IX-Summer School on Quantum Optics

The Summer School on Quantum Optics, the last of which was organized by J. Held, J. Czub and M. Gil of the University of Gdansk, at Cetniewo, Poland from 1-8 September 1981 has become a traditional event for young physicists from eastern and western European countries to discuss recent developments in their fields and to keep in contact. At Cetniewo, about 80 students and scientists from seven countries met at the well-appointed sports training centre on the Baltic sea. Three main subjects had been chosen and there were presented by lectures at sessions covering respectively experimental and theoretical aspects.

(1) The quantum theory of electromagnetic fields and their interaction with atoms and molecules were highlighted in a series of lectures which included light-induced collisional energy transfer and changes in atomic eigenstates by off-resonant monochromatic light. It was shown, that the emission spectrum of a resonant-excited two level system contains sidebands at the atomic Rabi-frequency of the laser field. Coherence and saturation phenomena in photoionisation and different aspects of optical bistability were also treated.

(2) Recent experimental developments in quantum optics and atomic physics gave special emphasis to the spectroscopy of Rydberg atoms. New results of double resonance experiments on high levels in indium served as an example to demonstrate the remarkably good agreement between theory and experiment. The use of thermionic diodes in experiments on lithium have allowed the determination of ground state isotope shifts, which had not been detected in Rydberg D-states. The possibility of using sensitive Rydberg-spectroscopy for the detection of infrared photons was discussed. Another interesting subject was trapped-ion spectroscopy. Very high precision experiments in different laboratories on hyperfine splittings have successfully demonstrated ion cooling, which was discussed in detail at the school. This session was completed by a lecture about X-ray polarisation in atomic collisions.

(3) The third session covered reactive collisions including the basis and recent results in chemiluminescence, chemical lasers, investigations of collisional energy transfer in vibrationally excited molecules, reactive formation of molecules in collisions and molecular beam scattering from solid surfaces.

Proceedings of the School will be published in *Acta Physica Polonica.*

G. Werth, Mainz

Physics of Intercalation Compounds

The main topic of the International Conference on the Physics of Intercalation Compounds which was organized by L. Pietronero and E. Tosatti and held on 6-10 July, 1981 in Trieste, concerned the Graphite Intercalation Compounds (GICs), although topics on the polyacetylenes were also treated. This is a very young subject, the dawn of rapid development of research being signalled by the first International Conference on Intercalation Compounds of Graphite which was held in La Napoule in 1977.

GICs are synthetic metals in which layers of intercalate (donors or acceptors) alternate with series of graphite layers. They have now been investigated theoretically and experimentally by both physicists and chemists, and it has become appreciated that hundreds of metallic materials can be produced from graphite, simply by intercalating a number of other materials. Moreover, this family of synthetic metals exhibits common exotic features which are remarkbly different from those of ordinary simple metals such as copper, silver and the alkalis. These features are: the existence of staging, i.e. the formation of ordered sequences of host and intercalant layers; high mobilities, an order of magnitude higher than those of ordinary metals; a maximum in the conductivity versus stage (carrier concentration) relationship; a T^2 temperature dependence of resistivity over a wide temperature region; the appearance of extraordinarily large orbital paramagnetism in alkali-metal graphite intercalation compounds; etc.

Many papers were presented at the Conference aimed at clarifying the microscopic origin of staging, the most fundamental feature of GICs which has recently attracted the interest of physicists and chemists. Two types of mechanism, electrostatic and elastic, have been proposed. However, self-consistent band structure calculations on higher stage GICs may go some way to answering the question. These non-empirical calculations based on first principles (including the σ-bands as well as the π-bands) have shown that only a fraction of the electrons transferred from the intercalant layers penetrate the interior graphite layers. Owing to the large screening by the σ-bands, most of the electrons remain in the bounding layers. This trend becomes weaker as the amount of charge decreases.

As a consequence one may conjecture that the mechanism of staging is due to the electrostatic interaction: the charged intercalant induces a significant fluctuation of charge density at the carbon atoms within each graphite layer, especially in the interior graphite layers where the net charge density is almost zero. This charge fluctuation (ripplon) may in turn produce a long-range interaction along the c-axis. On the other hand, experimental results on the pressure-induced staging transition through the coexistence region of mixed stage sequences observed in potassium, rubidium, and caesium GICs, suggest that the mechanism of staging is due to long-range elastic interactions, which may lead to the domain model of Daumas and Herold, for example. The question is thus still open and other techniques such as NMR with ^{13}C and alkali-metal nuclei are being used to investigate the staging mechanisms. In this context, the different Knight shifts for donor and acceptor GICs are worthy of note.

