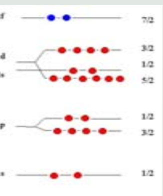
Hiu Ching Lee - NSCL/Michigan State University and the Chinese University of Hong Kong

and Michigan State University.

Maria Goeppert-Mayer, 1963 Noble Prize co-winner for the Nuclear Shell Model, and Magic Numbers



Magic number

N=20

N=10

N=2

Spectroscopic Factors measure the orbital configuration of the valence nucleons.

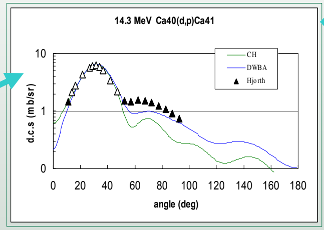
Within the Independent Particle Model (Austern): the values of the spectroscopic factors depend on the number of valence nucleons.

$S = n$ n even

$S = 1 - \frac{n-1}{2j+1}$ n odd

Definition of Experimental Spectroscopic Factor

$$S_{l,j} = \frac{\left(\frac{d\sigma}{d\Omega}\right)_{EX}}{\left(\frac{d\sigma}{d\Omega}\right)_{RM}}$$



DWBA Theory

For the reaction **A(a,b)B**, the transition amplitude (T) is

$$T = \iint \chi^{(-)}(\vec{\kappa}_f, \vec{r}_b)^* \langle \Phi_B | V | \Phi_A \rangle \chi^{(+)}(\vec{\kappa}_i, \vec{r}_a)\, d\vec{r}_a\, d\vec{r}_b$$

For (d,p) reaction in zero-range approximation

$$\langle \Phi_B | V | \Phi_A \rangle = \sum S_{jl}^{1/2} R_{jl}(r_{nA})(lsm\,\mu - m | j\mu)(s_p s m_p m_d - m_p | s_d m_d)$$
$$(J_A j M_A M_B - M_A | J_B M_B) D_0 \delta(r_n - r_p) Y_l^{m^*}(r_{nA})$$

Theoretical spectroscopic factor

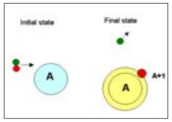
Take A(d,p)A+1 stripping reaction as an example:

Ψ_i^A can be expressed in terms of summation over the complete set of Ψ_f^{A+1}:

$$\Psi_i^A = \sum_f \Phi_f^i(\vec{r})\, \Psi_f^{A+1}$$

$\Phi_f^i(\vec{r})$ is the overlap function defined as:

$$\Phi_f^i(\vec{r}) = \Psi_f^{A+1} \Psi_i^A$$



The theoretical spectroscopic factor S_f^i is given by

$$S_f^i = \left(\int \Phi_f^i(\vec{r})\, d\tau\right)^2$$

Problems:

- Instead of a constant value independent of energy of the reactions, we see large fluctuations in the published spectroscopic factors .
- Consequence of using different optical model potentials and parameters for the DWBA reaction mode calculations.

Summary of the input parameters used in TWOFNR

Source : PRC 69 (2004) 064313

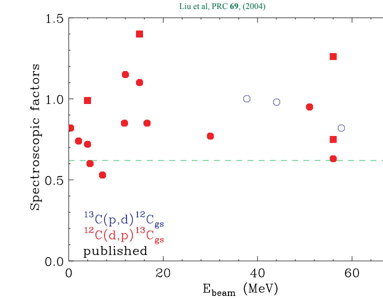
	DWBA	Adiabatic CH	JLM
Proton potential	Chapel-Hill [43]	Chapel-Hill [43]	JLM [47,48]
Deuteron potential	Daehnick [45]	**Adiabatic** [53] from CH	**Adiabatic** [53] from JLM
Target r.m.s radius /density			Shell model
n-binding potential	Woods-Saxon r_0=1.25, a=0.65	Woods-Saxon r_0=1.25, a=0.65	Woods-Saxon r_0=1.25, a=0.65
Hulthen finite range factor	0.7457	0.7457	0.7457
Vertex constant D_0^2	15006.25	15006.25	15006.25
JLM potential scaling λ	N/A	N/A	λ_v =1.0 and λ_w =0.8 [54]
Non-Locality potentials	p 0.85; n N/A; d 0.54	p 0.85; n N/A; d 0.54	p 0.85; n N/A; d 0.54

Adopt fixed parameters in DWBA calculations for the entire range of nuclei investigated.

