Nucleus ^{26}O: A barely unbound system beyond the drip line[†]

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The unbound nucleus ^{26}O has been investigated using invariant-mass spectroscopy following a one-proton removal reaction from a ^{27}F beam at 201 MeV/nucleon. The ground state of ^{26}O has recently been found to be barely unbound with respect to two-neutron emission – by 53 keV (1σ upper limit) in an intermediate energy reaction study[1,2] and by 120 keV (upper limit with a 95% confidence level) at high energies.[3] The 2_1^+ state has yet, however, to be located. It may be noted that Ref.[3] claimed the existence of a level at 4.2 MeV, which could be a proton-hole state, although the statistics were limited.

The ^{27}F secondary beam was produced by projectile fragmentation of ^{48}Ca (∼140 pnA) at 345 MeV/nucleon. It was purified using BigRIPS and transported to a secondary target of carbon (thickness 1.8 g/cm^2). The decay products, ^{24}O and neutron(s), were measured in coincidence using the spectrometer SAMURAI.[4] In addition to the measurements made of ^{26}O with the ^{27}F beam, data were also taken for one-proton removal from a ^{26}F beam leading to ^{25}O.

The obtained relative energy spectrum of ^{25}O was fitted with a d-wave Breit-Wigner line shape, following the prescription of Ref.[3], after taking into account the experimental response function. In practice this was done using a complete simulation of the setup based on GEANT4 and employing the QGSP_INCLXX physics model for the neutron interactions in NEBULA. A resonance energy of 749(10) keV and a width of 88(6) keV were deduced.

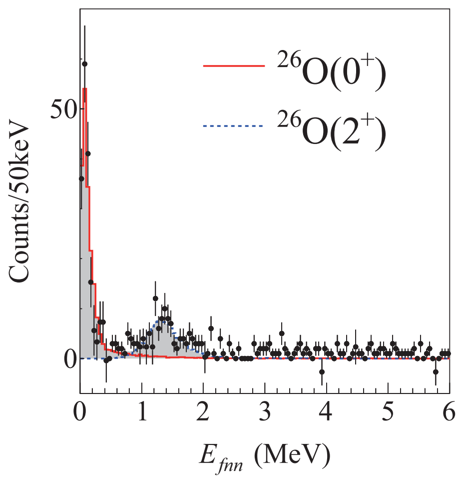

Fig. 1. Three-body decay energy spectrum of ^{26}O reconstructed from ^{24}O and two neutrons in the one-proton removal reaction from ^{27}F.

Turning now to ^{26}O, the ground-state resonance was found to lie only 18±3(stat)±4(syst) keV above the threshold (Fig. 1). In addition, a higher level, which is most likely the first 2^+ state, was observed for the first time at $1.28^{+0.11}_{-0.08}$ MeV. On the other hand, no resonance-like structure was observed at higher energies as reported in Ref.[3]. Comparison of the ^{26}O(2_1^+) energy with theory suggests that three-nucleon forces, pf-shell intruder configurations, as well as an appropriate treatment of the continuum are key elements to understanding the structure of the heaviest oxygen isotopes.

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