

First Observation of the Four-Proton Unbound Nucleus ^{18}Mg

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Background

Even-isotopes: 2p emitters

momentum correlations in
three-body decays



structure of the nucleus prior to its
decay

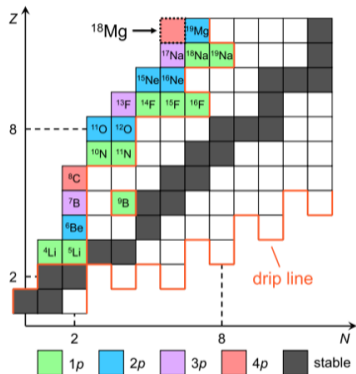
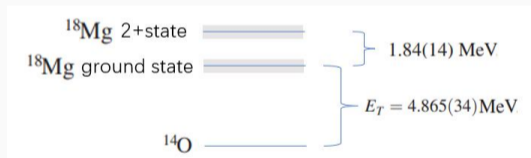


FIG. 1. Subsection of the chart of nuclei. Those nuclei which have been shown experimentally to decay by 1p (green), 2p (blue), 3p (purple), and 4p (pink) emissions are highlighted.

Overview

- Observed ^{18}Mg ($N=6$) through $^{14}\text{O}+4p$ events
- $^{18}\text{Mg} \rightarrow ^{16}\text{Ne} \rightarrow ^{14}\text{O}$
- Found $2+$ state in ^{18}Mg
- Found decay energy:



Importance: provide evidence for the demise of the $N = 8$ shell closure in ^{18}Mg .

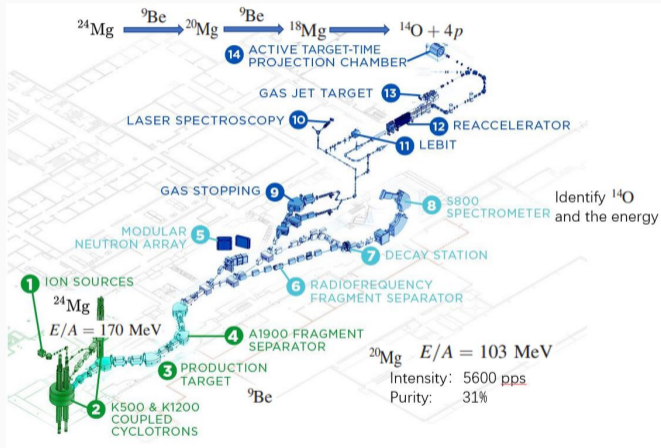
Experiment

Detection of proton:

silicon detector, backed by array of CsI(Tl) crystals.

Detection of ^{14}O :

array of scintillating fiber ribbons: provided the hit position;
S800 spectrograph : provide identification and energy.



Experiment

Calibration:

silicon detector: ^{232}U alpha source

CsI(Tl) detectors :use a 120 MeV proton beam and two degraders of different thicknesses.

invariant-mass method: reconstructing the previously measured invariant mass of ^{16}Ne .

$Q_{2p}(^{16}\text{Ne}_{g.s.}) = 1.425(4)\text{MeV}$, consistent with $1.401(20)\text{MeV}$ from AME2020 .

Experiment results

$$Q_{4p} = 4.865(34)\text{MeV}$$

$$E_T = 6.71(14)\text{MeV}$$

excitation energy : 1.84(14) MeV

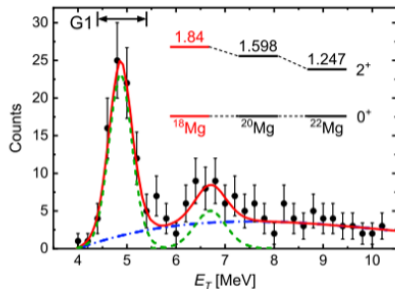


FIG. 2. Decay energy (E_T) spectrum for all detected $^{14}\text{O} + 4p$ events. The solid-red curve shows the fitted spectrum with the contributions for each state given by the dashed-green curves and the smooth background by the dashed-dotted-blue curve. The short solid vertical lines indicate the gate (G1) used to select $^{18}\text{Mg}_{\text{g.s.}}$ events. The inset shows the excitation energies of the first 2^+ states of the light magnesium isotopes. The numbers give the excitation energies in MeV of the 2^+ states.

Experiment results

Width of peaks { intrinsic decay widths of the resonances
experimental resolution

Obtain the intrinsic decay width:

Method: Monte Carlo simulation

- Breit-Wigner intrinsic line shapes
- experimental resolution and E_T dependent efficiency .

Result:

intrinsic widths : 115(100) and 266(150) keV.

experimental resolutions: 520 and 640 keV.

