Optics and Photonics in Uruguay

Cristina Masoller

In spite of its small size and developing economy, Uruguay has produced several high quality optics and photonics research groups over the past decade.

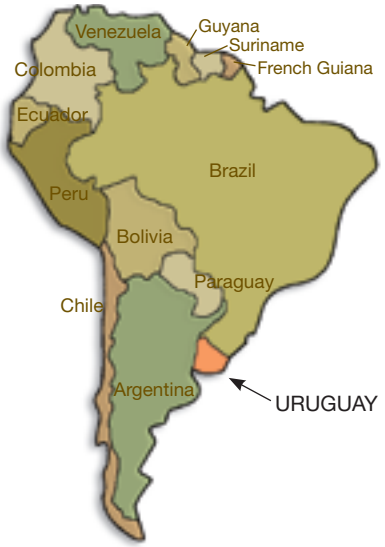
Avenida 18 de Julio in Montevideo.

Uruguay is a small South American country that is home to more than 3 million people. It is located on the coast of the Atlantic Ocean, between Argentina and Brazil. More than half the population lives in Montevideo, the nation's capital.

In the 1970s, the country was in the grip of a dictatorial government that repressed all forms of cultural expression. Scientific research was almost nonexistent. A democratic government took over in 1985 and, in the early 1990s, instituted the Program for the Development of Basic Sciences, which financially supported the repatriation of more than 70 Uruguayan scientists, and implemented M.Sc. and Ph.D. programs in basic sciences.

Nowadays, research in optics and photonics is conducted in the Faculty of Engineering and the Faculty of Sciences at the University of Uruguay in Montevideo. Although the government makes efforts to promote technology transfer, the local optics industry is still scarce, with a few small companies manufacturing equipment for opticians.

The Applied Optics Group of the Faculty of Engineering, directed by Prof. Jose A. Ferrari, works on the development of optical sensors for measuring angles, vibrations, electric currents, voltages and other physical magnitudes. They also perform polarization measurements, polarization interferometry and Berry's topological phases. Their experiments have allowed the direct observation of Berry's topological phase in optical fibers, and contributed to applications such as a polarization-based tunable interferometric filter.



Erna M. Frins—a member of the team—has developed a method for measuring atmospheric contaminating gas traces by using passive multi-axis-differential absorption optical spectroscopy (MAX-DOAS). The system analyzes solar light by pointing the receiving telescope of the spectrometer to non-reflecting surfaces or to "bright" targets placed at known distances from the measuring device, which are illuminated by sunlight.

The partial absorption of gas traces can be subtracted from the measured total absorption, thus allowing the calculation of average concentrations of gas traces such as NO_2, HCHO, SO_2, H_2O, glyoxal, BrO, etc. With tomography arrangements, two or three gas traces can be measured simultaneously. The system is compact, easily transportable (making it simple to measure the air contamination in different points of a city, for example) and economical because it avoids the use of expensive lamps or lasers.

The Laser Spectroscopy Group also resides in the Faculty of Engineering. Directed by Prof. Arturo Lezama, this group performs experimental and theoretical research on laser-atom interaction, with an emphasis on the spectroscopic manifestations of quantum coherence.

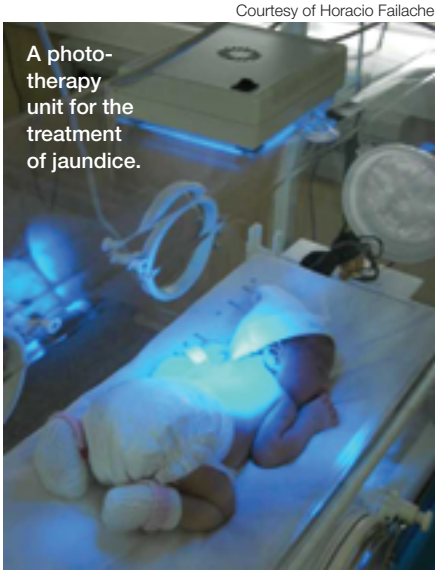
They have observed the phenomenon of electromagnetically induced absorption. In a two-level atomic transition possessing higher degeneracy in the upper level, the Raman resonance condition of the pump and probe fields with the ground-state Zeeman sublevels results in a nonlinear resonant increase in atomic absorption. The group characterized this increase and explored related effects such as slow and fast light propagation, transient evolution of dark and bright resonances, light storage and coherence-resonance spectroscopy of thin cells.

Because of budget restrictions, the group had to fabricate their own sources. They did this using a commercial diode laser coupled to an external cavity. (Spectroscopy experiments require coherent, tunable and very stable light sources, which are expensive.)

Team member Horacio Failache has developed a phototherapy unit for treating jaundice (a yellowing of the skin caused by excess bilirubin in the blood) using LEDs, providing unprecedented therapeutic light intensities. In his approach, the irradiated area of the skin is homogeneously illuminated, creating well-defined borders where the illumination falls sharply to dark. In this way, no light is wasted by over-illuminating some points or over the borders. Moreover, for a given irradiation intensity, this source uses the minimum number of LEDs, optimizing the efficiency and making the treatment unit more compact.

In the Faculty of Science, I have done theoretical research on nonlinear dynamics of semiconductor lasers. I am particularly interested in time-delayed feedback-induced instabilities, optical chaos, synchronization and stochastic phenomena. I did numerical work characterizing the regime of anticipated synchronization in unidirectionally coupled master-slave external-cavity lasers. I found that, under appropriate conditions, the slave laser can anticipate the chaotic output of the master laser.

Courtesy of Horacio Failache



A photo-therapy unit for the treatment of jaundice.

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I have also studied stochastic mode-hopping in external-cavity diode lasers, and stochastic polarization-switching of vertical-cavity surface-emitting lasers (VCSELs), both under the influence of delayed feedback. My work has attracted the attention of research groups in the United States and Europe, which have performed experiments to test and verify the model predictions.

Scientists in Uruguay have found ways to overcome the country's economic limitations and produce internationally recognized work that is published in leading journals, although it remains difficult for them to attend conferences in the United States, Europe and the East due to the high cost of travel and registration fees.

The government has taken steps to bolster scientific and humanistic research in Uruguay through a program called "Fondo Nacional de Investigadores" (FNI), which is aimed at developing and sustaining the local community of scientists. Although the program needs more funding, it is an important effort that is helping to prevent the emigration of young Uruguayan scientists.

To conclude, I would like to mention the second "Rio de la Plata" Workshop on Noise, Chaos and Complexity, which received support from OSA and other funding agencies. The workshop was held last December at the Radisson Hotel in Colonia del Sacramento, a charming town founded by the Portuguese in 1680 and declared a World Heritage City by UNESCO; it is located on the north bank of the Rio de la Plata estuary, downriver from Buenos Aires, and upriver from Montevideo.

The meeting drew about 50 participants from Argentina, Australia, Belgium, Brazil, Chile, Colombia, France, Germany, Ireland, Italy, Japan, Mexico, Spain, the United States, the United Kingdom and Uruguay. The purpose of the workshop was to discuss recent developments in nonlinear phenomena in lasers and optics with the local and international communities.

The workshop fostered the exchange of ideas and information in a relaxed environment and contributed to the development of new scientific collaborations. Among the topics covered at the meeting were spatial solitons, localized structures, pattern formation and nonlinear dynamics of optical devices. The science was at a very high level, with intense and stimulating discussions. The third workshop, which continues this series of meetings, will take place in Uruguay in December 2007.

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