1994 EGAS

Steady Progress and New Developments

The variety of topics presented at the 26th annual conference of the European Group for Atomic Spectroscopy (EGAS) demonstrated once again the great vitality of the field, which combines continuous progress on let us say classical problems with the development of new, exciting subjects. A field of intense activity involves **special atomic entities** such as negative ions, highly ionized atoms (or multi-charged ions), unstable or exotic atoms ($^{150}Eu^{+}$, muonium), and atoms or ions in superfluid helium. Two invited talks covered topics in these areas, with C. Blondel (Laboratoire Aimé-Cotton, Orsay) describing spectroscopic methods which are applied to negative ions as well as the measurements that can be made following the interaction of the ions with light. He also considered multiphoton absorption and detachment phenomena in these species. G. Huber (Mainz), in reporting on work carried out at a heavy-ion storage ring, discussed topics related to the cooling of ions and laser spectroscopy as well as the first results on the 1s hyperfine splitting of the "hydrogen-like bismuth" ($^{209}_{83}Bi^{82}_{4}$) ion which are relevant for testing QED and understanding nuclear magnetization. High-order QED corrections for multicharged ions are in fact being studied by several groups.

Concerning **coherent and non-linear atomic phenomena**: Rydberg states of atoms (*i.e.*, bound states near the ionization threshold) as well as auto-ionizing states (*i.e.*, "bound" states above the ionization threshold) of atoms, negative ions and molecules attracted much interest. H.B. van Linden van den Heuvell and co-workers (Amsterdam) reported a novel technique for studying wave-packet dynamics based on excitation using two identical ultrashort laser pulses for which the relative phase difference is modulated. These wave-packets are formed by the coherent excitation of several non-degenerate Rydberg eigenstates, and there is an increasing interest in their dynamic behaviour and its relation to classical mechanics (the eigenstates' time evolution mimics the motion of a classical particle).

Several presentations were devoted to the study of **single- and multi-photon processes** resulting from the interaction of intense light with atoms. The availability today of high-intensity lasers, such as the table-top terawatt (T^3) — "big table-top" — laser, makes it possible to generate picosecond pulses with field strengths up to 100 times stronger than the field experienced by the electron of the hydrogen atom in the first Bohr orbit. When atoms are irradiated with these intense pulses, new interesting phenomena appear, such as multi-photon ionization, tunnelling ionization, barrier suppression, above threshold ionization (ATI), and high harmonic generation. J.-P. Connerade and co-workers (Imperial College, London) reviewed several aspects related to some of these phenomena, particularly questions concerning the extent to which these phenomena may reveal new characteristics specific to the atom under study (*e.g.*, are the atomic features swamped by the effects of the strong field?). Present controversies

LIDAR Measurements of Volcanic Fluxes

LIDAR, an acronym for light detection and ranging — the optical counterpart to radar — is sometimes referred to as laser radar. Differential absorption LIDAR techniques have been developed to the point that they can be used to make range-resolved measurements of atmospheric pollutants, such as the flux of SO_2 above active volcanoes (an important issue for monitoring volcanic activity and environmental effects). This remote sensing technique can be considered to be an applied version of time-resolved laser spectroscopy, which in basic atomic physics is used for measurements of excited state lifetimes or level splittings employing quantum-beat phenomenon. The delayed detection of photons in laser radar is due to the passage of the photons through the atmosphere before being scattered back to a receiving telescope, rather than the delay in an excited state with a finite lifetime. It was this close resemblance between the techniques which constituted the starting point when laser radar research was taken up at Lund by our basic atomic physics group about 20 years ago.