Digitize ~400 angular distributions from (d,p) and (p,d) reactions measured in the past 40 years to extract the SF values for 79 nuclei from Li to Cr.

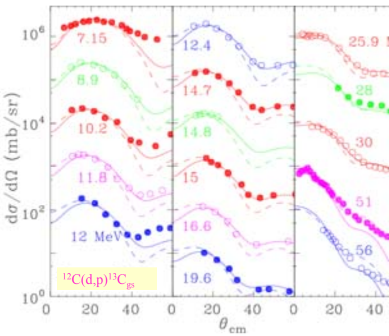
Perform Shell Model calculations for 59 nuclei from p to f $_{7/2}$ shells.

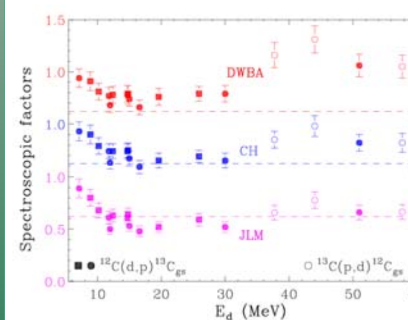
Consistent and Systematic Analysis



Procedure

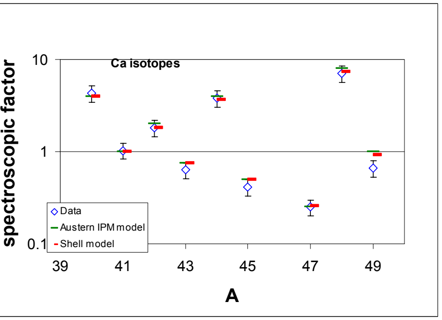
1. Digitize data from literature
2. Perform DWBA calculations using the modified version **TWOFNR** with adiabatic approximation to take into account the deuteron breakup.
3. Adopt a fixed set of parameters, global optical model potentials, nonlocality corrections and finite range corrections.



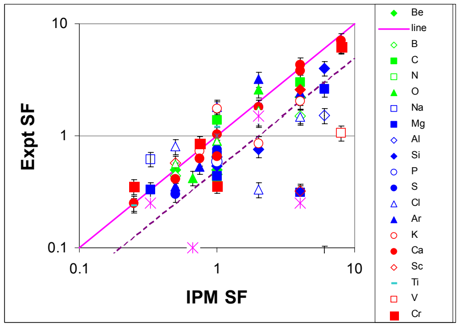


•The spectroscopic factors deduced in a systematic and consistent way show that we can extract spectroscopic factors within the measurement uncertainties.

Comparison with Independent Particle Model



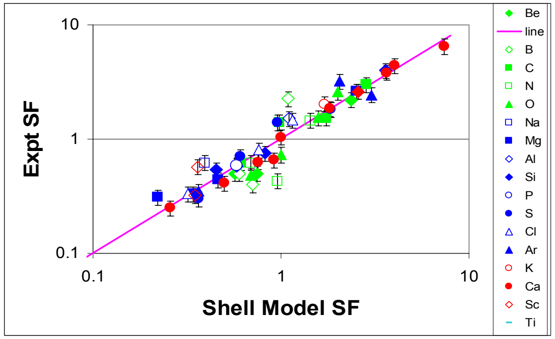
SF's of ^{40}Ca-^{48}Ca isotopes agree very well with IPM.
^{49}Ca SF value is lower than predicted.
The 1f$_{7/2}$ valence neutrons in Ca isotopes are good single particles with spherical cores.



Most experimental SF values are less than IPM predictions.
Discrepancies arise from neglect of interaction between nucleons and core in the simple IPM model.

Comparison with Shell Model (Oxbash)

Good agreement with most isotopes within $\pm$20%



Excluding deformed Ne, F and Ti isotopes, ground state neutron spectroscopic factors for Z=3-24 nuclei extracted using the

Acknowledgements
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