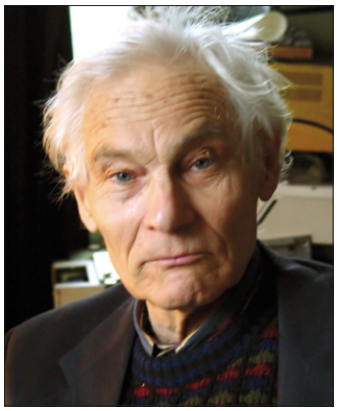
NEWSLETTER

Commission Internationale d'Optique • International Commission for Optics

Russia's first laser: a remembrance

Prof. Alexandr M Leontovich, lead researcher at the P N Lebedev Institute of Physics of the Russian Academy of Sciences in Moscow, shares his memories.



Alexandr M Leontovich, pioneer of laser development in Russia.

The first devices designed to generate electromagnetic radiation by means of stimulated emission – ammonia molecule masers – were made in 1954 by Nikolay Basov and Alexander Prokhorov in the Soviet Union and by the research group led by Charles Townes in the US. With that development the field of quantum electronics began to grow rapidly.

Research into lasers was initiated in the Soviet Union by Basov in 1958, in which year A L Schawlow and Townes, and Basov published papers about the prospects of generating radiation in the optical range using stimulated emission. Following Theodore Maiman's report in April 1960 of a partial ground-state depletion for chromium ions under flash-lamp excitation of ruby, Basov, who could conduct optics experiments in his laboratory only with difficulty, contacted the luminescence laboratory of the Lebedev Institute with a proposal to build a laser using ruby.

Mikhail Galanin, chief of the laboratory, gladly accepted this proposition and he, Zoya Chizhikova and I began working on this problem. Initially we repeated experiments conducted by the Americans on detection of the change in the population of the upper energy level of chromium ions under optical pumping using a pulsed flash-lamp. These results were not published because they were a replication of those obtained by the Americans, and were only included in an internal institutional report. In August 1960 Maiman reported a narrowing of the Cr+ luminescence line in ruby due to induced radiation. The spike generation in ruby and production of the pencil-beam characteristic of a laser was first reported by Schawlow and co-workers in October of 1960.

In spring 1961 we built our own laser (figure 1) with a ruby rod 4 cm long and a chromium concentration of 0.05%. The ruby was pumped by two xenon flash-lamps in a housing covered with MgO.

We achieved stimulated emission on 18 September 1961, one month after Maiman's publication in *Physical Review*. A detailed description of the laser was provided in an internal report of the Lebedev Institute in December 1961.

It should be noted that this was not an easy achievement. In the beginning, considerable effort went into obtaining high-quality ruby samples, which we could not produce in the luminescence laboratory. We obtained them from the Institute of Crystallography of the Academy of Sciences (IKAN) and from a "special purpose institute" that used to supply equipment for maser research and where the rubies were made by Alexandr Bebchuk and Yulia Solovyova. We first received a crystal of high optical quality from the IKAN. It had the required concentration of Cr (0.05%) but it was almost cubical (12 mm long and 10 mm thick) and had a weird yellow color. We could not get it to lase because, as we realized later, the crystal contained enough iron to quench the luminescence emitted by the chrome. IKAN then supplied us with crystals 45 mm long and 3 mm thick, but with very high concentration of chrome (0.5%) and of poor optical quality, which also did not work.

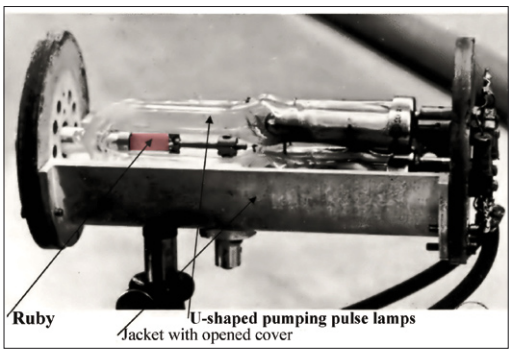
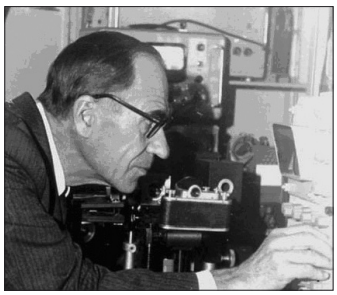


Figure 1. The first Russian laser.

