PHOTONICS NEWS

Bulletin from the International School of Photonics Vol. 01. (01), February 1999

Contents

The International School of Photonics

The International School of Photonics (ISP) at CUSAT was inaugurated by former Vice-Chancellor Dr. K G Adiodi on the National Science Day, February 28th 1995. ISP at CUSAT was formed by restructuring the activities of the Laser Division of the Department of Physics. The Laser Division in this University has been carrying out pioneering work by way of Research and Development in Lasers and their Applications as well as Fibre Optics Technology. The nucleus of the ISP was formed by de-linking the laser laboratories along with the faculty members of the laser group from the Physics Department of CUSAT. ISP now offers a three semester M.Tech degree course in Opto Electronics and Laser Technology and Ph.D. programme in all branches of Photonics/ Optoelectronics. A two semester M.Phil. programme has already been approved by the Academic Council of the University. Research and development work in frontline areas are pursued and these include topics like laser induced plasmas, photothermal and photoacoustic phenomena, nonlinear optics, photonics materials, laser material processing and fibre optics sensors as well as some defence related applications of lasers. Most of the research projects are being funded by the national funding agencies like Department of Science and Technology (Govt. of India as well as Govt. of Kerala), AICTE, DRDO, INSA etc. We are indebted to the former Vice-Chancellor Dr. K. Gopalan for his keen interest in promoting laser related activities in CUSAT.

Our present Vice-Chancellor Dr. K Babu Joseph was instrumental in establishing ISP and we are grateful to him for his continued help and co-operation in our efforts to make this School a unique one in this country.

ISP and International Collaboration

Major joint project of ISP with Eindhoven University of Technology, The Netherlands

The International School of Photonics (ISP) has established several collaborative research activities with a number of academic and research institutions abroad. Most important among these is the Technical University of Eindhoven (TUE) in Holland. The Netherlands government is offering major financial assistance for strengthening the activities of ISP under the Program of International Co-operation in Higher education (MHO).

The academic tie up between ISP and TUE will include the following special frontiers

- A market study in Indian photonics industry jointly conducted by ISP and TUE. Organizational study to suggest modifications with functioning of ISP with a long-term plan for further international co-oporation with other institutions abroad.
- Curriculum development in photonics at M. Tech. and M.Phil. levels which will suit the Indian conditions.
- Development of infrastructure facilities in ISP.

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- Identifying R&D programs to be taken as collaboration between ISP and TUE.
- Sandwich Ph.D program for the research students of ISP.
- Academic exchange programme for the permanent staff of ISP and TUE .

The MHO programme in photonics has taken off on 1st January 1999, as a new year gift to CUSAT. Market study has already been initiated by Prof. Hans Frankena and Dr. P Radhakrishnan. Prof. Frankena is a distinguished professor of optics at Delft University of Technology in The Netherlands and served as the Secretary General of International Commission on Optics. Ir. Graafmans and Prof. V M Nandakumaran are presently working on the organizational aspects of ISP. Curriculum development program is scheduled to be taken up during March 99 by Dr. De Graff from TUE and Prof. V P N Nampoori.

Out of the total Nuffic funding of DFL 1.87 million for the MHO assistance to ISP an amount of DFL 600,000 is ear-marked for infrastructure development of ISP in terms of equipment and support to research scholars of ISP, viz. Mr. Aneshkumar B and Mr. R Prasanth who have already been selected for participation with first phase which will begin during April 99. Under this program students will work in the laboratories of TUE and CUSAT during alternate years for a total period of four years. It is, in effect a golden opportunity for these young researchers to get exposed to the latest technology in the field of photonics.

Prof. V M Nandakumaran and Prof. C P Girijavallabhan will be visiting TUE during April and July 1999 under the academic exchange programme in the first year of the MHO programme. Visit of Prof. V P N Nampoori and Dr. P Radhakrishnan are scheduled towards the end of this year. Dr. J Haverkort and Ir. J Van Schijndel already visited ISP during January 1999. Dr. Haverkort delivered a talk on “Quantum Well lasers and Photinic Switching” on January 7th 1999. Prof. Frankena gave a talk on " Interferometry" on 3rd February 1999. Ir. Graafmans gave a talk on "Geron Technology" on 11th February 1999.

It is hoped that collaboration between ISP and the Dutch partner TUE will bear fruitful result in the near future and it will uplift the teaching and research activities of International School of Photonics to a truly international level.

