In this issue

Status of basic science

On pages 505–528 we publish a guest editorial and five articles on the status of basic science in India. We would very much like our readers to react to these articles and send us their comments and opinions.

Raman effect in the skies

Ever since its discovery Raman often discussed how his effect could possibly be observed in an astronomical context. He speculated (as did another eminent scientist, A. A. Kastler) on various ways of probing the atmosphere of the planets of the solar system to detect Raman scattering. Raman was conscious that very special conditions are required to observe this phenomenon, i.e. an extremely strong monochromatic source, preferably in the ultraviolet to exploit the λ^{-4} scattering law, and a dense cloud of molecular or atomic gas on which this monochromatic radiation can impinge. The eternal optimist that he was, he felt that with such a vast variety of unexpected star systems in the universe, there must be one at least, wherein the conditions for observing the Raman effect from earth would be satisfied. Indeed such conditions do seem to exist in a class of stellar systems called symbiotic stars. Two broad bands they emit were first tentatively interpreted by H. M. Schmid as due to Raman scattering; a conjecture made in 1988 as though to celebrate the golden jubilee of the discovery of the Raman effect! Now this interpretation seems to be beyond doubt.

P. W. Merril and M. L. Humason during their survey using the Mount Wilson Telescope discovered three stars which showed an unexpected anomaly. These exhibited not only strong absorption bands (TiO?) but also a very intense HeII emission line at λ4686. These indicate the existence in a single object with a stellar photosphere ($\approx$3000 K) and of a highly ionized region about 100,000 K. With uncanny prescience Merril named these symbiotic stars to describe an object containing two seemingly hostile or what appeared to be incompatible components. So far 150 such stars have been observed (most of them in our galaxy and a few in the nearby Megallanic cloud).

The model of symbiotic stars as a binary system was proposed by A. A. Boyarchuk of the Crimean Astrophysical Observatory and independently by T. Sahade of the Argentina Radio Astronomy Laboratory. (Boyarchuk was in Bangalore recently and gave a detailed overview of the subject.) In his picture a cool red giant and a hot companion star coexist in a binary system surrounded by a dense small nebula of ionised gas. Symbiotic stars exhibit many other exciting phenomena; however, we shall not deal with them here.

The spectra of many of these stars have been recorded and studied. Most of the lines in the visible region are sharp and have been identified. 50% of the stars show two broad bands near about λ6830 and λ7088—these are amongst the ten most intense lines in the visible region. The typical width of these bands is 20 Å. In a given star there is similarity between the profiles of the bands at λ6830 and λ7088. The profiles vary from star to star. λ7088 is seen only in objects having a strong λ6830 emission. These bands defied identification till H. M. Schmid suggested that these bands are due to Raman scattering by the high density neutral hydrogen which is in the atmosphere of the cool giants facing the hot companion. The incident radiation is from OVI (oxygen 6 times ionised) which exists in the inner part of the ionising source. This ion emits a resonance doublet at λ1032 and λ1038.

OVI doublet lies very close to the hydrogen Lyman β. Absorption of OVI by neutral hydrogen creates an intermediate state close to the bound state of hydrogen, $3p\,^2P_0$. OVI photons are absorbed by the hydrogen in its ground state $1s\,^2S$. The absorption leads to an intermediate state (see cover picture) where a photon is emitted and the hydrogen atom is left in the excited state $2s\,^2S$. Calculations show that the emitted photons should have wavelength very close to 6830 Å and 7088 Å. Since the scattering cross-section increases rapidly as the intermediate state approaches the bound state, the atomic hydrogen has a larger cross-section for λ1032 than λ1038 so that λ6830 has a much higher intensity than λ7088.

It was really the polarization studies which finally confirmed that the observed lines are indeed due to Raman scattering. Raman scattering being of the dipole type, it is polarized. The large polarization detected in λ6830 and λ7088 lines in the symbiotic stars strongly suggests that they are indeed generated by a scattering process. A pronounced anisotropy in the geometry is present in the binary configuration of symbiotic stars. There is a lack of rotational symmetry with respect to the line of sight. This avoids exact compensation of the polarization for different scattered regions. Since all photons in the Raman lines are produced in a scattering process, there is no contamination with thermally produced photons originating in a stellar or nebular source. The weaker line λ7088 shows a larger polarization. To explain this, one has to evoke multiple scattering.

The λ6830 and λ7088 lines fulfill all the important predictions of polarization and hence one can say with some conviction that these are truly Raman scattered lines.

