# Neutron density distribution and the Halo structure of $^{22}$C

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## Introduction

Recently Ta*naka* et.al. [1] have measured the reaction cross-section data from the neutron rich carbon isotopes A = 19, 20 and 22 at 40 MeV. They have observed a large enhancement of 1338 ± 274 mb for $^{22}$C as compared with 754 ± 22 mb for $^{19}$C and 791 ± 34 mb for $^{20}$C. Further the separation energy for the two valence neutrons in $^{22}$C is only 420 ± 940 KeV. These results are very similar to that for the halo nucleus $^{11}$Li.

This new data on carbon isotopes was analyzed by Tanaka *et* al.[1] using the Glauber model. Though they obtained reasonable agreement (shown in Table 1 of Ref. 1 ) for $^{19,20}$C, the enhancement for $^{22}$C was not reproduced. In order to reproduce the data they had to use an extended neutron density distribution for the two valence neutrons in $^{22}$C with the core $^{20}$C described by the Harmonic oscillator wave functions. The neutron separation energy 210 keV and an adjustable parameter (the critical radius, $r_c$) were used to describe the extended neutron distribution. The value of the parameter $r_c$, reported to be 5.39 fm, reproduces the experimental data. This leads to the matter radius of 5.4 fm for $^{22}$C.

In the present work we have analyzed the same data using the finite range Glauber model (FRGM)[2] and the microscopic optical potential calculated within the Brueckner Hartree Fock formalism (BHF).

## Calculations, Results and Discussions

Both these approaches require nucleon density distributions as an important input. We have used the RMF densities [3]. To test the halo structure, the extended neutron densities of Ref. 1 was also used for $^{22}$C.

In our Glauber model calculations we have used the parameters of the basic NN-cross sections as in Ref. 2. Thus there are no free parameters in our calculations.

The other important input for BHF calculations is the basic inter-nucleon potential. We have used the old Hamada-Johnston (HJ), Urbana v-14 and the Argonne v-18 inter-nucleon potential to calculate the microscopic optical potential.

The results are presented in the table. The table reveals that the results of all three inter-nucleon potentials are very close to each other, and also agree with the corresponding results of the FRGM.

The results for $^{19,20}$C agree closely with the experiment. The table reveals that for $^{22}$C only the results (marked * in the table) obtained with the extended neutron densities give reaction cross-section in agreement with experimental data.

It is satisfying to note that both the Glauber model as well as BHF prediction is in close agreement with each other as well as with the experimental data. Thus our results support the Halo structure for $^{22}$C.

However we feel there is an urgent need to complement the present data with differential elastic cross-section measurement to confirm the Halo structure in $^{22}$C.

Table 1 :

| | 40 AMeV p– Carbon Cross Sections (mb) | | | | |
|---|---|---|---|---|---|
| | UV-14 | AV-18 | HJ | FR-GM | Exp |
| $^9$C | 364 | 362 | 373 | 381 | |
| $^{10}$C | 407 | 406 | 428 | 413 | |
| $^{11}$C | 423 | 423 | 445 | 421 | |
| $^{12}$C | 456 | 455 | 482 | 445 | |
| $^{13}$C | 508 | 507 | 541 | 484 | |
| $^{14}$C | 558 | 558 | 597 | 525 | |
| $^{15}$C | 622 | 622 | 671 | 578 | |
| $^{16}$C | 683 | 683 | 741 | 629 | |
| $^{17}$C | 727 | 727 | 787 | 665 | |
| $^{18}$C | 784 | 783 | 850 | 713 | |
| $^{19}$C | 827 | 826 | 894 | 750 | 754 (22) |
| $^{20}$C | 869 | 868 | 938 | 785 | 791 (34) |
| $^{21}$C | 902 | 901 | 971 | 812 | |
| $^{22}$C | 928 | 926 | 996 | 833 | 1338 (274) |
| $^{22}$C (*) | 1339 | 1339 | 1532 | 1343 | |

## References

[1] K. Tanaka *et al.*, Phys. Rev. Lett. **104**, 062701, 2010.

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[3] Y. K. Gambhir *et al.* Ann. Phys. (NY), **320**, 429, 2005.