University of Brussels in Belgium collaborates with ISP

The samples of dye doped polymers made by Mr. Nibu A George, research scholar working under the supervision of Dr. P Radhakrishnan, ISP, has been found to be extremely useful to a group of researchers led by Prof. Hugo Thienpont of the Laboratory of Applied Physics and Photonics, Vrije University of Brussels, Belgium. These polymer samples doped with certain organic dyes have been found to be very useful for fabricating micro lenses, amplifying wave guides, and other such active components in an optical integrated circuit. The Belgium group has expressed their keenness for joint research activities in this area of research.

Joint project with Nanyang Technical University in singapore

The fiber optics group in ISP has established strong academic links with Nanyang Technical University in Singapore. Prof. Anand Asundi, the Director of the Center for Sensor Activators in Nanyang Technical University has expressed his willingness to promote joint research programme in the area of fiber optic sensors. The group is now trying to device Fiber Optic Sensors (FOS) for the measurement of corrosion in steel.

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Photonics as a novel discipline

Photons are the basic quantum units of light. The subject of Photonics is concerned with the generation, control and utilization of photons for performing a variety of tasks beneficial to the society. This novel discipline of Photonics came into existence as a consequence of the harmonious fusion of optical methods with electronics technology. The invention of lasers in 1960 was a major watershed in the history of science. Lasers for the first time provided intense, monochromatic, highly directional and coherent sources for optical radiation thereby triggering a laser revolution which made major impact on every conceivable branch of human endeavor like science, industry, medicine, communication, defence, entertainment etc. Widespread use of laser-based methods in electronics soon gave rise to Optoelectronics Technology which is now causing a paradigm shift in the vital sectors which are often mentioned as the 3C's viz. Communication, Control and Computing. It is anticipated that replacing the electrons with photons will enhance significantly the speed and efficiency in all the above three areas. All these wide and varied technologies now come under the single umbrella of Photonics which is envisaged as the science and technology for the 21st century. Though essentially multidisciplinary in character, the amount of progress made in this area is so vast that Photonics can now claim itself as a separate subject of study in its own right.

Silver lines-Golden letters

Dr. S S Harilal, former research scholar of ISP, who is currently working in SN College, Cherthala has received Von Humbolt Fellowship to work in the area of laser produced plasma at the University of Bochum in Germany.

Mrs. Bindu Harilal, who is working as a research associate at ISP, is also offered a postdoctoral position of Ruhr University, Bochum, Germany.

Mr. Pramod Gopinath, research scholar of ISP, has been selected to participate in the three week workshop on "Spectroscopy and Applications" at ICTP, Trieste, Italy. He has proceeded to Italy on 1st February, 1999. Previously Dr. Santhosh Chindangail, Research Associate of ISP also went to Trieste on similar assignment.

Dr. A. V. Ravikumar who worked in ISP for his Ph.D. Degree is proceeding to Osaka University in Japan on a Japanese government postdoctoral fellowship. Dr. Ravikumar is currently a scientist at Institute of Plasma Research (IPR) at Gandhigram, Ahamedabad.

International School of Photonics congratulate Mr.Pramod Gopinath, Dr. Hairlal, Dr. Ravikumar and Mrs. Bindu Harilal for their outstanding academic achievements.

Recognitions

1. Professor C P Girijavallabhan, Director of ISP has been elected as the Vice-president of the Indian Laser Association (ILA). ILA is the largest organization of laser scientists, technologists and teachers in this country.

2. The paper entitled *'Time resolved study of CN band emission from plasma generated by laser irradiation of graphite"* by S S Harilal, R C Issac, C V Bindu, P Gopinath, V P N Nampoori and C P G Vallabhan has been ranked among the top 14 papers published in "Spectrochimica Acta" (Elsevier Science, The Netherlands) during 1997.

3. The paper entitled *"Molecular Excitations by Prompt Electron Impact during Laser Beam*

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Editorial

It is with great pleasure that we bring out the first edition of "Photonics News".

The International School of Photonics (ISP) is completing its fourth year of existence on 28th February 1999. Even though the progress in the development of infrastructure of ISP has not been up to our expectation, there has been a perceptible growth in the matter of academic pursuit. The major achievements during the four years of existence of ISP is its academic tie up with Eindhoven Technical University of The Netherlands under the MHO programme. The project has already been initiated and the details of the same are included in this issue.

