Optics in 2008

PANEL CHAIR: **Robert D. Guenther,** Duke University

GUEST EDITORS: **Madeleine Glick**, Intel Research; **Robert Jopson**, Bell Labs, Lucent Technologies; **R. John Koshel**, Lambda Research Corp.; **George I. Stegeman**, University of Central Florida, CREOL; and **James M. Zavislan,** University of Rochester

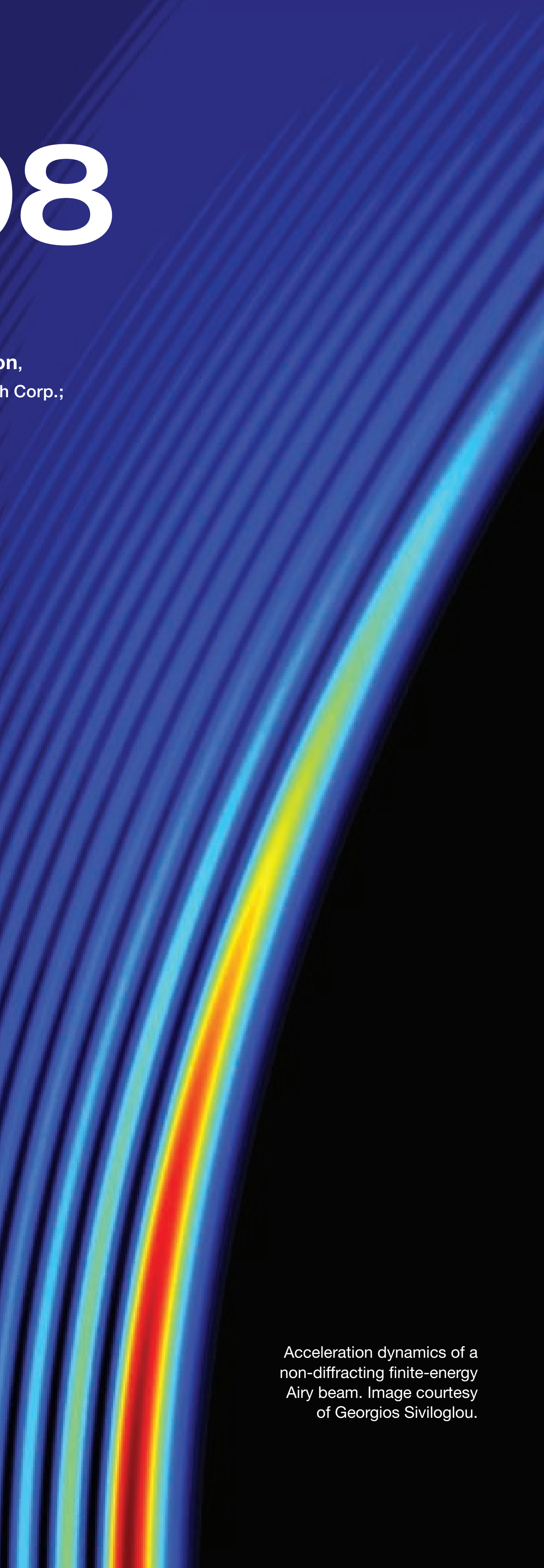
This special issue of *Optics & Photonics News* (OPN) highlights the most exciting research to emerge in the preceding 12 months in the fast-paced world of optics. Optics in 2008 offers readers a unique opportunity to access, in a single source, summaries of cutting-edge optics research reported in the peer-reviewed press. The areas covered in 2008 include beam engineering, biophotonics, diffractive structures, lasers, material processing, microscopy, nonlinear optics, optical engineering, optical storage, optical tweezers, plasmonics, quantum optics, remote sensing, scattering, terahertz technology, ultrafast optics and nano-optics.

This year's issue comprises 30 summaries representing the work of more than 140 authors from 13 countries. Submissions were judged on the basis of the following criteria:

- The accomplishments described must have been published in a refereed journal in the year prior to publication in OPN.
- The work should be illustrated in a clear, concise manner that is readily accessible to the at-large optics community.
- The authors should describe the topical area as a whole and then discuss the importance of their work in that context.

Although OPN makes every effort to ensure that achievements in all optics subfields are recognized, there are no requirements in the selection process for inclusion of specific topical areas. When we receive a large number of submissions for a specific area, it is taken as evidence that the topic has been fertile ground for activity and research. OPN strives to ensure that engineering, science and technology are all represented.

OPN and OSA would like to thank all the researchers from around the world who submitted summaries, as well as to our panel chair and guest editors.



Acceleration dynamics of a non-diffracting finite-energy Airy beam. Image courtesy of Georgios Siviloglou.

