Candidates for the $K^\pi = 1^+\ \frac{5}{2}^+[402]_\pi - \frac{3}{2}^+[402]_\pi$ Band in ^{186}Os ◇

A.A. Phillips [a], P.E. Garrett [a], L. Bettermann [b], N. Braun [b], D.G. Burke [c], G.A. Demand [a], T. Faestermann, P. Finlay [a], K.L. Green [a], R. Hertenberger, R. Krücken, K.G. Leach [a], M.A. Schumaker [a], C.E. Svensson [a], H.-F. Wirth, and J. Wong [a]
[a] Department of Physics, University of Guelph, Guelph, ON, Canada N1G 2W1
[b] Institut für Kernphysik, Universität zu Köln, D-50937 Köln, Germany
[c] Department of Physics and Astronomy, McMaster University, Hamilton, ON, Canada L8S 4M1

1. Introduction

A resolution of the vibrational structure debate of the $K^\pi = 4^+_1$ bands in Os isotopes may be emerging. The nature of the 4^+_3 states was argued to be dominantly a single-hexadecapole phonon structure, or a two-phonon γ-vibration. The hexadecapole view is supported by inelastic scattering results [1] and population in single-proton transfer (t,α) studies [2], while the two-phonon view is supported by B(E2) value measurements and lifetimes [3,4,5]. We set out to provide more data for the debate by performing ^{185,187}Re(^{3}He,d)^{186,188}Os reactions, in which we observed a strong population of the 4^+_3 states that was consistent with recently published Quasiparticle Phonon Model (QPM) calculations [6]. These calculations reveal a dominant hexadecapole component along with a large $\gamma\gamma$ component, providing a unified interpretation of all available data in this conflict. Since the 2007 annual report focused the 4^+_3 debate, this report will provide an update regarding other results on the structure of ^{186}Os.

2. Experiment

The 1.2 μA 30 MeV ^{3}He beams bombarded ^{185,187}Re targets mounted on carbon backings, while the Q3D spectrograph was used at 9 angles between 5° and 50° to separate the reaction products according to momentum. The position-sensitive proportional counter with cathode-foil readout provided particle identification and energy measurements, with typical energy resolutions ranging from 6.3 keV to 13 keV FWHM. Two momentum bites were employed to examine states up to 3 MeV in excitation energy and known peaks from ^{194,195}Pt(^{3}He,d)^{195,196}Au allowed identification of Os levels through an energy calibration. The uncertainty in level energies is approximately 1-2 keV resulting from the uncertainty on the peak position combined with the uncertainties in the calibration polynomial.

3. Results

Since odd-A targets were used, the observed cross section is a summation over all allowed angular momenta, however, it was found that the (^{3}He,d) angular distributions were well approximated by a single ℓ value. The cross sections can be expressed as:

$$\frac{d\sigma}{d\Omega} = g^2 C^2_{j,\ell} U^2 \left|\langle I_i K_i j \Delta K | I_f K_f\rangle\right|^2 \left[N\frac{d\sigma}{d\Omega}(\theta,\ell,j)\right] \quad (1)$$

which includes the Nilsson wave function amplitudes ($C^2_{j,\ell}$), a pairing factor (U^2), a Clebsch-Gordan coefficient to account for angular momentum selection rules, and distorted wave Born approximation calculations of the angular distribution of a particle being transferred with j,ℓ angular momentum. Note that if one j-value has a dominant $C_{j,\ell}$ for a rotational band, the population of band members is governed by the size of the Clebsch-Gordan coefficient, therefore a band member search was conducted looking for measured cross-sections which have similar ratios to Clebsch-Gordan coefficients(Table 1). Candidates for $K^\pi = 1^+$ bands were found in ^{186}Os and are summarized in Table 2. If it is assumed that the moment of inertia of a $K^\pi = 1^+$ band is similar to the ground state band, only states in the first group of Table 2 are candidates for being rotational band members. We propose that the 2321.5(5) keV, 2406.7(6) keV, and 2513.1(11) keV levels be further explored as candidates for the 1,2,3 members of a $K^\pi = 1^+$ band.

	Clebsch-Gordon Coefficients $\langle\frac{5}{2}\frac{5}{2}\frac{3}{2}-\frac{3}{2}\mid I_f 1\rangle$			Rotational Energy $I_f(I_f+1)$	
I_f	CG	$\lvert$CG$\rvert^2$	Ratio	$-K_f(K_f+1)$	Ratios
1	0.707	0.500	1	0	0
2	0.598	0.357	0.714	4	1
3	0.354	0.125	0.250	10	2.5
4	0.134	0.018	0.036	18	4.5

Table 1: Expected properties of a $K^\pi = 1^+$ band from the $\frac{5}{2}^+[402]_\pi - \frac{3}{2}^+[402]_\pi$ configuration. The rotational parameter of the ground state band is about 21 keV, so the rotational energies would be approximately 0 keV, 84 keV, 210 keV, and 378 keV.

Energy (keV)	$\frac{d\sigma}{d\Omega}$ (μb/sr)	Ratio	Spacing (keV)	Ratio
2321.5(5)	15.9(10)	1	0	0
2406.7(6)	12.4(8)	0.78(7)	85.2(8)	1
2513.1(11)	4.4(5)	0.28(4)	191.6(12)	2.25(5)
2406.7(6)	12.4(8)	1	0	0
2531.3(6)	9.0(10)	0.73(9)	124.6(9)	1
2659.4(15)	3.5(6)	0.28(5)	252.7(16)	2.03(3)
2542.7(8)	13.1(11)	1	0	0
2583.0(10)	8.4(7)	0.64(8)	40.3(13)	1
2659.4(15)	3.5(6)	0.27(5)	116.7(18)	2.90(9)

Table 2: Properties of $K^\pi = 1^+$ band member candidates in ^{186}Os. The cross section measurements used are at a 40° deuteron scattering angle. Three separate groups for the 1,2,3 members are presented, but only the states in the first group are considered to be candidates.

References

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◇ Supported in part by the Natural Sciences and Engineering Research Council of Canada