CCRI(III) Invited Seminar

BIPM, Tuesday 29 May 2007

Future Challenges in Neutron Metrology

Horst Klein

Neutron standards laboratories offer calibration measurements at the highest achievable accuracy. The calibration fields required for the specification and calibration of detectors, spectrometers and dosimeters are well defined in ISO standards, e.g. ISO 8529 (1-3), and cover the energy range from thermal to 20 MeV. Most measurement techniques used in nuclear technology can be supported. The quality of these calibration fields and/or primary standards instruments or methods is regularly controlled by key comparisons organized by Section III of the CCRI.

The energy range already had to be extended in recent decades up to some hundreds of MeV in order to fulfil the requirements of modern neutron experiments and radiation protection dosimetry at spallation sources (NTOF) and at high energy accelerators (CERN, GSI) as well as to characterize the cosmic ray induced neutron fields at flight levels. Detectors, spectrometers and dosimeters had to be developed, characterized and calibrated. However, neutron fields suited for this purpose are not yet standardized and calibration measurement capabilities are still scarce. Quality control by key comparisons is not possible due to the lack of participants. Calibration measurement capabilities at reference levels should be established also in this energy range because the application of high energy ion accelerators for cancer therapy will become a standard worldwide, and the power of accelerators used in fundamental research is increasing dramatically. Cancer therapy with high energy neutrons may also be revitalized. Spallation sources are the basis for ADS and transmutation experiments.

Next generation fusion experiments are presently being set-up, namely ITER in France and IFMIF in Japan, and will provoke new challenges, too. The neutron yields will be increased by orders of magnitude compared with existing facilities such that new detector systems for the specification of the primary fields in terms of total neutron yield, spectral neutron fluence (rate) and tests of neutron transport calculations and radiation protection shielding will be needed. Among others, foil activation techniques, originally developed and standardized for in-core reactor metrology, may be extended to higher energies with the help of activation by means of (n,xn) reactions, e.g. on Ag-samples.

Laser based neutron sources may also be available in near future. Using terra- or even peta-watt lasers, ions can be generated and accelerated to some tens of MeV. Neutrons can then be produced by means of appropriate converters for (p,n)- and (d,n)-reactions around the ion source. In this case, mixed, ps-pulsed fields must be investigated, preferentially at short distances, with dedicated spectrometric systems.

In conclusion: neutron calibration measurement capabilities will increasingly be demanded, however at much higher dynamic ranges concerning neutron energy and flux. Spectrometers and dosimeters must be optimized for new applications. The standards laboratories should collaborate in these developments and provide quality control of the new measurement systems. The future challenges in neutron metrology will be outlined.