Contributions of Prof. O. S. K. S. Sastri from 5th September 2023 to 15th January 2025
Best Teacher Award

Research Publications: (Annexure 1)

1. Three papers in A*;
2. One paper in A;
3. Four papers in B, and
4. One paper in C quality journals.

Books Published: (Annexure 2)

1. "**Computer Simulations in Quantum Physics**" by Prof. O. S. K. S. Sastri, published by Notion Press and also avaialable on Kindle, Amazon

Project Publications:

1. **PAS 8108 H – Review of Literature and Research Proposal - 4 Credits**
2. **PAS 8109H: Research Work – 4 Credits**

All three B.Sc. (Physics) students' Research has been published in DAE-HEP, December 2024 (**Annexure 3**)

3. **PAS 9106: Literature Review and Research Proposal – 4 Credits**
    1. Two papers published in DAE-BRNS 2023 Annual Symposium in Nuclear Physics (**Annexure 4**)
4. **PAS 9206: Project Work – 12 Credits**
5. **PAS 9207: Publication – 2 Credits**
    1. Four M.Sc (Physics) projects, from 2022-2024 batch, published in an International Conference at Central University, Jammu. (**Annexure 5**)

Courses Offered:

1. **PAS 9105: Theoretical Nuclear Physic**s – **4 Credits** (Designed this new course completely in tune with NEP-2020 guidelines and introduced many new innovations from our research into it. A list of Innovative Activities is attached) (**Annexure 6**)
2. **PAS 9102**: **Scientific Writing and Presentation – 2 Credits**
3. **PAS 7107**: **Innovation Project** – **4 Credits** (The students were divided into 11 groups and have been assigned innovative projects. Details are attached.) (**Annexure 7**)
4. **PAS 8207**: **Bharateeya Astronomy and Kaal Ganana – 2 Credits** (A new perspective of Cosmological Model from Brahmananda valli of Taitteriya Upanishad was given by me. Other ideas were delivered from Vedic Physics book by Keshav Dev Verma.) **(Annexure 8)**
5. **PAS 8107**: **Indian Knowledge Systems – 2 Credits** (Developed the content by referring to more than 15 books)
6. **PAS 8404A: Quantum Mechanics – 4 Credits** (Designed new content and incorporated NEP-2020 guidelines. Developed activities to go hand-in-hand with the theory classes. Introduced Super Symmetric Quantum Mechanics - SUSY for the first time in PG Curriculum) **(Annexure 9)**
7. **PAS-8202A: Advanced Quantum Mechanics – 2 Credits** (Introduced Geometric Algebra) **(Annexure 10)**
8. **PAS-8107H: Advanced Nuclear Physics – 4 Credits**

Workshops and Conferences Organised:

1. Workshop on "**Indian Knowledge Systems in the Context of NEP**" 29th February to 2nd March, 2024 at IUAC, New Delhi.
2. Two day National Conference on "**Indian Knowledge Systems in Physics and Astronomy**", on 11th and 12th July, 2024 at IUAC, New Delhi.
3. "**Three Day 38th Annual National Convention of Indian Association of Physics Teachers**", in collaboration with NIT, Hamirpur, GC, Dharamsala, GC Nagrota Bhagawan and Rainbow International School, Nagrota Bhagawan. Received funding of Rs 2 lakhs from CUHP and 2 lakhs from IAPT. This was held from 16th to 18th October, 2024. (**Annexure 11**)
4. **"One day pre-convention workshops on 11 different topics**" with many of them as hands-on workshops to enhance the mandate of NEP-2020. This was held on 15th October 2024 and attended by about 300 students. **(Annexure 12**)
5. "**One day Workshop on Arduino and its Applications**" organised at Rainbow International School, Nagrota Bhagawa. (**Annexure 13**)

Honours Recieved:

1. **Visiting Associate** at IUAC, New Delhi for the year 2023-24. (**Annexure 14**)
2. **Training of 26 Scientists and Engineers** recruited at IUAC, New Delhi from June 2023 to June 2024.
3. Keynote Speaker "**Indigenous Technologies in Vikisit Bhara**t" for Science Day Celebrations on 28th February 2024, at IUAC, New Delhi. (**Annexure 15**)
4. Nominated as **"Chief Editor of Physics Education Journal",** sanctioned 3.5 lakhs per annum for 5 years, an amount of Rs 17.5 Lakhs.
5. **Chief Guest** for Valedictory function of International Conference on Recent Advances in Materials and Biological Sciences, 19-20 November, 2024. (**Annexure 16**)
6. **Vice-President** of IAPT- RC03 from January 2022 to December 2024.