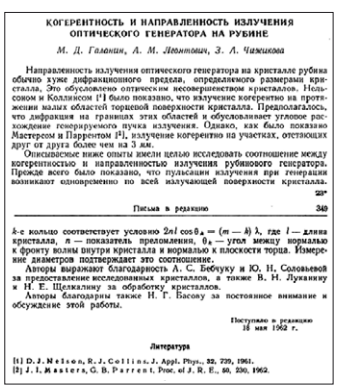
In spring 1961, having had no success with crystals from any of our sources, we left the laboratory for the holidays and gave the crystals received from IKAN to our graduate student, Boris Fedyushin, and to a member of Prokhorov's laboratory, Pavel Pashinin, who continued the experiments. They also failed to get these crystals to lase. When we came back we tackled more seriously the testing of optical quality of rubies (mainly using a Michelson interferometer) and we were able to achieve lasing with crystals received from Bebchuk. At the same time we received an American ruby (through espionage) with which we also achieved stimulated emission. Parameters were approximately the same as in our samples.



M D Galanin.

A M Leontovich.

Z A Chizhikova.



КОГЕРЕНТНОСТЬ И НАПРАВЛЕННОСТЬ ИЗЛУЧЕНИЯ ОПТИЧЕСКОГО ГЕНЕРАТОРА НА РУБИНЕ

М. Д. Галанин, А. М. Леонтович, З. А. Чижикова

Направленность излучения оптического генератора на кристалле рубина обычно хуже дифракционного предела, определяемого размерами кристалла. Это обусловлено оптическим несовершенством кристаллов. Нельсоном и Коллинсом [1] было показано, что излучение когерентно на протяжении малых областей торцевой поверхности кристалла. Предполагалось, что дифракция на границах этих областей и обусловливает угловое расхождение генерируемого пучка излучения. Однако, как было показано Мастерсом и Парренто [2], излучение когерентно на участках, отстоящих друг от друга более чем на 3 мм.

Описываемые ниже опыты имели целью исследовать соотношение между когерентностью и направленностью излучения рубинового генератора. Прежде всего было показано, что пульсации излучения при генерации возникают одновременно по всей излучающей поверхности кристалла. 229*

Письма в редакцию 349

k-е кольцо соответствует условию $2nl\cos\theta_k = (m - k)\lambda$, где l — длина кристалла, n — показатель преломления, θ_k — угол между нормалью к фронту волны внутри кристалла и нормалью к плоскости торца. Измерение диаметров подтверждает это соотношение.

Авторы выражают благодарность Л. С. Бобчуку и Ю. Н. Соловьевой за предоставление исследованных кристаллов, а также В. Н. Лукашину и Н. Е. Щелкалину за обработку кристаллов.

Авторы благодарны также Н. Г. Басову за постоянное внимание и обсуждение этой работы.

Поступило в редакцию 16 мая 1962 г.

Литература

[1] D. J. Nelson, R. J. Collins, J. Appl. Phys., 32, 739, 1961.
[2] J. I. Masters, G. B. Parrent, Proc. of J. R. E., 50, 230, 1962.

The first and last pages of the first paper published about lasers in the Soviet Union.

After studying the coherence properties of our laser, the three of us (see left) published, in the *Journal of Experimental and Theoretical Physics*, the first paper published in the Soviet Union about an experiment with a laser.

Extending this work we also published a short report in the journal *Optics and Spectroscopy* about pulsations in ruby laser emission. In this and a subsequent report presented at the Third International Quantum Electronics Conference, held in Paris in February 1963, we demonstrated that the pulsations and the coherence of the radiation are related (oscillograms of chaotic pulsations are presented in figure 2).

We also took "mode pictures", or cross-sectional distributions of the radiation intensity for one type of oscillations generated – a mode in each separate spike, as illustrated in figure 3. The mode structure agreed with theoretical calculations for a resonator with spherical mirrors. This "sphericalness" arose from both optical impurities of the ruby samples and thermo-optical distortions caused by the pumping light.

There was some prejudice back then concerning the shape of the samples: all early rubies had parallelepiped shape, both American and ours. This was probably a legacy from the maser era. It became clear afterwards that the critical issue was not the resonator's shape but rather the parallelism of the crystal's faces, which at that time were coated with silver amalgam. Later came rods of cylindrical shape and also, when external mirrors came into practice, rods with Brewster faces.

