^{13}C(π,π),(π,π′)

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	J. H. Kelley, C. G. Sheu and J. E. Purcell	NDS 198,1 (2024)	1-Aug-2024

1976DyZY: ^{13}C(π^+,π^+) E=50 MeV; measured $\sigma(\theta)$.
1977AmZZ: ^{13}C(π^+,π^+),(π^+,$\pi^{+\prime}$) E=50 MeV; measured σ.
1978Dy01: ^{13}C(π^+,π^+) E=50 MeV; measured $\sigma(\theta)$; deduced isotopic effects. Optical model analysis.
1978EiZZ: ^{13}C(π^+,π^+) E=50 MeV; measured σ.
1979De34: ^{13}C($\pi^\pm$,$\pi^\pm$),($\pi^\pm$,$\pi^{\pm\prime}$) E=162 MeV; measured $\sigma(\theta)$. ^{13}C deduced pure n, p transitions. Shell-model, weak coupling-model configurations.
1979GyZZ: ^{13}C(π^-,π^-) E=29 MeV; measured ratios of $\sigma(\theta)$ for ^{12}C and ^{13}C targets. Optical model analysis.
1979Jo08: ^{13}C(π^-,π^-) E=29.2-49.5 MeV; measured $\sigma(\theta)$. ^{13}C deduced neutron radius relative to ^{12}C. Neutron rms radius is 2.35 fm *3*. Optical model analysis.
1979MaYZ: ^{13}C(π^-,π^-) E=30,50 MeV; analyzed $\sigma(\theta)$. ^{13}C deduced model dependence of neutron radius. Optical model, absorption parameter constraints, different pion-nucleon phase shifts, modified harmonic osillator density distribution. Found the neutron rms radius is 2.372 fm *+15−22*.
1979MaZB: ^{13}C(π^-,π^-) E=30,50 MeV; measured $\sigma(\theta)$. ^{13}C deduced neutron radii. Optical model, global fit parameters.
1979Sc25: ^{13}C($\pi^\pm$,$\pi^\pm$),($\pi^\pm$,$\pi^{\pm\prime}$) E=180 MeV; measured $\sigma(\theta)$. ^{13}C levels deduced $\sigma(\pi^-)/\sigma(\pi^+)$.
1979TrZR: ^{13}C(π^+,$\pi^{+\prime}$) E=116,162,180,200,240 MeV; measured σ(E,θ). ^{13}C deduced levels, J, π.
1980Sc30: ^{13}C($\pi^\pm$,$\pi^{\pm\prime}$) E=148,180,230 MeV; measured $\sigma(\theta)$. High resolution pion spectrometer.
1980Th01: ^{13}C($\pi^\pm$,$\pi^{\pm\prime}$) E=162 MeV; measured π^+/π^- asymmetry.
1981Se08: ^{13}C($\pi^\pm$,$\pi^{\pm\prime}$) E=100-300 MeV; measured σ(θ,E). ^{13}C deduced dominant ΔS=1 transitions. One-step mechanism, fixed scatterer impulse approximation.
1981SeZX: ^{13}C($\pi^\pm$,$\pi^\pm$),($\pi^\pm$,$\pi^{\pm\prime}$) E=162 MeV; measured $\sigma(\theta)$; deduced $\sigma(\pi^-)/\sigma(\pi^+)$. ^{13}C levels deduced B(E2). Optical, collective model analyses.
1982An18: ^{13}C($\pi^\pm$,$\pi^\pm$),($\pi^\pm$,$\pi^{\pm\prime}$) E=100 MeV; measured $\sigma(\theta)$.
1982Se04: ^{13}C($\pi^\pm$,$\pi^{\pm\prime}$) E=162 MeV; measured $\sigma(\theta)$. ^{13}C levels deduced L. Microscopic DWIA analysis, shell model wave functions.
1983Bl11: ^{13}C($\pi^\pm$,$\pi^\pm$) E=65,80 MeV; measured $\sigma(\theta)$; deduced isospin effects, pion-nucleus optical potential parameters.
1983Se15: ^{13}C($\pi^\pm$,$\pi^\pm$),($\pi^\pm$,$\pi^{\pm\prime}$) E=162 MeV; measured $\sigma(\theta)$. ^{13}C levels deduced neutron, proton B(λ) components. Optical, collective model analyses.
1984An11: ^{13}C($\pi^\pm$,π^π),($\pi^\pm$,$\pi^{\pm\prime}$) E=100 MeV; measured $\sigma(\theta)$, σ(E(π)). Isobar-hole model analysis.
1987MiZX: ^{13}C($\pi^\pm$,$\pi^{\pm\prime}$) E=65,50 MeV; measured $\sigma(\theta)$; deduced medium corrections energy dependence.
1988Mi02: ^{13}C($\pi^\pm$,$\pi^\pm$),($\pi^\pm$,$\pi^{\pm\prime}$) E=65 MeV; measured $\sigma(\theta)$. ^{13}C levels deduced deformation lengths, $\sigma(\pi^-)/\sigma(\pi^+)$ enhancement features; deduced deformation length. Comparison with DWIA calculations with ρ-squared medium corrections.
1990Se04: ^{13}C(π^-,π^-) E=30,50 MeV; measured $\sigma(\theta)$for elastic scattering; deduced optical model fits. ^{13}C enriched targets, range spectrometer. DWBA analysis.
1990Ye06,1991Ye01: ^{13}C($\pi^\pm$,$\pi^\pm$) E=114-226 MeV; measured analyzing power vs θ. Polarized target. DWIA analyses.
1992Br02: ^{13}C($\pi^\pm$,$\pi^\pm$),($\pi^\pm$,$\pi^{\pm\prime}$) E=100 MeV; measured analyzing power. Polarized target. Model analysis.
1994Ye06: ^{13}C($\pi^\pm$,$\pi^\pm$) E=130-180 MeV; ^{13}C(π^+,π^+) E=223 MeV; ^{13}C(π^-,π^-) E=226 MeV; measured analyzing power $A_y(\theta)$, $\sigma(\theta)$ for elastic scattering; deduced spin-flip transition quadrupole component role. Polarized, unpolarized targets. DWIA, optical, and Δ-hole models.