Parallel and Real-time Trapping, Manipulating and Characterizing Microscopic Specimens

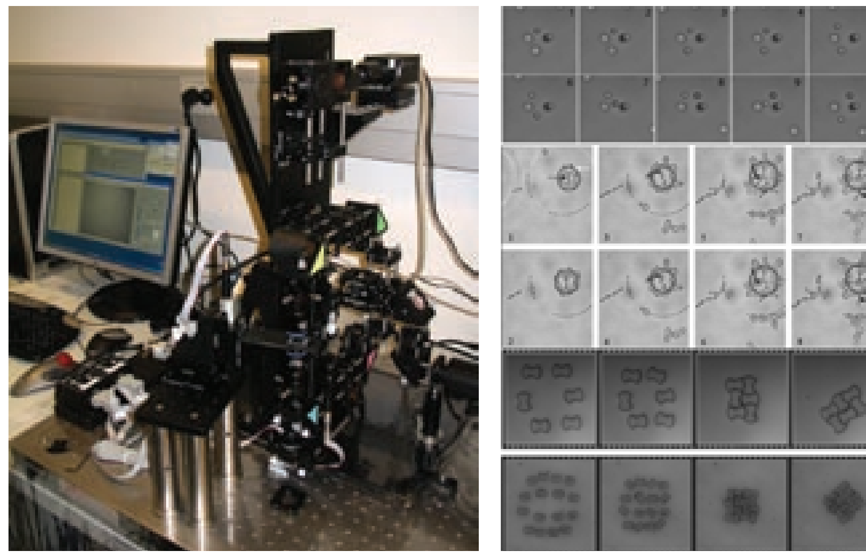
Jesper Glückstad, Darwin Z. Palima, Jeppe S. Dam and Ivan P.-Nielsen

In the mesoscopic regime, very small forces that result from light-matter interaction are strong enough to significantly influence the motion of tiny particles. Until just a few years ago, virtually all laser manipulation schemes were based on trapping particles inside a single strongly focused beam and moving them into a desired position by translating the laser focus. Now, two decades later, a great deal of progress has been achieved in optical trapping and manipulation, both in terms of applications and technical developments.

Particularly, much more versatile and general manipulation of particles and cell colonies is now possible by using specially tailored structures of light.[1] Such light patterns have unprecedented potential for manipulating mesoscopic objects and have already been successfully used to organize small particles, including microorganisms, in desired patterns and to sort samples of particles according to their size.[2]

Optical trapping and manipulation of a plurality of micro-particles is now viable using reconfigurable patterns of optical fields.[3] This opens up research possibilities for many interdisciplinary fields, particularly those with biomedical relevance. With the advent of computer-addressable spatial light modulators, the reconfigurability of light patterns that can act as confining optical potential landscapes is made even more feasible with a great degree of interactive user-control.[4]

We invented the "all-optical biophotonics workstation" to trap, manipulate and characterize microscopic specimens in parallel. We used an optical mapping from a beam-modulation module to obtain reconfigurable intensity patterns, corresponding to two independently addressable regions relayed to the sample volume, where the optical manipulation of a plurality of micro-objects takes place. The generated array of counter-propagating trapping-beams is easily aligned using a computer-guided alignment procedure.[5]



The BioPhotonics Workstation and examples of real-time 3D experiments.

The spatial addressing of the expanded laser source is done in real-time through a high-speed computer-controlled spatial light modulator that is integrated in the beam modulation module. Through a computer interface, the operator can simply select, trap and move the desired objects with a mouse or joystick. Once the object is trapped, one can also manipulate them using arbitrary motion patterns that can be programmed for the micro-objects and orchestrate complicated moving patterns of many independent samples.

The fluid-borne microscopic particles can be ushered in through a rectangular cuvette, where they are trapped and steered in three dimensions using the real-time reconfigurable matrix of counter-propagating structured laser beams. The counter-propagating geometry currently generates up to 100 powerful optical traps using well-separated objectives; this eliminates the need for the high-numerical-aperture oil immersion objectives that are required with conventional optical tweezers. It also generates a large field of view and leaves vital space for integrating other enabling tools for probing the trapped particles, such as linear and nonlinear microscopy or micro-spectroscopy. ◭

Jesper Glückstad (jesper.gluckstad@fotonik.dtu.dk), Darwin Z. Palima, Jeppe S. Dam and Ivan P.-Nielsen are with the department of photonics engineering at DTU Fotonik, Roskilde, Denmark.

References

1. J. Glückstad. "Sorting particles with light," Nature Materials **3**, 9-10 (2004).
2. J. Glückstad et al. "Optical 3D manipulation and observation in real-time (invited paper)," J. Robotics Mechatronics **18**(6), 692-7 (2006).
3. P.J. Rodrigo et al. "2D optical manipulation and assembly of shape-complementary planar microstructures," Opt. Express **15**, 9009-14 (2007).
4. I. Perch-Nielsen et al. "Autonomous and 3D real-time multi-beam manipulation in a microfluidic environment," Opt. Express **14**, 12199-205 (2006).
5. J.S. Dam et al. "Three-dimensional imaging in three-dimensional optical multi-beam micromanipulation," Opt. Express **16**, 7244-50 (2008).