Single Neutron Stripping Reactions for Structural Study of ^{23}O

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Topic of thesis

"To Study the Nuclear Breakup of Unstable Nuclei Lying Close to Drip Line"

Goal of study is to analyses

1. Structural
2. Dynamical characteristics of Halo Nuclei

What is Halo Nuclei ?

1985 Tanihata and His Group

1. Low Binding Energy (much less than the stable nuclei)

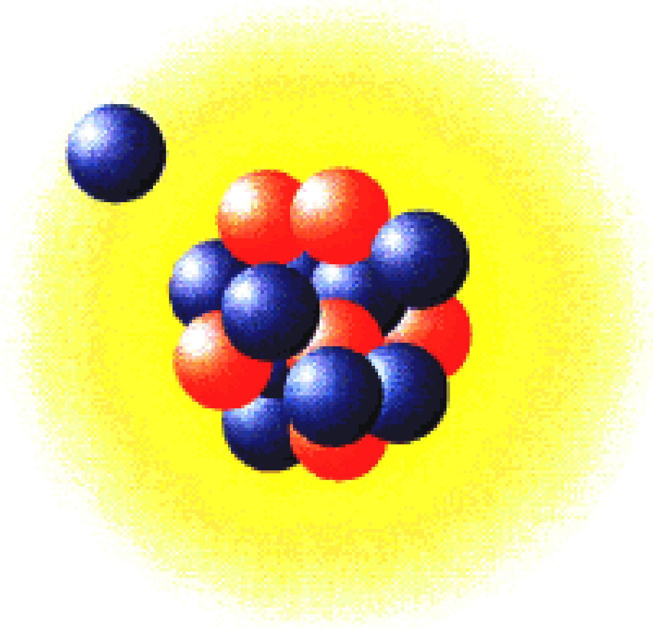
2. Much Larger R M S Matter Radii

3. Narrow Momentum Distribution

4. Much Higher Breakup Cross Section

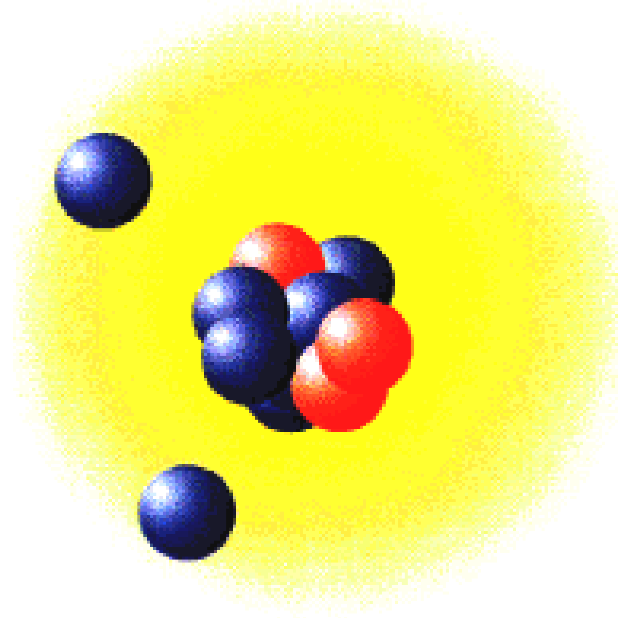
5. Long Tail in Density Distribution

Halo Nuclei



1- n Halo Nuclei
19C

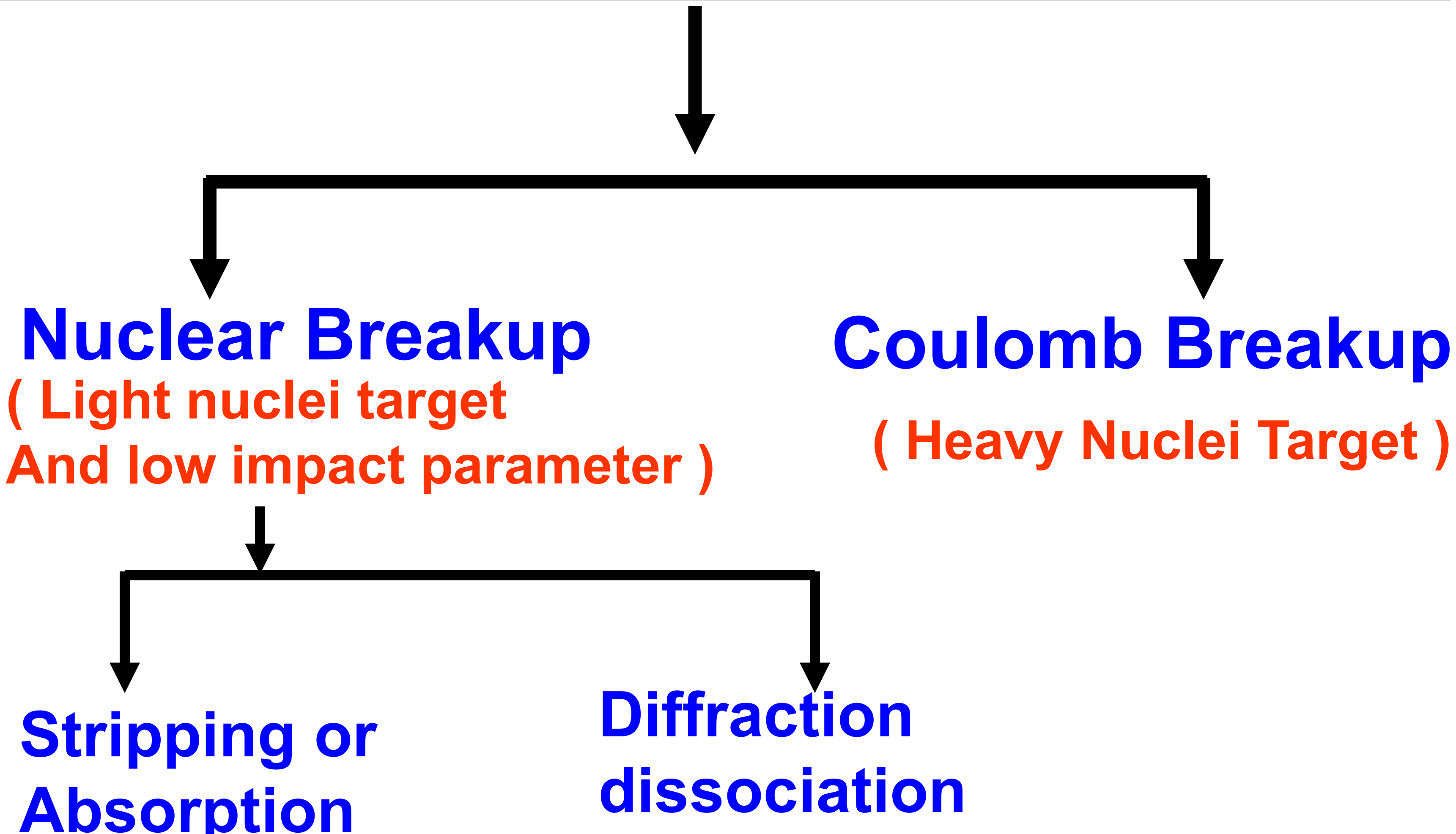
11Be, 14B, 17C, 19C
22N, 22O, 23O etc.