Further research was dedicated to studying the modes of a gigantic laser pulse. Young researchers and graduate students participated in this work, not only from our laboratory but from other laboratories as well: M N Popova, A N Veduta, V V Korobkin, M Ya Shchelev, N K Belsky, A M Mozharovsky and others. On the basis of the results of all of this work, they successfully defended their doctoral theses. Also, with our help, V S Zuev, a co-worker of Basov's, along with young researcher P G Kryukov, familiarized themselves with laser techniques and then, together with Basov, published their findings on the Q-switching laser.

Our work generated considerable interest, not only at the Lebedev Institute but among physicists in other institutions in the Soviet Union who came to us to consult and to share experience. I E Tamm came from Lebedev to see first-hand the working laser, as did the director of the institute, D V Skobeltzin, and others. There were high-ranking guests too: the chair of the department of science of the CPSU Central Committee, academician V A Kirillin, and the leaders of the Academy of Sciences. Once Basov brought in to us D F Ustinov who at that time, though not yet minister of defense, was a chairman of the committee for military equipment and a vice-chair of the Council of Ministers of the USSR. Using our laser we burned holes in razor blades for him. It seems that Basov tried to convince Ustinov to start building an anti-missile laser. As I recently learned from an article by P V Zarubin (*Quantum Electronics* **32** 1048–1064), Basov succeeded in his objective and this gigantic but in my opinion useless and very expensive device was built in the vicinity of Balqash lake with 192 replaceable rubies. It was built not as a weapon but rather as an optical radar (which does not work in cloudy weather). It is now rusting in peace.

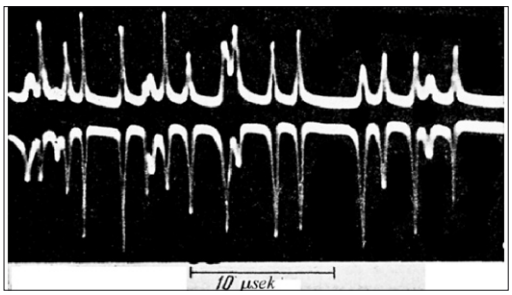


Figure 2. Oscillogram of the emission from two sections of the end face of a ruby laser crystal.

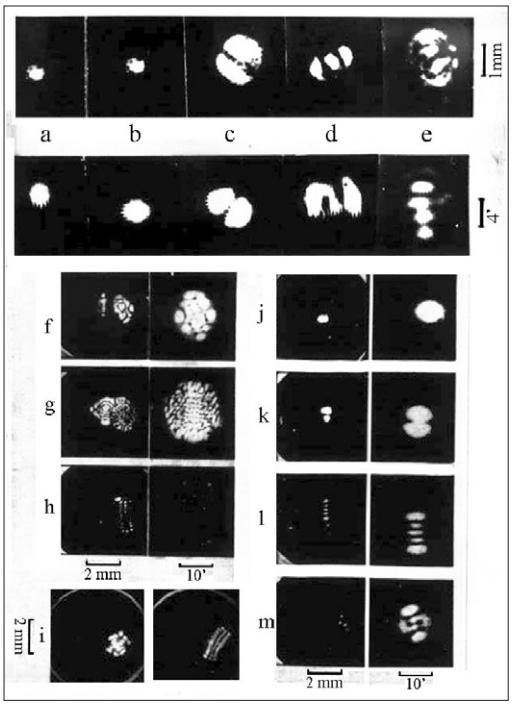


Figure 3. Emission distribution – rod sides and far field.

We studied the chaotic pulsations of the laser output. In the course of this research I created models on a computer and in some of them I came very close to the results that were later obtained by the mathematician Lorenz who discovered (also by computational means) the phenomenon of strange attractors. This was one of the greatest discoveries in mathematics of our time and nowadays it is studied worldwide in many schools of mathematics in connection with the theory of chaos. I learned about this work only later. Analogous results were

achieved at Lebedev in the work of Orayevski, who also studied the theoretical problems of chaotic pulsations.

Interestingly it turned out that chaos in pulsations is not related to the problem of the strange attractor, but is caused by temperature instabilities of thermal and optical- mechanical origin, brought about by the heat from the very same lamp that produces optical pumping.