Special Courses and Lectures Delivered:

1. **Computational Physics Course –** 3 (2T + 1L) Credits.
2. **Research Methodology Course –** 3 (2T + 1L) Credits.
3. Series of Lectures and Hands-on Sessions at "**Training Program on Computer Interfaced Experiments in Physics using ExpEYES**" at IUAC from 9th-14th October 2023. (**Annexure 17**)
4. Series of Lectures and Hands-on Sessions at "**Training Program on Computer Interfaced Experiments in Physics using ExpEYES**" at IUAC from 6th **-**11th May, 2024.(**Annexure 18**)
5. Presented talk on "**Reflections on Laws of Motion in Vaisesikha Darshanam**" at IKS Conference on Physics and Astronomy held at IUAC from 11-12 July, 2024.
6. Series of Lectures and Hands-on Sessions at "**Training Program on Computer Interfaced Experiments in Physics using ExpEYES**" at IUAC from 23rd-28th September 2024.(**Annexure 19**)
7. One day Hands-on workshop on **'Quantum Physics Simulations using Spreadsheets'** on 29th September 2024, at St. Bedes, Shimla. (**Annexure 20**)
8. One day Hands-on workshop on "**Model Based Simulations in Classical Physics**" on 3rd October 2024, at St. Bedes, Shimla. (**Annexure 21**)
9. One day Hands-on workshop on "**Video and Image Analysis using Tracker**" on 4th October 2024, at RKMV, Shimla. (**Annexure 22**)
10. A session on "**Computer Simulations in Quantum Physics**" for teachers as part of Refresher Course for Physics, on 17th December 2024, organised by PMNMTT, Central University, Jammu
11. Presented talk on "**God is Omnipresent, Omniscient and Omnipotent: A Comprehension based on Fourier Transform**" at International Conference on Viswa Veda Vijanana Sammelanam organised from 23-25 December, 2024. **(Annexure 23)**
12. Keynote Address on the topic "**How to Know Oneself**" at workshop on Enhancing Visibility and Quality of Research Output and Research" organised by SoES and SHoDH on 9th October 2024.
13. Presented talk on "**Numerical Simulation of Nuclear Scattering Studies using Phase Function Method**" on 9th November 2023, at SLENA, SINP. Kolkatta.
14. Presented a talk on "**Swatantra Se Pehele Ke Vygnanic Prateek**" on 16th October 2023, at IUAC, New Delhi.

Participation towards Learning by attending capacity building workshops:

1. Completed "**One Week National Workshop on SLENA"** attended at Saha Institute of Nuclear Physics, Kolkatta from 7th to 10th November, 2023. Partially funded by CUHP. (Certificate attached)
2. Completed **8-week** NPTEL Online Course on "**Learner Centric MOOCs**" (Certificate Attached) from January to March 2024, as per the guidance of Honorable Vice-Chancellor.
3. Completed **One week training program** entitled "**National Future Leadership Programme**", at IIT Roorkee from 6th to 10th January, 2025. Had been nominated for the same by Honorable Vice-Chancellor. (Certificate Attached).

Participation as VC Nominee in Board of Studies of Department of Sanskrit, Department of Computer Science, Department of Physics and Astronomical Sciences and School Boards of SoPMS, etc.

MoU with National Remote Sensing Agency (NRSA) has been initiated with installation of Lightening Detection Sensor System at CUHP by the Honourable Vice Chancellor.

Been **member of Executive Council** of CUHP up to 2023.