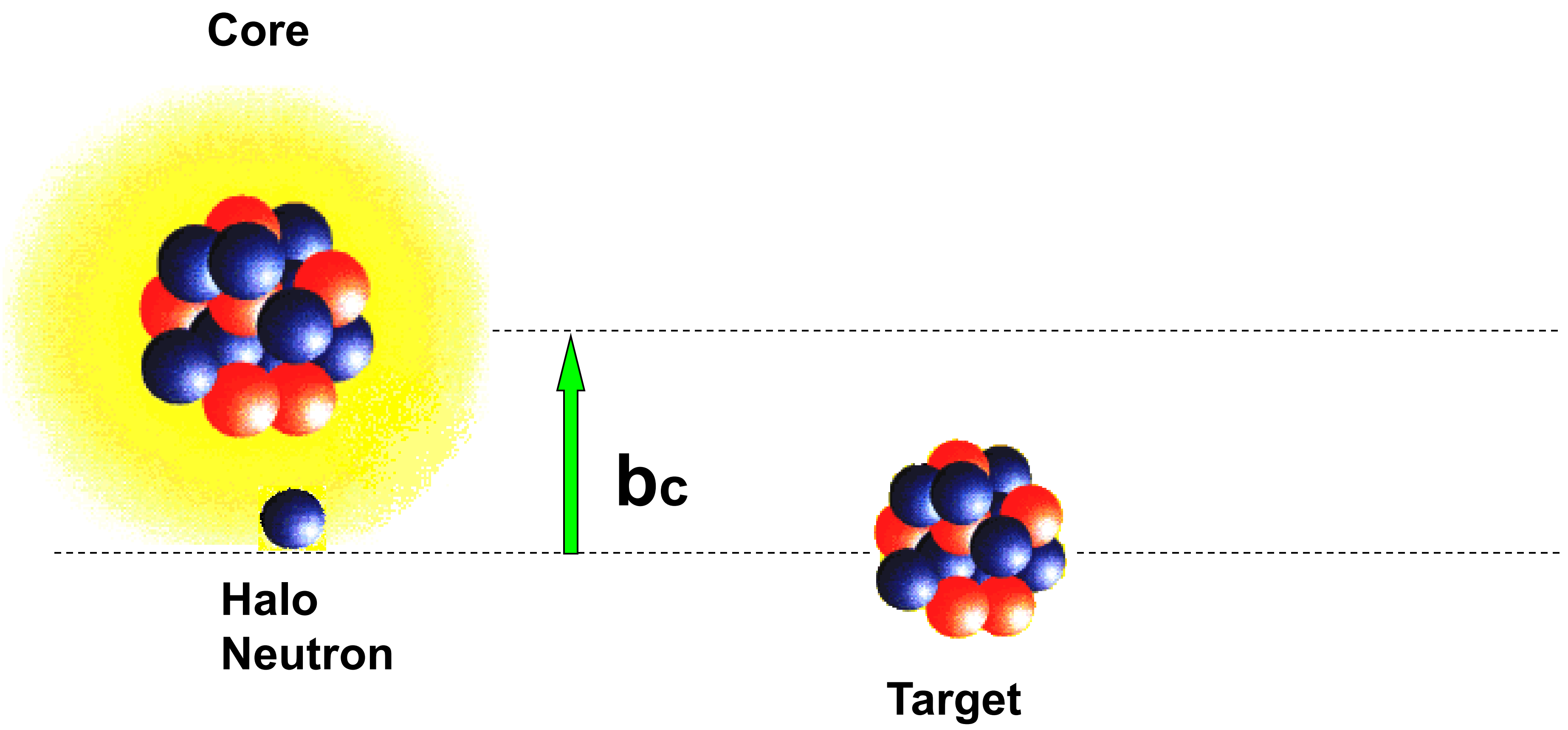
2- n Halo Nuclei
11Li

6He, 11Li, 14Be, 17B
19B, 22C, 27F etc.

Dissociation of Halo Nuclei



Stripping Reaction



Theoretical formalism

Eikonal approximation

Single Neutron Stripping Cross Section

$$\sigma_{sp}^{str}(n\,l\,j, S_n^{eff}) = \frac{1}{4\pi^2}\int d\vec{b}\int d\vec{s}\,[1-\left|S_n(\vec{b}+\vec{s})\right|^2]\left|S_c(\vec{b})\right|^2\int dz\,R_l^2(r)$$

Longitudinal Momentum Distribution of Core fragment

$$\left(\frac{d\sigma}{dk_z}\right)_{str} = \frac{1}{2\pi\hat{l}^2}\sum_{m_l}\int d\vec{b}\,d\vec{s}\,[1-\left|S_n(\vec{b}+\vec{s})\right|^2]\left|S_c(\vec{b})\right|^2\left|\int dz\,e^{ik_z.z}R_l(\sqrt{s^2+z^2})\,Y_l^{m_l}(\hat{r})\right|^2$$

Main ingredient

Core target interaction profile function $S_c(b)$

Single neutron target interaction profile function $S_n(b+s)$

Radial part of relative motion wave function $R_l(r)$

Profile functions

Profile functions S_c and S_n can have various forms

1. Black Disk

2. Diffuse profile function

3. Realistic profile function (using optical potential)
JLM, CH89 etc.

Realistic Profile function
Using R L Varner et al systematic

$$S_i(b_i) = exp\left[-\frac{i}{\hbar v} \int dz\, V_i\left(\sqrt{b_i^2 + z^2}\, \right) \right] \qquad ; \; i = n \; or \; c$$

v **is the velocity of the projectile**

V_i **Optical potential for n or c**

Folding model $V_{cT}(\mathrm{r}) = \int d\vec{x}\;\; \rho_c(x) V_{nT}(|\vec{r} - \vec{x}\,|)$

$V_{nT}(\vec{r})$ **Neutron target optical potential,** $\rho_c(x)$ **Core density**