Using an advanced mobile system aboard the Italian research vessel Urania, the Swedish group, together with Italian partners (CNR-Biofiscia, Pisa, and CNR-Geocronologia, Pisa) recently measured the total flux of sulphur dioxide from the Italian volcanoes Etna, Stromboli and Vulcano [Edner H. *et al., J. Geophys. Res.* **99** (1994) 18827]. The transmitter was a frequency-doubled dye laser, pumped by a Nd:YAG laser, firing 10 mJ pulses vertically as the ship made traverses under the volcanic plumes. Every second laser pulse was tuned to the SO_2 absorption line at 299.3 nm, while the intermediate pulses were fired at a nearby non-absorbed reference wavelength (300.0 nm). A 400 mm in diameter telescope received the on- and off-resonance LIDAR return signals, which are mainly caused by elastic Mie scattering off atmospheric aerosols, and averaging of the two kinds of transients was performed in separate computer memories. Finally, the range-resolved signals were divided for each range interval, thus revealing differential intensity effects due to SO_2. Influences owing to non-uniform distributions of aerosol particles were then also eliminated.

Data from a September 1992 passage under the Etna plume are shown in the figure. It can be seen how the plume, emitted from the crater at an elevation of about 3300 m and at a distance of about 23 km, has spread horizontally over the Straight of Messina. By multiplying the concentration data given in the figure by the wind velocity it is possible to obtain the total flux; in this case about 50 tonnes/hour. Corresponding numbers for Stromboli and Vulcano were found to be 6 and 1 tonnes/hour, respectively. Simultaneous measurements by the so-called DOAS (differential optical absorption spectroscopy) technique using the blue sky as a passive light source were also performed. Only the path-averaged value is obtained in this case, and a correction must be applied since part of the light is scattered inside and below the plume rather than above the plume. The LIDAR measurements allow a calibration of the data obtained with the simpler DOAS technique.

A new measurement campaign of the same kind was made in September 1994 on Mount Etna, but this time also involving scientists from the Volcanological Institute in Catania. The Catania group used simultaneously a correlation spectrometer (a so-called COSPEC instrument), which like DOAS analyzes the spectral content of the sky's radiation. Measurements of this kind will allow an absolute calibration of correlation spectrometric measurements that have being performed at many volcanoes for a number of years.

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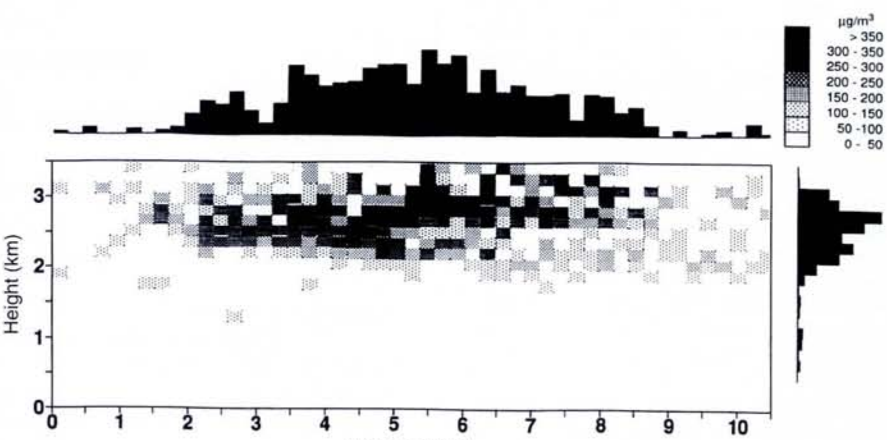

An example of the SO_2 distribution over a vertical section through the plume from Mount Etna on 5 September 1992 as it spread across the Straight of Messina. The data were obtained using range-resolved LIDAR measurements from aboard a ship as it passed underneath the plume. Integration of the data leads to the flux of SO_2 from the volcano — Europe's largest and most studied.

about these issues were also reviewed. L. Roso (Salamanca) reported in detail theoretical progress on understanding an unusual phenomenon that has been observed recently, namely the suppression of ionization at high frequencies and intensities (it can be related either to an adiabatic stabilization of the atoms or to an interference between Rydberg states).

Recent progress in the wonderful new field of **atom optics and interferometry** was attractively presented by A. Aspect (Université de Paris-Sud) in an invited talk. The amazing degree of control of the atomic centre-of-mass motion which can be achieved allows one to carry out with atoms the same kinds of experiments that can be performed with photons, thereby illustrating very dramatically the concept of wave-particle duality.