Annexure 1

1. **Sastri, O. S. K. S.**, Sharma, A., & Awasthi, A. (2024). Constructing inverse scattering potentials for charged particles using a reference potential approach. ***Physical Review C***, *109*(6), 064004. **[A*]**
2. Awasthi, A., Sharma, A., Kant, I., & **Sastri, O. S. K. S.** (2024). High-precision inverse potentials for neutron-proton scattering using piece-wise smooth Morse functions. ***Chinese Physics C***, *48*(10), 104104. **[A*]**
3. Awasthi, A., & **Sastri, O. S. K. S.** (2024). Comparative study of α-α interaction potentials constructed using various phenomenological models. ***Turkish Journal of Physics***, *48*(3), 102-114. **[B]**
4. Awasthi, S., Kant, I., Khachi, A., & **Sastri, O. S. K. S.** (2024). Elastic scattering study of α-3 H and α-3 He modeled by Malfliet–Tjon potential using phase function method. ***Indian Journal of Physics***, 1-9. **[B]**
5. Khachi, A., Awasthi, S., Kumar, L., & **Sastri, O. S. K. S**. (2024). Algorithm to Obtain Inverse Potentials for α–α Scattering Using Variable Phase Approach. ***Computational Mathematics and Mathematical Physics***, *64*(10), 2320-2332. **[B]**
6. Sharma, A., Sharma, A., **& Sastri, O. S. K. S**. (2024). Simulation Study of Arbitrary 1D Periodic Potentials by Modified Marsiglio's Matrix Approach using Gnumeric Spreadsheet. ***Resonance***, *29*(12), 1627-1641. **[B]**
7. Awasthi, S., & **Sastri, O. S. K. S.** (2024). Real and imaginary phase shifts for nucleon–deuteron scattering using phase function method. ***Physics of Atomic Nuclei***, *87*(3), 311-318. **[C]**

Constructing inverse scattering potentials for charged particles using a reference potential approach

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An accurate way to incorporate long-range Coulomb interaction alongside short-range nuclear interaction has been a challenge for theoretical physicists. In this paper, we propose a methodology based on the reference potential approach for constructing inverse potentials for charged particle scattering. The central idea is to obtain the inverse potential directly from the expected scattering phase shifts by comparing them with those obtained by solving the phase equation for a chosen reference potential. The design of the reference potential is key to incorporating the Coulomb interaction successfully. Here, a combination of two smoothly joined Morse functions, one regular followed by an inverted one, is considered. While the former takes care of short-range nuclear and Coulomb interactions, the latter accounts for expected barrier height due to the long-range Coulomb part that dominates once nuclear interaction subsides. The final step is to incorporate the phase equation within an iterative loop of an optimization algorithm to obtain the model parameters for the reference potential by minimizing the mean absolute percentage error between the obtained and expected scattering phase shifts. We have applied the methodology to the $\alpha - \alpha$ system and constructed the inverse potentials for its S, D, and G states with mean absolute percentage errors of 0.9, 0.5, and 0.4 respectively. Their respective resonances (experimental), in MeV, are found to be at 0.1240 (0.0918), 2.95 (3.03), and 11.89 (11.35). One can conclude that the reference potential approach using a combination of smoothly joined Morse functions is successful in accurately accounting simultaneously for the short-range nuclear and the long-range Coulomb interactions between charged particles in nuclear scattering studies.

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I. INTRODUCTION

The key to scattering phenomena is to model the underlying interaction potential that gives rise to the scattering phase shifts (SPS) that are responsible for the observed experimental scattering cross sections. The theoretical approaches [1–3] most often utilized rely upon determination of the scattering phase shift from the wave function that is obtained by solving the time independent Schrödinger equation (TISE). The potential is chosen by modeling the interactions primarily due to nuclear and Coulomb forces and, in some cases, by adding perturbation terms due to the interplay of spin, isospin, and orbital angular momentum. These potentials are typically represented by various mathematical functions that best represent the nature of the interaction as can be elicited from the phase shift values and the trends they follow at different laboratory energies [4]. An alternative approach is to rephrase the second order TISE as a first order nonlinear Ricatti equation for different ℓ channels as in the phase function method [5,6]. One advantage of this latter method is that it deals with the interaction potential directly, eliminating the requirement for a wave function. This enables the construction of inverse potentials directly from the available experimental data, as in inverse scattering theory [7].

Theoretically, constructing inverse potentials [8] requires not only information regarding all the bound state energies E_n $(n = 0, 1, \dots, N)$ along with their related normalization constants C_n but also the phase shifts for all scattering energies $E > 0$ ranging to infinity. Most often, phase shift data are available for only certain energies within a limited range and hence a rigorous solution of the quantum mechanical inverse problem is extremely difficult to compute. The inverse problem is akin to the machine learning (ML) paradigm wherein one obtains the model of interaction from large amounts of available data. Typically, one prefers neural-network-based models [9], when the number of available experimental data is very large, say $\geqslant$1000. Otherwise, it is more appropriate to use metaheuristic algorithms [10–12] as part of these ML models and enhance their performance by incorporating the knowledge of the problem from the physics that underlies the phenomenon.

