BNL-18977

Conf-740920--7

AVERAGE P-WAVE RESONANCE CAPTURE SPECTRA FROM ISOTOPES OF MOLYBDENUM[+]

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ABSTRACT

The 24 keV Fe-filtered beam has been used to study p-wave capture on even Mo targets. The capture γ-ray spectra show pronounced correlations with final state spectroscopic factors. The valence model is only of limited success in accounting for these correlations.

The observation of correlations between radiative intensities and neutron widths in resonances has been most pronounced near the 3p neutron single particle resonances.[1] In this paper we report the results of average resonance capture in Mo isotopes, using the 24.3 keV filtered beam with $\Delta E \approx 2$ keV, at the HFBR reactor at Brookhaven. We discuss capture in ^{92}Mo, ^{94}Mo, ^{96}Mo and ^{98}Mo, a sequence of targets in which the d5/2 shell is filling, and in which the low-lying states are predominantly s and d levels with large single-particle components. Of particular interest is the behavior of the averaged resonance radiative strength with the final state spectroscopic factor and the size of the average radiative strength.

The Mo samples were highly enriched isotopes in metallic powder or oxide form. The samples, from 12 to 50 grams in weight, were viewed with a 24 cm^3 intrinsic planar germanium diode shielded by 7.6 cm of ^{6}LiH. Each sample was run for about 3 days in a 24 keV flux of $\sim 10^5$ n/cm/sec, and a detector resolution of 7 keV. Composite samples of ^{10}B and molybdenum were run to obtain partial cross sections relative to the ^{10}B(n,$\alpha\gamma$) reaction. The odd isotopes ^{95}Mo and ^{97}Mo were also examined, but these are not discussed here.

The results of these experiments are summarized in figures 1-4, which compare, in arbitrary units, the observed partial radiative cross sections to the predictions of the valence neutron model,[2] based on (d,p) data of Moorhead and Moyer.[3] Also shown in figure 5 is a typical spectrum of the set, the one for ^{92}Mo(n,γ)^{93}Mo.

A casual examination of these intensity plots suggest the presence of correlations between the (n,γ) and (d,p) intensities. A quantitative measure of the correlation is given in the figures for each isotope; in each case the correlation is significant, being highest for ^{98}Mo. These results confirm the suggestions of previous experiments that simple reaction mechanisms compete favorably with statistical decay in this region. We briefly summarize the results of our measurements in the following paragraphs.

<u>^{92}Mo(n,γ)^{93}Mo</u>. Due to the large level spacing of ^{92}Mo resonances only a few resonances contribute to the capture. The p3/2 resonance at 23.9 keV is expected to dominate the capture spectrum. A comparison of the spectrum with that obtained

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[+]Work supported by the U.S. Atomic Energy Commission.

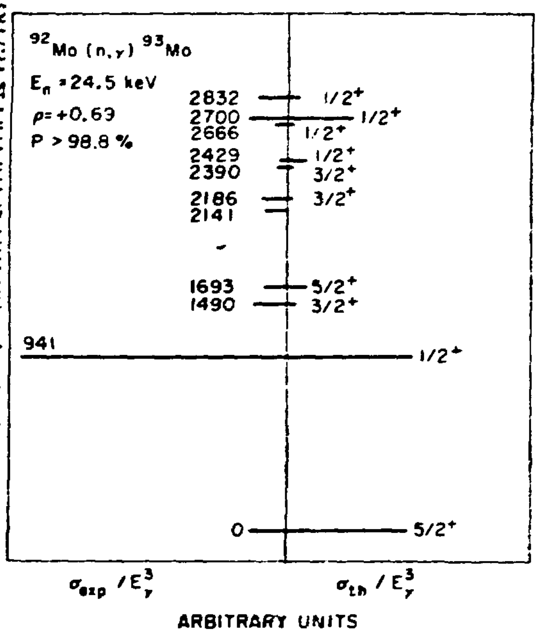

Fig. 1. Radiative intensities compared to d,p stripping factors for ^{92}Mo targets.

