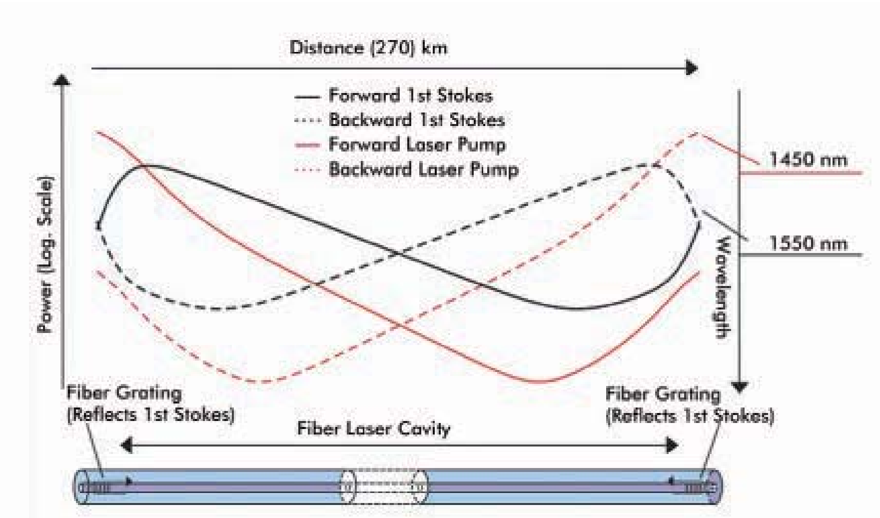

This schematic depicts an ultralong Raman fiber laser design and optical power distribution. Pumping at 1450 nm generates laser radiation at 1550 nm. Reprinted with permission from Turitsyn et al, *Physical Review Letters*, 103, 133901 (2009). ©American Physical Society 2009.

effects; first, backreflection of light resulting from fiber medium inhomogeneities.

As reported in the Sept. 25, 2009, issue of *Physical Review Letters*, the technique combines several optical technologies, including the fundamental nonlinear effect of stimulated Raman scattering.

First, distributed Raman fiber amplification provides a gain medium for signal transmission in standard telecommunication optical fiber over distances of 100 km or more. Second, the laser cavity is formed by fiber Bragg gratings, which act as reflectors for 1.5-µm wavelength light. And, finally, both the pumping and signal waves propagate close to the window of transparency of silica, minimizing fiber losses.

The team believes that new applications and technologies will continue to emerge from studying the physics of ultralong fiber lasers.

"Our results indicate that the physical mechanisms underlying the operation of such lasers involve nontrivial, nonlinear interactions of the resonator modes and are quite different from those in other types of lasers," Turitsyn concluded. "We have revealed interesting connections between the new field of ultralong fiber lasers and many areas of fundamental science, and we plan to study the physics involved in more detail."

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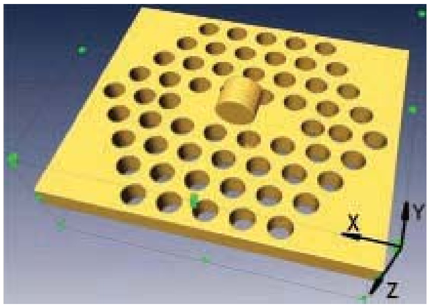
Nanocavity brings optical tweezing down to size

SHANGHAI, China – An international team of researchers is taking steps to bridge the gap between nanophotonics and nanomechanics by harnessing the induced near-field force within a nanocavity.

Yuchuan Jian at Fudan University and at Duke University in Durham, N.C., together with colleagues Junjun Xiao at Hong Kong University of Science and Technology and at Harbin Institute of Technology in Shenzhen and Jiping Huang at Fudan University, has designed the first powerful optical tweezer system that operates on the nanoscale.