The current issue of "Photonics News" is the inaugural edition of the news bulletin which is designed to highlight R & D activities of ISP, in the field of Photonics and related areas. Controlling of chaos is a current field of interest which finds application in diverse fields. We bring to you the details of a method to control chaotic lasers discovered by Prof. V M Nandakumaran and his student Thomas Kuruvilla. Other items included in this issue are the details of fiber optic based sugar sensor developed by Dr. P Radhakrishnan and Shelly John M, discovery of energetic photoelectron from laser irradiated silver targets by the ISP group.

Interaction with Silver Target" by Riju C Issac, Promod Gopinath, S S Harilal, Geetha K Varier, Binoy Paul, V P N Nampoori and C P G Vallabhan has won the best paper award in the National Laser Symposium (NLS) heald during Dec. 10 - 12, 1997. The symposium was organized by Physical Research Laboratory, Ahmedabad.

Taming of Chaotic Lasers

The theory group of ISP has developed a scheme to tame chaotic lasers. Details of their work is described in this article.

Transition to chaos through a sequence of period doubling bifurcation has been observed in many non-linear dynamical systems both in numerical simulations and in experiments. Lasers are good candidates for observing these bifurcation experimentally. One of the earliest experimental observations of this period doubling route to chaos was in a CO2 lasers in which the cavity losses was modulated by an electro-optic modulator. Irregular intensity fluctuations in the frequency doubled output of a diode pumped multimode Nd-YAG laser with an intracavity KTP crystal has been investigated for sometime. Since the frequency doubled intensity is in the green region the problem came to be known as the *"green problem "*.

In a recent work (Thomas Kuruvilla and V M Nandakumaran, CHAOS, Vol. 9, No. 1, in press) it was shown that an Nd:YAG laser operating in two orthogonally polarized modes undergoes a sequence of reverse period doubling bifurcation from chaos to stability when the relative orientation between the KTP and the Nd: YAG crystal is varied continuously. In the chaotic regime there is a chaotic exchange of energy between the two modes. As the relative orientation is varied the energy exchange between the two orthogonally polarized modes become periodic. The transition from chaos to periodicity is also established by computing the Lyapunov exponents.

Suppression and control of chaos in dynamical systems has been another area which has generated a lot of research in the last decade. Various methods have been employed to control chaos both numerically and experimentally. Recently Thomas

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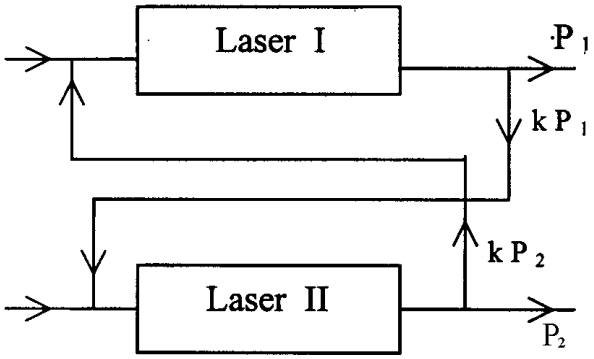
Kuruvilla and V M Nandakumaran (Phys Lett A, in press) have numerically studied a mechanism to suppress chaos in semiconductor lasers with high frequency current modulation. Such semiconductor lasers are known to exhibit chaotic behaviour for certain range of parameter value. In numerical studies, semiconductor lasers are modeled by rate equations for the photon density and carrier density. The current modulation provides the third degree of freedom necessary for the observation of chaos.



Numerical investigations were carried out on two such chaotic lasers by coupling them in such a way that a current proportional to the output power of one laser was electronically fed into the input of the other as shown in figure.
This effectively introduces a coupling between two lasers characterized by a coupling constant K. For small values of **k** both $\mathbf{P_1}$ and $\mathbf{P_2}$ are chaotic. However, as **k** is varied output follow a sequence of period doubling bifurcation and passes through 8, 4, 2 ... cycles to attain a steady $\mathbf{P_I}$ and $\mathbf{P_2}$. Thus with appropriate values of the coupling constant **k**, the chaos in either of the lasers could be suppressed. This is an interesting method to suppress chaos which could be experimentally implemented.

