



The Optical Society of India NEWSLETTER

Number 2

December, 2004

From the Editor

The second issue of the OSI NEWSLETTER is in your hands. We have received some encouraging response to its first issue. However, it seems that not many members have received or read it. Did you get the first issue? If you would like to receive the PDF copy by email, please send an email to the Editor (asharma@physics.iitd.ac.in). The Society would like to see the OSI NEWSLETTER become a vibrant forum for discussion and dissemination of information among the members. At present it contains only two pages and is issued quarterly. We should aim to increase both size and frequency in the near future. This can happen only if the members want it that way and contribute accordingly.

- EDITOR

Focus on Optics

Optical Tweezers

D.S. MEHTA

One of the most remarkable chapters in the history of science and technology was the development of lasers in 1960s. The phenomenon of trapping, acceleration, and levitation of particles using radiation pressure forces from laser beams was realized soon afterwards. The 1997 Nobel Prize in Physics was awarded to Steven Chu, Claude Cohen-Tannoudji and William D. Phillips for the development of methods to cool and trap atoms with laser light which opened many branches in physics, such as, atom optics, atom interferometry, atom holography and atom laser.

Optical tweezers were first demonstrated by Arthur Ashkin and his co-workers at Bell Labs (Murray Hill, NJ) in 1986. Optical tweezers use strongly focused laser beams to trap and manipulate micro-particles. The trapping and manipulation of particles is based on the radiation pressure forces of laser beams arising from the momentum of light itself. Radiation pressure forces generated by lasers have been used to accelerate, decelerate, deflect and guide particles. This is a direct consequence of high intensities and high intensity gradients generated by laser beams. Laser trapping and manipulation techniques have been applied to the particles as diverse as atoms, large molecules, small dielectric spheres and biological specimens such as viruses, single living cells and organelles. A laser beam has a Gaussian profile, so the most intense part of the beam lies at the center of the beam axis. The force, therefore, confines the particle to the beam axis, and as the focus of the beam is the most intense part of the beam along the beam propagation direction, it draws the particle toward the focus. Optical tweezers can

trap particles three dimensionally and give remarkable degree of control over the dynamics of the small particles. In an optical tweezer trap there are mainly two kind of forces: *gradient force* arising due to intensity gradient of the beam which is directed towards high intensity gradient and the *scattering force* arising due to the radiation pressure of the laser beam acting towards the direction of the beam propagation. To create large enough forces to achieve this 3-D trapping effect, power needed is typically a minimum of a few milliwatts. Trapping particles in this way has led to various applications in Biological and Physical Sciences. In Biological Sciences, the optical tweezers have been used for trapping and manipulation of cells, bacteria, organelles etc.; study of cell-to-cell interaction; pico-Newton (pN) order force measurement; micro-tubule bending & stiffness measurements; interaction of a single myosin molecule with a single suspended actin filament; RBC deformability studies and single myosin molecule assays. It is also possible to measure the elastic properties of DNA by grabbing hold of beads attached to the ends of the molecules and stretching them. Similarly, the force-producing properties of molecular motors, such as kinesin, may be studied with optical tweezers. Particles are easier to probe if they are trapped. By combining optical tweezers with other laser beams, researchers can perform microsurgery on biological specimens. For instance, they can grab chromosomes and then cut them into small pieces for further analysis using an IR (1064 nm) trapping beam and a green (532 nm) cutting laser, known as optical scissors. This is possible because most biological matter does not absorb strongly in the IR spectral region but does at green wavelengths.

In Physical Sciences, optical tweezers can be combined with Raman spectroscopy, two-photon spectroscopy, and confocal microscopy. Optical tweezers have also been used as non-contact, non-destructive probes for near-field scanning optical microscopy (NSOM) and in atomic force microscopy. Recent research involving a special class of light beam, one that does not diffract, is opening up intriguing new avenues of research. Optical tweezing is entering a new phase, with maturation of existing techniques, and with creation of sophisticated light patterns becoming easier with new technologies such as spatial light modulators, holographic array generators, diffractive optical elements (DOEs) and optical vortex beams. With the help of these new techniques optical tweezers are being used for micro-rotation and micro- & nano-fabrication. In the Laser Applications and Holography Laboratory, Instrument Design Development Centre (IDDC) Indian Institute of Technology Delhi, we have conducted several experiments to generate spatial beam patterns, such as, spiral pattern, fork pattern, and several other types of

