International Journal of Engineering, Science and Mathematics
Vol. 10 Issue 12, December 2021,
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

# ANALYSIS OF NEW APPROACH FOR HEAVY ION FUSION SPIN DISTRIBUTIONS

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**Abstract:**
In order to derive fusion spin distributions, the process of optical model analysis has been used to evaluate generalised elastic scattering angular distributions (GESA). The coupling channel fusion spin distributions are repeated using this method. The method provides large mean quadruple spin values in accord with "anomalous" values derived from test fission fragment anisotropy when applied to experimental results, in particular on fissile systems such as $^{16}O+^{232}Th$.
The interaction of 12C,14N and 16O projects with 59Co, 51V,128Te and 165Ho targets for at≈3-8MeV / nucleon-specific energies has been studied. The dynamics of the heavy-ion fusion reaction involved This research focuses on the association between the properties of the entry channel and the invalid fusion reaction. Test-driven excitation functions of different reaction products, with full and/or incomplete 12C+59Co, 128Te, 14N+128Te and 16O+ 51V, 165 Hoprojectile-target systems in the literature.
**Keywords:**
heavy-ion, heavy-ion fusion, spin distributions, RRD, GESA

## Introduction:

The study of heavy ion reactions in low energies in recent years has generated a strong degree of excitement because of the rich interplay between the dynamics of reactions and the nuclei 's nuclear structure. Measures on many aspects of the collision nuclei such as elastic and inelastic reactions, reactions to the transition, fusion, etc. have shown that these processes correlate and seek to create a model that takes all of them into consideration. All of this definition is defined by an understanding of the importance of connexions between different canals, indirectly by optical models or by the coupled channels (CC) method explicitly. In addition to the direct one-stage amplifications, these couplings lead to major multi-step contributions to different reaction channels, typically assessed by methods such as the DWBA, barrier penetration models, optical model, etc. In fact , a large number of coupling channel equations are difficult to resolve and thus many approximations are taken, in addition to restricting the number of channels that are essential for a specific reaction. These calculations cause severe variations between theoretical and experimental measurements. In the fusion reaction, the fusion partial wave cross-section can not be clarified by many models [12] while the complete fusion cross-section is considered. Therefore, it is appropriate to understand the reaction mechanism for each partial wave and their contribution to various reaction channels in order to test any theory of heavy ion reactions. In this context, it is highly desirable to experimentally calculate partial wave cross sections for various reaction channels. In this paper we are testing the method by fitting general elastic scattering angular distribution (GESA) to the partial transverse wave segment for the fusion channel. The GESA is known as the sum of strictly elastically adjustable unelastic channels and a reduced reaction intersection is called [2]. In general, the easiest

In order that the reaction cross-section is collected, the measurements are analysed and correctly calculated to ensure that the overall reaction cross-section includes contributions from all potential reaction channels. If an angular distribution is available for any non-elastic channel, a GESA can be set by adding it to the strictly elastic angular distribution.

Oeschler et al [13] for heavy ion collisions, the lower cross-sectional reaction and the partial wave distribution obtained by fitting the GESA has been shown to comply with the total cross-sectional reaction for all remainder channels not applied to the generalised elastic channel. In heavy ion diffusion, the elastic canal also contains contributions from ~ow-lying Coulomb excitement and [13] focus was placed on the question of the consistent value of the reduced transverse reaction when the flow into the remaining canales is analysed for the amount of Coulomb excited inelastic states and elastic diffusion (GESA). In order to obtain an adequate potential for coupling channel computations, an optimum optical model was also observed for GESA. In comparison, due to the long range of Coulomb excitations, the purely elastic dispersion often proves hard-to-fit. This method was applied to obtain the partial wave cross-section for the GESA mixing channel. Both results of channel coupling can also be found in the fusion partial wave cross-section. However, all the non-fusion reaction channels require the angular distributions. Direct measurement of partial-wave cross-sectional fusion measurements based on 7-ray multiplicity measurements is difficult , especially for fissile targets. Indirect methods are typically employed to achieve a medium square spin in the studies of model-dependent and often anomalous fragment-based anisotropies. This method is useful for obtaining a cross-sectional fusion as a reduced cross-sectional reaction by mounting GESA which contains everything other than fusion channels.

