most powerful telescopes using Berkeley Lab-designed instruments. As of now, 42 Type Ia supernovae have been discovered, which are remarkable in that they have known luminosities and can therefore serve as 'standard candles'. From the data on these SNe, all of which are at redshifts between 0.18 and 0.83, the mass density, $\Omega_{\rm m}$, and cosmological-constant energy density, Ω_Λ, of the universe have been obtained. For a flat ($\Omega_{\rm m} + \Omega_\Lambda = 1$) cosmology predicted by the inflationary universe model, it is found that $\Omega_{\rm m} = 0.28^{+0.09}_{-0.08}$ (1 sigma statistical). The cosmological constant Λ is nonzero with probability of 99%. The Hubble constant is $H \approx 0.63$ km s^{-1} Mpk^{-1} giving the universe age of $14.9^{+1.4}_{-1.1} \times 10^9$. The reliability of the results depends on the accuracy with which Ia SNe may be considered as standard candles.

Source: http://xxx.lanl.gov/abs/astro-ph/9812133

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