Raman scattering and its polarization can also be used effectively to probe the nature and properties of symbiotic stars. For example, the scattering geometry in these systems changes periodically relative to the line of sight, due to the binary motion. Therefore systematic changes are expected not only in the *line strengths* but also in the amounts and orientation of the polarization in the Raman scattered emission lines. Time sequences will allow the determination of the orbital period; the inclination and orientation of the orbital plane. From these parameters it may even be possible to estimate stellar masses etc. Three papers of significance have appeared: H. M. Schmid (*Astron. Astrophys.*, 1989, **211**, L31), H. M. Schmid and H. Schild (*Ibid*, 1990, **236**, L13), H. M. Schmid (*Astron. Astrophys.*, 1992, **254**, 224). When we were about to summarize these, an excellent article appeared in *Gemini* by the discoverer

H. M. Schmid and his collaborator, which we reproduce on **page 536**.

Of palms, root (wilt) and the human heart

Among the muscle diseases of the heart known as cardiomyopathies, endomyocardial fibrosis is remarkable for its geographical distribution and the characteristic changes seen in the heart. Most of the reports on the disease trace their origin to far-flung areas of the tropics in the Ivory coast, Nigeria, Uganda, Kerala and Brazil and they seldom fail to emphasize the young age and poverty of patients. In the heart, a dense layer of fibrosis or scarring converts the endocardium into a thick mantle to the detriment of cardiac function. The geographical profile, characteristic scarring and the fatal outcome of the disease attracted much scientific interest and theories appeared, over the years, suggesting viral, auto-immune, eosinophilic and other factors in its causation. The theories however, failed to find support in experimental evidence and the genesis of the disease continued to remain an enigma. A few years ago, the finding of magnesium deficiency in association with the raised level of cerium in the cardiac tissues of patients suggested a link between the disease and the soil and shifted the discussion on causation to the nontraditional context of geochemistry. This observation was followed by other reports on the enhancement of cerium concentration in magnesium-deficient plants, mimicking of magnesium by cerium in enzymatic reactions and the stimulations of collagen synthesis by cerium at nanogram levels. If the deficiency of magnesium and abundance of cerium in the soil could be deleterious to the human heart, the question naturally arose whether it could have similar effects on other forms of life in the environment.

Valiathan and colleagues (**page 565**) report their findings on the reciprocal relationship in the levels of magnesium and cerium in the leaves of coconut palms affected by root (wilt) which is a major economic problem in Kerala. What is striking in their data is the higher level of cerium in the leaves of the diseased palms in Kerala in comparison with that of the healthy controls from Manvalakurichi where monazite deposits are plentiful. The authors have attributed the difference to the relative insufficiency of magnesium in the diseased palms in Kerala. This would raise further questions and possibly trigger newer field of studies in coconut root (wilt). As the enrichment of the soil with magnesium improves the productivity of the affected palms only partially, it may be interesting, for example, to examine the role of chelators in interventional experiments.

If the reciprocal relationship between magnesium and cerium turns out to be the common basis for coconut root (wilt) and a human cardiomyopathy, it would point to the evolutionary origins of the degenerative response to a bioinorganic challenge. In any case the attempt to unify the behaviour of palms and the human heart in disease is reminiscent of J. C. Bose who sought a common basis for the response of plants and the humans in health to pain and other noxious stimuli.

RNA: Burgeoning interest

Ribonucleic acid (RNA) has often been in the news in the past few years. The discoveries of RNA splicing, processing and the enzymatic activity of RNA, have provided an enormous impetus to the study of this class of biological molecules and have indeed inspired conjectures regarding a primordial RNA world. Scenarios where RNA molecules would have served to carry information and also perform catalytic functions place them as evolutionary forbears of their modern day DNA and protein counterparts. Closely related to the better-known deoxyribonucleic acids (DNAs) differing indeed only in possessing an additional hydroxyl group on the sugar backbone and in a single base (uracil for thymine), RNAs have only recently moved to the centre stage of molecular biology. Ribosomes, intracellular structures which are the focus of much of RNA's functions, provide the setting for the reading of the message encoded in messenger RNAs and the concomitant building-up of the polypeptide chain by sequential transfer of amino acids from transfer RNAs. In the background lie the ribosomal RNA molecules, long thought to provide the scaffolding for a complex ribonucleoprotein structure. The enormous sizes of the ribosomes, their heterogeneity and the diversity of their components have thus far precluded an atomic level analysis of their structures. Nevertheless, considerable information has emerged over the years, as accounts of many painstaking studies of ribosome structure and function have been reported. Most recently, the provocative finding that ribosomal RNA might indeed serve as a peptidyl transferase (Noller *et al.*, *Science*, 1992, **256**, 1416), together with a companion study that ribozymes can hydrolyse amino acyl esters (Piccirilli *et al.*, *Science*, 1992, **256**, 1420), thus expanding the catalytic repertoire of RNA beyond phosphodiester chemistry, suggests that research in this area may become frenetic in the years ahead. This world of RNA and ribosomes is reviewed by D. P. Burma (**page 550**).

Organometallics in water

Organometallic chemistry conjures up visions of careful experimenters working with rigourously defined conditions, excluding moisture and air with meticulous precision from their reaction flasks. The notorious instability (reactivity) of many organometallics has invested this area with more than its share of horror stories of failed reactions and decomposing reagents and products. It is therefore a bit surprising to hear of organometallic chemistry in water, although on reflection the example of an organometallic natural product, coenzyme B-12 springs to mind. Indeed, stable water-soluble organometallics are over a century old, as noted by A. G. Samuelson (**page 547**). The prospects for enhancing the versatility of organometallic reagents by working in aqueous media appear bright.