NOTICE

MIN ONLY

**PORTIONS OF THIS REPORT ARE ILLEGIBLE. It
has been reproduced from the best available
copy to permit the broadest possible avail-
ability.**

NOTICE
This report was prepared as an account of work
sponsored by the United States Government. Neither the
United States nor the United States Department of
Energy, nor any of their employees, nor any of their
contractors, subcontractors, or their employees, makes
any warranty, express or implied, or assumes any legal
liability or responsibility for the accuracy, completeness
or usefulness of any information, apparatus, product or
process disclosed, or represents that its use would not
infringe privately owned rights.

SYSTEMATICS OF FRAGMENTATION OF NILSSON STRENGTH NEAR $A=190^*$

MASTER
MASTER

R. F. Casten, D. D. Warner and J. A. Cizewski

Brookhaven National Laboratory, Upton, New York,
Institut Laue Langevin, Grenoble, France and
State University of New York, Stony Brook, New York

ABSTRACT: It is shown that the systematics of the fragmentation of
Nilsson strength in the Hf-Os region can be understood in terms of
varying quadrupole and hexadecapole deformations.

The low-lying states in the Hf and W nuclei are well understood
in a Nilsson model basis. At higher energies, many more levels are
populated in the (d,p) reaction than are expected. In Os, such
states occur below 500 keV and, in fact, even the lowest states are
not as simply understood. The "high lying" Nilsson strength is thus
clearly fragmented and a detailed description of individual levels
is not currently within reach. Yet, sums of (d,p) cross sections
over ensembles of states show a dramatic systematics, shown in Fig.
1, which suggests that the gross trends may have a simple origin.
In Fig. 1 the empirical sums only include unassigned levels and are
mostly only recently available, due primarily to the use of average
resonance capture (n, γ) measurements to establish complete sets of
 $1/2^-, 3/2^-$ levels and, by elimination, non- $1/2^-, 3/2^-$ levels. For
 191Os , the measured (d,p) cross sections have been divided by em-
pirical U^2 factors to get effective single particle strengths. We
also note that the distribution of $J^\pi=1/2^-, 3/2^-$ strength in 187W
and 191Os , and of $J^\pi \neq 1/2^-, 3/2^-$ strength in $191, 193\text{Os}$, splits into
two major groupings, at energies of ~ 0.5 and ~ 1.5 MeV. For 193Os ,
nearly all $1/2^-, 3/2^-$ (d,p) strength is below 500 keV and the cross
section to the lowest states, assigned to the $1/2^-$ -[510] and $3/2^-$ -[512]
orbitals, greatly exceeds that expected.

A simple interpretation of these systematics relies on the
characteristic behavior of the relevant Nilsson orbits which fall
into two classes, namely equatorial orbits, $\{1/2^-$ -[501], $3/2^-$ -[501]
and $5/2^-$ -[503] $\}$, which are strongly upsloping with increasing ϵ_2 and

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

ep

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

ϵ_4 and polar orbits, $\{1/2+[651], 1/2+[640], 1/2-[770] \text{ and } 3/2-[761]\}$, which are downsloping with increasing ϵ_2 and upsloping with increasing ϵ_4 . The $J^\pi=1/2^-, 3/2^-$ cross section originates almost solely in the $1/2-[501]$ and $3/2-[501]$ orbits, the $J^\pi \neq 1/2^-, 3/2^-$ strength in the $5/2-[503]$ and $N=6$ orbits.

Calculations, with the code DIET written by B. S. Nilsson, of Nilsson energies are presented in Fig. 2 for ϵ_2 and ϵ_4 values based on Coulomb nuclear interference measurements^{4,5} in adjacent even-even nuclei. We note that the interpretation below relies not so much on the absolute values of ϵ_2 and ϵ_4 as on the relative changes in them.

