Extracting electric dipole breakup cross section of one-neutron halo nuclei from inclusive breakup observables

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The neutron halo structure is one of the novel properties of unstable nuclei. One possible probe for the halo structure is the breakup cross section $\sigma(\mathrm{E1})$ due to the electric dipole (E1) field [1] . It was shown in Ref. [1] that $\sigma(\mathrm{E1})$ on Pb target at 250 A MeV is very large for ^{19}C, a one-neutron halo nucleus. The authors also found a large $\sigma(\mathrm{E1})$ for ^{31}Ne, and concluded that ^{31}Ne has a one-neutron halo structure. Since $\sigma(\mathrm{E1})$ is not an observable, in the analysis the following equation was used:

$$\sigma(\mathrm{E1}) = \sigma^{\mathrm{Pb}}_{-1n} - \Gamma\sigma^{\mathrm{C}}_{-1n}, \tag{1}$$

where $\sigma^{\mathrm{A}}_{-1n}$ is the one-neutron removal cross section by a target nucleus A and Γ is a scaling factor ranging from 1.7 to 2.6 for the ^{31}Ne projectile. However, no quantitative justification of Eq. (1) or the value of Γ was made. Since Eq. (1) is a key formula in the study of Ref. [1], it is very important to clarify the validity of the equation. Equation (1) assumes that the interference between nuclear and Coulomb breakup is negligible and the Coulomb breakup cross section can be replaced with the electric dipole (E1) transition cross section.

We describe one-neutron removal processes by means of the continuum-discretized coupled-channels method with the eikonal approximation (E-CDCC) [2, 3] for the elastic breakup and the eikonal reaction theory (ERT) [4, 5] for the one-neutron stripping process. These reaction models can test the assumptions mentioned above. We performed the calculation for 10 nuclei having a core plus valence neutron structure with small binding energy. The n-core relative angular momentum ℓ in the ground state, ℓ_0, and the separation energy S_n for each nucleus are shown in the table below. We found that the assumptions mentioned above and Eq. (1) are valid for the

	^{11}Be	^{15}C	^{19}C	^{29}Ne	^{31}Ne	^{33}Mg	^{35}Mg	^{37}Mg	^{39}Si	^{41}Si
ℓ_0	0	0	0	0	1	1	1	0 or 1	1	1
S_n [MeV]	0.503	1.218	0.580	0.330	1.260	2.640	1.011	0.489	2.080	0.300

one-neutron removal reactions of those 10 nuclei at 250 A MeV. Furthermore, the Γ is defined by the ratio of the one-neutron removal cross sections due to the nuclear interaction: $\Gamma = \sigma^{\mathrm{Pb}}_{-1n(\mathrm{N})}/\sigma^{\mathrm{C}}_{-1n(\mathrm{N})}$. The Γ factors have clear S_n dependence as shown in Fig. 1, and are well fitted with the function of S_n: $\Gamma = (2.30\pm0.41)e^{-S_n} + (2.43\pm0.21)$. See Ref. [6] for more detail.

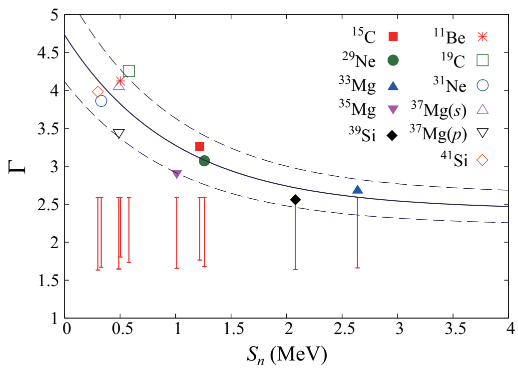

Figure 1: Plot of Γ as a function of S_n. The vertical bars show the range of Γ taken in Ref. [1].

References

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