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Cross sections for 54Fe(n,n') 54Fe and 54Fe(n,p') 54Mn deduced from the detection of de-excitation γ rays

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Iron is an important component of many structural materials; examples include energy production complexes, laboratories, devices, and shipping containers that often cross borders. The properties of iron alloys in the structural materials—strength, ductility, and stability—depend on defects that develop and grow from neutron scattering and (n, p) and (n, γ) reaction rates. 54Fe is only 5.5% abundant, but neutron scattering cross sections and reaction rates for this nucleus can affect fast reactor systems and energy transport and deposition. Neutron scattering cross sections obtained by the detection of the scattered neutrons offers the clearest path to the desired cross sections in the fast neutron region1, but such measurements are typically limited to scattering from only the lowest few excited levels because of the large energy spreads (10s to 100s of keV) inherent in neutron experiments. The detection of de-excitation γ rays (< 2.5 keV resolution) following inelastic scattering or proton production on 54Fe offers a rare opportunity to investigate (n, p) and (n, n') cross sections to higher-lying levels in a consistent way by the examination of γ-ray production rates.
Measurements have been performed on an enriched 54Fe sample (97.6%) using the neutron production and γ-ray detection facilities at the University of Kentucky Accelerator Laboratory. γ-ray excitation functions were measured for incident neutron energies from 1.5 to 4.7 MeV. Angular distributions and Doppler shifts were measured at En = 4.5 MeV. γ-ray production cross sections were deduced by considering all γ rays feeding or resulting from the decay of each level. Analogous measurements were made on natural Ti, V, Al and Fe samples for absolute normalization purposes. The results of our measurements will be presented in comparison to evaluated data (ENDF, JENDL, JEFF libraries) and with TALYS calculations.
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[1] J. R. Vanhoy et al., Nucl. Phys. A 972, 107 (2018).

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