Several presentations dealt with **high-resolution spectroscopy**, where the powerful technique of Doppler-free laser spectroscopy based on two-photon absorption, saturated absorption, or atomic beam techniques are being used to extract valuable information from atoms. In his invited talk, F.S. Pavone (European Laboratory for Nonlinear Spectroscopy — LENS, Florence) described experiments on high-precision frequency measurements of the 2^3S-3^3P transition at 389 nm of He, from which the 2^3S Lamb shift has been extracted with an accuracy that is more than two orders of magnitude greater than the current best theoretical predictions. The results represent a new test of quantum electrodynamics and have allowed the determination of the charge nuclear radius of ^{3}He in a regime of low energy and momentum transfer. Phenomena such as optical rotation (parity nonconserving rotation) in heavy atoms have been detected. The use of ion and atom traps and new laser sources such as the Ti-sapphire ring laser and the narrow-band semiconductor lasers are stimulating investigation of possible new frequency standards in the optical region.

A totally different subject, but nonetheless strongly linked to atomic spectroscopy, is the **Opacity Project** presented by C.J. Zeippen (Observatoire de Paris, Meudon). It involves workers in five countries, and has the same objectives as a similar undertaking called OPAL which is based at the Lawrence Livermore National Laboratory in the US. Using different strategies, both groups are computing accurate opacities for stellar envelopes (*i.e.*, those regions of stellar interiors in which atoms exist and are not excessively perturbed by the plasma environment). Opacity in this context is the resistance of the medium to the transport of radiative energy, and can be influenced by bound-bound and bound-free transitions in atoms and ions. Accurate calculations should be able to resolve the long-standing discrepancies between the Cepheid (pulsating stars) masses predicted using stellar evolution and stellar pulsation theories.

Applications of atomic spectroscopy are becoming increasingly important at EGAS conferences. A symposium on *Spectroscopy for Environmental Analysis* was held at this year's event. Different techniques combining appropriate laser sources with sensitive detection systems and, in some cases, with other techniques such as mass spectrometry, are now being used to monitor, with very high sensitivity, trace concentrations of polluants in the atmosphere, hydrosphere and vegetation [see insert by S. Svanberg, Lund Institute of Technology], to detect explosives and chemical warfare agents (K.W.D. Ledingham, Glasgow) and radiotoxic isotopes (K.D.A. Wendt, Mainz), and to control combustion emissions (U. Boesl, TU Munich). These last three contributors use the ultra-sensitive detection technique known as resonance-enhanced multiphoton ionization spectroscopy (REMPI). P. Cancio and F.S. Pavone (LENS, Florence) showed how recent improvements in diode laser technology make this simple device very useful for the spectroscopic characterization of molecular species such as acetylene and methane. J. Henningen (Danish Institute of Fundamental Metrology) and A. Olafsson (University of Iceland) reviewed the various techniques that are available techniques for use in different spectral domains to monitor molecules of environmental interest.

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26th EGAS

Some 215 researchers from 25 different countries attended the 26th European Group for Atomic Spectroscopy annual conference which was held in Barcelona on 12-15 July 1994. As usual, young scientists were strongly encouraged to participate and many of them had the opportunity to present their research work and to discuss it with young colleagues from other countries, as well as with more senior scientists. Financial support from various Spanish institutions and private companies as well as the availability of lecture rooms, restaurants and students' residence at the campus of the Universitat Autoñoma de Barcelona, allowed the cost for participants to be kept reasonably low. Moreover, 65 grants were awarded to participants from east and central Europe.

EGAS 1995 in 1996

27th EGAS: forms part of ECAMP-5 *(5th European Conference on Atomic and Molecular Physics)*: 3-7 April 1995; Edinburgh, Scotland. Sec.: N.J Mason, Physics and Astronomy Dept., Univ. College, Gower St., London WC1E 6BT, UK [tel.: +44-71-380 77 97; fax: +41-71-380 71 45; ucaps7n @ ucl.ac.uk]

28th EGAS: Graz, Austria; July 1996. Organizer: L. Windholz, Institut für Experimentalphysik, TU Graz, Petersgasse 16, A-8010 Graz [tel.: +43-316-873 81 41; fax: +43-316-81 26 58; windholz @ fexphds01.tu-graz.ac.at]