In this issue

Neutrinos and the Universe

Standard Model (SM) is the basis of *all* that is known in High Energy Physics. Although it is believed that SM is only an effective low energy description and it is to be replaced by something beyond, so far SM has resisted all attempts at overthrowing it. All the precision tests performed so far are in beautiful agreement with SM. All the experimental signals that seemed to suggest its overthrow, disappear in about six months to one year, except one signal, namely the signal that neutrino has a mass.

Neutrinos are unique in the SM. Neutrino is the only particle, a part of which (namely its right-handed part) has zero quantum number and so it is not acted on by the gauge forces of the SM. So, its right-handed part is presumed to be absent in SM and as a consequence the natural mass of the neutrino within SM is zero. That is why neutrino mass is regarded as a signal beyond SM.

Further, the tiny mass of the neutrino can be used to probe superhigh mass scales which are not otherwise directly accessible to present-day experiments. This is because of the so-called see-saw mechanism which can operate if neutrino is a self-conjugate fermion (i.e. fermion = antifermion). This mechanism links the neutrino mass m_ν to the inverse of a superhigh mass scale M, the formula being $m_\nu \sim m_q^2/M$, where m_q is a low mass scale which may be of the order of 1 GeV. Thus, for instance, 0.1 eV for m_ν is linked to 10^{10} GeV for M. This is the importance of measuring these tiny masses of the neutrino. Also, note how the 'small' is linked to the 'big'.

Finally, if the neutrino mass is not zero, neutrino becomes a candidate for the eagerly looked for 'dark matter' that is supposed to constitute more than 90% of the Universe. That is the cosmological importance of neutrino. If this scenario turns out to be correct, then it is the tiny neutrino that controls the Universe!

> To see a World in a grain of sand,
> And a Heaven in a wild flower,
> Hold Infinity in the palm of your hand,
> And Eternity in an hour.
>
> *William Blake*

As I said above, the signal for nonvanishing m_ν has remained robust. It has remained robust for 30 years! This signal has been extracted by the study of the neutrinos from the Sun. The very first signal was obtained by Davis *et al.* using the ^{37}Cl detector, about 30 years ago. Subsequent experiments by the same group, as well as other independent experiments done over these three decades have only confirmed it. To this, one must now add the signal obtained by studying atmospheric neutrinos. Although this signal is a late starter, it has picked up strength and the latest announcement by the Super-Kamiokande group has almost clinched the issue of the neutrino mass. These and related issues are discussed by R. Cowsik (**page 558**). Its value is enhanced further since Cowsik himself has made seminal contribution to the topic of neutrinos in the cosmological context.

G. Rajasekaran

Acid showers: Disturbing present and alarming future

There was a hue and cry about acid rain many years ago, which gradually died down as new, more pressing, problems pushed it into the background – the usual fate of almost all headlines-grabbing items. Unfortunately, however, the problem did not go away. In fact, as described in detail by Manju Mohan and Sanjay Kumar on **p. 579** of this issue, over the years, the rainwater seems to have been steadily becoming more and more acidic.

There is neither a mystery nor any controversy (hopefully!) about what causes acid rain. The oxides of sulphur and nitrogen are the main factors, while organic acids and to an extent hydrochloric acid also contribute to it. The sources of these gases are also well-known: industrial emissions, coal-based thermal power plants, petrol and diesel burning vehicles generally head the list. Occasionally, Nature also lends a mighty hand in the form of volcanic eruptions. Fortunately, however, these are rare in India as of now.

By examining the pH values of rain water recorded at many places in India (Jodhpur to Minicoy and Srinagar to Kodaikanal), Manju Mohan and Sanjay Kumar have pointed out that there is an increasing trend towards acidification almost all over the country. More disturbingly, acid rain has been reported at places like Kodaikanal and Port Blair (in addition to Nagpur and Mohanbari) – showing that the places where the effect is felt can be very far from the places where gases are emitted (another potential item for inter-state acrimony!).

A somewhat positive feature emerging from the compilation of world-wide figures is that India is much better off compared to many of the other (even European) countries as far as acid rain situation is concerned. Nature has again been kind to India. The alkaline soils offset the effects of acid rain to an extent, and the sand-storms originating in the Thar desert do their part by increasing the pH of the water in the clouds.

With industry, power-plants and traffic as the major offenders, it goes without saying that acid rain can be

labeled as an inevitable consequence of development. Looking at the pace of developments during the last few decades, it is only to be expected that acids will become stronger and stronger. Using a sophisticated simulation model, Manju Mohan and Sanjay Kumar have attempted to project the acid rain potential over the next many decades at many locations in India, and have identified a few places where the situation can become critical. They also discuss, on what can be done to prevent, or at least, to mitigate, these problems. In one sense, the steps are very similar to (in fact, exactly the ones) those needed for cutting down overall pollution levels – so one hopes that they will be taken sooner or later. If not, the damage may be far, far, higher than what one imagines. It is like very small doses of poison being administered very regularly over long times; it does not grab as much attention as a slap, blow or a kick – but the results are certainly more disastrous.

N. V. Joshi

Surface deformation

A majority of earthquakes occur along the boundaries of tectonic plates, now fairly well defined. A small number of moderate, yet highly destructive ones also occur in the otherwise stable continental regions (SCR), cataclysmically releasing their long, albeit slow, accumulating storage of elastic strain, often at unsuspected sites. SCR strain reservoirs set in comparatively rigid terrains, have smaller capacity and receive only a fraction of the strain pumped annually by plate displacements. They, therefore, have long renewal periods, of several thousand years, between ruptures, which dims human memory (unless written records exist), even as it does earthquake sculpted landforms. They also tend to be more randomly distributed, nestling in the various scars of a long accreted ancient landmass, unlike the more ordered plate boundary earthquakes orchestrated by an active mechanical process.

The long inter-seismic quiescence of SCR earthquakes combined with their strong individuality, make it a daunting task to chart their loci and evaluate their seismogenic potential. But, the high density of human habitats and activities encouraged by the putative stability of these regions also makes this task, the most challenging one of modern seismology. For, in such regions of burgeoning human life and works, even a moderate earthquake can take a disproportionately high toll of life and property as shown by the recent Killari and Jabalpur earthquakes of the Indian Shield. Despite these intrinsic difficulties, however, a great deal can be learnt through well-designed investigations of past SCR seismic environments, as shown by the paper on the 1819 Kachchh earthquake by Rajendran *et al.* (**page 623**). This earthquake, one of the strongest recorded in a SCR, created extensive surface deformation including a 95 km long escarpment – the Allah Bund – still, fortunately, well preserved to yield some significant clues regarding the causative fault mechanism as the authors deduce, as well as to provoke potentially revealing questions that may sharpen our understanding of these stealth earthquakes.

V. K. Gaur