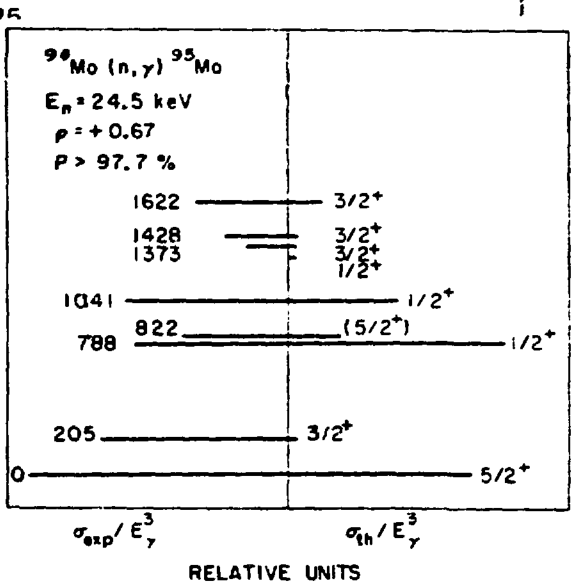

Fig. 2. Radiative intensities compared to d,p stripping factors for ^{94}Mo targets.

by Wasson and Slaughter at Oak Ridge for the 23.9 keV resonance shows that the two spectra are similar.

The large correlation is due mainly to the strong transition to the 941 keV 1/2 + level in ^{94}Mo. In fact, the spectra of all isotopes are noticeable for the s1/2 transition strengths. The partial cross sections to the $5/2^+$ g.s., 941 keV $1/2^+$, and 1490 keV $3/2^+$ states are 2.1, 11.1, and 1.0 mb, respectively. The valence model, or single particle transition model, can only account for about 3.7 mb out of the observed 11.1 mb cross section; thus we agree with the conclusions of Wasson and Slaughter that the valence, or single particle transition model, is inadequate to account for the strength of the p3/2 or p1/2 → s1/2 transition.

<u>^{94}Mo(n,γ)^{95}Mo.</u> Here the single particle strength of the final states is more fragmented. We see strong transitions to the 6 low-lying levels of ^{95}Mo. The ground state transition is observed to have an average partial cross section of 5.6 mb. The valence model cannot predict the 3.9 mb observed strength to the $3/2^+$ 204 keV state, which has a small spectroscopic factor, but for the other transitions the agreement is reasonably good. The two low-lying s1/2 states at 788 and 1041 keV are strongly fed.

<u>^{96}Mo(n,γ)^{97}Mo.</u> With the further filling of the d5/2 orbital the single particle strength is

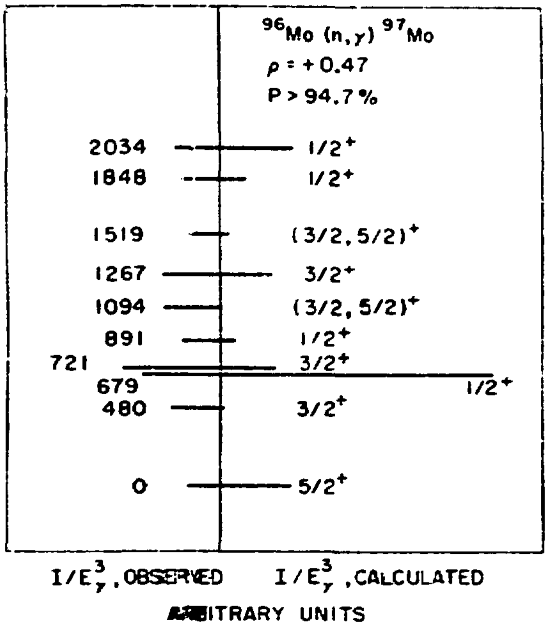

Fig. 3. Radiative intensities compared to d,p stripping factors for ^{96}Mo targets.