Selg [13] proposed using Morse functions as the zeroth reference to obtain the scattering phase shift, and went on to solve the Marchenko integral equation that gives rise to the inverse potential. We proposed a computational approach to construct inverse potentials [4,7] for nucleon-nucleon by utilizing a single Morse function as a reference. Although this method is effective in calculating the inverse potentials for scattering in scenarios where the projectile or target particles

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High-precision inverse potentials for neutron-proton scattering using piece-wise smooth Morse functions*

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Abstract: The aim of this study is to construct inverse potentials for various ℓ-channels of neutron-proton scattering using a piece-wise smooth Morse function as a reference. The phase equations for single-channel states and the coupled equations of multi-channel scattering are solved numerically using the 5th order Runge-kutta method. We employ a piece-wise smooth reference potential comprising three Morse functions as the initial input. Leveraging a machine learning-based genetic algorithm, we optimize the model parameters to minimize the mean-squared error between simulated and anticipated phase shifts. Our approach yields inverse potentials for both single and multi-channel scattering, achieving convergence to a mean-squared error $\leq 10^{-3}$. The resulting scattering lengths "a_0" and effective ranges "r" for $^3S_1$ and $^1S_0$ states, expressed as [a_0, r], are found to be [5.445(5.424), 1.770(1.760)] fm and [–23.741(–23.749), 2.63(2.81)] fm, respectively; these values are in excellent agreement with experimental ones. Furthermore, the calculated total scattering cross-sections are highly consistent with their experimental counterparts, having a percentage error of less than 1%. This computational approach can be easily extended to obtain interaction potentials for charged particle scattering.

Keywords: inverse potentials, neutron-proton scattering, piece-wise smooth Morse function, phase function method, reference potential approach, genetic algorithm

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I. INTRODUCTION

Current high-precision nucleon-nucleon potentials, available for scattering data up to the pion-threshold of 350 MeV, are provided by various groups; these include the Argonne v_{18} [1], Bonn [2], Reid [3], Nijmegen [4], and Paris [5] potentials. These potentials are modeled such that the NN interaction comprises one pion exchange potential for long inter-nuclear distances of $r \geq 2$ fm. The main differences between these high precision potentials stem from the way the nucleon-nucleon interaction is modeled for intermediate/medium (1.0 fm $< r <$ 2 fm) and short-ranges ($r <$ 1.0 fm) [6]. This modeling is performed using a central potential along with an interplay of orbital, tensor, spin-orbit, and quadratic spin-orbit terms. The approach involves simultaneously solving for the wave-functions based on the model potential and optimizing approximately 40−50 parameters for obtaining the phase shifts for all ℓ-channels for nucleon-nucleon scattering, from which the total cross sections are predicted to match the experimental ones [7]. An alternative methodology is to construct the inverse potentials utilizing the phase function method or variable phase approximation [8–10], which has the advantage of obtaining phase shifts by directly utilizing the potential, without the wave-function. Here, the second-order time-independent Schrödinger equation is transformed into a set of independent first-order non-linear Ricatti equations for each ℓ channel. Thus, one can determine the potentials corresponding to phase shifts for individual channels. This methodology is equivalent to constructing the model potential directly from the available scattering phase shifts data, which is the basic premise of the machine learning paradigm [11, 12].

Ideally, to obtain a complete inverse scattering solution, N discrete bound state energies $E_n < 0$ (n = 1, 2, …, N) and all possible scattering phase shifts for energies $E >$ 0, up to ∞, are required [13]. However, the available experimental data are limited to very few projectile energy values. Hence neural network-based machine learning models are not suitable, and we propose to utilize meta-

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Comparative study of α - α interaction potentials constructed using various phenomenological models

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Abstract: In this paper, we have made a comparative study of $\alpha-\alpha$ scattering using different phenomenological models like Morse, double Gaussian, double Hulthén, Malfliet-Tjon, and double exponential for the nuclear interaction, and atomic Hulthén as the screened Coulomb potential. The phase equations for S, D, and G channels have been numerically solved using the 5^{th}-order Runge-Kutta method to compute scattering phase shifts (SPS) for the elastic scattering region consisting of energies up to 25.5 MeV. The model parameters in each of the chosen potentials were varied in an iterative fashion to minimize the mean absolute percentage error (MAPE) between simulated and expected SPS. A comparative analysis revealed that all the phenomenological models result in exactly similar optimized potentials with closely matching MAPE values for S, D, and G states. One can conclude that any mathematical function that can capture the basic features of two-body interaction will always guide the construction of optimized potentials correctly.