Alexandr M Leontovich

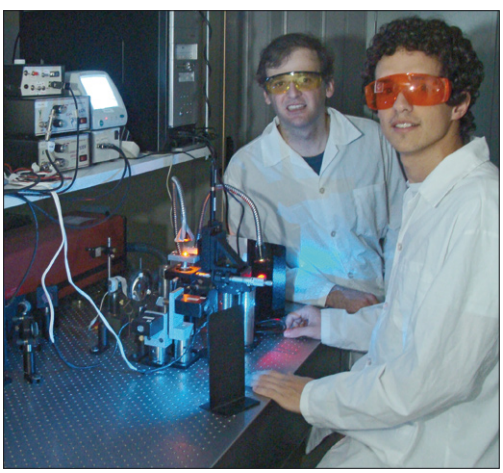
Special thanks to Prof. Konstantin Vodopyanov, Stanford University, for initiating contact with Prof. Leontovich.

Mendonça wins Gallieno Denardo Award

Brazilian scientist is rewarded for his work in nonlinear optics and interdisciplinary collaborations.

The ICO/ICTP Gallieno Denardo prize is awarded to scientists under 40 years of age who conduct and promote research activities on optics in a developing country. Members of the Award Committee are Ahmadou Wague (chair), Joe Niemela, Anna Consortini and Mitcho Danailov.

This year the prize was awarded to Dr Cleber Mendonça of Brazil "for the development of novel methods and procedures of nonlinear optics, in particular the use of femtosecond pulses and femtosecond laser micro-fabrication in polymers for investigating nonlinear optical properties of organic compounds, and for establishing effective interdisciplinary collaborations within Brazil". The award ceremony took place at ICTP during the Winter College on Optics and Energy.



Cleber Mendonça (behind) with one of his students.

Dr Mendonça received his PhD in physics in 2000 from the University of Sao Paulo, Brazil, studying saturable and reverse saturable absorption in organic materials. Upon completing his doctorate he spent seven months working on two-photon absorption in organic materials as a postdoc at the College of Optics and Photonics (CREOL) in Florida. In July 2001 he was hired as a faculty member at the University of São Paulo (Institute of Physics of Sao Carlos) to start research into the nonlinear optical processes of organic compounds with femtosecond lasers. After two years he co-founded the Photonics Group at the University of Sao Paulo, which was created with the purpose of focusing on research projects related to photonics and applied optics. In August 2005 Mendonça joined Dr Eric Mazur's group at Harvard University as a visiting scientist, where he stayed for almost three years, working with femtosecond laser micromachining and ultrafast dynamics in solids.

For the last several years Mendonça's research interest has focused on understanding the relationship between the molecular structure of organic compounds and their nonlinear optical properties induced by ultrashort pulse excitation in particular, seeking to develop a fundamental understanding of how to control the light-matter interaction. He has been conducting pioneering work in Latin America in this field. Such knowledge provides information for the design and synthesis of molecules and materials with enhanced characteristics for applications in optics, photonics, and materials processing.

A major focus of Mendonça's research involves nonlinear optical processes and ultrashort pulses, mainly multi-photon absorption wherein a molecule absorbs two or more photons simultaneously. The nonlinear dependence of these processes on the laser intensity allows their use in the activation of photo-chemical or photo-physical processes with high spatial resolution in 3D. His research in this direction includes the investigation of structure-property relationships for multi-photon absorption in conjugated molecules and polymers with the aim of learning how to design efficient multi-photon absorbers, with implications in photonic devices. These studies involve measurements of the multi-photon absorption spectra on molecules with systematically varied structures, quantum chemistry calculations and theoretical modeling.

He has also conducted studies into the coherent control of light-matter interaction in nonlinear processes through the spectral phase manipulation of ultrashort pulses.

Another research interest of Mendonça is two-photon absorption-driven photopolymerization for the 3D microfabrication of complex microstructures. Using femtosecond pulses, his group has fabricated 3D microstructures with interesting properties aiming at integrated optical devices, as well as biomedical applications.

Besides his scientific achievements, Mendonça has also been involved in outreach programmes through seminars, demonstrations and special lectures prepared to show science and to complement school science education.

Mendonça stimulated the establishment of the Optical Society of America student chapter at the Institute of Physics of Sao Carlos, serving as the adviser of the chapter since its creation in 2005. The student chapter has promoted special seminars and schools in optics and photonics for undergraduate and graduate students. The chapter also created an outreach programme in which chapter members give lectures, special presentations and demonstrations of physics to students of public schools in poor neighborhoods in the city of Sao Carlos.