interference patterns for optical tweezers. Recently, researchers at Biomedical Applications Section, Center for Advanced Technology (CAT), Indore, have demonstrated the controlled intracellular rotation of microscopic objects using a simple rotating line optical tweezers, which has remarkable applications in developmental biology. This study was recognized as one of the most exciting researches in the area of Optics in 2003 by the Optical Society of America and was summarized in the December 2003 issue of the Society's *Optics and Photonics News*. In conclusion optical tweezing will make a significant contribution in many interdisciplinary subjects over the coming years.

Further Reading

1. Arthur Ashkin, "Acceleration and trapping of particles by radiation pressure" *Phys. Rev. Lett.* Vol. 24 (1970) 156-159.
2. Arthur Ashkin, "Applications of laser radiation pressure," *Science* vol. 210 (1980) 1081-1088.
3. Arthur Ashkin, J. M. Dziedzic, J. E. Bjorkholm, S. Chu, "Observation of a single-beam gradient force optical trap for dielectric particles," *Opt. Lett.* Vol. 11 (1986) 288-290.
4. Arthur Ashkin, J. M. Dziedzic, T. Yamane, "Optical trapping and manipulation of single cells using infrared laser beams," *Nature* vol. 330 (1987) 769-771.
5. Arthur Ashkin, "Optical trapping and manipulation of neutral particles using lasers" *Proc. Natl. Acad. Sci. USA*, Vol. 94, pp. 4853-4860, May 1997.
6. V. Garce's-Chavez, D. McGloin, H. Melville, W. Sibbett & K. Dholakia, "Simultaneous micromanipulation in multiple planes using a self-reconstructing light beam," *Nature*, Vol. 419, 12 September 2002, pp.145-147.
7. R. Dasgupta, S. K. Mohanty and P. K. Gupta, "Controlled rotation of biological microscopic objects using optical line tweezers," *Biotechnol. Lett.* 25, 1625-8 (2003).
8. R. Dasgupta, S. K. Mohanty and P. K. Gupta, "Rotating Line Optical Tweezers Enables Controlled Intracellular Rotation of Microscopic Objects," *Optics & Photonics News*, December 2003, pp. 16-17.

(Members are requested to send proposals to the Editor for this column for future issues)

Member News

Prof. K. Thyagarajan (IIT Delhi) has been elected **Fellow** of the Optical Society of America (2005).

Mr. Nahar Singh, Mr. Subhash C. Jain, Dr. A.K. Aggarwal and Dr. R.P. Bajpai (CSIO, Chandigarh) have been presented the **K. Suryanarain Rau Award (2004)** by the Indian Society for Advancement of Material and Process Engineering for their contribution in the development of "Extrinsic Fabry Perot Interferometric (EFPI) Sensor for Smart Technology Applications."

Prof. R.S. Sirohi (IIT Delhi) was presented the **C.V. Raman Birth Centenary Award** of the Indian Science Congress Association for the year 2004-2005 by the Prime Minister at the Science Congress, 2005.

Prof. A.K. Ghatak (IIT Delhi) has been awarded the **Dr. Biren Roy Memorial Lectureship (2005)** by the Indian National Science Academy (INSA) for his outstanding contributions in the field of Physics and Engineering.

(Members are requested to send items to the Editor for column for future issues)

Reflections

Congratulations! The first issue of the newsletter was quite interesting. Printing and the layout are good. Keep it up.

If we review the progress of optics in India for the last 25-30 years then if not outstanding, we grade it as good or above average and comparable with some developed countries. There are many scientists today who have more than 100 research papers to their credit and that too in recognized international journals. They have won international and national awards, and brought glory to our country. I salute to all of them. However, we cannot say the same thing about our optical industry (which also definitely is a part of optical community). Barring a couple of industries, none is capable of making any impact in the national and international market. This is rather surprising. Since optics is a labour intensive industry, where skilled labour play a very vital part, there is no reason why we could not take a lead. Labour in India is far more inexpensive compared to other countries. Then what went wrong? You will be surprised to learn (I hope it is a news to you) that big industrial houses such as Tatas, Bajaj, Kirloskars etc. had started this industry long back, but finally wound up. So definitely lack of growth of this industry in India was not due to shortage of funds. Even now I am in touch with few industrialists, who are ready to invest over 20 Crores for this purpose. Talking about the manpower about 35 batches of post-graduate students in applied optics have passed out in IIT, Delhi itself. Considering that each batch had about 10 students, where are these 350 people? Why not even a few start their own venture?

