RESEARCH CONFERENCES

ESF-FWF Conference in Partnership with LFUI

Trends in Optical Micromanipulation

Universitätszentrum Obergurgl
(Ötz Valley, near Innsbruck) • Austria
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SCIENTIFIC REPORT

Introduction (up to 2 pages)

Introduction on the topic in non-specialist terms (especially for highly technical subjects)

Optical Micromanipulation makes clever use of the physical properties of light to influence microscopic particles: The photon energy can be applied to heat, weld, cut or fuse; the momentum that light carries may accelerate, trap or stretch particles; and since light may carry angular momentum, we even have a “handle” to induce torques or induce rotations, respectively.

Thus it is very appealing as a technology for instance in cell biology: it is clean, safe (typically one uses milli-Watt laser beams), relatively cheap and allows interactive monitoring under the microscope. Besides being a contact-free means for “manoeuvering” particles in desired ways, optical traps can also be used as measurement devices for tiny forces in the pico-Newton regime.

Being strongly interdisciplinary and close to industry, the topic reflects the typical characteristics of present day research. Optical Micromanipulation is a very rapidly growing field, a fact that creates a large demand for cross-linking among the increasing number of groups on the development and on the application side.

I hereby authorize ESF - and/or the Fonds zur Förderung der wissenschaftlichen Forschung in Österreich (FWF) and the Leopold-Franzens-Universität Innsbruck (LFUI) - to publish the above two-page Introduction on a special page dedicated to 'Conference Highlights' within the Research Conferences website.

Date & Signature:

Scientific Content

Summary of the conference sessions focusing on the scientific highlights

The conference was dedicated to the emerging new technologies for the laser-manipulation of particles in the micro- and nano-world and covered topics on optical traps including holographic optical tweezers, optical binding and self-assembly of particles, laser micro-beams, and biological and technological applications of these.

These topics were mirrored in the partition into the Sessions "Optical Vortices and Angular Momentum" (Chair: M. Ritsch-Marte), "Holographic Tweezers and Optical Rotors" (Chair: K. Dholakia), "Many-Particle Systems and Microfluidics" (Chair: S. Bernet), and "Quantitative Applications I+II" (Chairs: H. Rubinsztein-Dunlop and A. van Blaaderen).

Apart from these main topics, stimulating "side-glances" to related topics ranging from nanotechnology to microfluidics were included in the interspersed Sessions "Biological Applications" (Chair: G. Spalding), "Molecular Applications" (Chair: M. Padgett) and "Related Technologies" (Chair: J.-M. Fournier).

A programme overview of all Sessions is included in a separate sheet.

Assessment of the results and their potential impact on future research or applications

The beauty of the conference venue and the fact that there exists no established European Conference Series on the topic helped to attract major trend-setters and promising young researchers in the field. 103 participants from 22 countries attended the conference. All major European groups were represented, and also a considerable number of representatives of leading non-European groups, e.g. from the USA and from Australia.

As anticipated, the conference provided excellent opportunities for scientific discussion, as the time schedule left ample time for scientific discussions and for establishing new scientific contacts. Many participants have assured that they were able to create new bonds to other research groups.

The inclusion of representatives from industrial companies such as K. Schütze from Palm Technologies (who was supported by the Tiroler Zukunftsstiftung) helped to bridge the gap between methodology and application.

At several instances, in personal discussions and statements as well as in the plenary discussion, participants expressed their feeling that the conference has raised their awareness of the importance of the close contact with industry and with researchers interested in applications of Optical Micromanipulation. Consensus therein was generally

seen as an important outcome of the conference.

Forward Look Plenary Discussion

State-of-the-art in the field

Five prominent scientists in the field (K. Dholakia, K.-O. Greulich, K. Helmerson, J. Käs, K. Schütze) agreed to form a Panel of Experts making personal statements on the state of the art of the field as well as on their views on future developments.

The state-of-the-art was seen as follows. Light beams as universal “contact-free” tools have been refined to a level that specimens from atoms up to cells can be handled. Multiple traps enable the manipulation of thousands of particles, and the manipulation can be interactively controlled in real-time by applying holographic methods on spatial light modulators. Considerable progress has been made towards a microfluidic “lab on a chip”.

In general, the panel experts agreed that the field has been advanced to a level where purely physical experiments are now ready to be applied to cell biology. At present efforts are still necessary towards cheap and reliable systems.

Emerging topics

Apart from the already mentioned requirement to make the systems more and more user-friendly, for easy use by non-physicists in biology, medicine, and the material sciences, the following issues were identified as promising directions in the field.

Nano-self-assembly, especially, was seen as an important emerging topic. A higher impact of the whole field (also in a commercial sense) could be created, if the throughput of the available systems, i.e. the number of investigated cells per second, can be further increased. On the pure science side, careful investigations of non-equilibrium systems and non-equilibrium thermodynamics could be facilitated by optical micromanipulation in the future. Handling of very different materials and objects would also boost the field by enlarging the range of possible applications.

Visions for the future of the research field – identification of issues in the 5-10 years & timeframe

The “Lab-on-a-chip technology”, where all investigations on a cell sample are done on a single miniaturized “chip”, remains a far term goal motivating the advancement of the field. Many necessary features have be demonstrated as proof of principle, but the handling of the systems has to be made easy, reliable, and stable for the use of “hard-core-biologists” as end users. Open-mindedness of the physics community will very likely result in still unforeseen new applications.

▪ Is there a need for a foresight-type initiative?

Sure!

Here I would also like to mention that the participants strongly and repeatedly expressed their strong wish for a follow-up conference in 2 or 3 years.

■ The reaction of the participants to the location and the organization, including networking, and any other relevant comments

The response to both, the scientific programme and the location was overwhelmingly positive, if not enthusiastic. The choice of topics and people was considered a good mixture. For the future it was suggested to have more talks delivered by younger researchers and to invite also chemists (e.g. addressing applications of optical methods in polymer chemistry) in addition to physicists and biologists.

My personal highlight concerning the reception of the conference was the fact that one participant literally said that "*the conference changed his general view of the field*".

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