New ICTP director welcomes TSOSA committee

Members of the TSOSA advisory committee met Prof. Fernando Quevedo, new director of ICTP, during the Winter College on Optics and Energy.

More than a decade ago, when optics activities were expanding from the Abdus Salam International Centre for Theoretical Physics (ICTP) to Elettra, Gallieno Denardo created the Trieste System on Optical Sciences and Applications (TSOSA), which includes ICTP, the University of Trieste, Elettra and, more recently, the INFN/ICTP laboratory for quantum cascade lasers. He asked the international community for support in the activities of the system and there has since been enthusiastic participation from all major international organizations and societies.

In 1994 Anna Consortini proposed the creation of the ICO/ICTP award, now called the ICO/ICTP Gallieno Denardo Award to honour his memory, and ICO started offering ICTP advice for the organization of the Winter College on Optics and Energy. Before long, all ICO member societies were sending representatives to the TSOSA committee, which for several years was chaired by former ICO secretary general Pierre Chavel. It is now chaired by current ICO secretary general Angela Guzman.

At this year's Winter College Prof. Quevedo, new director of ICTP, spent several hours with the TSOSA committee, attended the ICO/ICTP Galieno Denardo Award ceremony and had meetings with representatives from the various organizations present, all of which impressed him with their commitment to ICTP's activities. ICO and the international community that it represents welcomes Quevedo's leadership and wishes him great success in continuing the efforts of his distinguished predecessors, particularly in favour of researchers from developing countries.

Participants in the ICTP Winter College on Optics and Energy 2010.

ICO/ICTP Gallieno Denardo Award 2010 ceremony. From left: Elisa de Quevedo, Cleber Mendonça (award winner), Fernando Quevedo (new ICTP director) and Maria L Calvo (ICO president).

Topical meeting boosts optics in Greece

The 2009 ICO Topical Meeting took place in Delphi, the navel of the world for the ancient Greeks and home of Pythia and her oracle.

The ICO Topical Meeting for 2009 – "Emerging Trends and Novel Materials in Photonics" – was held on 7–9 October at the European Cultural Center in Delphi, Greece. It was the first large-scale international optics and photonics conference ever hosted in Greece.

With the magnificent Delphic landscape as a backdrop – the Faidriades rocks and olive tree valley overlooking the Corinthian Gulf – more than 280 registered participants from 28 countries conducted an energetic scientific forum on photonics. The participation of high-calibre scientists, postdocs and students provided strong evidence of success for this newborn topical meeting and of its positive impact on the related photonics and materials research communities. The scientific programme of the conference encouraged fruitful exchange of ideas in areas such as advanced photonic materials, nanocomposites, plas-

Conference delegates in Konstantinos Karamanlis, the amphitheatre at the European cultural centre of Delphi.

Anna Consortini and the 2007 winner of the Galileo Galilei Award, Oleg V Angelsky.

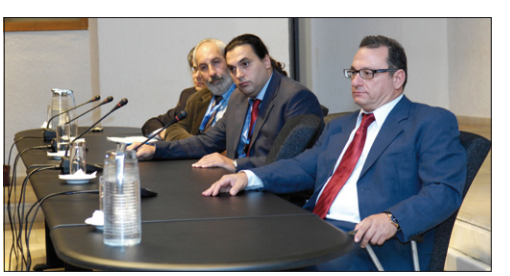
Min Gu, chair of the ICO Prize Committee, gives the 2008 Ernst Abbé medal to Zeev Zalevski.

monics, optical sensing, photonic crystal fibres, metamaterials, and quantum and nonlinear optics in active photonic media.

In one of several special events, the conference hosted the award ceremonies for the 2007 ICO Galileo Galilei Prize, awarded to Oleg V Angelsky, and the 2008 ICO Prize (or the Ernst Abbé medal), awarded to Zeev Zalevsky. The ICO Bureau Meeting was also conducted during the conference, along with an opening presentation on the forthcoming ICO-22 Congress to be held in Puebla, Mexico in 2011.

In the plenary session on the European Research Policy in Photonics, representatives from the EC, the European Science Foundation COST Office, the Photonics21 Technology Platform and the Research Chair in Photonic Network Technology of Canada provided an overview of the field in terms of dynamics, thematic priorities, clustering and market size.

