Coulomb Breakup of ^{15}C and ^{17}C $^{\mathrm{B,G}}$

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Coulomb breakup of secondary beams of unstable nuclei at intermediate energies has developed into a standard spectroscopic tool in exploring properties of weakly bound nuclei. Here, this method has been applied to a study of ^{15}C and ^{17}C isotopes which have very small neutron separation energies of 1.2 and 0.73 MeV, respectively.

Radioactive beams of ^{15,17}C were produced in a fragmentation reaction of a primary ^{40}Ar beam, delivered by the synchrotron SIS at GSI, Darmstadt, and were subsequently separated in flight by the FRS. The incoming beam and fragments were identified utilizing energy-loss and time-of-flight measurements together with the known magnetic rigidity. Neutrons and γ-rays were detected by the LAND and Crystal Ball spectrometers, respectively. From the measured momenta of all decay products of the projectile after inelastic scattering followed by breakup, the excitation energy of the nucleus was determined. The Coulomb dissociation cross sections with the Pb (1.8 g/cm^2) target were obtained after subtracting nuclear contributions determined from the data with a C (0.573 g/cm^2) target.

By comparing measured differential cross sections $d\sigma/dE^*$ (excitation energy E^*) for electromagnetic excitation with calculated cross sections (see below) one can deduce information on the ground state structure. The Coulomb breakup cross section can be written [1]:

$$\frac{d\sigma}{dE^*} = \left(\frac{16\pi^3}{9\hbar c}\right) N_{E1}(E^*) \sum_m |< q \mid (Ze/A) r Y^1_m \mid \psi(r) >|^2 \ .$$

$N_{E1}(E^*)$ represents the number of equivalent dipole photons of the target Coulomb field, computed in a semiclassical approximation, ψ(r) represents the ground state single particle wave function of the neutron and $< q \mid$ describes the wavefunction of the neutron in the continuum.

In the case of ^{15}C with the known g.s. spin $I^\pi = 1/2^+$, the experimental data show that Coulomb breakup populates predominatly the ground state of ^{14}C, a small branch of about 10 % feeding excited states at 6 - 7 MeV is observed in addition. A comparision between our measured $d\sigma/dE^*$ for this isotope with the fragments in its ground state and the calculated one, delivers a spectroscopic factor (0.72) for a ℓ=0 neutron which is consistent with an earlier reported value [2].

The ground state spin of ^{17}C is not fully established experimentally. Our experimental data for Coulomb break up of ^{17}C show that most of the cross section yields the ^{16}C core in its first excited state, $I^\pi = 2^+$, and an excited state at an excitation energy around 3 MeV. Only a small part of the cross section leaves the core in its ground state. Fig. 1 (top) shows the sum energy spectra of the γ decay from ^{16}C fragments and indicates the relative partial cross sections for the population of different core states. The lower part of the Fig. 1 shows $d\sigma/dE^*$ for electromagnetic excitation of ^{17}C in coincidence with the 1.766 MeV γ transition ^{16}C($2^+ \to 0^+$) without acceptance and efficiency corrections for the neutron detector. These corrections, however, are taken into account in the cross sections calculated according to equ. (1). A proper choice of relative contributions from $\ell = 0$ and $\ell = 2$ neutrons forming the ^{17}C g.s. wave function, as shown Fig 1, can reproduce well the data. Thus, ^{16}C(2^+)$\otimes \nu_{s,d}$ is the predominant g.s. configuration and one can rule out a $1/2^+$ ground state spin of ^{17}C. The major part of our results is in agreement with those from a different method, i.e. obtained from a knockout reaction [3].

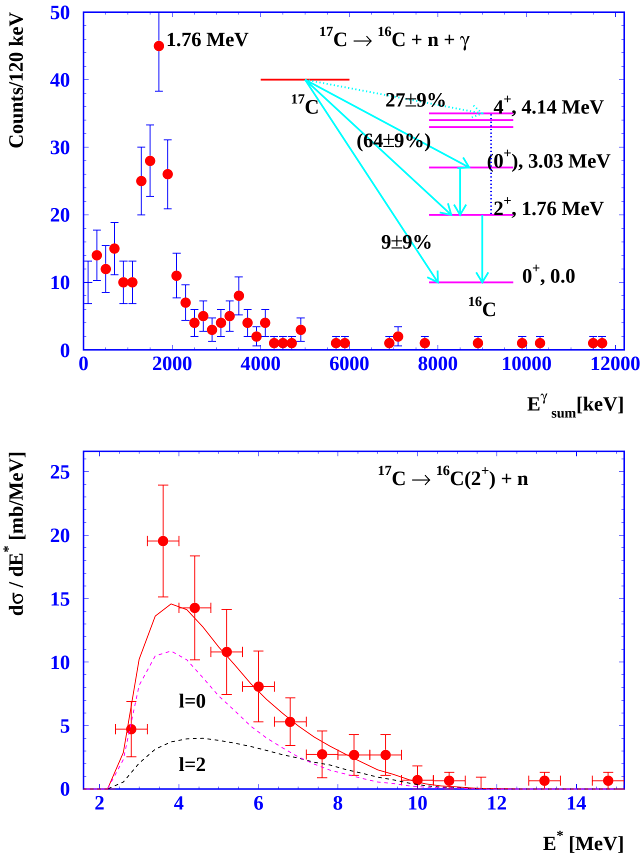

Fig. 1: Sum energy of γ decay transitions (top). Differential Coulomb dissociation cross section (bottom).

References

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