Nuclear Radiation detection and measurement

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Abstract

Instrumentation and measurement methods in nuclear environments are key aspects that contribute to the quality of scientific and technological programs in the fields of physics, energy, nuclear fuel cycle, safeguards and radioactive waste management. Furthermore, measurements relying on nuclear physics now play an important role in various fields of application such as biology, medicine and environment [1].

For nuclear physics and technology side, nuclear power and/or experimental/research reactors are widely used around the world for various purposes, such as energy production, irradiation of material or fuel samples for present and future power reactors, safety studies, assessment of neutronic parameters (such as neutron absorption cross sections or reaction rates), production of artificial radio-elements, etc.

To perform accurate and innovative progress and developments in such R&D fields, specific and ad hoc instrumentation, irradiation devices, measurement methods are necessary. These experiments require beforehand in situ and on line sophisticated measurements to accurately determine parameters such as thermal and fast neutron fluxes and nuclear heating in order to precisely monitor and control the conducted assays [2] [3], [4].

Starting from the physical principles, the lecture will discuss the performances and the limitations of various radiation detectors [5], [6], [7] that can be used in nuclear media as nuclear reactor as well as in the subsequent stages of the nuclear fuel cycle. Specific applications will illustrate the practical applications of the detection techniques: neutron and photon detection in fission reactors and nuclear monitoring of the fuel cycle and radioactive wastes (passive and active neutron measurements, sensing via photofission, coupling of measurements and combined interpretation).

Finally, measurement in harsh media such in the nuclear reactor core needs to be:

- **Reliable**: (impossible or difficult maintenance on irradiated objects)
- **Accurate**: (to meet scientific requirements; e.g. µm dimensional measurements)
- **Miniature**: (narrow location: few mm available)
- **High temperature resistant**: (> 300°C, up to 1600°C)
- **Corrosion resistant**: (operation in pressurized water, high temperature gas, liquid metals…)
- **Neutron / γ "resistant"** (dose > 1GGy/d and > 10dpa/y in Material Testing Reactors)

To meet such requirements specific innovative detection systems have been developed and/or are under research and development. For selective neutron detection under high radiation (neutron and gamma) innovative works and developments have been carried out among which those linked to silicon carbide (SiC) neutron detector [8], [9]. Silicon carbide (SiC) semiconductor due to its high-temperature operation, high critical breakdown voltage, high thermal conductivity and its radiation resistance/hardening can be used to fabricate devices capable to operate under extreme and harsh conditions. Progress works, new developments and specific challenges will also be presented and discussed.

The course will be structured as follows:

1. Interaction of radiation with matter
2. Physical principles of radiation detectors
    a. Gas-filled detectors
    b. Scintillation detectors
    c. Solid-state detectors
    d. Activation detectors
3. Examples of specific measurement methods and their applications. This item will mainly concern the second part of the course untitled: *Instrumentation for Harsh and Severe Media*.

References:

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Short Bio

Prof. Dr. Abdallah Lyoussi was born in Fes, Morocco in 1965. He received his MSc in nuclear physics from Fes University in 1988 and MSc in Nuclear Engineering from French institute of nuclear sciences and technologies (INSTN) in 1990. In 1994 he got his PhD in nuclear physics from Blaise Pascal University (Clermont-Ferrand, France). He has worked on nondestructive measurement methods such as photofission interrogation, neutron interrogation by using different kinds of detectors, electronics, data acquisition systems and advanced particles production machine like LINAC; neutron generators, X tubes. He developed, patented and published various works and innovative and advanced nuclear measurement methodologies.

Abdallah Lyoussi is Professor at INSTN and Aix-Marseille University where he cochairs a master on "Instrumentation & Measurements in Harsh Media". He is currently working at CEA (French Atomic & Alternative Energies) Cadarache centre as researcher in physics and international expert in nuclear measurement. Finally, since May 2010, Abdallah Lyoussi is scientific chair of a new common instrumentation and measurement Lab. between CEA and University of Provence LIMMEX.

Abdallah Lyoussi is IEEE distinguish lecturer since 2014.

He is the founder and the General Chair of ANIMMA conference (www.animma.com).