^{12}C(^{12}C,3α) 1991Ca01,2007Fr17,2010Mu05

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, J. E. Purcell and C. G. Sheu	NP A968,71 (2017)	1-Jan-2017

1991Ca01: ^{12}C(^{12}C,3α) E=7.5 MeV/nucleon; measured $\alpha\alpha$ coin. Deduced ^{12}C levels, J$^{\pi}$, decay branching ratios.

2007Fr05: ^{12}C(^{12}C,3α) E=104, 106 MeV; measured $\alpha\alpha$ coin.

2007Fr17: ^{12}C(^{12}C,3α) E=82-106 MeV; measured $\alpha\alpha$ coin. Deduced ^{12}C levels.

XUNDL dataset compiled by McMaster, 2007.

Analysis of previous E=82-106 MeV experiment at the Australian National University. Charged particles were measured in the MEGHA chamber using the Charissa array (composed of eight Si strip detectors). Excited states identified based on α-decay to ground and excited states in ^{8}Be. Resolution (FWHM)=200 keV. Measured angular distributions.

2010Mu05: ^{12}C(^{12}C,3α) E=101.5 MeV; measured $\alpha\alpha$ coin. Deduced ^{12}C levels, J$^{\pi}$, decay branching ratios.

2011Ma04: ^{12}C(^{12}C,^{12}C),(^{12}C,^{12}C′) E=121.5 MeV, measured reaction products. Deduced $\sigma(\theta)$, properties of the Hoyle state.

2010Mu05: ^{12}C(^{12}C,3α) E=101.5 MeV, measured reaction products, E$_{\alpha}$, I$_{\alpha}$. Deduced excitation energy spectrum, J, π, no evidence of J$^{\pi}$=2$^{+}_{2}$ state. XUNDL dataset compiled by TUNL, 2010.

Measured the 3α breakup of ^{12}C in search of the 2^{+} excitation of the ^{12}C*(7.65) J$^{\pi}$=0^{+} state. No conclusive evidence is found in the region of E$_x$=9-10 MeV.

A beam of E(^{12}C)=101.5 MeV ions, from the Australian National University Pelletron, impinged on a 50 μg/cm^2. The ejected 3α particles were detected in an array of position sensitive ΔE-ΔE-E detectors. While the excitation of the ejected 3α system was determined by kinematic reconstruction, the participation of ^{12}C*(0,4.4,9.6 MeV) in the residual was also deduced. Experimental resolution ranges between ≈90 keV for ^{12}C*(7.65 MeV) to ≈175 keV for ^{12}C*(9.64 MeV). An angular correlation analysis was used to enhance the experimental sensitivity for a J$^{\pi}$=2^{+} resonance.

2016Mo05: XUNDL dataset compiled by TUNL, 2016.

The authors analyzed the decay of ^{12}C*(7654), populated in ^{12}C(^{12}C,^{12}C′) and ^{12}C(^{12}C,^{24}Mg*→^{12}C+^{12}C*) reactions to gain a better understanding of the intensity of various exotic decay modes of ^{12}C*(7654).

A beam of 95 MeV ^{12}C ions impinged on a ≈85 μg/cm^2 ^{12}C foil placed in the target position of the GARFIELD+RCo detector, which provides roughly 80% of 4π coverage. Segmented detectors give particle identification from either ΔE-E or CsI(Tl) pulse shape analysis. Events are roughly categorized in 2 types: first are peripheral binary inelastic scattering reactions, where the projectile is excited while the target remains in its ground state, second are hot central collisions, where the ^{24}Mg compound nucleus is formed prior to decay into six α particles. Events corresponding to population of ^{12}C*(7654) were identified and analyzed. Other states at ^{12}C*(0,4440,7654,9640,10800) were observed to participate. For the ^{12}C*(7654) events, Dalitz plots were used to determine the contributions from sequential decay (via ^{8}Be$_{g.s.}$), direct decay (DD), direct decay with equal energy sharing among the 3α particles (DDE), 3α direct decay in a linear chain (DDL), and uniform population of the 3-body phase space (DDΦ).

