

RESONANT STRUCTURE IN THE REACTION CHANNELS OF $^{14}\text{C} + ^{14}\text{C}$

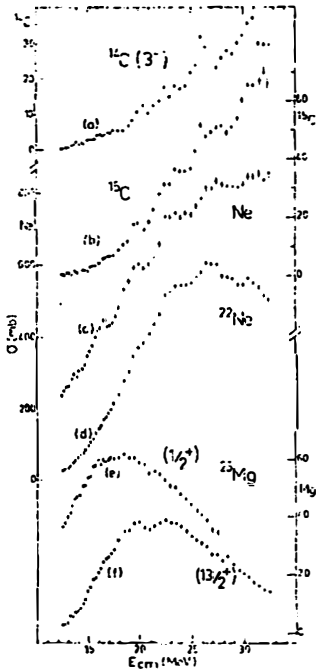
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Strong resonant behavior has been observed in the γ -ray yields of the $^{14}\text{C} + ^{14}\text{C}$ reaction channels, which have been measured at the Munich MP Tandem from $E_{\text{C.M.}} = 12.5$ to 32.5 MeV. The regular oscillation correlated in inelastic, transfer and fusion-evaporation channels corroborates the resonant gross structure in elastic scattering studied by the Munich group and Cindro et al. ¹⁾. This periodic gross structure closely resembles the shape resonances found in $^{16}\text{O} + ^{16}\text{O}$ reaction channels ²⁾ which are out of phase with the broad strong structures in the 90° elastic scattering data ³⁾.

This resonant feature is especially striking in direct reaction channels where grazing partial wave effects are strong, as illustrated by Fig. a and Fig. b where the results for inelastic scattering to the 3^- state of ^{14}C and one neutron transfer channel are shown. The evaporation processes are dominated by the (αxn) channels leading to Ne isotopes and by the (xn) channels to Mg isotopes. The summed cross section to the Ne isotopes (Fig. c), including the individual contribution for ^{22}Ne (Fig. d), exhibits a persisting resonant structure roughly correlated with that of peripheral channels. The $^{25}\text{Mg} + 3n$ fusion channel is illustrated by the excitation functions for the formation of two states of ^{25}Mg : the first excited state ($J^\pi = 1/2^+$, $E_x = 585$ keV) and a high spin state ($J^\pi = 13/2^+$, $E_x = 5462$ keV) are shown in Fig. e and Fig. f. Little structure appears but more pronounced for the high spin state, because resonant behavior is enhanced for higher angular momentum partial waves.



The resonances seem to be correlated in all the reaction channels (at $E_{C.M.} \approx 13, 16.1, 19.2, 23.0, 27.0$ and 31.5 MeV) as the quasi-molecular resonances observed in the reaction cross sections for $^{16}O + ^{16}O$ (2). Although ^{14}C is not a pure α -cluster nucleus $^{14}C + ^{14}C$ is very similar to $^{16}O + ^{16}O$ scattering : the striking resonant structure is not obscured by strong absorption. These two reactions are induced by identical bosons and, therefore, strong parity dependent effects are related to the fact that the reaction is described by the even partial waves only. The ^{14}C nucleus like the doubly-closed-shell nucleus ^{16}O is very stable : it is characterized by a closed neutron shell and a closed proton subshell. ^{14}C and ^{16}O are spherical nuclei with no low-lying 2^+ collective states : they are the only two nuclei heavier than 4He where the gap between the ground state and the first excited state is greater than 6 MeV. The gross structure phenomena observed in these two reactions is linked to the peripheral partial waves which are weakly absorbed. This surface transparency can be understood by the fact that very few direct channels are able to carry away the large angular momenta brought in by the entrance channel.

This experiment along with $^{12}C + ^{14}C$ (4) and $^{14}C + ^{16}O$ (5) data confirms the microscopic calculations of the Brussels group (6), which predict that ^{14}C induced reactions are very good candidates to observe molecular resonances. The resonant structure observed in the $^{14}C + ^{14}C$ reaction is moreover in perfect agreement with the occurrence of a molecular resonance region proposed by Abe (7).

- 1) D. Konnerth et al., Phys. Rev. Lett. 45 (1980) 1154.
D.M. Drake et al., Phys. Lett. 98B (1981) 36.
- 2) J.J. Kolata et al., Phys. Rev. C16 (1977) 891.
- 3) J.V. Maher et al., Phys. Rev. 188 (1969) 1665.
- 4) R.M. Freeman et al., Phys. Lett. 90B (1980) 229.
- 5) J.J. Kolata et al., Phys. Rev. C23 (1981) 1056.
- 6) D. Baye et al., Nucl. Phys. A308 (1978) 229.
P.H. Heenen and D. Baye, Phys. Lett. 81B (1979) 295.
- 7) Y. Abe, International Conference on Resonant Behavior of Heavy Ion Systems, Aegean Sea, Greece, 23-26 June 1980.