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A Novel Method To Distinguish Fissile From Non-Fissile Materials Using Linearly Polarized Gamma-Ray Beams[1]

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We have developed a novel method to distinguish fissile materials, such as those which may be used as fuel in a nuclear reactor or in a nuclear weapon, from non-fissile materials. Our method relies upon using a linearly-polarized γ-ray beam to induce fission within a sample and then measuring the outgoing fission neutrons. The High Intensity γ-ray Source (HIγS) generated the γ-ray beams used in our experiments designed to test this novel method. The HIγS beam is quasi-monoenergetic and nearly 100% linearly polarized. We performed photofission experiments using beams from 5.3 to 7.6 MeV on a variety of actinides: ^{232}Th, ^{233,235,238}U, ^{237}Np, and ^{239,240}Pu. In the fission process, on average 2-4 neutrons are emitted almost simultaneously with the fission event itself; these are known as prompt fission neutrons. An array of 12-18 liquid scintillator neutron detectors was used to measure the ratio of prompt fission neutron yields parallel to the plane of beam polarization to the yields perpendicular to this plane as a function of beam energy. A ratio near one was found for photofission of ^{233,235}U, ^{237}Np, and ^{239}Pu while a significant ratio ($\sim$1.5-3) was found for ^{232}Th, ^{238}U, and ^{240}Pu. This large difference could be used to distinguish fissile isotopes (such as ^{233,235}U and ^{239}Pu) from non-fissile isotopes (such as ^{232}Th, ^{238}U, and ^{240}Pu). These ratios are in agreement with a model based on prompt neutron emission in fission and previously measured fission fragment angular distributions.

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