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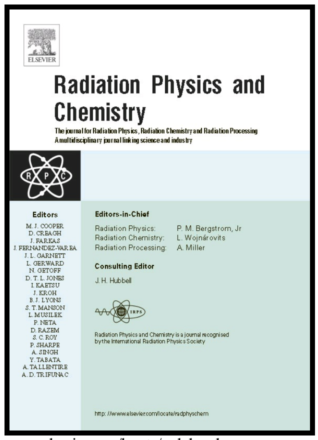

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ACCEPTED MANUSCRIPT

Characterisation of an isotopic neutron source: a comparison of conventional neutron detectors and micro-silica glass bead thermoluminescent detectors

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Abstract

As a result of their thermoluminescent response, low cost commercial glass beads have been demonstrated to offer potential use as radiation dosimeters, providing capability in sensing different types of ionising radiation. With a linear response over a large range of dose and spatial resolution that allows measurements down to the order of 1 mm, their performance renders them of interest in situations in which sensitivity, dynamic range, and fine spatial resolution are called for. In the present work, the suitability of glass beads for characterisation of an Americium-Beryllium (^{241}AmBe) neutron source has been assessed. Direct comparison has been made using conventional ^{3}He and boron tri-fluoride neutron detectors as well as Monte Carlo simulation. Good agreement is obtained between the glass beads and gas detectors in terms of general reduction of count rate with distance. Furthermore, the glass beads demonstrate exceptional spatial resolution, leading to the observation of fine detail in the plot of dose versus distance from source. Fine resolution peaks arising in the measured plots, also present in simulations, are interesting features which based on our best knowledge have previously not been reported. The features are reproduced in both experiment and simulation but we do not have a firm reason for their origin. Of greater clarity is that the glass beads have considerable potential for use in high spatial resolution neutron field characterisation, subject to the availability of a suitable automated TLD reader.

Keywords: neutron detection, glass bead TLD, thermoluminescence, ^{3}He, boron tri-fluoride

1. Introduction

Mapping mixed radiation fields with conventional gas based neutron detectors to achieve mm spatial resolution is a challenge. However, detailed knowledge of different radiation intensities as a function of position surrounding neutron sources is required to use these sources as a characterisation tool (for example in detector testing or neutron activation studies). Hence, in this work, we report the potential to use the thermoluminescent response of 1.1 mm diameter micro-silica glass beads to map the radiation field caused by an AmBe neutron source submerged in a water tank.

The convolution of neutron emission energies with the moderation due to the presence of the water and reduction in intensity per area with increasing distance is known to cause peaks in the distribution of the neutron capture cross section (Lorch, 1973; Coehlo et al., 1989; Thompson and Taylor, 1965; Anderson and Neff, 1972); indeed, this was seen in prior studies (Taggart, 2007; Nicolaou, 1983; Matthews, 1979) of the neutron tank, albeit at far poorer spatial resolution than the present study. The dosimeter size of ∼1 mm (Jafari et al., 2014b,a) enables a far finer $\Delta E(neutron)$ sensitivity than that provided by alternative techniques. The energy response of the glass beads has previously been reported in (Jafari et al., 2014c), whilst that of conventional gas detectors are well-documented.

Work thus far has concerned the effectiveness of glass bead dosimeters for use with the latest radiotherapy developments (Teoh et al., 2011; Chang and Timmerman, 2007) and specifically that the dimensions of the dosimeter should be small with respect to the radiation field dimensions (Jafari et al., 2014a; Bjarngard et al., 1990; Higgins et al., 1995; Fracescon et al., 1998; Sauer and Wilbert, 2007; Aspradakis et al., 2010) whereas the focus of the most recent studies have been the introduction of a mixed

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