In this issue

Criticality and nuclear data

The development and maintenance of nuclear facilities and technologies rely on the availability of nuclear, atomic, and molecular data to provide accurate numerical descriptions of the underlying physical processes. The data needed include energy-dependent reaction probabilities (cross-sections) for many combinations of a variety of targets and projectiles, angular and energy distributions of reaction products, nuclear and atomic energy levels, and radioactive decay data. In addition, for criticality safety calculations, different neutron data like fission-product capture cross-sections, fission-product scattering cross-sections and distributions, and fission-product yields are needed. The field of nuclear data includes the study of the structure of atomic nuclei and the analysis of interactions between a variety of nuclear radiation and matter.

The design and safe operation of nuclear installations has been possible because of accurate calculations using nuclear, atomic and molecular data, as input. The amount of data needed for such calculations, can be enormous. Typically, for understanding the physical behaviour of the core of a research reactor and its safe operation, data concerning more than a hundred nuclides may be needed. More detailed data are required to design a nuclear reactor for production of electricity and to take decisions on the fuel cycle. This design must conform with the strict safety regulations and still remain cost effective. The requirements for the quality and accuracy of data for this purpose are very stringent. Another example of application of nuclear techniques is radiation therapy for cancer patients. Different types of nuclear radiations, e.g. X-rays, gamma rays, electrons, neutrons and charged particles are used for this purpose. To minimize damage to surrounding normal tissues, an accuracy of the dose delivery should be known to better than 5%. High quality atomic, molecular and nuclear data are needed to determine the dose delivery with such precision.

Other areas that rely on the availability of accurate nuclear and atomic data are in fission reactor design, nuclear fuel cycles, nuclear safety, nuclear safeguards, reactor monitoring, nuclear waste monitoring and waste disposal. Nuclear waste monitoring over decades or even centuries is a very important activity as it influences the environment in a complex manner. Many nuclear applications outside the field of fission reactor technology that are of growing economic significance and that have substantial data requirement include accelerator shield design, cancer therapy, chemical analysis by activation methods, detection of concealed explosives and illegal drugs, environmental monitoring and clean-up, exploration for oil and other minerals, fusion device design and plasma processing technologies, personnel dosimetry and radiation safety, production of radioisotopes for medical and industrial applications, and radiation damage studies.

Nuclear and atomic data are extracted from results of experimental measurements, nuclear physics model calculations and data evaluations. Measurements are performed using research reactors, neutron generators, charged particle accelerators, spectrometers and other devices including sophisticated radiation detectors. Several million nuclear data points have been measured and compiled into digital computerized databases such as EXFOR and ALADDIN for further processing and application. The compiled data are evaluated to arrive at tables of recommended values, supplemented with theoretical predictions (fit to available experimental data where possible) which are needed by the users. Nuclear model calculations and evaluations make use of considerable computer resources and the theoretical results obtained require, quite often experimental testing and verification. Because of the varied activities, the nuclear data community producing and processing nuclear data covers a wide range of disciplines and specialists including nuclear physicists and chemists who perform the basic experiments and develop theoretical models to explain them, the analysts who evaluate and systematize the database and the experts who prepare the data libraries and develop the computer programs used for nuclear applications.

The International Atomic Energy Agency (IAEA) promotes the contribution of atomic energy to peaceful purposes in all its aspects and has a continuing programme to collect, analyse, recommend and disseminate such data through its Nuclear Data Section established in 1964 within the Division of Physical and Chemical Sciences. The Nuclear Data Section maintains several comprehensive, up-to-date and user friendly international standard data libraries and regularly updates databases needed for such areas of applications as mentioned earlier. An important part of the nuclear-data system is the international network of data centers.

IAEA coordinates, maintains and evaluates nuclear and atomic data files like ENDF/B-VI, JEF-2, JENDL-3, BROND-2 and CENDL-2 contributed, respectively by the USA, NEA Data Bank, Japan, Russia and China, free of charge, literature index on microscopic neutron data CINDA, published by the IAEA, literature index on atomic and molecular data CIAMDA, published by the IAEA, numerous special purpose nuclear and atomic data files, computer programs for nuclear data treatment, etc. The IAEA collection includes about 100 nuclear data and atomic data libraries. The most voluminous data library EXFOR contains more than 4 million experimentally measured data points from all over the world.