Theory:
1977Fu10: ^{13}C(π^+,π^+); calculated scattering.
1980Ch08: ^{13}C(π^+,$\pi^{+\prime}$) E=120-226 MeV; calculated $\sigma(\theta)$. Coupled-channels, momentum space.
1980Ei01: ^{13}C(π^+,$\pi^{+\prime}$) E=75-200 MeV; calculated $\sigma(\theta)$; deduced connection between charge exchange, inelastic scattering processes near (3,3) resonance. Optical potential, eikonal approximation.
1980Le02: ^{13}C($\pi^\pm$,$\pi^{\pm\prime}$) E=162 MeV; calculated $\sigma(\theta)$.
1980Le17: ^{13}C($\pi^\pm$,$\pi^{\pm\prime}$) E=162 MeV; calculated $\sigma(\theta)$; deduced structure effects. DWIA, momentum space.
1980Sa04: ^{13}C($\pi^\pm$,$\pi^\pm$) E=150 MeV; calculated $\sigma(\theta)$. Isobar-doorway optical potential.
1981HaZU: ^{13}C($\pi^\pm$,$\pi^\pm$), analyzed data; deduced excess neutron density distributions.
1981Li02: ^{13}C($\pi^\pm$,$\pi^\pm$) E=180 MeV; calculated $\sigma(\theta)$. Coupled-channels method, single charge exchange mechanism, pion

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absorption.

1981Mo11: ^{13}C($\pi^{\pm}$,$\pi^{\pm\prime}$) E=resonance; calculated ($\sigma(\pi^{-})$-$\sigma(\pi^{+})$)/($\sigma(\pi^{-})$+$\sigma(\pi^{+})$); deduced isospin effects in pion-nucleon scattering amplitude.