On the last day of the conference the Round Table on Photonics and Nanotechnologies provided discussions of particular interest, exposing new trends and opportunities and providing new grounds for collaboration and interdisciplinary research. In addition, workshops of the COST actions MP0604 and MP0805, and the FP6 ToK NOLIMBA were hosted under the auspices of the main event.



From left: Prof. Emmanuel Paspalakis and conference chairs Stelios Couris, Stavros Pissadakis and Nikolaos Vainos.

The Delphi meeting was warmly welcomed by the local community and supported by the Prefecture of Fokida. A rich social programme included Delphi archaeological tours, a traditionally celebrated gala, sightseeing and a reception hosted by the municipality of the town of Amfissa.

The conference proceedings will be published by the American Institute of Physics, while special issues of international photonics journals are scheduled for publication. The conference website www.ico-photonics-delphi2009.org provides access to rich photographic and video archives and to the latest information about relevant actions.

Thai calendar celebrates the laser

The National Electronics and Computer Technology Center of Thailand received an award from the Public Relations Society of Thailand for the best calendar for 2010. The calendar's design and content (in Thai) celebrate the 50th anniversary of the laser. More than 4500 hard copies have been distributed to schools, government organizations and the public in general.

A link to the calendar can be found on the ICO website, www.ico-optics.org.

Some of the members of the team that designed the calendar. From left: Ariya Pacharawan, Sarun Sumriddetchkajorn (director of the Photonics Technology Laboratory in Thailand), Kullaprapa Navanugraha (editor) and Jessada Jongsukvarakul.

Contacts

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Forthcoming events with ICO participation

Below is a list of events with ICO participation that are coming up. For further information, see www.ico-optics.org/events.html.

12–16 April
SPIE Photonics Europe
Brussels, Belgium
Contact: Karin Burger, tel +44 2920894749, fax +44 2920894750, e-mail karin@spieeurope.org
http://spie.org/x12290.xml

19–21 April
7th International Conference on Optics-Photonics Design and Fabrication "ODF 10"
Yokohama, Japan
Contact: Tsuyoshi Hayashi, tel +81 78-332-2505, fax +81 78-332-2506, e-mail odf10@pac.ne.jp
www.odf.jp

20–24 September
RIAO/OPTILAS 2010: VII Ibero-American Conference on Optics (RIAO) & X Latin-American Meeting on Optics and Applications (OPTILAS)
Lima, Peru
Contact: Guillermo Baldwin Olguín, tel 511-6262000, fax 511-6262085, e-mail gbaldwin@pucp.edu.pe
www.pucp.edu.pe/conferencia/riao-optilas

28–30 September
OWLS 11
Quebec City, Canada
Contact: Brian Wilson, tel +1 416 946 2952, fax +1 416 946 6529, e-mail wilson@uhnres.utoronto.ca
www.biophotonicsworld.org/events/79-optics-within-life-sciences-owls-11

17–21 October
Transparent Conductive Materials (TCM2010)
Crete, Greece
Contact: George Kiriakidis, tel +30 2810391271, fax +30 2810391306, e-mail kiriakid@iesl.forth.gr
www.tcm2010.org

26–29 October
ICO/EOS Topical Meeting on Optics and Energy (TOM7) & Annual Meeting of the European Optical Society (EOS AM 2010)
Paris, France
Contact: Silke Kramprich, tel +49 511-2788-117, e-mail kramprich@myeos.org
www.myeos.org/eosam2010

11–15 December
Photonics 2010, International Conference on Fiber Optics and Photonics
India
Contact: Sunil Khijwania; tel 91-361-2582716; fax 91-361-2582749, e-mail skhijwania09@gmail.com
www.iitg.ernet.in/photonics2010

8–10 July 2011
Education and Training in Optics and Photonics (ETOP)
Tunis, Tunisia
Contact: Zohra Ben Lakhdar, tel 00216 1 872600, fax 00216 1 885073, e-mail zohra.lakhdar@fst.rnu.tn

15–19 August 2011
International Commission for Optics Congress (ICO-22)
Puebla, Mexico
Contact: Fernando Mendoza Santoyo, tel +52 477 44142, fax +52 477 441-4208, e-mail fmendoza@cio.mx
www.cio.mx/ICO2011/1.htm

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