Steady and continuous development in our understanding of electronic properties, lattice vibrations, lattice instability and many other aspects of GIC behaviour could be observed at the Conference, and for the first time, experimental results on the temperature dependence of the thermal conductivity were reported. This technique will also be useful for studying the roles of electrons and phonons and their scattering in GICs.

A new family of GICs discussed were the magnetic GICs, produced by intercalating magnetic atoms or molecules into graphite. These new materials show varying degrees of anisotropy, depending on the staging, and they form an attractive topic for the solid state physicist. New superconducting GICs were also presented, namely C_4KHg, C_4RbHg, C_8KHg, C_8RbHg, $KTl_{1.5}C_4$ and $KTl_{1.5}C_8$. A long-standing question is why the first stage alkali-metal graphite intercalation compounds become superconductors, although neither graphite nor the alkali metals are superconducting themselves. It is now understood that charge transfer from the alkali-metal layers to the graphite layers is an important feature. The electrons of three-dimensional character interact strongly with the electric field of longitudinal polarization waves, a mechanism which is characteristic of intercalation compounds.

A smaller number of reports at the Conference dealt with transition metal dichalcogenides. Particular mention should be made of a new interpretation based on the polarizable ion model for the occurrence of lattice distortions in layered compounds. This idea is very interesting, and it differs from the ordinary charge density wave mechanism. I hope these contrasting mechanisms will stimulate further investigations on the microscopic mechanism of lattice distortions in layered materials.

Polyacetylenes and doped polyacetylenes were also much discussed as they have attracted a great deal of interest in parallel with GICs. There are a number of similarities between graphite intercalation compounds and polyacetylene systems despite the two-dimensional character of GICs and the one-dimensional character of polyacetylene systems. Examples are the nature of the bonding between carbon atoms, the nature of dopant species and the charge transfer between dopant and host.

The above is just a sample of the many interesting topics that were discussed at the Conference. Full Proceedings will however be published shortly with the reference: "Physics of Intercalation Compounds", Eds. L. Pietronero and E. Tosatti, *Springer Series in Solid State Sciences*, vol. 38 (Springer, Berlin, Heidelberg and N.Y.) 1981.

H. Kamimura, Tokyo

Hollow Cathode Laser Research

M. Jánossy, K. Rózsa and L. Csillag, Budapest

(Central Research Institute for Physics)

Research on hollow cathode lasers carried out at the Central Research Institute of Physics in Budapest was a natural continuation of research performed earlier on positive column He-Ne and He-Cd gas lasers.

From the point of view of obtaining laser oscillation, both the negative glow region near the cathode surface and the positive column are interesting. However, if the cathode surface is concave a strong discharge can occur in the hollow of the curved cathode, which offers a good possibility of developing medium power gas lasers operating in the blue-green and ultraviolet region of the spectrum. While this kind of output is usually achieved using noble gas ion lasers, operating in the positive column part of the discharge, the advantage of a hollow cathode discharge (HCD) is that it contains more high energy electrons than are present in the positive column. The "beam-like" component of high energy electrons is very efficient in exciting high lying ionic and metastable energy levels, sufficiently populated to give the population inversion necessary for laser oscillation.

Research on hollow cathode lasers began around 1970 with an investigation of a He-Cd hollow cathode laser which consisted of a slotted hollow cathode 50 cm long and 4 mm inner diameter mounted over 21 anode pins. Cd was evaporated from two side-arms set between the anodes. Laser oscillation was obtained on visible transitions of the Cd ion (4416 Å blue, 5378 Å green 6360 Å red) but it was noticed that the Cd vapour distribution was not homogeneous along the tube, so that above a certain discharge current, the negative glow discharge contracted into an arc. Evidently the arrangement of many anode pins was not too effective in producing a stable discharge and moreover, the mW output power of the laser was rather low. Research therefore concentrated on two main problems:

1. Construction of a tube with good discharge stability;
2. Producing an appropriate metal vapour discharge.

Investigations on the structure of hollow cathode lasers were pursued in the light of a discovery made during measurements on a laser tube with a copper hollow cathode of small (1.65 mm) inner diameter (Fig. 1). Laser operation was being investigated in a He-Ne mixture at the well-known 6328 Å transition using for excitation 50 Hz half wave rectified a.c. when suddenly a strong laser signal appeared in the high current region as the laser mirrors were being adjusted. This was clearly in the infrared region as only the weak red light of the 6328 Å transition could be seen visually. Determination of the wavelength of the oscillation gave the unexpected value of