I can go on and on, on this subject. I definitely feel that we made mistakes. And even now it is not too late to take some corrective action. I feel that there should be a national debate on this subject on platforms like various national symposiums and seminars.

VASANT BANDE
Light Guide Optics Pvt. Ltd.
Indore

(Members are requested to responses to the Editor for future issues)

Forthcoming Events

International Topical Conference in Applied Photonics

Core theme: Superresolution and Photonics
15-16 February 2005, Kolkata

Contact: Prof. L.N. Hazra, Department of Applied Physics, University of Calcutta, 92 A.P.C. Road, Kolkata - 700 009
Email: superresolution@rediffmail.com

International Conference on Optics and Optoelectronics (ICOL-2005) (XXXI OSI Symposium)

December 12-15, 2005, Dehradun
Contact: Dr. Ashok Kaul, Convener, ICOL-2005, IRDE, Dehradun - 248 008
Email: ashk_kaul@hotmail.com
URL: <http://www.icol2005.com>

Suggestions & Contributions

A regular publication this OSI NEWSLETTER can be sustained only through active participation of the members and we seek suggestions to improve its contents and presentation. We also seek contributions from members to various columns of the OSI NEWSLETTER. In additions to the columns in this and the earlier issues, the future issues will also have interesting anecdotes/incidents involving optics or members, historical notes and any other information that could be useful or interesting to the members. Readers are particularly urged to send their responses/reactions to this and earlier issues. Contributions and proposals may please be sent to the editor. The next issue is scheduled for March, 2005. Members who want to receive the future issues of the OSI NEWSLETTER by email may send their email addresses to the editor.

PHOTONICS-2004

December 9-11, 2004, Kochi

The 7th International Conference on Optoelectronics, Fiber Optics, and Photonics (PHOTONICS-2004) was organized by the International School of Photonics of the Cochin University of Science and Technology (CUSAT) and NeST Photonics Pvt. Ltd at the International Convention Center of Hotel Le Meridien at Kochi (previously known as Cochin) at the backdrop of the famous back-waters of Kerala during 9-11 December 2004. Prof. V.P.N. Nampoori (CUSAT) and Prof. P. Radhakrishnan (CUSAT) were the conveners of the conference and it was a grand success with the number of participants exceeding 700 of which about 100 were from abroad. Actual conference was preceded by one-day tutorial level short courses totaling 4 in number on various topics of great current interest. These short courses were attended by a large number of students besides researchers and teachers (e.g. the tutorial on *Basics of Fiber Optics* was attended by as many as 80 participants), for which the participation fee was kept low at Rs. 500.00. Prof. C.P. Girijavallavan (CUSAT) and Dr. Surseh Nair (NeST), the Conference and Program Chairs, respectively, professionally conducted the inaugural session, which was very well attended. The recently appointed Vice Chancellor of CUSAT, Prof. P.K. Abdul Aziz presided over the function and delivered an address. In addition Mr. Javed Hassan, Chairman of NeST, delivered an interesting lecture deliberating on IT boom, the so-called IT bubble burst that followed and recent recovery trend seen in Optical Telecommunication. Vice-Admiral from the local Indian Navy base delivered the keynote address, in which he highlighted need for collaboration between the Defense and academics on high technology areas like Fiber Optics and Photonics, which have various applications in the Defense. There were four plenary talks on topics like Optical Fiber Sensors (Prof. B. Culshaw), Broadband connectivity and Fiber in the access network in India (Prof. Ashok Jhunjunwala), Derivative Speckle Interferometry (Prof. R.S. Sirohi), and Photonic Crystal Fibers (Prof. P.St.J. Russell). A large variety of topics under the broad area of Photonics were covered through 45 invited and 132 contributory paper presentations through 4 parallel sessions as could be seen from the very broad distribution of papers covering across the technical areas of Fibers/Components/Sensors, Integrated Optics, Optoelectronic Materials and Devices, Optical Networks, Lightwave Communications, Nonlinear Optics, Polymeric Photonics and Organic Electronics, Displays/Optical Instrumentation, Information Storage and Displays, Optical and Quantum Computing, and Biophotonics. In addition a large number of poster papers (in all 131 on Day-1 and 129 on Day-2) were presented. A total of about 440 papers were accepted out of over 500 papers submitted. A techno-commercial session was conducted on Day-2 in which NeST Photonics and Laser Spectra Services made audio-visual presentations about their companies. Largest number of papers was presented under the category of Fibers/Components/Sensors and Optoelectronic Materials and Devices. An exhibition was also held concurrently with the conference, in which a large number of companies had participated and which was also very well attended. On the evening of Day-2 a cultural program depicting Kathakali Dance was presented by a well-known dance troupe from Kerala. The next conference of this biennial event would be organized at Hyderabad in 2006. A selection of photographs can be seen on the conference website: www.photonics2004.com. - B.P. PAL