R. L. Varner, W. J. Thompson, T. L. McAbee, E. J. Ludwig, and T. B. Clegg, Phys. Rep. 201 (1991) 57.

The core density $\rho_c(x)$ is obtained by **Harmonic Oscillator Model**

$$\rho_c(x) = \rho_0[1 + \alpha(x/a)^2]exp[-(x/a)^2]$$

parameter a is related to α by the following expression

$$\alpha = \alpha_0 a_0^2 /(a^2 + \frac{3}{2}\alpha_0(a^2 - a_0^2))$$

$$a_0^2 = (a^2 - a_p^2)\frac{A}{(A-1)}$$

$$\alpha_0 = (Z-2)/3$$

$$a_p^2 = \frac{2}{3}\langle r^2 \rangle_{proton}$$

a is adjusted to reproduce the charge radii of core

Relative Motion Wave Function of Core and Halo Neutron of Projectile

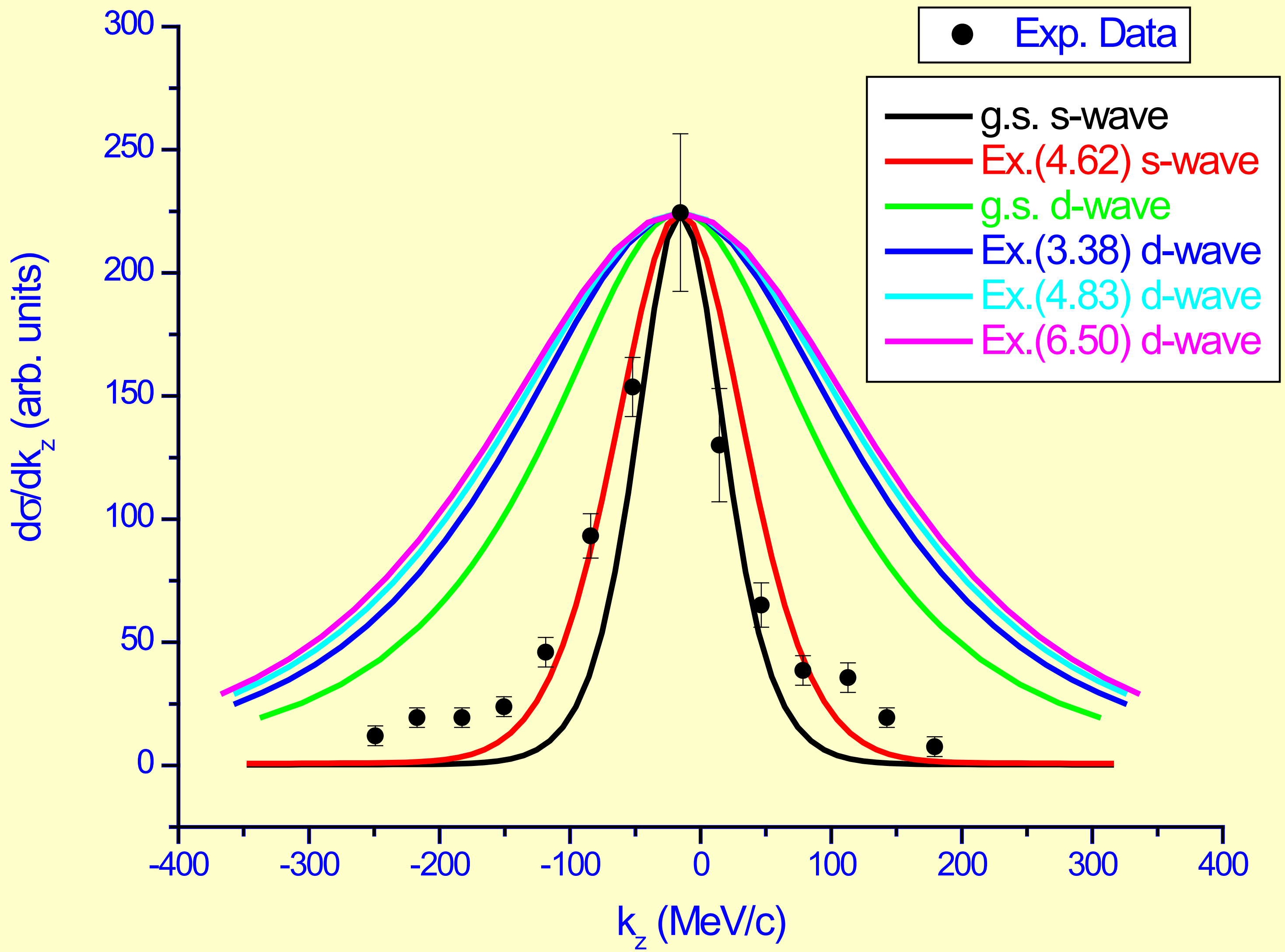
Realistic wave function is obtained by solving Schrodinger wave equation in a Woods Saxon potential

The range and diffuseness parameters of the potential are tuned locally while the depth is adjusted to reproduced the observed binding energy of the loosely bound nucleon (s).