Near $183, 184\text{W}$, ϵ_4 is a maximum and all the orbits considered are high lying and partly outside the energy ranges studied leading to reduced empirical strength. For $1/2^-, 3/2^-$ states, the closeness of the $3/2-[501]$ and $N=7$ orbits, with their consequent $\Delta N=2$ and Coriolis mixing, further fragments the strength. In 187W , 191Os , ϵ_4 drops, and so do the $N=5$ orbits. $|E(3/2-[501]) - E(3/2-[761])|$ increases and thus the $\Delta N=2$ mixing decreases. Thus the $J^\pi=1/2^-, 3/2^-$ strength from the $3/2-[501]$ is both less fragmented and considerably lower in excitation energy. However, now the $1/2-[501]$ orbit drops close to the $N=7$ orbits and thus forms a second "pocket" of fragmented $1/2^-, 3/2^-$ strength ~ 1 MeV above the lower group. The decreases in ϵ_2 and ϵ_4 near 191Os combine to force a sharp drop in energy for the $5/2-[503]$ orbit and, due to offsetting effects, a lesser drop for the $N=6$ orbits. The summed $J^\pi \neq 1/2^-, 3/2^-$ strength should increase and appear lower in the spectrum but here as well a split should develop.

Fig. 1 Ratios of summed (unassigned) experimental (refs. 1,2) to theoretical (d,p) cross sections plotted separately for the convenient spin categories $J^\pi=1/2^-, 3/2^-$ (or the nearly equivalent $0^+, 1^+, 2^+$ states in 184W) and $J^\pi \neq 1/2^-, 3/2^-$. See refs. 3 for further details.

Fig. 2 Nilsson energies (quasiparticle energies are lower) and energy differences.

In ^{193}Os , the principal deformation change is a drop in ϵ_2 . Thus, the $N=6$ and 7 orbits rise sharply and the $N=5$ orbits drop. The $3/2^-$ -[501] and $5/2^-$ -[503] orbits approach very close to the Fermi surface. A fragment of the $1/2^-$ -[501] orbit (unperturbed energy ~ 1 MeV) is also probably forced rather low in energy by interaction with nearby vibrational modes. The behavior of the $N=6$ and $5/2^-$ -[503] orbits increases the split of $J^\pi=1/2^-, 3/2^-$ strength and supports the present ideas in that the states contributing to the lowest $J^\pi=1/2^-, 3/2^-$ strength in ^{193}Os have indeed recently been assigned as $5/2^-$. The presence of most of the $N=5$ strength well below vibrational energies accounts for the falloffs in Fig. 1. First, considerable strength is artificially lost due to pairing correlations ($U^2 \neq 1$). Secondly, as explained in another contribution to this conference (Warner et al.), a more quantitative treatment now becomes possible and shows that the low lying $3/2^-$ $1/2^-$ -[510] and $5/2^-$ $3/2^-$ -[512] states receive substantial (d,p) cross sections from the $3/2^-$ -[501], $5/2^-$ -[503] and $1/2^-$ -[501] orbits via Coriolis mixing. This cross section, appearing in "assigned" states was not included in the sums in Fig. 1.

Although the above interpretation accounts for the gross trends and even some details of the fragmentation systematics one must, however, be cautious in relying too heavily on a Nilsson model description in this region characterized by rapidly changing core shapes. An alternate approach, under current study, is an intermediate coupling scheme which may provide a more flexible means of incorporating non-rotational anharmonicities.

REFERENCES

- * Work supported by the U.S. DOE under Contract No. EY-76-C-02-0016.
- 1. M.N. Vergnes and R.K. Sheline, Phys. Rev. 132, 1736 (1963); D. Benson, Thesis, Florida State Univ. Also, D. Benson et al. Z. Phys. A281, 145 (1977) and A285, 405 (1978).
- 2. R.F. Casten et al., Mat. Fys. Med. Dan. Vid. Selsk 38, No. 13 (1972).
- 3. R.F. Casten and W.R. Kane, Phys. Rev. C7, 419 (1973); R.F. Casten et al. Nucl. Phys. A228, 493 (1974) and A285, 235 (1977).
- 4. F.T. Baker et al., Nucl. Phys. A258, 43 (1976).
- 5. I.Y. Lee et al., Phys. Rev. C12, 1483 (1975) and Phys. Rev. Lett. 33, 383 (1974).