Optics and Photonics

December 20-21, 2004, New Delhi

A two-day Seminar on *Recent Advances in Optics and Photonics* was organized at IIT Delhi by the Physics Department, IIT Delhi and the Delhi Section of the Optical Society of America, during Dec.20-21, 2004. The Seminar was intended for students, teachers, scientists, and others interested in the general areas of Optics and Photonics, and was attended by over 100 participants. The two-day event comprised of 18 Invited Talks of 30 and 45 min durations, and a Poster Session. Apart from the faculty of IIT Delhi, the speakers included several visiting scientists from abroad (Brazil, Germany, Japan, the UK and the USA). The participants comprised of scientists and engineers from CEERI-Pilani, CSIO-Chandigarh, IRDE-Dehradun, LASTEC-Delhi, NPL-Delhi, and students and teachers from various colleges and universities. A monograph titled *Guided Wave Optics - Selected Topics*, edited by Prof. Anurag Sharma, and published by Viva Books Pvt. Ltd. New Delhi, was released by Prof. M. S. Sodha on the first day. The book was brought out as a *festschrift* in honour of Prof. Ajoy K. Ghatak on his 65th Birth Anniversary. The Seminar concluded on the second day with a General Body Meeting of the Delhi Section of the Optical Society of America in the evening. At the end of the Seminar, a number of participants expressed the view that such events should be organized periodically in various institutions involved in R & D activities in the general area of Optics and Photonics.

- M.R. SHENOY

Optics Directory of India

The Executive Committee of the OSI decided in its meeting on 16.9.2003 that a directory of optics activity in India should be compiled and the responsibility of this work was given to the undersigned. For this purpose all the scientists, researchers, engineers, developers and industrialists involved in any area of optics are requested to send the information for inclusion in the Directory. The format for sending the information is as follows:

A. Groups/Industries

1. Name of the Group/Unit
2. Address
3. Contact person: telephone, fax, email
4. Other permanent members of the Group (names)
5. Area of Activity (include classification, see below)
6. Major Contributions (not more than 200 words)
7. Up to 10 notable publications, patents
8. Major recognitions, awards, prizes, etc.
9. Educational/Developmental Activities (description limited to 100 words)
10. Major products, in case of Industry (description limited to 100 words)

B. Individuals

1. Name
2. Present Position, Address, telephone, fax, email
3. Area of Activity (include classification, see below)
4. Major Contributions (not more than 100 words)
5. Up to 5 notable publications/patents/books/products
6. Major recognitions, awards, prizes, etc.

The directory will have two sections: one devoted to the Groups & Industries and the other to the individuals. For classification of topics, use OSA's OCIS available at <http://www.osa.org/pubs/ocis/>.

The information should be sent preferably by email to asharma@physics.iitd.ac.in or by post to PROFESSOR ANURAG SHARMA, PHYSICS DEPARTMENT, INDIAN INSTITUTE OF TECHNOLOGY DELHI, NEW DELHI-110 016 by February 15, 2005.

The support and inputs are required from all those engaged in optics activity to make this effort successful and all the contributions would be invaluable. This information may be brought to the notice of those who may not receive it otherwise.

- ANURAG SHARMA