1983Li15: ^{13}C(π^{-},$\pi^{-\prime}$) E=180 MeV; calculated $\sigma(\theta)$. DWIA, core excitation, eikonal distorted waves.

1984HiZX: ^{13}C(π,π′); analyzed data. ^{13}C deduced M4 excitation isoscalar, isovector transition densities.

1986AmZX: ^{13}C(π,π′); analyzed form factors, $\sigma(\theta)$; deduced structure effects.

1988ChZU: ^{13}C($\pi^{\pm}$,$\pi^{\pm\prime}$) E=50-100 MeV; calculated σ asymmetry. Polarized target. DWIA.

1990Gl09: ^{13}C(π^{+},π^{+}) E=132 MeV; compiled data analyses.

1993Si15: ^{13}C($\pi^{\pm}$,$\pi^{\pm}$) E=114-226 MeV; analyzed $\sigma(\theta)$, analyzing power data.

1995Av07: ^{13}C(π^{-},π^{-}) E=132,226 MeV; calculated $\sigma(\theta)$, asymmetry vs θ in some cases. Polarized targets, spin effects.

1995Ku04: ^{13}C($\pi^{\pm}$,$\pi^{\pm}$),($\pi^{\pm}$,$\pi^{\pm\prime}$) E=114-226 MeV; analyzed $\sigma(\theta)$, asymmetry data; deduced first-order core polarization effects related features. DWIA.

1999Ta33: ^{13}C(π^{+},π^{+}) E=162-223 MeV; calculated $\sigma(\theta)$, Ay(θ). ^{13}C(π^{-},π^{-}) E=114-226 MeV; calculated Ay(θ). Isobar-doorway state model, comparisons with data.

2004Sa28: ^{13}C($\pi^{\pm}$,$\pi^{\pm}$) E≈80-800 MeV; analyzed $\sigma(\theta)$; deduced strong absorption model parameters.