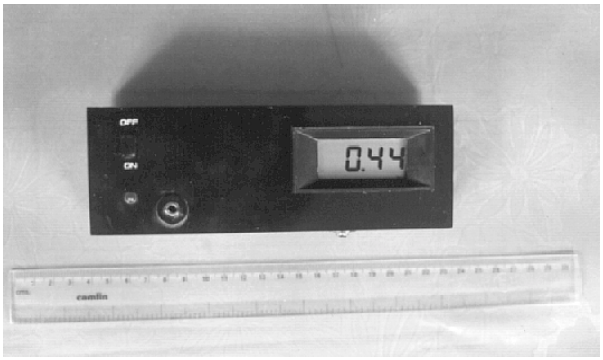
For details contact: Dr. V M Nandakumaran, International School of Photonics, Cochin University Of Science & Technology, Cochin-22.

News From ISP Labs

Optical fiber based urine sugar sensor.

A group of researchers under the leadership of Dr. P. Radhakrishnan has developed a urine sugar sensor using optical fiber. This compact hand-held sensor works based on the principle of evanescent wave generated in an optical fiber. The device perfected by Dr. P Radhakrishnan and his student Mr. Shelly John. M will make the analysis of sugar in urine much simpler. Since the instrument makes use of optical fiber measurement, the analysis can be included under the category of instruments in the new field of tele-medicine.

For details contact: Dr. P Radhakrishnan, International School of Photonics, Cochin University of Science of Technology, Cochin-682022, Tel: 0484 532848, 0484 620811.



Detection of Energetic Photoelectrons from silver target irradiated with pulsed laser

Metals are known to emit electrons when irradiated with light of appropriate frequency. This phenomenon is known as photoelectric effect and Einstein provided a simple explanation for the photoelectric effect in which the photons cause

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ejection of free electrons in the metal. Invariably the energy of such electrons will be lower than that of the photons. However when metal targets are irradiated with high power laser pulses we do find an extremely different kind of photoelectric effect. As soon as the laser pulses are incident on the metal target prompt electron emission does take place; but the energy of such electrons are found to be several times larger than the photon energy. Such energetic electron emission has been measured when silver is irradiated with focused Nd: YAG laser pulses at 1.06 micro meter wavelength. Measurements with electrical probe show that these electrons can have energies as high as 150 eV. This is a clear example where the usual quantum concepts are no longer valid. Classical electromagnetic theory credits strong pondor motive force which when acting on the electron can accelerate them to such high energies. A recent paper published from ISP by Riju C Isac, Pramod Gopinath, Geetha K Varier, C P Girijavallabhan and V P N Nampoori (App. Phy. Lett. Vol.73, pp.163, 1998) describes the characteristics of such electrons emitted by silver target. Other workers in United States have also found relativistic electron emission from targets irradiated with femto second laser pulses. Scientists from ISP have suggested that this is an excellent method for producing ultra short pulses of electrons.

Interdisciplinary Studies.

Mutagenic effect of laser light on plants

The International School of Photonics supports interdisciplinary research. ISP in collaboration with Bio technology department of CUSAT has recently studied the mutagenic effect of laser radiation in faba bean (vicia faba)and onion (Allium cepa). Studies conducted by Dr.Padma Nambisan and her colleagues have revealed stimulatory effect of laser light on growth and yield of faba bean and onion. Laser radiation also causes mutation resulting into aberrations in mitotic cell divisions.

We hear that.....

Complete Quantum Teleportation using NMR

Quantum Teleportation (QT) is an example of information processing capability that is not possible with classical devices. In QT quantum state of a system is transported from one location to another without moving through the intervening space. Although the spatial implementations of QT over macroscopic distances have been achieved using optical systems, the final stage of the teleportation procedure which attains the complete recovery of original stage - was omitted. Prof. Neilson and his group at Log Alamos National Laboratory, USA report on experimental implementation of full QT over inter atomic distances using liquid - state NMR. Quantum state of a carbon molecule was teleported to a hydrogen molecule in a molecule of trichloroethylene by exploiting the material phase de-coherence of carbon molecule. Such a QT scheme may be used as a surfeiting in larger quantum computations or quantum communications, they claim.

An atomic Dimmer switch

Doron Meshulach and Yaron Silberag of Weizmann Institute show how absorption of light by atoms can be controlled using the phase of light incident on them. This new technique of " coherent control" for manipulating the internal quantum dynamics of atoms and molecules employs the coherence properties of light rather than the intensity or colour.

When an atom is subjected to intense laser light, nonlinear absorption takes place using two or more photons. Nonlinear optical effects are sharper when light is compressed into a short, intense pulse.

