Neutron Emission Spectra from Inelastic Scattering on Ni, Mo and Pb with a White Neutron Source at FIGARO

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Inelastic neutron scattering has been used in studies of nuclear structure and reaction mechanisms for many years. The data over a wide range of energies are also of great importance for applications. Experimentally, inelastic scattering has been studied with monoenergetic or continuous-in-energy (white) neutron sources. With the former, neutron-emission spectra can be measured by time-of-flight techniques for incident neutron energies available with monoenergetic sources ($E_n < 8$ MeV and 13 MeV $< E_n <$ 17 MeV). Gamma-ray production can be studied with either type of source. In this work, we measure neutron-emission spectra with incident neutrons produced by a white source by use of a double time-of-flight technique. This approach is intended to extend the neutron energy range available with monoenergetic sources and to take advantage of white-source techniques to measure these quantities over a wide range of incident neutron energies simultaneously in one experiment. To signal an inelastic scattering event, the gamma ray from the first excited level of the target nucleus to the ground state is detected either by a high-resolution germanium detector or a barium-fluoride scintillator. This is the start signal on measuring the time of flight of the emitted neutrons to liquid scintillators about 1 meter from the sample. From the time-of-flight information, the energy of the emitted neutrons can be calculated. We have studied the energy spectra of outgoing neutrons from the reactions Ni(n,n-γ)Ni, Mo(n,n-γ)Mo and Pb(n,n-γ)Pb as a function of incident neutron energy, using the white neutron beam of the WNR facility at the Los Alamos Neutron Science Center and the FIGARO facility over a range of incident neutron energies from threshold to 20 MeV. The high-resolution gamma-ray detector signals inelastic events on specific isotopes so that isotopic information can be obtained with elemental samples. Results of the emission spectra will be presented and compared with predictions of nuclear model calculations.

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