In this issue

A mathematical phenomenon

Vladimir Igorevich Arnol'd, of the Steklov Mathematical Institute, Moscow, contributes two articles to this issue—one on Newton's Principia (with V. A. Vasil'ev) (**page 89**) and the other on the partially complete encyclopaedia project (**page 69**) undertaken by Soviet mathematicians. His recent one-week visit to Bangalore was a memorable one for almost anyone concerned with mathematics. Apart from giving three exciting lectures on singularity theory —a speciality of his school—one on quasicrystals and one on the Principia, Prof. Arnol'd was immersed in almost continuous animated discussions on any subject that his stream of visitors chose to raise with him, ranging over non-linear waves, galaxy dynamics, magnetic fields and many other areas. Typically, one would go back from such a discussion with much to think about—new ideas, problems, and connections with other fields, and most of all the question of how one person could keep up with so many things with so much speed, depth and enthusiasm. Clearly all this activity was not a sufficient outlet for his energies since he was often seen doing a dozen or more lengths in the swimming pool at the Indian Institute of Science.

It would be difficult to list here all his contributions to mathematics and related areas. One of the best known has become part of the vocabulary of physics under the name of Kolmogoroff–Arnold–Moser (KAM) theory and orginates in one of the very fundamental and difficult problems of celestial mechanics—Is the solar system stable? More technically, the theory gives a rigorous analysis of how the qualitative properties of planetary motion change when one includes their effects on each other—effects which are tens of thousands of times weaker than that of the sun but which act over more than a billion orbits. The modern area of dynamical systems owes much to Prof. Arnol'd and his school.

Algebraic curves

Vishwambhar Pati's article (**page 82**) with this title began as an attempt to help readers with some of the concepts used in the article by Arnol'd and Vasil'ev, but has grown into an expository piece which we hope will be very useful and instructive in its own right. One of the many traits of mathematicians which sets them apart from mere users (e.g. most physicists) is their facility with 'geometrical' objects described by complex numbers. While there is no royal road to such facility, Pati does give us a first glimpse of the world of such objects which has been explored by the greatest mathematicians for hundreds of years.

The Chitra valve

More than 20,000 patients in India each year need an artificial heart valve to replace their diseased one. Providing a new lease of life to these patients, most of whom suffer from rheumatic heart disease, is a major medical effort. Artificial heart valves and the story of India's successful project to make one that meets international standards are described by M. S. Valiathan (**page 77**) and A. V. Ramani (**page 73**). See also editorial, **page 67**.

EPR spectroscopy

Hans van Willigen, one of the distinguished visiting chemists to Bangalore, uses electron paramagnetic resonance (EPR) for many of his researches. He has written a brief but thought-provoking article (**page 95**) on the current trends in EPR spectroscopy. A very large number of sophisticated EPR instruments have now appeared in the market. To name a few: pulsed time domain EPR, high frequency continuous wave and pulsed EPR (going up to 250 GHz instead of the usual 9-10 GHz), FT EPR, two-dimensional FT EPR, EPR imaging, etc. Some of the most modern aspects of chemistry are being studied using these instruments, e.g. how centres (paramagnetic) are created by ionizing radiation, how these get distributed and diffuse; the study of fast chemical reactions initiated by pulsed laser excitation; transient free radicals, their reaction mechanisms, kinetics and decay; the dynamical motion and electron exchanges; the electronic and geometric structure of amorphous materials, the study of extremely tiny single crystals of biological materials.

Is it volcanism or asteroid impact?

Many puzzling things seem to have happened at the end of the Cretaceous period—the most spectacular one being the extinction of the dinosaurs. On **page 97** appears an article which examines whether Deccan volcanic activity could be the cause of many of these happenings. Argon age determinations indicate that this enormous upheaval in the Deccan when a million cubic km of lava seems to have been thrown out was during a very short period of one million years about sixty five million years ago. At that time India was thirty degrees south of its present position and was probably passing over the Reunion hot spot. The energy involved in this massive activity has been estimated to be between 10^{30} and 10^{33} ergs.

Luis Alvarez, the Nobel prize-winning nuclear physicist, gave an alternative hypothesis and suggested that a celestial object about 10 km in diameter may have hit the earth at that time. The catastrophic effects of this collision (dust it unsettled and the 'greenhouse' gases evolved) must have blotted out the sun long enough to kill most of the organisms on earth to make way for new species. The most striking and convincing evidence for this impact hypothesis is that the layer of clay at the Cretaceous–Tertiary boundary contains abnormally high amounts of iridium and other elements which are normally scarce on earth but common in celestial objects.

One is of course familiar with some of the spectacular impact craters of the world. Even in India, there are the Lonar Crater in Maharashtra and the Rajghar Crater in Rajasthan. Unfortunately, most impact craters are being obliterated by the dynamic forces that are continually operating on the earth's surface. Therefore, other methods to detect impact from extraterrestrial bodies have to be established. The best evidence is the presence of shocked quartz and feldspar grains which display visible streaking along certain crystallographic lattice planes. The X-ray diffraction photographs show obvious signs of shock and these grains also exhibit a lowering of the refractive index. The minimum shock pressure to cause these effects in these crystals is 90 kbar while the maximum is about 300 kbar. This pressure range is far above that which could be caused by volcanism.

The cosmologists and geochemists favour the impact hypothesis while the geologists and palaeontologists feel that the Deccan volcanism may be the cause of the Cretaceous anomaly. The debate seems to be inconclusive as both impact and volcanism can give rise to similar phenomena. In both cases the energy involved is more than 10^{30} ergs, the dust ejected can blanket the sunlight, 'greenhouse' gases are released with the consequent possibilities of cessation of photosynthesis and extinction of fauna and flora.

In this review, the authors examine the evidence available on the Deccan and its vicinity where the effects are expected to be most pronounced. They also study the marine and continental sediments of India near/at the Cretaceous boundary. They conclude that the Deccan volcanism may be inadequate to explain many of the observed effects, including the peak concentration of iridium. According to them there is a fair amount of evidence in favour of cometary or asteroidal impact. They feel that crucial studies of the osmium–iridium ratio may possibly help us to resolve this issue.