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The group at Weizmann Institute was able to control light absorption using multiphoton absorption from two arms of an interferometer. By manipulating phases, any particular resonant frequency in the spectrum can be made to vanish, there by reducing the absorption at that frequency to naught

Atomic interferometer and the origin of quantum mechanical complementarity

The principle of complementarily refers to the ability of quantum mechanical entities to behave like particles or waves under different experimental conditions. For example, in the famous double slit experiment, a single electron can apparently pass through both apertures simultaneously, forming an interference pattern. But if 'which way' detector is employed to determine the particles' path, the interference pattern is destroyed. This is usually explained in terms of Heisenberg's uncertainty principle, in which acquisition of spatial information increases the uncertainty in the particle momentum, thus destroying the interference. A group of researchers from University of Kanstanz, Germany have another explanation for the phenomena deduced using the results obtained from their studies using atom interferometer. They found that in an atom interferometer, the "back action" of the path detection on atoms' momentum is too small to explain the disappearance of the interference pattern. They attributed it, instead, to correlation between the "which - way detector " and the motion.

Conference News

National Seminar on High Power Lasers and Their Applications Feb 27-28.

For details, contact Dr. P Radhakrishnan, International School of Photonics, Cochin University of Science & Technology, Cochin-682022.

Some of the recent Publications from ISP

1. An optical fiber based evanescent wave sensor to monitor the deposition rate of thin films, Deepa Jose, M Shelly John, P Radhakrishnan , V P N Nampoori and C P G Vallabhan, Thin Solid Filims (325) 1998.

2. A force sensor using polarization maintaining fiber, M Shelly John, S Bindu, P Radhakrishnan, V P N Nampoori and C P G Vallabhan, Comm Instr. January -- March 6 (1998)

3. A fiber optic sensor to measure glucose concentration, M Shelly John, P Radhakrishnan, V P N Nampoori and C P G Vallabhan Comm. in Instr. vol.6, No.1 April - June(1998)

4. Influence of ambient gas on the temperature and density of laser produced carbon plasma, S S Harilal, C V Bindu, V .P N Nampoori and C P G Vallabhan, Appl. Phys. Lett. 72 167 (1998).

5. Time evolution of electron density and temperature of laser produced plasmas from $YBa_2Cu_3O_7$, S S Harilal, C V Bindu, V P N Nampoori and C P G Vallabhan, Appl.Phys. B 66 633 (1998)

6. Electron density and temperature measurements of laser induced $YBa_2Cu_3O_7$ plasma, S S Harilal, C V Bindu, V P N Nampoori and C P G Vallabhan, Applied Spectroscopy (in press) 1998.

7. Dynamics of laser produced silver plasma under film deposition conditions studied using optical emission spectroscopy , Riju C Issac, K Vasudevan Pillai, S S Harilal, Geetha K Varier, C V Bindu, Pramod Gopinath, P Radhakrishnan, V P N Nampoori and C P G Vallabhan, Appl. Surf. Sci. 125, 227 (1998)

8. Twin peak distribution of electron emission profile and impact ionization of ambient molecule during laser ablation of silver target,, Riju C Issac, Pramod Gopinath, Geetha K Varier, V P N Nampoori, C P G Vallabhan, Appl. Phys. Lett. 73 (1998) 163.

9. Collective diffusion of laser produced plasma from the multi component $YBa_2Cu_3O_7$ target in air, Riju C Issac, Geetha K Varier, S S Harilal, V P N Nampoori, C P G Vallabhan, Appl. Phys B, (in press) 1998.

10. Prompt electron emission and collisional ionization of ambient gas during laser ablation of silver target, Riju C Issac, Geetha K Varier, Pramod Gopinath, S S Harilal, V P N Nampoori, C P G Vallabhan, Appl. Phys. A, (in press) 1998.

11. Ionic temporal profile from laser produced silver plasma at the plasma ambient boundary in low pressure nitrogen gas, Riju C Issac, Geetha K Varier, Pramod Gopinath, V P N Nampoori, C P G Vallabhan, J. Appl. Phys (in press)

!2. Studies of nonlinear absorption and aggregation in aqueous solution Rhodamine 6G using a transient thermal lens technique, C V Bindu, S S Harilal, V P N Nampoori, C P G Vallabhan, J. Appl. Phys. 32 (1999) 1-5

13. A fiber optic evanescent wave sensor for monitoring the rate of pulsed laser deposition of metal thin films, M Shelly John, P Radhakrishnan, V P N Nampoori and C P G Vallabhan, Meas. Sci. Technol. 10 (1999) N17- N20