Physics News Update

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A Realistic Laser-Operated Molecular Locomotive

A realistic laser-operated molecular locomotive has been proposed by a Texas A&M researcher (Zhisong Wang, nargate@jewel.tamu.edu). For those designing materials at the smallest workable scales, a major dream is to build nano-locomotives that would move through a molecular-scale track to perform various tasks, such as transporting building blocks for nanomachines.

Earlier proposals have outlined some innovative designs for these nanoengines (for example, see Update 490). While nano-locomotives are still in the blueprint stage, a new model brings the idea closer to reality by incorporating the latest working knowledge of nanomaterials as well as the probabilistic, jiggly nature of the molecular world.

In Wang's design, a nano-locomotive would have a main body consisting of cars each made up of a linear polymer chain. Either end of the train would have a chemically tailored "head" group that could bind to or break from a track, which would be a cylinder-shaped microtubule found in biology. Either end of the locomotive could attach via covalent bonds to special molecular groups on the track. Laser pulses would move the train: one light pulse would break the bond from one of the train's ends and another laser pulse would cause each car of the train to change its molecular configuration, and expand its size to reach the next part of the track. Thermal fluctuations of the motor itself and the environment play a vital role, for example as the train's head seeks the next binding site on the track. Wang has proposed a multistep "optomechanical work cycle" that precisely outlines the laser steps needed to move the train, and even reverse its direction.

The locomotive would work not only as a motor, but a powerful molecular engine that could generate a pulling force 10 times greater than of the natural biomotor kinesin. Such forces, of about 100 piconewton, could allow the nano-locomotive to break molecular bonds and help in constructing nanomaterials while delivering cargo. (Wang, Physical Review E, 15 September 2004; also see Physical Review Focus article).

Finding A Vein

Finding a vein, necessary for administering intravenous solutions, can often be difficult. A new device, called a Vein Contrast Enhancer (VCE), uses sensitive infrared sensing to find the vein beneath the skin and then also projects the rather spooky vein image back onto the patient's wrist. This makes it appear as if the veins were lying right on top, making it easy for a nurse to make an injection.

How does it work? An array of light emitting diodes shines infrared light at the subject, and one depends on the fact that red blood cells scatter light differently from surrounding fatty tissue. The scattered light passes through some filters and then is captured by a CCD TV camera, processed by computer, and rendered as a sort of movie at a rate of 30 frames per second. These images can be projected onto the subject through a careful aligning process to register the surface projection with subcutaneous anatomy (see figure at Physics News Graphics).

Herbert Zeman and his colleagues at the University of Tennessee Health Science Center in Memphis have done extensive clinical trials with VCE devices and are now doing trials with the projection capability. The general spatial resolution of the process is about 0.1 mm. Veins as deep as 8 mm have been imaged. This work is being presented at this week's Frontiers in Optics meeting in Rochester, co-sponsored by the Optical Society of America (OSA) and the American Physical Society (APS). (See also http://www.conenhill.com/)

Surprising Properties of Sunlight

Surprising properties of sunlight is another highlight of the Frontiers in Optics meeting. Greg Gbur, now at the University of North Carolina at Charlotte (gjgbur@uncc.edu), and his colleagues reexamined 19th-century-physics-based estimates for the coherence of sunlight and found that an assumption used in those estimates is technically inaccurate, but the results are surprisingly correct.

Generally, we only think of a highly controlled source such as a laser as producing coherent light. All light, however, including sunlight, has some degree of spatial coherence, *i.e.* some extent to which its fluctuations at different points in space are correlated (have precise interrelationships).

In 1869, Emile Verdet derived a rough estimate for the area within which sunlight falling on the Earth's surface may be considered spatially coherent. Verdet implicitly assumed, however, that the Earth is in the "far zone" of the Sun, which was conventionally understood to be the distance at which the Sun appears as a point object. Of course, this is not true on the Earth, as we are 10^{15} km too close, and this raised the question of whether Verdet's results, and those which followed, are accurate.

Gbur and colleagues performed new simulations of filtered light emanating from an incoherent spherical source, standing in for the Sun. Surprisingly, they found that the light behaved as if it were in the far zone even when viewed only a few wavelengths from the source. So Verdet's assumption is correct, but only because the far zone for an incoherent source is much, much closer than expected.

One of Gbur's co-authors on this study is the University of Rochester's Emil Wolf, a key developer of the modern theory of coherence, and the other is Oklahoma State University's Girish S. Agarwal, another influential figure in the development of coherence. (Paper FTuF6 at meeting; also Agarwal, Gbur, and Wolf, Optics Letters, March 1, 2004.)

After publishing their Optics Letters paper, the authors discovered that a little-appreciated paper (Leader, Journal of the Optical Society of America 68, 1978) made similar findings but did not discuss the results in the context of sunlight.

Back to Physics News Update