NEUTRON RESONANCE STUDY OF A DELAYED NEUTRON EMITTER, ^{87}Kr

B.Fogelberg
The Studsvik Science Research Laboratory,
S-611 82 Nyköping, Sweden

J.A. Harvey, R.L. Macklin, S. Raman and P.H. Stelson
Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830*)

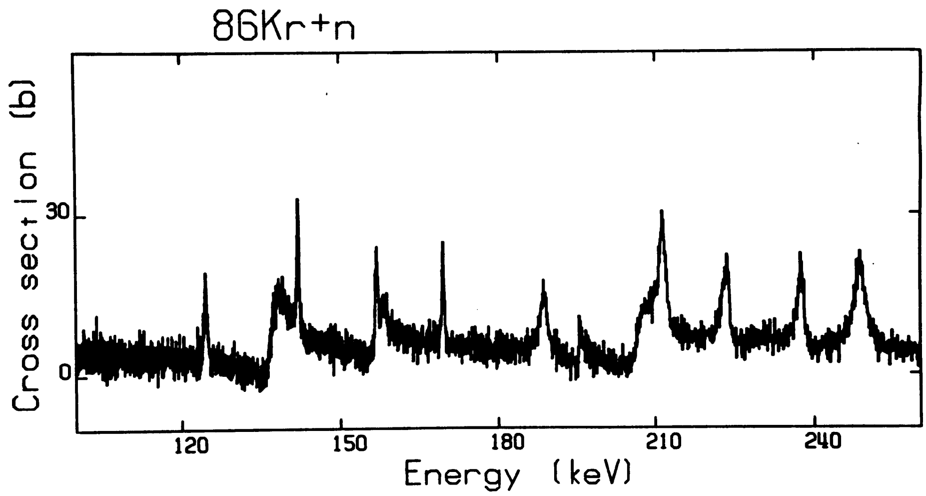
Abstract

The unbound levels in ^{87}Kr have been studied as neutron resonances up to 400 keV neutron energy at the ORELA linear electron accelerator. The observed p-wave resonances, with $I^{\pi} = 1/2^-$ and $3/2^-$ can also be populated in the β-decay of the $3/2^-$ ground state of ^{87}Br. When comparing the present results with previous studies of β-delayed neutron spectra, we find that almost all observed p-wave resonances can be identified with peaks in the delayed neutron spectra.

1. Introduction

The properties of the system $^{86}Kr + n$ is of considerable interest since the nucleus ^{87}Kr is a delayed neutron emitter, the daughter of the delayed neutron precursor ^{87}Br. The latter nucleus is, from systematics, believed to have a ground state spin and parity of $3/2^-$. Consequently, the unbound levels in ^{87}Kr with $I^{\pi} = 1/2^-$ and $3/2^-$ which are populated in the β-decay of ^{87}Br, can also be seen as resonances in high resolution measurements of the neutron cross section of ^{86}Kr. The β-decay populates also $5/2^-$ levels which are too narrow to be observed as neutron resonances even with the best of the present day facilities.

The most detailed delayed neutron spectrum obtained so far[1], has a resolution of about 15 keV which is not good enough to completely resolve the peaks in the spectrum. This has caused some debate about the significance of the peak structure observed in delayed neutron spectra. Statistical calculations made by Gjøtterud et al.[2] and Hardy et al.[3] show that delayed particle spectra of medium mass nuclei in general are recorded with far too low resolution to permit interpretation of the observed peaks as individual transitions. Other workers, e.g. Kratz et al.[4] and Prussin et al.[5] claim that there may be good reasons to expect only a small number of unbound levels with a strong β-particle population, which would make delayed neutron spectroscopy a new method to study individual levels, at least in selected cases. This debate can not be settled without a good knowledge of the level density in the unbound region, which so far has been unknown for delayed neutron emitters. The main goal of the present study has been to provide data for an accurate determination of the level density in ^{87}Kr, for the first few hundred keV over the binding energy and also to compare high resolution neutron cross section results with the delayed neutron and γ-ray studies of the ^{87}Br decay.



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2. Experiment

The measurements were carried out using time of flight techniques at the ORELA pulsed neutron source at ORNL. The figure shows the total cross section for ^{86}Kr obtained in transmission for neutron energies 100 - 260 keV. The s-wave resonances, representing $1/2^+$ levels, are seen as broad asymmetric structures. The p-wave resonances, corresponding to $1/2^-$ and $3/2^-$ levels are sharper and symmetric. In the delayed neutron, measurement by Nuh et al.[1], all except two of the p-wave resonances seen here were observed as delayed neutron transitions.

References

1) F.M. Nuh, D.R. Slaughter, S.G. Prussin, H. Ohm, W. Rudolph and K.L. Kratz, Nucl. Phys. A293, 410 (1977).

2) O.K. Gjøtterud, P. Hoff and A.C. Pappas, Nucl. Phys. A303, 295 (1978).

3) J.C. Hardy, B. Johnsson and P.G. Hansen, Nucl. Phys. A305, 15 (1978).

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5) S.G. Prussin, Z.M. Oliveira and K.L. Kratz, Nucl. Phys. A321, 396 (1979).

DISCUSSION

J.C. Hardy: This is a very valuable test of the methods used to analyse delayed-neutron spectra. It is particularly gratifying to see that the results bear out expectations of level-densities in this region. As expected, ther is a one-to-one correspondence between delayed-neutron peaks and individual levels for the first few hundred keV in the spectrum from the decay of ^{87}Br. However, the implications of this are that at higher energies, and in other neutron emitters, statistical expectations will also be borne out: There the one-to-one correspondence will not hold, and each neutron peak will correspond to several (or many) levels.

B. Fogelberg: That is true. Delayed neutron spectroscopy must be made with a lot of caution with the resolution available today. At higher neutron energies, corresponding to higher excitation, the level widths will also become so large that meaningful spectroscopy is impossible.

K.L. Kratz: On the basis of the existing data for ^{87}Kr (neutron cross sections and ^{87}Br β-delayed neutrons) we have performed neutron spectrum simulations similar to those of Gjøtterud et al. and Hardy et al., which indicate that peak stripping analyses for the low-energy range of neutron spectra from precursors not too far from stability are reasonable. By comparing the results of the analyses of experimental and simulated spectra, one can deduce level densities with rather good precision. A first application to the case ^{137}I is presented in Z.Physik A236 (1980) 23, Figs. 5 and 6.

P.G. Hansen: Whether the lines are resolved or not, we expect the distribution of the reduced widths within one class of I^π to be governed by the Porter-Thomas law. Have you fitted your data to this, what is the expected number of unobserved resonances, and can these explain the discrepancy between calculation and theory of level densities that was shown by Kratz?

B. Fogelberg: The experimental detection limit together with the Porter-Thomas distribution data give an estimate of 6 unobserved resonances in the region 0-400 keV. This small number is insignificant for the level density derived here. I can't answer the second question.