In this issue

Green pesticides

The use of synthetic chemicals in crop protection has been widespread for the last five decades. DDT introduced in the 1940s was the forerunner of many synthetic pesticides which have proved crucial in controlling pests, which are estimated to destroy a very significant fraction of the world's yearly harvest every year. Unfortunately, the bulk of the agrochemicals used as pesticides do not act only on their targets but instead contaminate the environment, leave toxic residues in the soil and in plants and pose a host of ecological problems. To compound the issue, pests very quickly learn to develop resistance to the pesticides, forcing the development of new chemicals in an unending cycle. The phenomenon here is not too different from the problem of drug resistance in human pathogens, a problem of serious concern in biomedical research.

A popular alternative has been to hunt for 'natural pesticides', which are expected to be more environment friendly. Varma and Dubey (**page 172**) discuss the possibility that 'botanical and microbial products' will find widespread use in the future. The neem tree has, of course, attracted the greatest attention in recent years, with many promising leads being present in the enormous range of secondary metabolites produced. The authors survey a wide spectrum of natural sources. This area of bioprospecting is based on the thesis clearly stated by the authors: 'Biologicals because of their natural origin are biodegradable and they do not leave toxic residues to contaminate the environment. Several plants have thousands of years of history and the nontoxicity at least on oral level is proved'. The validity of these expectations will of course, be tested by future research. One feature is however clear. Research in the area of natural products and extracts is now being driven by both agricultural and medical imperatives.

P. Balaram

Laser cooling and trapping of atoms

In the last couple of decades, atomic physics has been revolutionized by the development of techniques of using laser light to manipulate atoms and ions. The field of laser cooling and trapping has enabled researchers to cool clouds of atoms to unprecedented low temperatures of only a few billionths of a degree above absolute zero, the temperature at which all motion ceases. At these low temperatures, atoms are moving at a sluggish pace of a few mm/s, compared to the fast speeds of about a km/s at room temperature. This gives researchers a long time to probe the inner secrets of the atoms and study their properties in exquisite detail. These low temperatures have also resulted in the observation of Bose–Einstein condensation, a novel quantum phase of matter predicted by Bose and Einstein 70 years ago. It is indeed appropriate that the 1997 Nobel Prize in Physics was awarded to recognize these developments.

The alkali atoms sodium, rubidium and caesium are especially advantageous in laser cooling because of their simple energy level diagram and their strong transitions. Many novel experiments are currently being carried out in various laboratories abroad on manipulation of atoms with lasers, atom–laser interaction, precision measurements of inertial effects, realization of time standards with enhanced precision, Bose–Einstein condensation of atoms and atom beam interferometry. In India a few laboratories have just started building simple laser cooling experiments. It was felt that the time was opportune to hold a micro-symposium on laser cooling and trapping of atoms at the Annual Meeting of the Indian Academy of Sciences at Kottayam to bring to the attention of a large community of scientists the possibilities offered by this area of research.

There were six talks at this symposium and these talks are presented (**page 183–221**) in this special section. These talks will serve as an introduction to the field for any one interested in pursuing research in this area.

Unlike the absorption line of sodium which occurs at 589 nm, the absorption wavelengths of Rb and Cs occur at 780 and 852 nm respectively. These wavelengths are conveniently attained by using tunable semiconductor diode lasers. Diodes with 30 to 50 mW of output power can be purchased for a few hundred dollars. It is thus possible using these atoms to build a laser cooling set up at a relatively moderate expense. In the first article by Srinivasan (**page 183**) a brief introduction is given to the Doppler cooling mechanism and the optical molasses to cool a cloud of atoms. This is followed by a description of a simple set up for realizing laser cooling of rubidium.

While the laser diode is a convenient tunable source, the width of the single mode laser line varies from 10 to 100 MHz. For laser cooling experiments, the line width has to be reduced below 1 MHz and the laser line has to be tuned to one of the transitions between the hyperfine levels of the ground and excited states. The frequency of the laser has to be stabilized. Techniques for reducing the line width, tuning and locking the frequency of the laser beam to one of the hyperfine transitions are discussed in the article by Santa Chawla (**page 190**).

The optical molasses is a viscous medium for the atoms. In the molasses region one can only build up a density of 10^6 atoms/cm^3 and these atoms will leak out of this region in a few seconds. To enhance the density of the atomic cloud to 10^{11} atoms/cm^3 and retain the atoms for times of the order of a hundred seconds one should use a trap. The most convenient trap for neutral atoms is a magneto-optic trap. In this trap one uses a quadrupolar magnetic field produced by two identical coaxial coils carrying currents in opposite directions. The laser beams are suitably circularly polarized. Jagatap *et al.* (**page 207**) discuss the theory of the MOT, the factors limiting the achievable density in such a trap and the mechanisms resulting in loss of trapped atoms. They describe magneto-optic traps constructed in BARC.

Ions can be trapped by using inhomogeneous electromagnetic fields to produce a suitable trapping potential. The Penning trap uses a magnetic field in conjunction with an inhomogeneous electrostatic field produced by a set of hyperbolic electrodes. The Paul trap on the other hand uses shaped electrodes with an *rf* electric field. In the article on Ion Trapping Techniques, Renuka Prasad *et al.* describe the principles of these traps (**page 200**).

Once a cloud of atoms is trapped and cooled, one would like to measure its temperature. The atoms in the cloud have a Maxwellian distribution of velocities appropriate to the temperature. One uses one of several methods to measure the temperature. Of these the time of flight technique leads to most reliable results. All these methods provide an indirect measure of the temperature and need careful experimentation and analysis of data to yield a reliable value of temperature. These matters are discussed in the article by Hema Ramachandran (**page 213**).

One can do a variety of experiments with such cold atoms. It will be impossible to describe all of them within the scope of the micro-symposium. One of the most exciting fields of research opened up by laser cooling is the study of atoms in the Bose–Einstein condensed state. The laser-cooled atoms in a MOT still do not have the required phase space density to achieve Bose–Einstein condensation. A subsequent stage of compression in a magnetic trap followed by evaporative cooling is required for this purpose. This is described in the article by Vasant Natarajan (**page 216**). He also deals with a second class of experiments to test whether atoms have an electrical dipole moment in the ground state.

Right now most of the groups in the country embarking in this area of research are subcritical in size. As the expertise in this area is acquired, it is expected that the size and effort of each group will grow. One of the purposes of publishing this special section in *Current Science* is to generate interest in the young experimental scientists in the country in this field. It is hoped that this will encourage more of them to take up this challenging area of research.

R. Srinivasan