The pre consistently low-energy (4 to 7 MeV / nucleon) pre-compound (PCN) emission process has been the subject of recent interest [1] because it is predicted to occur generally in a relatively high energetic range of 10-15 MeV/ nucleon [2]. The PCN method can be interpreted as the fusion of two heavy nuclei so that the composite nucleus forms far from the statistical equilibrium and a significant portion of its energy can be considered an orderly translation movement of the nucleons of the projecttile and target nucleus [3–8]. When the composite nucleus enters a state of thermal equilibrium called a compound nucleus (CN), this thermalizing process ends. It is conceivable that one nucleon or cluster of nucleons with significant energies is expelled into the continuum when an excited composite system is thermalized. As soon as there are thermal balances, sufficient energy will accumulate in the random sequence of events and thus require significantly more emission times that improve the emulation of low-energy particles on a single nucleon or cluster of nucleons. Before the thermodynamic balancing of the composite system the emission of these light particles is called PCN particles and the reaction mechanism is called the PCN process.

Nuclear physics has gained a new frontier with the introduction of heavy-ion reactions. Many experiments were conducted to clarify the internal nucleus structure and nuclear characteristics. This contributed to the creation of nuclear models that seek to describe the nucleus structure. However, there is a very dynamic, difficult to understand, relationship between the nuclei and their constituents. There were many ways of understanding nuclear structure complexity and heavy ion reaction dynamics thanks to the available heightened ion beaches from particulated accelerator. One of the key aims of today's low-energy , nuclear heavy ion reactions is to consider the balance mechanism of the composite system in various degrees of freedom. Heavy ion reactions give us a strong opportunity to monitor the reaction in the degrees of enthusiasm, corner momentum and mass symmetry.

**Heavy ion reaction**

Heavy ion reactions are generally taken to be more lourd than an alpha particle as projectile-induced reactions. With the heavy ion-induced reactions, a long-range repulsive Coulomb force and a short-range nuclear force come into play with two heavy nuclei touching each other.

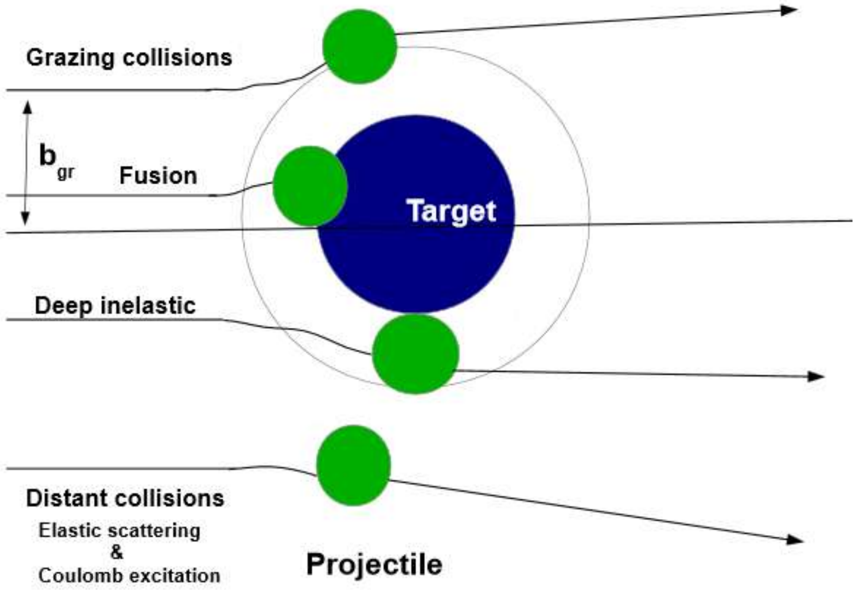


**Figure 1:** Different processes observed as an effect parameter in heavy ion collisions.

Both these forces describe a barrier, which is called Coulomb barrier, both the repulsive and the attractive balance between forces. In order to fuse or capture the nuclei, the energy of relative motion of two heavy nuclei must be sufficient to overcome the Coulomb barrier. Different nuclear reactions can take place according to different parameters like mass , energy, angular momentum etc.