2014It01: XUNDL dataset compiled by TUNL, 2014.

The authors measured the full kinematics of ^{12}C+^{12}C→^{12}C$_{g.s.}$+^{12}C*(7.65 MeV)→^{12}C$_{g.s.}$+3α to better constrain the decay mechanism of the ^{12}C*(7.65 MeV) Hoyle state.

A beam of 110 MeV ^{12}C ions, from the Tohoku University CYRIC facility impinged on a 50 μg/cm^2 ^{nat}C foil that was rotated by 60° with respect to the incident beam. Products from the ^{12}C(^{12}C,^{12}C$_{g.s.}$+^{12}C*(7.65 MeV)) reaction were detected using two Si detector telescopes. The recoiling ^{12}C$_{g.s.}$ ejectile was detected at θ=−67° in a 150 μm thick detector, while the three breakup α-particles were detected in a 5 cm×5 cm position sensitive double sided strip detector that covered $\theta_{horizontal}$=3.0° to 12.2° and $\theta_{vertical}$=−4.6° to +4.6°.

The kinematic relation between the ^{12}C recoil and the 3α breakup particles was selected to isolate excitation of the α-unbound ^{12}C*(7.65 MeV) state exclusively; a total of 21,000 decay events were measured. A Dalitz plot was generated to analyze the energy correlations of the breakup α-particles. Three decay configurations were considered.

Results are consistent with a 100% SD mechanism. Limits of I(DDE)<0.08% and I(DDΦ) are placed on the other decay modes. The width of the Hoyle state, along with the partial widths are of critical importance for determining the triple-α rate.

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SD:      Sequential Decay through 8Beg.s..
DD:      Direct Decay
DDE:     Direct Decay with equal energy α-particles.
DDL:     Direct Decay in linear chain.
DDΦ:     Direct Decay to 3-body phase space.
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^{12}C Levels

E(level)	J$^{\pi}$[d]	Comments
7.65×10^3†‡#@&[a]	0$^+$	Decay (2016Mo05) is via: SD=(97.8 *12*)%. DD=(1.1 *4*)%. DDE<0.05%. DDL=(1.1 *2*)%. DDΦ<0.4%. Branching ratios (95% confidence level) for 3α breakup of the Hoyle state are (2014It01): SD≈100%. DDE<0.08%. DDΦ<0.2%.
9.64×10^3†‡#@&[ab]	3$^-$	$\Gamma_{\alpha 0}/\Gamma$=0.972, $\Gamma_{\alpha 1}/\Gamma$=0.027 (2007Fr17).
10.30×10^3@	0$^+$	
10.84×10^3†‡#@&[a]	1$^-$	
11.16×10^3?@[a]	2$^+$	$\Gamma_{\alpha 0}/\Gamma$<0.38 (2007Fr17). E(level): The existence of this state is controversial. It was first reported in the ^{11}B(^{3}He,d) reaction, but subsequent measurements have found no evidence for its production in that reaction. The result of (2007Fr17) do not provide sufficient evidence for the state's existence (private communication, M. Freer, June 2017).
11.80×10^3?@	1$^-$	Γ=Broad.
11.83×10^3†‡@[bc]	(4$^-$)	
12.50×10^3?@	3$^-$	Γ=Broad.
12.71×10^3†‡@[bc]	1$^+$	
13.35×10^3@[c]	(2$^-$,3$^+$,4$^-$)	J$^{\pi}$=4$^-$ is preferred (2007Fr17).
14.08×10^3†‡@[ab]	4$^+$	$\Gamma_{\alpha 0}/\Gamma$=0.17, $\Gamma_{\alpha 1}/\Gamma$=0.83 (2007Fr17).

† Reported in (1991Ca01).
‡ Reported in (2007Fr05).
# Reported in (2010Mu05).
@ Reported in (2007Fr17).
& Reported in (2016Mo05).
[a] Observed in α+^{8}Be$_{g.s.}$ decay.
[b] Observed in α+^{8}Be*(3.03 MeV) decay.
[c] Unnatural parity state (2007Fr17).
[d] From (2007Fr17).