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Inelastic scattering of fast neutrons from excited states in ^{56}Fe

R. Beyer [a], R. Schwengner [a,*], R. Hannaske [a,b], A.R. Junghans [a], R. Massarczyk [a,b], M. Anders [a,b], D. Bemmerer [a], A. Ferrari [a], A. Hartmann [a], T. Kögler [a,b], M. Röder [a,b], K. Schmidt [a,b], A. Wagner [a]

[a] *Institute of Radiation Physics, Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany*
[b] *Technische Universität Dresden, 01062 Dresden, Germany*

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Abstract

Inelastic scattering of fast neutrons from ^{56}Fe was studied at the photoneutron source nELBE. The neutron energies were determined on the basis of a time-of-flight measurement. Gamma-ray spectra were measured with a high-purity germanium detector. The inelastic scattering cross sections deduced from the present experiment in an energy range from 0.8 to 9.6 MeV agree within 15% with earlier data and with predictions of the statistical-reaction code Talys. In addition to the γ-ray production cross sections, level cross sections for the 2^+, 4^+ and 6^+ yrast states in ^{56}Fe were deduced.

Keywords: Inelastic neutron scattering; Scattering cross sections; Photoneutron source; Gamma-ray spectra; Germanium detector; Statistical models

1. Introduction

Cross sections of neutron-induced reactions attract growing interest in the context of future nuclear technologies. In particular, there is a need of data with high accuracy for neutron capture and fission induced by fast neutrons for isotopes of uranium, plutonium, and minor actinoids.

* Corresponding author.

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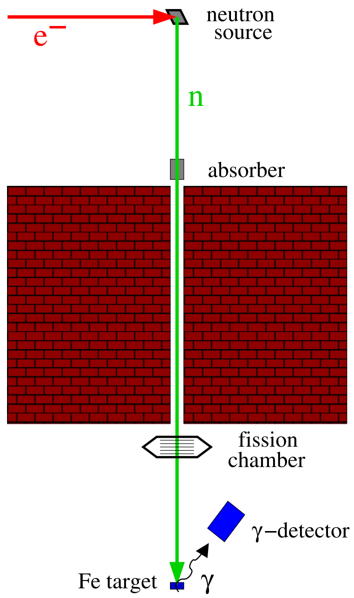

Fig. 1. (Color online.) Time-of-flight setup at the photoneutron source nELBE.

In addition, cross sections of inelastic scattering of fast neutrons from structural materials, such as sodium, iron, and lead are of great interest [1].

The present work describes experiments studying the inelastic scattering of neutrons in the energy range from 0.8 to 9.6 MeV using the photoneutron source nELBE at the superconducting electron accelerator ELBE of the Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Germany. We deduce cross sections and excitation functions of states in ^{56}Fe from intensities of γ rays following inelastic neutron scattering.

2. The photoneutron source nELBE

The photoneutron source nELBE consists of a circuit of liquid lead. The electron beam of about 3 mm in diameter passes a beryllium window and hits the liquid lead circulating in a molybdenum channel of 11.2 mm width. The intersection of the beam with the lead channel defines a volume of 0.6 cm^3. Liquid lead was chosen as the radiator material because the thermal load deposited by the electron beam (up to 25 kW) is too high to be dissipated from a solid target of such small size by gas cooling and heat radiation. Cooling with water is unfavorable because of neutron scattering and moderation. A detailed description of nELBE is given in Ref. [2].

The neutrons traveling at an angle of 95° relative to the incident electron beam enter the experimental area after passing a collimator in the concrete wall of 2.40 m thickness, followed by a 10 cm thick lead wall. The collimator consists of a combination of borated polyethylene and lead cylinders [2]. The experimental setup is schematically shown in Fig. 1. The incident neutron flux was monitored with a calibrated ^{235}U fission chamber [3] delivered by the Physikalisch-Technische Bundesanstalt (PTB) Braunschweig. As no moderation was applied, the short accelerator beam pulses of about 5 ps provided the basis for a good time resolution for time-of-flight experiments at a flight path of 6.2 m. The neutron intensity at the target position