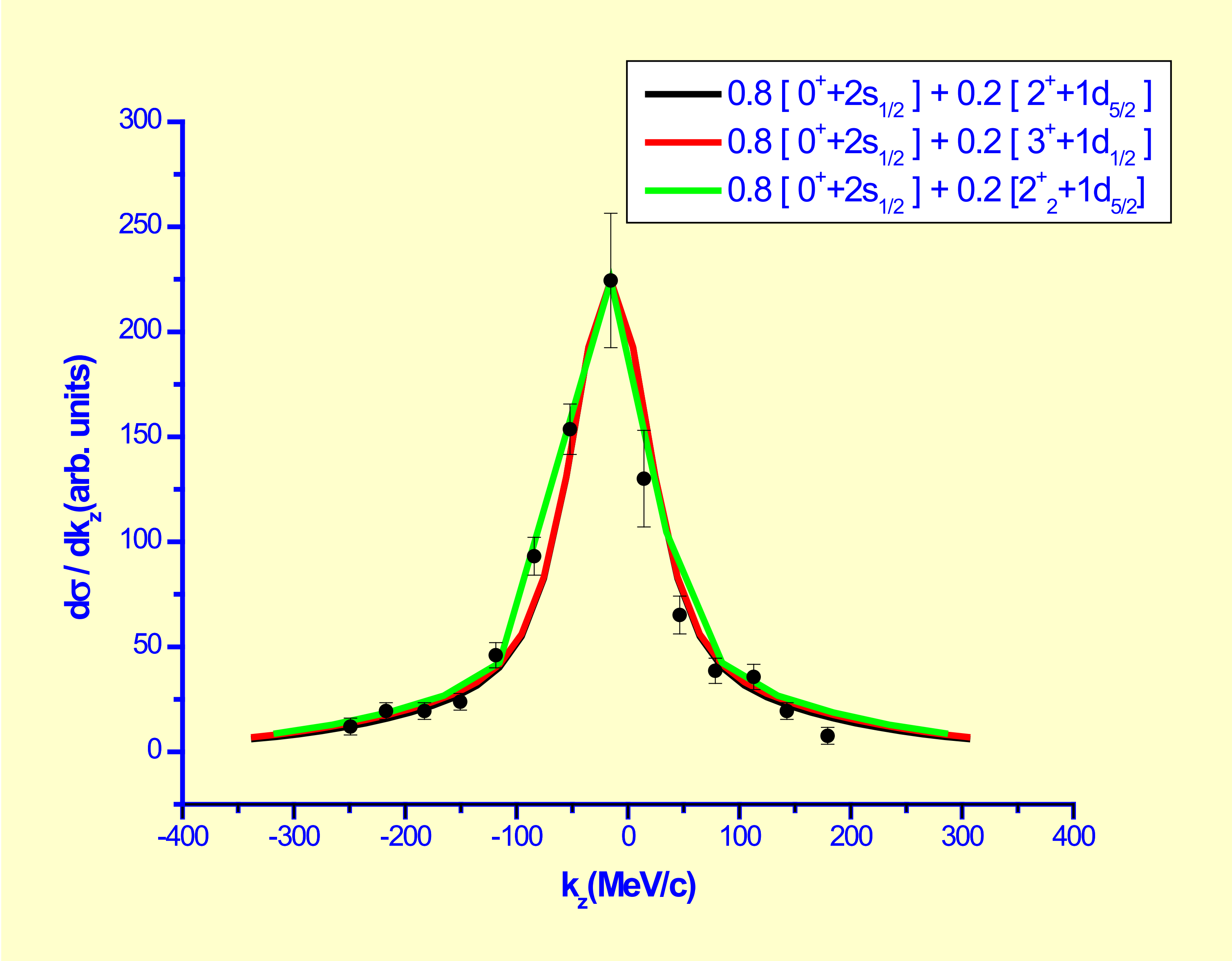
Obtained Partial Cross Section

E_{ex}^{C} (MeV)	S_{n}^{eff} (MeV)	Spin coupling [core ⊗ neutron]	σ_{str} (mb)	C^2S	FWHM of LMD (MeV/c)
0.(g.s.)	2.74	$[0^{+} \otimes 2s_{1/2}]_{1/2^{+}}$	39.23	0.797	80
4.62	7.36	$[0_{2}^{+} \otimes 2s_{1/2}]_{1/2^{+}}$	20.34	0.115	116
3.38	6.12	$[2^{+} \otimes 1d_{5/2}]_{1/2^{+}}$	15.55	2.13	306
4.83	7.57	$[3^{+} \otimes 1d_{5/2}]_{1/2^{+}}$	13.89	3.079	327
6.50	9.24	$[2_{2}^{+} \otimes 1d_{5/2}]_{1/2^{+}}$	13.29	0.242	342

