# Study of Spectroscopic Factor Strengths Using Ab Initio Approach

Anindita Karmakar* and Praveen C. Srivastava
*Department of Physics, Indian Institute of Technology, Roorkee 247667, INDIA*

## Introduction

Ab initio effective interactions are very crucial to explain nuclear structure properties of unstable nuclei. If one is able to choose an effective Hamiltonian and model space, it is possible to learn more about low lying energy states, in between transitions and spectroscopic factors. Spectroscopic factor strengths (S) have been one of the main tools to be used to know the structural factors of initial and final nuclei of a transfer reaction. We can relate experimental cross section of a reaction and cross section calculated through *Distorted Wave Born Approximation* by this S factor [1].

Overlap of matrix elements between nucleus of entry and exit channels defines S factors theoretically. By measuring the matrix elements for single-nucleon spectroscopic factors in the nuclear structure calculations, it is possible to elucidate transfer of single nucleons in stellar burning processes. [2]

Surveys of excited state neutron spectroscopic factors for Z = 8-28 nuclei are produced by Tsang et al [3]. In that work they extracted 565 neutron SFs for sd and fp shell nuclei by analyzing (d,p) angular distributions, they also compared the experimental results with shell-model results.

In our present work, shell model calculations for one nucleon transfer reactions have been done for the sd shell i.e. Z=8-14. We used *In Medium Similarity Renormalization* as our main tool and compared that with results from USDB approach and experimental values to know which approach works better.

*Electronic address: akarmakar@ph.iitr.ac.in

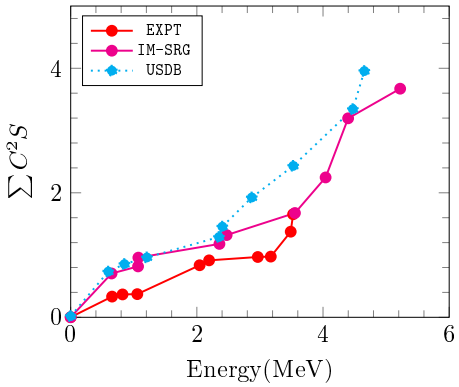


FIG. 1: Comparison of $\sum C^2$S for the reaction $19F(d,p)20F$ with the experimental data and different interactions.

## Results

Similarity Renormalization Group(SRG) consists of a long array of unitary transformations that results in suppression of off-diagonal elements and an block diagonal form of Hamiltonian.

The code we used for our calculation is NuShellX. The difference between USDB and ab initio IM-SRG interaction is that USDB focuses on the whole model space while IM-SRG interaction is nuclear mass dependent and hence customised for different individual nuclei. The core of the valence shell is used as the point of reference by IM-SRG [4].

In our calculation for sd space, we use the $^{16}$O core. Valence protons and nucleons of further elements are calculated with respect to this core. Proper steps were followed to calculate the spectroscopic factors using these interactions. This is done by calculating all the energy levels up to 4+ for even nuclei and $\frac{5}{2}^+$ for odd nuclei.

Fig. 1 shows values for spectroscopic factors corresponding the energy values up to 6 Mev.

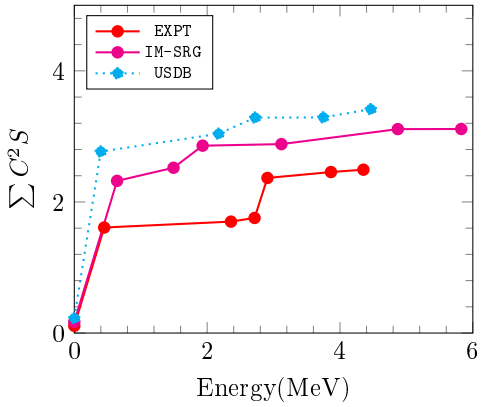


FIG. 2: Same as Fig. 1, but for $24Mg(p,d)23Mg$ reaction.

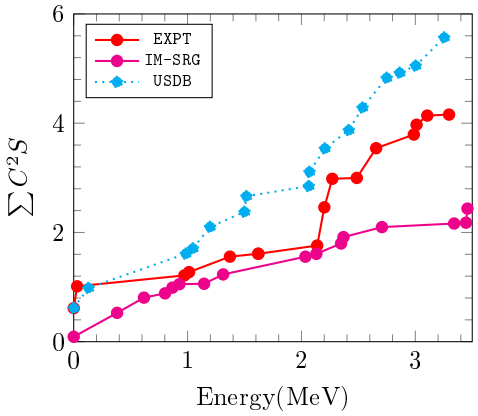


FIG. 3: Same as Fig. 1, but for $27Al(d,p)28Al$ reaction.

The values of $\sum C^2S$ follows the same trend in all the cases but the values extracted from experiments is lower than theoretical values. This is because of the fact that there are many excited states of $^{20}$F whose corresponding SF value is not yet available experimentally inconsidered energy range. From Fig. 2, IM-SRG and USDB both over estimates the values of SF. But,the experimental plot tend to be of more equivalence with IM-SRG compared to USDB.

Fig. 3 shows that graphs have different trends but still USDB matches with experimental values to some extent. Although the values we get are much different than the experimental data. So, for Al and Mg, we deduce that the wavefunctions considering only the model sd space is not enough to describe the whole phenomenon and contributions from upper model spaces should be included so that we get a more precise spectroscopic factor values than these. Our results are in good agreement in case of Silicon. If we consider the reaction $28Si(d,p)29Si$, not only the trends from both IM-SRG and USDB matches, but the values calculated are almost accurate as depicted in Fig. 4.

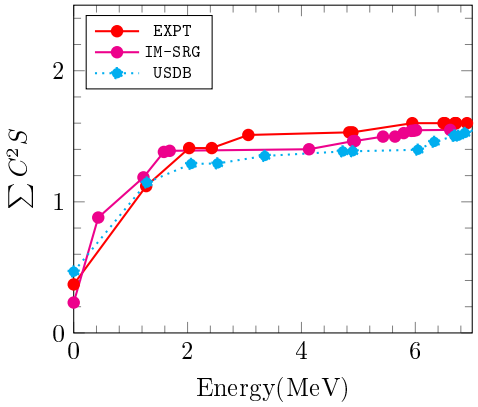


FIG. 4: Same as Fig. 1, but for $28Si(d,p)29Si$ reaction.

## Acknowledgement

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## References

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