**Methodology:**

The total scattering amplifier that includes phase variations of 6 t is calculated by

$$f(x) = \frac{1}{2ik}\sum_l (2l+1)[(e^{2i\sigma_l} - 1) + e^{2i\sigma_l}(e^{2i\delta_l} - 1)]p_l(x),$$

$$= f_C(x) + f_n(x). \qquad (1)$$

If the amplitude f(x) is used with optical theorem, it can be proved that [ 13],

$$(4\pi/k)\mathrm{Im}[f_n(x=1)] = \sigma_R + 2\pi\int[\sigma_{el}(x) - \sigma_{Ruth}(x)]\mathrm{d}x, \qquad (2)$$

where the total cross-sections of elastic and Rutherford are given

$$\sigma_{el} = 2\pi\int|f(x)|^2\mathrm{d}x \quad \text{and} \quad \sigma_{Ruth} = 2\pi\int|f_c(x)|^2\mathrm{d}x$$

The contribution on the left side of (2) is very small in relation to the overall overall reaction cross-section $a_R$ in presence of the strong Columbus field as in case of heavy ion dispersion and, by setting it to zero, the overall reaction cross-section can be written, as the difference between Rutherford and elastic angle distributions is considered properly (for details see ref. [13] and references therein)

$$\sigma_R = \lim_{\varepsilon \to 0} 2\pi \int_{\varepsilon}^{\pi} [\sigma_{Ruth}(\theta) - \sigma_{el}(\theta)] \sin\theta \, d\theta. \quad (3)$$

The above equality justifies the use of widespread elastic spreads to achieve the reduced cross-sectional response. Let (*V*, *W*) be a set of real and imaginary optical potential for the rigorously elastic scattering and $a_R$ for the necessary cross-section of reaction.

**Experimental details and analysis:**

The following three measurements (i) recoil range distributions(RRDs) distributions(RRDs), (ii) product spin distributions (SDs) and (iii) excitation functions (EFs) have been performed in the present paper in the interaction between 16O projectile and 159 and 169Tm objectives. The following steps are automatically taken: The identification of delayed γ-rays residue oscillations occurs via an offline activation technique based on the recoil captors in both RRDs and EFs measurements. Measurements of SDs however are based on the identification in forward and backward directions of prompt γ-rays products in a coincidence of particles-γ. A brief summary and results are given below for any experiment conducted in the Inter University Accelerator Center (IUAC), New Delhi , India;

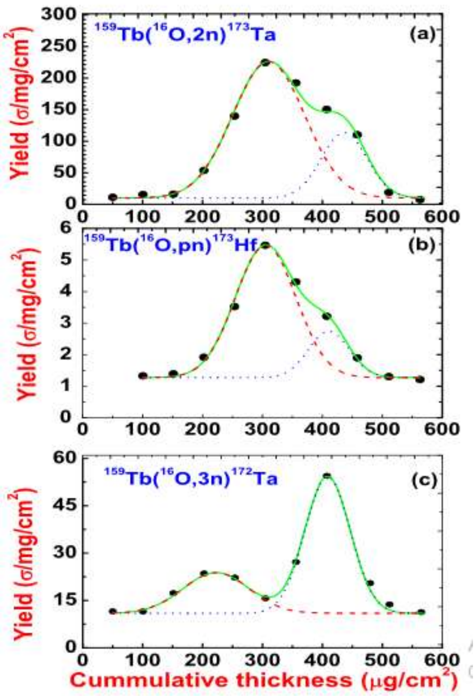


**Figure 2.**(Color online) The experimentally measured RRDs for the reactions159Tb(16O,2n)173Ta,159Tb(16O,pn)173Hf and159Tb(16O,3n)172Ta at energy⥉90 MeV. The Gaussian peak (blue dotted curve) generated from ORIGIN software is CN in this figure whereas the other Gaussian (red dotted curve) is of a lower thickness PCN.