LMD width corresponding to different s and d states



Mixing of different configuration



The Results of *s* & *d* Mix Configurations

Mix configuration	σ_{str} (mb)	FWHM of LMD (MeV/c)
$0.8[0^+ \otimes 2s_{1/2}]_{1/2^+} + 0.2[2^+ \otimes 1d_{5/2}]_{1/2^+}$	34.49	95.21
$0.8[0^+ \otimes 2s_{1/2}]_{1/2^+} + 0.2[3^+ \otimes 1d_{5/2}]_{1/2^+}$	34.15	95.21
$0.8[0^+ \otimes 2s_{1/2}]_{1/2^+} + 0.2[2_2^+ \otimes 1d_{5/2}]_{1/2^+}$	34.04	110.36
	Exp. FWHM = 94 ± 12 MeV/c	

Conclusions

1. **Neither pure s nor pure d state could reproduce the experimental data.**

2. **The admixture of *s* and *d* configurations with the spectroscopic factors 0.8 and 0.2 have been found to represent the LMD data nicely.**

3. **For the exact determination of spectroscopic factors multi nucleon theory is required.**

Publication in International / National Journals in last two year

1. Rajesh Kharab, **Ravinder Kumar**, Pardeep Singh and H C Sharma, “One neutron stripping reaction of light nuclei” , ***Parmana-Jour. Phys. Vol.68, No.5, (2007) 779-787.***

2. Rajesh Kharab, Pardeep Singh and **Ravinder Kumar**, “Effects of E2 and E1-E2 interference on coulomb dissociation of 19C”, ***Chin. Phys. Lett. Vol. 24, No 03(2007) 656.***

3. Rajesh Kharab, Pardeep Singh and **Ravinder Kumar**, “Influence of finite range of nuclear interaction on coulomb brakup of 11Be”, ***Ind. Jour. Phys. 81 No. 3, (2007) 1-8.***

4. Rajesh Kharab, **Ravinder Kumar**, Pardeep Singh and H C Sharma, “Comparison of halo of 11Be, 15C and 19C on light target”, ***Phys. At. Nucl.*** **(accepted)**

5. Rajesh Kharab, Pardeep Singh and **Ravinder Kumar**, “Effect of E2 transition in the coulomb dissociation of 11Be and 19C”, ***Ind. Jour. Theo. Phys.*** **(accepted)**

6. Rajesh Kharab, Pardeep Singh, **Ravinder Kumar** and H C Sharma, “Contribution of E2 and E1-E2 interference in the coulomb breakup of 11Be” ***Int. Jour. Mod. Phys. E*** **(accepted)**

7. Rajesh Kharab, **Ravinder Kumar,** Pardeep Singh and H C Sharma, "Structural analysis of 23O through single neutron stripping reaction", ***Com. Theo. Phys*. (communicated)**

8. Rajesh Kharab, Pardeep Singh and **Ravinder Kumar,** "Coulomb breakup of neutron rich isotopes of light nuclei", ***PINSA*,(communicated)**

9. Rajesh Kharab, Pardeep Singh, **Ravinder Kumar,** "Structural analysis of 19C through coulomb dissociation reactions", ***J. Phys. G: Nucl. Part.*** **(communicated)**

PAPER PUBLISHED IN SYMPOSIUM/ CONFERNCE

1. **Ravinder Kumar,** Rajesh Kharab, Pardeep Singh and HC Sharma, "Stripping reaction of neutron rich 11Be and 19C nuclei", ***Proc. DAE-BRNS Symp. on Nucl. Phys. Vol. 51(2006)465.***

2. Rajesh Kharab, Pardeep Singh and **Ravinder Kumar,** "Angular distribution of 10Be in the coulomb breakup of 11Be", ***Proc. DAE-BRNS Symp. on Nucl. Phys. Vol. 51(2006)473.***

Thanks for your patience