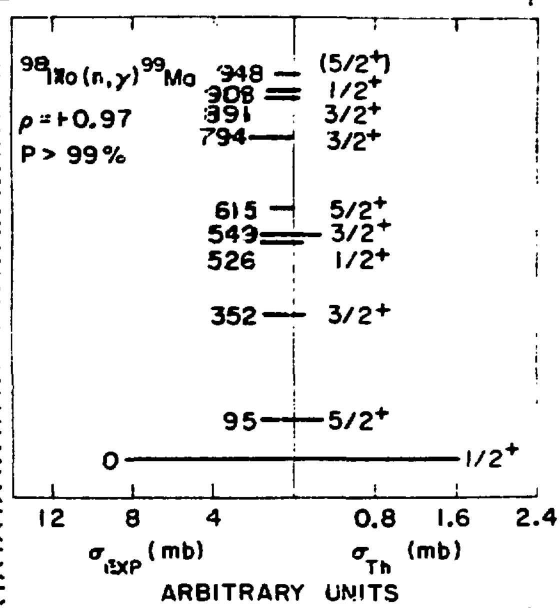

Fig. 4. Radiative intensities compared to d,p stripping factors for ^{98}Mo targets.

further diluted among many states and here the spectrum does not exhibit the strong transitions observed in ^{92}Mo and ^{94}Mo. A positive correlation is still observed but the correlation coefficient is smaller than in the case of ^{92}Mo and ^{94}Mo. The ground state transition is observed to have a cross section of 1.65 mb. The valence model generally underpredicts the observed cross section, except for the s1/2 state at 680 keV, where the agreement is good. On the other hand, the giant dipole resonance extrapolations[5] accounts reasonably well for the other transition strengths.

^{98}Mo(n,γ)^{99}Mo. In ^{98}Mo the d5/2 orbital is closed and the transition to the s1/2 ground state in ^{99}Mo is the dominant transition in the spectrum. A large correlation is observed between the experimental cross section and the calculated strength for the valence neutron transition as seen in figure 4. The ground state γ-ray transition has a strength of 7.7 mb which may be compared to a valence model prediction of 5.0 mb, or a giant dipole resonance extrapolation of 2.5 mb. The transition to the 3/2$^+$ 794 keV level (2.1 mb) appears to be higher than predicted by the giant resonance extrapolation (1.2 mb). This situation is similar to that observed in 3/2$^+$ levels for ^{94}Mo or ^{96}Mo targets, and cannot be explained by the valence component, since the final state spectroscopic facts are small.

In general it may be concluded from the intensity plots of figures

1-4 that the valence model is considerably more successful in ^{98}Mo than in ^{92}Mo. On the basis of the predicted and measured strength to the s1/2 states in these nuclides, one would estimate that about 35% of the strength in ^{92}Mo can be attributed to valence transitions, while about 65% can be so attributed in ^{98}Mo. This difference in the relative valence contribution can be related to the neutron strength function, which increases a factor of two in going from ^{92}Mo to ^{98}Mo. No such large change is noticeable the E-1 strength function.

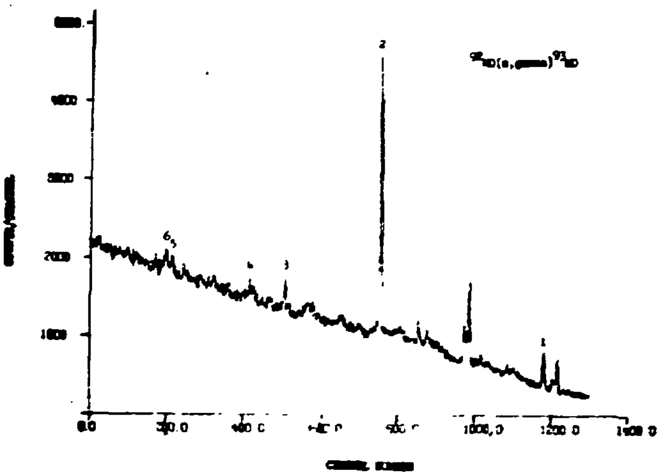

Fig. 5. Capture spectrum for ^{98}Mo at 24.3 keV.

Evidently both core and valence excitations play a part in radiative decay the Mo isotopes. The enhanced transition strengths, particularly in ^{92}Mo, may explainable as a superposition of these two reaction mechanisms.

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