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Refuting the Nature of the Sixth 0+Hoyle-analogue State Candidate in ¹⁶O

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Clustering Experimental Apparatus and Technique

Clustering



[D.M. Brink, 1967]

- The 0_6^+ state in ¹⁶O, situated at 15.097 MeV, is a primary candidate for a Hoyle-analogue state.
- In particular, theoretical predictions suggest that this state may be a Bose Einstein Condensate.

[P. Schuck et al., Alpha-Particle Condensation in Nuclear Systems,J. Phys. Conf. Ser. Journal of Physics: Conference Series 413 (2013)]

• There is disagreement between the experimentally observed width of 166(5) keV and the theoretically calculated width of 34 keV.

[Y. Funaki et al., Phys. Rev. C 82, 024312 (2010)]



Clustering Experimental Apparatus and Technique

Previous Results



K.C.W. Li Refuting the Na

Refuting the Nature of the 0_6^+ Hoyle-analogue State Candidate in ${}^{16}O$

Clustering Experimental Apparatus and Technique

The K600 Spectrometer Vault



- The reaction of interest was ¹⁶O(α, α') with a beam energy of 200 MeV and a Li₂CO₃ target.
- The K600 spectrometer was configured for a $0^{\circ}-2^{\circ}$ measurement.
- At 50 MeV/u, the dominating direct single-step reaction mechanism predominantly excites low-spin, natural-parity states.
- The CAKE (Coincidence Array for K600 Experiments) silicon array was used to detected coincident charged particle decays.



Clustering Experimental Apparatus and Technique

The K600 Spectrometer Vault



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Singles Coincident Decay Events Angular Distributions

Singles



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Singles Coincident Decay Events Angular Distributions

Coincidence matrix (gated on higher angles)



 $\alpha_0 \text{ decay from low-spin natural-parity states}$

Introduction

Singles



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Singles Coincident Decay Events Angular Distributions

The α_0 Decay Channel





Singles Coincident Decay Events Angular Distributions

The α_0 Decay Channel





Singles Coincident Decay Events Angular Distributions

The α_1 Decay Channel





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Singles Coincident Decay Events Angular Distributions

The p_0 Decay Channel





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Extraction of α_0 angular distributions





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Extraction of α_0 angular distributions





Singles Coincident Decay Events Angular Distributions

The α_0 Decay Channel





Singles Coincident Decay Events Angular Distributions

The α_0 Decay Channel





Singles Coincident Decay Events Angular Distributions

The α_0 Decay Channel





Singles Coincident Decay Events Angular Distributions

The α_0 Decay Channel





Singles Coincident Decay Events Angular Distributions

The α_0 Decay Channel





Singles Coincident Decay Events Angular Distributions

The α_0 Decay Channel





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Singles Coincident Decay Events Angular Distributions

The α_0 Decay Channel





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The α_0 Decay Channel





Singles Coincident Decay Events Angular Distributions

The α_0 Decay Channel





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The α_0 Decay Channel





Singles Coincident Decay Events Angular Distributions

The α_0 Decay Channel





Singles Coincident Decay Events Angular Distributions

The α_0 Decay Channel





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Angular Distributions of Charged Particle Decay





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Angular Distributions of decay from ¹⁶O at $E_x \approx 15.1$ MeV











Singles Coincident Decay Events Angular Distributions

 $E_x \approx 15 \text{ MeV: } p_0 \text{ decay}$





Singles Coincident Decay Events Angular Distributions

 $E_x \approx 15$ MeV: α_0 and α_1 decay





Refutation of the 15.097 MeV 0_6^+ state in ${}^{16}O$ Acknowledgements

Conclusions

- The data suggests that the resonance, previously observed at 15.097 MeV and identified as the 0_6^+ resonance in ¹⁶O, has a contribution from a non-zero spin resonance.
- A previously unidentified resonance may explain the disagreement between the experimentally observed width of 166(5) keV (162(4) keV for this work) and the theoretically calculated width of 34 keV.

[Y. Funaki et al., Phys. Rev. C 82, 024312 (2010)]

• This unidentified resonance may be interpreted to be consistent with the data from Itoh *et al.*, Journal of Physics: Conference Series, 569 (2014).





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Refuting the Nature of the 0_6^+ Hoyle-analogue State Candidate in ${}^{16}O$

Refutation of the 15.097 MeV 0_6^+ state in ¹⁶O Acknowledgements

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Refutation of the 15.097 MeV 0_6^+ state in ¹⁶O Acknowledgements

Angular Distributions of Charged Particle Decay



Refutation of the 15.097 MeV 0_6^+ state in ¹⁶O Acknowledgements

Coincidence matrix



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Angular Distributions of Charged Particle Decay



Refutation of the 15.097 MeV 0_6^+ state in ¹⁶O Acknowledgements

Coincidence matrix - Gated on Ring 1 of CAKE



Refutation of the 15.097 MeV 0_6^+ state in ¹⁶O Acknowledgements

Coincidence matrix - Gated on Ring 8 of CAKE



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Coincidence matrix - Gated on Ring 16 of CAKE

