Title	Development of standard n-γ mixed fields for dosimetry studies in BNCT
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Form 3

Abstract of Thesis

Name	(徐 子虚)
Title	Development of standard n-γ mixed fields for dosimetry studies in BNCT (BNCTにおける線量計測のための中性子・ガンマ線混合標準場の開発)

Abstract of Thesis

Boron Neutron Capture Therapy (BNCT) is a promising and rising radiation therapeutic treatment for malignant tumors. However, the treatment field of BNCT is a n-γ mixed field, since contaminant gamma-rays with maximum energy above 10 MeV are produced by neutrons interactions with surrounding substances. Since neutron and gamma-ray deliver different biological effects to human bodies, it is essential to distinguish the exposure absorbed doses of neutron and gamma-ray to patients and radiation workers. Currently, Thermoluminescence Dosimeter (TLD), Optically Stimulated Luminescence Dosimeter (OSLD), and Radio-photoluminescence Glass Dosimeter (RPLGD) are widely used dosimeters for gamma-ray dose measurement in BNCT. In the BNCT project of Osaka University, a method of material-filtered Radio-photoluminescence Glass Dosimeters (RPLGD) has been newly proposed for simultaneous and separate measurement of neutron and gamma-ray doses. To validate the glass dosimeters developed for BNCT, standard fields were demanded but still scarce. Hence, in this dissertation, various types of standard n-γ mixed fields were designed and developed, including fast-neutron (F), epithermal-neutron (E), thermal-neutron (T) -dominated fields, as well as gamma-ray-only fields. In this dissertation, five chapters were contained.

In Chapter 2, the theories and methods used in this dissertation were introduced, including neutron nuclear reactions, neutron and gamma-ray sources, and Monte Carlo simulation software, i.e. Monte Carlo N-Particle code (MCNP) and Particle and Heavy Ion Transport code System (PHITS).

In Chapter 3, various types of n-γ mixed fields were designed by irradiating different moderator assemblies with a D-D neutron source at OKTAVIAN of Osaka University, Japan. The moderator assemblies were designed with different combinations of Fe, W, Pb, Bi, LiF, MgF_2, TiF_3, C, and PE materials. The n-γ mixed fields were determined with the specific characteristics as follows: (1) the dose ratios of gamma-ray to neutron are 1.0-977.0% for F-dominated field, 5.0-921.1% for E-dominated field, 0.7-946.3% for T-dominated field, and 11880.6% for gamma-ray-only field; (2) the proportions of fast, epithermal, and thermal neutron doses to total neutron dose are 98.4-100.0% for F-dominated field, 74.0-85.4% for E-dominated field, and 90.1-90.8% for T-dominated field, respectively; (3) the maximum gamma-ray energy is up to 12 MeV.

In Chapter 4, a ~10 MeV standard gamma-ray field, with characteristic gamma-rays at 2.22, 3.68, 4.95, 5.92, 6.02, 6.38, 6.51, 7.28, 7.64, 8.89, 9.30, and 10.04 MeV, was developed by irradiating a Fe-PE Cd moderator assembly with a 2.95 MeV p-Li (thick) neutron source at Fast Neutron Laboratory (FNL), Tohoku University, Japan. The gamma-ray dose rate, $\dot{D}_{\gamma_{air}}$, was confirmed as 3.43×10^{-2} μGy·μC^{-1} using GD-301, a type of Radio-photoluminescence Glass Dosimeter (RPLGD), which was consistent with the results of 3.58×10^{-2} μSv·μC^{-1} and 3.56×10^{-2} μSv·μC^{-1} via MCNP6 and PHITS calculations, respectively. The gamma-ray spectrum was confirmed using a Ge detector (GC1818, CANBERRA) to identify the characteristic gamma-ray peaks at 2.22 MeV, 5.92 MeV, 6.02 MeV, 7.64 MeV, and 9.30 MeV.

In Chapter 5, a summary of this dissertation and prospects for future work were provided. Plans for future work were proposed to conduct validation experiments on F-dominated, E-dominated, and T-dominated fields, including methods of measuring neutron and gamma-ray doses and spectra separately. In conclusion, these reference n-γ mixed fields can reproduce the neutrons and gamma-rays with the same energy range and spectral shape in BNCT, which is valuable for characterization, optimization, and validation of novel neutron and gamma-ray dosimeters and detectors used in a wide energy range.

様 式 7

論文審査の結果の要旨及び担当者

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論文審査の結果の要旨

Boron Neutron Capture Therapy (BNCT) is a promising and rising radiation therapeutic treatment for malignant tumors. However, the treatment field of BNCT is a n-γ mixed field, since contaminant gamma-rays with maximum energy above 10 MeV are produced by neutrons interactions with surrounding substances. Since neutron and gamma-ray deliver different biological effects to human bodies, it is essential to distinguish the exposure absorbed doses of neutron and gamma-ray to patients and radiation workers. Currently, Thermoluminescence Dosimeter (TLD), Optically Stimulated Luminescence Dosimeter (OSLD), and Radio-photoluminescence Glass Dosimeter (RPLGD) are widely used dosimeters for gamma-ray dose measurement in BNCT. In the BNCT project of Osaka University, a method of material-filtered Radio-photoluminescence Glass Dosimeters (RPLGD) has been newly proposed for simultaneous and separate measurement of neutron and gamma-ray doses. To validate the glass dosimeters developed for BNCT, standard fields are demanded but still scarce. Hence, in this dissertation, various types of standard n-γ mixed fields are designed and developed, including fast-neutron (F), epithermal-neutron (E), thermal-neutron (T) -dominated fields, as well as gamma-ray-only fields. In this dissertation, five chapters are contained.

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In conclusion, it is confirmed that this paper is recognized to be a valuable doctor dissertation.