^{13}C Levels

E(level)†	J$^{\pi}$†	L	Comments
0	1/2^{-}		E(level): See (1978Dy01, 1979De34, 1979Sc25, 1982AnZW, 1982Se04, 1983Bl11, 1983Se15, 1988Mi02, 1984An11, 1990Se04, 1994Ye06).
3090	1/2^{+}		E(level): See (1979De34,1982Se04,1994Ye06).
3680	3/2^{-}	2	E(level): See (1979De34, 1979Sc25, 1981Se08, 1982AnZW, 1982Se04, 1983Se15, 1988Mi02, 1984An11, 1994Ye06). L: L transfer (1981Se08,1982Se04,1988Mi02). Spin transfer ΔS=0 (1981Se08,1988Mi02). The extracted deformation lengths (βR) in fm: $(\beta R)_{+}$=1.34 *11*, $(\beta R)_{-}$=1.40 *25*; $(\beta R)_{avg}$=1.37 *14*, $(\beta R)_{+}/(\beta R)_{-}$=0.95 *20* (1988Mi02). See also (1983Se15).
3850	5/2^{+}		E(level): See (1979De34,1982Se04,1994Ye06).
6860			E(level): See (1994Ye06).
7490	7/2^{+}		E(level): See (1979De34,1983Se15).
7550	5/2^{-}	2	E(level): See (1979De34, 1979Sc25, 1981Se08, 1982AnZW, 1982Se04, 1983Se15, 1988Mi02, 1984An11, 1994Ye06). L: L transfer (1981Se08,1982Se04,1988Mi02). ΔS=0 (1981Se08,1988Mi02). The extracted deformation lengths (βR) in fm: $(\beta R)_{+}$=1.30 *10*, $(\beta R)_{-}$=1.10 *10*; $(\beta R)_{avg}$=1.19 *7*, $(\beta R)_{+}/(\beta R)_{-}$=1.18 *12* (1988Mi02).
8860	1/2^{-}	0	E(level): See (1982Se04,1988Mi02,1994Ye06). L: L transfer (1988Mi02). ΔS=0 (1988Mi02), ΔS=1 (1982Se04). The extracted deformation lengths (βR) in fm: $(\beta R)_{+}$=0.10 *1*, $(\beta R)_{-}$=0.09 *1*; $(\beta R)_{avg}$=0.095 *10*, $(\beta R)_{+}/(\beta R)_{-}$=1.11 *15* (1988Mi02).
9500	9/2^{+}		E(level): See (1979De34, 1979Sc25, 1981Se08, 1982AnZW, 1982Se04, 1988Mi02, 1984An11, 1994Ye06). J$^{\pi}$: Assigned by (1982Se04). The enhancement factor $\sigma(\pi^{-})/\sigma(\pi^{+})$≈9 is consistent with a pure neutron transition and a 9/2^{+} assignment (1979De34); see also (1982Se04). The transitions to ^{13}C*(9.5) is enhanced by a factor of 4.0 *+20–7* in π^{-} scattering indicating an almost pure neutron transition (1979Sc25). ΔS=1 (1981Se08).
11700			E(level): See (1979Sc25,1984An11).
11820	(5/2^{+},7/2^{+})	3	E(level): See (doublet: 1982Se04,1983Se15,1988Mi02 and 1994Ye06). J$^{\pi}$: Assigned by (1982Se04,1983Se15,1988Mi02). L: L transfer (1982Se04,1983Se15,1988Mi02). ΔS=0 (1988Mi02). The extracted deformation lengths (βR) in fm: $(\beta R)_{+}$=1.48 *13*, $(\beta R)_{-}$=1.02 *7*; $(\beta R)_{avg}$=1.23 *8*, $(\beta R)_{+}/(\beta R)_{-}$=1.45 *16* (1988Mi02).
14800			E(level): See (1984An11). Probably the same state reported at E_x=15 MeV in (1979Sc25).
16050 *50*	9/2^{+}		E(level): From (1982Se04); see also E_x=16050 keV (1981Se08), ≈16000 (1979De34: a group of states). J$^{\pi}$: Assgined by (1982Se04); see also J$^{\pi}$=(9/2^{+},7/2^{+}) (1981Se08).

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^{13}C Levels (continued)

E(level)[†]	J^{π}[†]	Comments
		$\Delta S=1$ (1981Se08,1982Se04).
17500		E(level): See (1979Sc25).
17920 *50*	$(9/2^+,7/2^+)$	E(level): From (1982Se04); see also E_x=17920 keV (1981Se08). J^{π}: Assgined by (1981Se08,1982Se04). $\Delta S=1$ (1981Se08,1982Se04).
21370 *50*	$(9/2^+,7/2^+)$	E(level): From (1982Se04); see also E_x=21370 keV (1981Se08). J^{π}: Assgined by (1981Se08,1982Se04). $\Delta S=1$ (1981Se08,1982Se04). The π^-/π^+ asymmetry near 21.5 MeV suggests that there is isospin mixing between T=1/2 and 3/2 states of $J^{\pi}=7/2^+$ and/or $9/2^+$ (1982Se04).
21600 *50*	$(9/2^+,7/2^+)$	E(level): From (1982Se04); see also E_x=21600 keV (1981Se08). J^{π}: Assgined by (1981Se08,1982Se04). $\Delta S=1$ (1981Se08,1982Se04).
≈22000		E(level): See (1979De34,1979Sc25); probably a group of states. Not placed in Adopted Levels. The centroid of a group of states near 22 MeV is found in (π^-,$\pi^{-\prime}$) at a higher excitation energy than in (π^+,$\pi^{+\prime}$) (1979De34).

[†] From shell model and DWIA analyses in (1982Se04) and (1979De34), except where noted.