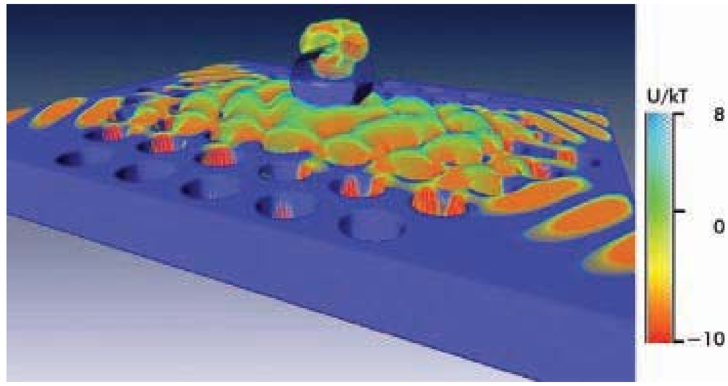
In the device, a strong local field is generated by a nanocavity within a photonic crystal slab. This intense localized force can be used to manipulate, sort and select nearby complex dielectric nanorods.

"For the first time, we have proposed the use of a remarkably localized nanocavity as a general light source," Jian said.



This schematic graph shows the system of a nanorod coupled with the cavity of a photonic crystal slab. Notice that the system axis Z is perpendicular to the slab (X-Y plane) in the figure. Images courtesy of Duke University.

Shown is distribution of the normalized electromagnetic energy (U) in the coupled system. Here, k is the Boltzmann constant and T, the room temperature. An attractive optically induced potential ball is formed at the top part of the nanorod.



"The photonic crystal cavity can exert an optical force on dielectric nanorods that have a high refractive index – much in the same way as a near-field optical tweezer."

Today's optical tweezers use the concentrated gradient potential nature of a tightly focused laser beam to trap cells. However, manipulating objects on the nanoscale requires much stronger confinement of light, beyond the normal diffraction limit.

Jian and colleagues turned to photonic crystal nanocavities, which are ideal candidates for next-generation near-field optical tweezers because of their compact size and straightforward fabrication process. Jian said the devices can locally address individual nanorods, promising benefits to biosensing, cell/DNA isolation and molecule sieving applications.

"Our device could be used in future on-chip integrated photonic circuits on the nanoscale," he noted. "Our specific goal is to show that a potential all-optical coupling operation using light can be achieved by the synthesized optomechanical potentials in this integrated system. We also want to demonstrate that the device can be applied in current semiconductor nanodevice fabrication processes."

In the computational experiment, described in the *Journal of Physical Chemistry C* on Sept. 3, 2009, a dielectric nanorod is placed above a high-Q photonic crystal cavity. An optical-dipole force field surrounds the cavity and interacts with the nearby nanorod. In turn, the nanorod creates small perturbations within the high-Q cavity, which affects the system's behavior and stability.

"An optical force is exerted on the nanorod, which pushes or pulls it to an equilibrium position, thanks to the evolving attractive/repulsive interaction between the nanorod and cavity," Jian said. "What's more, this optical force or light source is tunable through spontaneous emission within the nanocavity."

The Fudan-Duke group recognizes that much work still must be done to bridge the gap between current fundamental research and future industrial applications. The next step is to extend the calculations to investigate an array of nanocavities to see whether both parallel and large-scale manipulation is possible. Another avenue of research planned by the team is to shift the working frequency to determine whether broadband operation is possible.

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Synchronized flying in space makes for good detection

TEDDINGTON, UK – Researchers from the National Physical Laboratory (NPL) are using femtosecond laser combs and optical imaging features on multiple spacecraft with the idea of creating one large detector that will enhance Earth observation and exploration of the universe.

Their theory, that formation-flying spacecrafts could gather data in a way different from a standard spacecraft, might help determine the place from which all magnetic fields originate, answer the age-old question of how the universe developed after the big bang and ascertain whether Albert Einstein's general theory of relativity is true.

Absolutely accurate

"Rather than trying to launch a craft hundreds of meters in size, comparable performance might be obtained by having two or more small crafts hundreds of meters apart," said Geoffrey P. Barwood, a member of the time quantum and electromagnetics team at NPL. The method is comparable to an individual spacecraft operation because x-rays taken from a "formation flight can have the [same] resolution of a single craft that is of the size of the [overall] formation," he said.

During formation space missions, two spacecrafts are engaged in flight with a regulation of a minimum of tens to hundreds of meters between them. The crafts operate autonomously, positioning themselves in relation to each other via femtosecond laser combs, a detector and optical imaging systems.

To establish formation, the lasers precisely measure absolute distance between crafts by emitting very short pulses of light, each lasting about 5 fs, with a repetition rate of 250 MHz and average power of 70 mW. The pulses are centered at a