Comment on "Experimental Evidence of Core Modification in the Near Drip-Line Nucleus ^{23}O"

A recent Letter by Kanungo *et al.* [1] presents measurements of inclusive one- and two-neutron removal reactions of ^{23}O at a beam energy of 72 MeV/nucleon. The longitudinal momentum ($p_{\|}$) distributions of the residues were analyzed in a model which couples a nucleon to inert core states. The conclusion was that the "first clear evidence" was obtained of a structure change in the ^{22}O core. In this Comment we point out that a well-developed framework exists [2,3] for analysis of such data. For the neutron-rich oxygen isotopes this approach is in good agreement with the measurements and moreover with the normal expectations of the *p-sd* shell structure.

Difficulties in the paper by Kanungo *et al.* arise on two fronts: (i) one cannot describe one-neutron removal reactions without recourse to the many-body nature of ^{23}O, and (ii) partial cross sections to individual final states, obtained for other nuclei from γ ray coincidences, were not measured. Still, inclusive measurements can provide a stimulating first survey [4].

Energy levels and spectroscopic factors for states in the daughter nucleus ^{22}O up to the neutron threshold of 6.85(6) MeV obtained with the universal *sd* (USD) interaction [5,6] in the *sd* model space are given in Table I. With USD ^{23}O has a $1/2^+$ ground state with a first excited $5/2^+$ state at 2.7 MeV [6], close to the neutron threshold of 2.74(12) MeV. Since it is known in this mass region that the $0d_{5/2}$, $1s_{1/2}$, and $0d_{3/2}$ shells are regularly spaced with pronounced submagic numbers at 14 and 16 [7], a near-quantitative understanding of the results can be reached by elementary means. We may approximate ^{23}O as the configuration $[0d^6_{5/2}] \otimes 1s_{1/2}$. Taking the $\ell = 0$, two single-particle cross sections σ_ℓ from Table I as 64 and 23 mb, we estimate $\sigma_{1n} = \sigma_0 + 6\sigma_2 = 202$ mb, which agrees with the datum [1] of 233(37) mb. This configuration also suggests that the $0d_{5/2}$ hole and $1s_{1/2}$ particle will couple to 2^+ and 3^+ final states with spectroscopic factors of 2.5 and 3.5. The cross section for removing one *d*-shell neutron from ^{22}O has been measured [4] at 51 MeV/nucleon to be 122 mb, likewise in good agreement with the elementary estimate $6\sigma_2 = 125$ mb. The $p_{\|}$ distribution has a measured width of 206(4) MeV/c compared with the calculated value of 225 MeV/c.

TABLE I. Calculated spectroscopic factors and nucleon removal cross sections in the reactions ^{12}C(^{23}O, ^{22}O(I^π))X.

Energy (MeV)	I^π	ℓ	C^2S	σ_{sp} (mb)	σ_{1n} (mb)
0	0^+	0	0.797	64.2	51.2
3.38	2^+	2	2.130	22.8	48.6
4.62	0^+	0	0.115	32.0	3.7
4.83	3^+	2	3.079	20.4	62.9
5.32	1^-	1	0.851	17.8	15.2
5.93	0^-	1	0.332	16.9	5.6
6.50	2^+	2	0.242	18.0	4.4
				Sum:	191

Results of the full *sd* shell calculation are given in Table I. We may identify the 2^+ and 3^+ states with the 3.19 and 4.57 MeV levels of Sorlin *et al.* [8]. The table also includes the *p*-shell strength below the neutron threshold obtained with the *p-sd* shell WBP interaction [9]. The σ_{1n} is now 191 mb, in agreement with experiment.

The one-neutron knockout to unbound *p*-shell states may account for most of the measured σ_{2n}. With estimated $p_{1/2}$ and $p_{3/2}$ separation energies of 12 and 17 MeV, the total cross section from the unbound *p*-shell states (with a total $C^2S = 4.82$) is 55 mb. A further contribution comes from simultaneous $2n$ knockout. Extending the eikonal expressions [3] we obtain cross sections 0.91 and 0.57 mb for *sd* and *dd* pair removal, respectively. Simple combinatorics give 6 *sd* and 15 *dd* pairs, a direct σ_{2n} of 14 mb, and a total of 69 mb, in agreement with the measurement of 82(25) mb [1].

The $p_{\|}$ distribution for σ_{1n} with has a FWHM of 122 MeV/c. The measured values are 114(9) [4] and 73(15) MeV/c [1]. As this width results from s (75 MeV/c) and d (225 MeV/c) distributions, its shape is sensitive to their C^2S values and to the neutron separation energy. γ coincidence data [3] are crucial for a complete test of our results. The $p_{\|}$ distribution for σ_{2n} is expected to be dominated by a single-neutron $\ell = 1$ knockout with FWHM of about 160 MeV/c which would account for most of the data of Fig. 3(c) in [1].

Contrary to the statement in [1] that "proper reaction theory" is lacking, we find that all observations in this work can be accounted for.

The support of NSF Grants No. PHY 0110253 and No. PHY 0070911 and EPSRC (U.K.) Grant No. GR/M82141 is acknowledged.

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Received 29 April 2002; published 17 April 2003
DOI: 10.1103/PhysRevLett.90.159201
PACS numbers: 21.10.Dr, 27.30.+t

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 0031-9007/03/90(15)/159201(1)$20.00