MAP-fis Essay Proposal, 2013-2014

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Title

Radiation Induced Absorption processes applied ionizing radiation sensing with optical fibers

Area

(*Materials*, *Optics*, *Condensed Theory*, *High Energy Theory*,....);

Radiation Physics, Fiber Optics, Instrumentation

Summary of Proposal

Ionizing radiation is an important tool in many fields of society, probably most visible in the medical field for diagnosis and oncological treatments, in the industry for sterilization processes, and in the field of energy production wherever nuclear energy processes are involved.

The persistent will to improve safety for people subject to environments where ionizing radiation may be present led to the development of different procedures and instrumentation to monitor radiation, and to account for exposure and its potential risks in humans. The effects of ionizing radiation are induced at a microscopic scale and under normal conditions are not immediately revealed. Low level exposure accumulated dose does not produce an immediate effect on the subject, but is related to the increase of probability of cancer development. In radiation therapy procedures, patient exposure is high only within a certain volume of interest; medical physicists and doctors optimize treatment sessions in order to prevent unnecessary damage to surrounding tissues. The Fukushima accident also remembers the importance of environmental monitoring of radiation.

The market already offers some solutions for online radiation exposure monitoring based on semiconductor devices. Nevertheless, the most trusted dose sensors are based on accumulated dose and require offline reading procedures, such as thermo-luminescent detectors (TLDs). If any unpredicted situation occurs it may take a long time for the sub- or over-exposure to be known.

Optical fibres have been used for remote sensing and measurement. Their success is linked to the advantage long distance optical probing without electromagnetic interference, but also to the small size (diameter) and flexibility of fibers that in a smaller scale allow the implementation of endoscopic sensing solutions. Most recently, the coupling of fibers with radio-luminescent organic materials also led to the development of fiber dosimeters.

Different fiber materials have a distinct behavior when under irradiation and after irradiation. The high energy of the particles interact strongly with structural defects of doped glass materials, and these are revealed by the emission of Cerenkov radiation, but also by radiation induced absorption processes (RIA), changing the fiber behavior as a function of irradiation. These processes are usually unwanted and taken as noise. Sensing configurations try to cope with them by using additional referencing of the sensor, or by using advanced signal manipulation.

In this proposal the use of the RIA mechanism and possibly Cerenkov emission when using optical fibers for measuring ionizing radiation exposure will be reviewed. The review will establish its applicability to radiation monitoring in Medical Applications and Industrial processes, according to the current state of the art, and will try to identify new challenges and development guidelines.

References

(*to allow students first look at topic*)

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