**Measurement and Analysis of Spin Distributions**

The second experiment was conducted based on the coincidence technique of particulate gamma to measure spin state population during reaction residue excitation. The spin-distributions of the reaction in the current work $^{159}$Tb($^{16}$O,2n)$^{173}$Ta at⥉93 MeV and for$^{169}$Tm($^{16}$O,2n)$^{183}$Ir at⥉88 MeV was tested with GDA and the Charged Particle Detector Array (CPDA), using the Gamma Detector Array (GDA). Ref. [9] offers the Experimental

De-tails. However, for ready reference we list them here briefly. The GDA consists of 12 HPGe γ- high-resolution, compressed Compton spectrometers with an axis of $45^0$, $99^0$ and $153^0$ angles, and four detectors are available at each angle. The CPDA is a group of 14 phoswich detectors found in a scattering chamber with a diameter of 14 cm and a total angle of almost 90%. The residual reaction was detected from its distinctive rapidly changing γ- transition lines [10]. The relative outputs of the residue is calculated by the spin $j_{obs}$ observed corresponding to fast gamma transitions [11], i.e. the measured region below the pick of experimentally measured fast gamma lines with a proper correction of detector efficiency. The relative yield with the minimum observed turn has been normalised ($J^{min}{}_{obs}$)at highest yield ($Y^{max}{}_{obs}$). The experimentally calculated SDs are from prompt γ-rays reported in forward and backward directions for the reac-tion as a representative case $^{169}Tm(^{16}O,2n)^{183}Ir$ Figures 3 (a) and 3 (b), respectively, are shown at 88 MeV. The calculated SD and thus its pattern of decay for that reaction, as can be seen in these figures, differ distinctly from each other in the front and reverse directions suggesting widely different mechanisms of reaction. The completely different types of SDs in the forward and reverse directions can be pointed out, showing that both processes are very different in their existence.

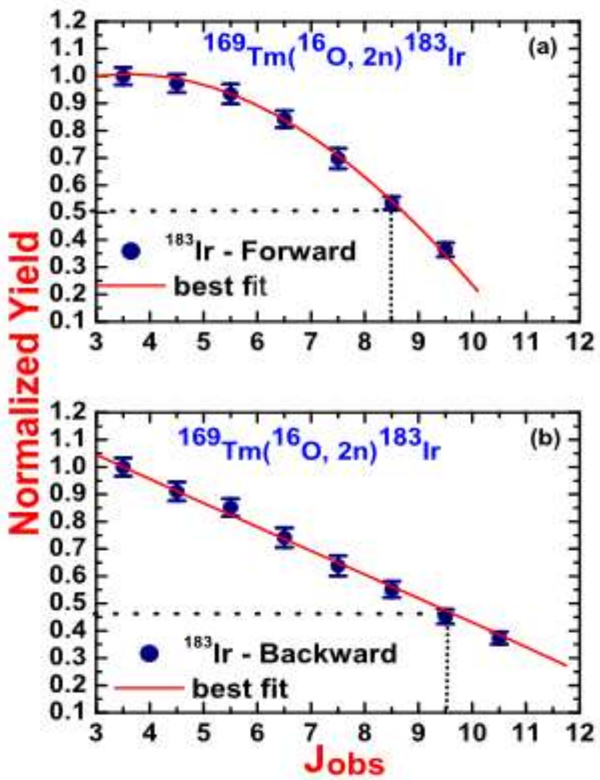


**Figure 3.**(Color online) The spin distribution in front and back directions is experimentally calculated for reactions $^{169}Tm(^{16}O,2n)^{183}Ir$. This figure's curve and line direct the eye to ensure that the PCN and CN processes experimentally normalise the spin distributors.

The lower value observed in forward direction for the mean input corner momentum (⇡8.5~) is because the emission of two PCN neutrons eliminates a large proportion of the angular moments. On the other hand, due to the emission of two balanced neutrons, a somewhat higher value of the average angular dynamum input in reverse direction (⇡11.5~) is observed. Therefore, it has been concluded that different SDs directly demonstrate the PCN emission mechanism. Therefore, the findings of the SDs measurements complement the results obtained from the measurements of the RRDs.