In this issue, S. Ganesan *et al.* (**page 667**) from BARC, deal with the nature of criticality of protactinium with atomic mass 231, one of the minor actinide elements that occurs in fission-waste. A 'critical' nuclear system is one where exactly one of the neutrons produced in a fission reaction survives, escape or absorption to continue the nuclear chain reaction. Such a system is said to have a neutron multiplication of one, or $k_{eff} = 1$. In a 'subcritical' system, fewer than one neutron survive on the average, and the fission chain reaction will rapidly die away. If the multiplication factor is greater than one, the system is 'supercritical'. The fission rate will rapidly increase until things get hot enough to disperse the system (it requires very specific conditions to turn such a runaway reaction into a bomb though). This supercritical system will produce large amounts of dangerous radiation and radioactive contamination.

It is the role of the Criticality Safety Engineer to evaluate the conditions that must be met to avoid a runaway fission process, or 'criticality accident', wherever nuclear materials are stored, transported, or processed. It is against this scenario, we note that the results of earlier (1989–1991) studies performed in BARC led to the conclusion that ^{231}Pa could be fissile with a high value of $k_{eff} > 2$ and therefore a very good nuclear fuel. Ganesan *et al.* have had a second look at the nature of this element based on state-of-the-art nuclear data measured and calculated based on state-of-the-art theoretical models. They conclude that '^{231}Pa does not become critical even for *infinite* (emphasis mine) mass'. It is clear that these and similar results can lead to radically different approaches to handle ^{231}Pa in particular and perhaps nuclear waste containing a variety of elements in general.

K. R. Rao

Sex associated sequences in *Piper longum*

Presence of heteromorphic sex chromosomes such as XY or ZW is a reflection of the evolutionary status of the species because in less evolved ones, sex chromosomal dimorphism is usually missing. A great deal of information is available in animal systems on the genomic organization and evolution of heteromorphic sex chromosomes and sex-specific sequences. However, such information in plants is almost negligible. Further, due to often non-sexual mode of reproduction, the evolutionary processes responsible for giving rise to heteromorphic sex chromosomes tend to get impeded. Chromosome analysis in *Piper longum* L. has shown the absence of discernible heteromorphic sex chromosomes. Therefore, identification of sex-specific band reported in this species based on RAPD approach by Banerjee *et al.* (**page 693**) appears to be a favourable situation. This observation may prove to be an entry point to the analysis of plant genome with respect to organization and evolution of sex chromosomes. Cloning and sequencing of sex-specific band reported in this paper will prove to be a rewarding proposition to mount database searches for ascertaining their homology with other heteromorphic sex chromosome-related sequences in the higher eukaryotes. This may also enable to narrow-down the search for progenitor sequences responsible for spreading the heterochromatic DNA in the plant genome. It would be of interest to establish if evolutionary forces acting upon these sequences favour them equally in the related species or they show divergence. Finally, sex-specific sequences may be used as molecular tags to uncover the status of the same in related plant genomes. Consequently, the present study, albeit ephemeral, will have much wider ramification for the analysis of plant genomes if pursued further.

Sher Ali

The Park gets bigger: New fossils of Jurassic dinosaurs from India

In this issue, K. Satyanarayana *et al.* (**page 639**) report exciting information of a new locality in Kuar Bet, Kutch where the remains of Jurassic dinosaurs and large petrified tree trunks are found. This record along with several other recent reports from other parts of India during the last two decades [Sahni, A., in *Encyclopaedia of Dinosaurs* (eds Currie, P. J. and Pandian, K.), Academic Press, New York, pp. 361–368] re-emphasizes the potential of India for dinosaurian studies. The first dinosaurian fossils in India were reported as early as 1828 by Captain (later General) Sleeman at Jabalpur.

Dinosaurs originated in the Triassic some 230 million years ago and one of the earliest records of these magnificent creatures, namely *Alwalkeria maleriensis*, is from the Late Triassic of the Pranhita–Godavari Valley in Andhra Pradesh. The younger, Jurassic sequence of the Kota Formation has yielded a rich fauna comprising besides dinosaurs, a diverse assemblages of fishes, crocodiles and mammals. In the early 1960s, intensive field work in the region yielded one of the world's best known sauropod dinosaurs, *Barapasaurus tagorei* – that stands as a mounted skeleton at the Geological Museum of the Indian Statistical Institute, Calcutta.

The record of Indian Cretaceous dinosaurs is excellent and suggests that these globe-trotting animals had spread as far as South America, Madagascar and southern Europe. The last record of these animals in India is associated with the Deccan volcanics at a time coinciding with their global extinction.

The present report highlights the fossil wealth of the Jurassic sections of Kutch which have served as classic reference sections for over a hundred years. The reported finds of what indeed appears to be a dinosaurian skeletal graveyard is therefore a significant scientific contribution.

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