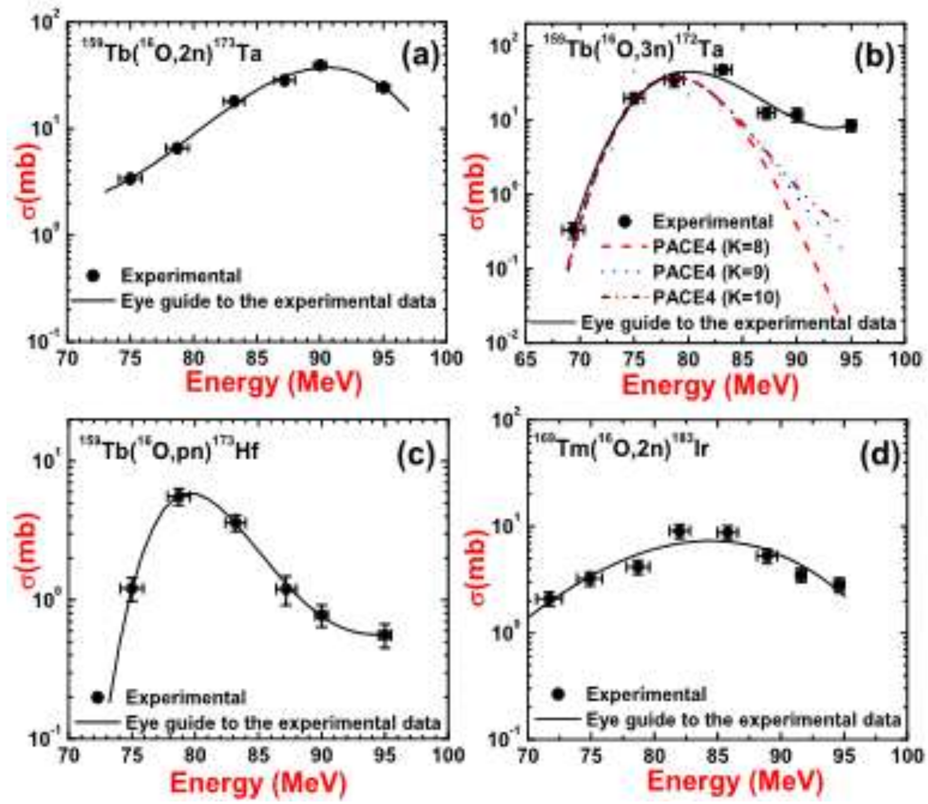


Figure4. (Color online) (a-d) The EFs assessed for reactions are experimentally $^{159}$Tb($^{16}$O,2n)$^{173}$Ta,$^{159}$Tb($^{16}$O,pn)$^{173}$Hf,$^{159}$Tb($^{16}$O,3n)$^{172}$Ta,and$^{169}$Tm($^{16}$O,2n)$^{183}$Ir, respectively. For all these reactions, with the exception of codepace4 theoretically determined EFs give negligence small cross-sections values. $^{159}$Tb($^{16}$O,3n)$^{172}$Ta. EFs and thepace4 predictions with various K-values from K=8 to K=10 for the reaction were experimentally measured $^{159}$Tb($^{16}$O,3n)$^{172}$Ta Figure 4(b) is also shown

**Conclusion:**

SD measurements confirm the findings obtained by RRDs. RRD steps are a responsive means of decrypting the processes of CN and PCN. In the auxiliary EF measurement studies, the RRD and SD measurements are found to be consistent.

It has been found that the GESA approach can be employed in the experimental, elastic and non-elastic angular distributions of the fusion spin distributions. In the presence of inelastic and transfer channel connectors, the validity of this approach was tested. The method gives broad median square spin when applied to fissile structures, in line with the "anomalous" values calculated. The study also indicates that the fusion is vying for transfer processes for all partial energy waves while the transfer indicates place in l-space at high energy. At high energy. These findings are model-specific as only the experimental angular distributions for related reaction channels are used.

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