Key words: α -α scattering, phenomenological models, screened atomic Hulthén, scattering phase shifts, resonance energies

1. Introduction

Scattering studies of α particles with ^4_2He nuclei are important for understanding the nature of nuclear force and gaining insights into few-body [1] and cluster models [2, 3]. Rutherford and Chadwick were the first to study α-α scattering in 1927 [4] and since then, numerous experiments have been performed at various energy levels to deepen our understanding. In 1956, Heydenburg and Temmer presented experimental scattering phase shifts (SPS) for the low-energy range of 0.6 MeV to 3 MeV [5]. Tombrello and Senhouse, in 1963, provided experimental SPS covering the energy range of 3.84 MeV to 11.88 MeV [6]. Nilson et al., in 1958, reported SPS for energies between 12.3 MeV and 22.9 MeV [7]. Subsequently, Chien and Brown, in 1974, contributed experimental SPS for the energy range of 18 MeV to 29.50 MeV [8].

The SPS data obtained from these experiments were compiled by Afzal et al. [9], which is generally considered by theoretical physicists for studying $\alpha-\alpha$ scattering. However, it is worth noting that their compilation included data only up until 1969. Recognizing the significance of incorporating Chien and Brown data from 1974, Khachi et al. updated the database for α-α scattering in 2022 [10].

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ORIGINAL PAPER

Elastic scattering study of α- ^{3}H and α- ^{3}He modeled by Malfliet–Tjon potential using phase function method

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Abstract: The interaction potentials for the resonant states of elastic scattering of $\alpha -^3 H$ and $\alpha -^3 He$ systems have been obtained using phase function method. While the interaction for nuclear part has been chosen as the Malfliet–Tjon (MT) form, the infinite-range Coulomb repulsion has been modeled using Hulthén, providing a screening effect to cut off the potential. The scattering phase shifts have been obtained by solving the phase equation for $\ell = 3$ using RK-5 method. The interaction parameters are optimized iteratively to minimize the mean absolute percentage error between the obtained and expected scattering phase shifts. Finally, the resonance energies for the $[5/2^-, 7/2^-]$ states of $\alpha -^3 H$ and $\alpha -^3 He$ systems have been obtained(experimental) in MeV, from the plots of their partial cross-sections, yielding [2.20 (2.18), 4.18 (4.14)] and [2.98 (2.98), 5.02 (5.14)] respectively. It can be concluded that the interaction potentials obtained using a combination of MT and Hulthén satisfactorily explain the observed scattering data.

Keywords: Scattering phase shifts; Malfliet–Tjon potential; Hulthén potential; Phase function method; RK-5 method; Elastic scattering; α-^{3}H scattering; α-^{3}He scattering; Partial Scattering cross section

1. Introduction

Abundance of most chemical elements in the Universe has been created by nucleosynthesis processes. Among these elements, heavier ones were produced by nuclear reactions, while lighter ones such as hydrogen, helium and lithium were generated during the Big Bang. The primordial abundance of ^7Li in the universe [1] is determined by $^3He(\alpha,\gamma)^7Be$ and $^3H(\alpha,\gamma)^7Li$ radiative-capture processes. These are also competing reactions in the proton-proton chain of solar hydrogen burning and are astronomically significant [2]. The production of ^7Be and ^{8}B neutrinos in the pp-II and pp-III branches is also determined by these reactions. Both these reactions are crucial for obtaining the correct fraction of proton-proton (*pp*) branches resulting in ^{7}Be versus ^{8}B neutrinos [3].

The important input information required for premordial nucleosynthesis is the nuclear reaction rate $N_A\langle\sigma v\rangle$, and $N_A\langle\sigma v\rangle$ which further depends on the velocity-averaged cross section (σ) of the nuclear reaction. The total cross section of the nuclear reaction is also required for obtaining the astrophysical S-factor. The astrophysical S-factor can be obtained experimentally, but for most of the thermonuclear reactions, it is feasible only at low energies, specifically between 100 KeV to 1 MeV [4, 5]. To properly describe any nuclear reaction existing in the Universe, the astrophysical S-factor requires considering electromagnetic transitions between different nuclear states.

From a nuclear physics viewpoint, these reactions are also important [6] because both odd-A nuclei, ^3He and ^3H are magic nuclei. After interaction with α particles, they form compound nuclei ^7Li and ^7Be both of which are again odd-A magic nuclei. The interaction between the valence nucleons in odd-A mirror nuclei can be determined by their scattering because the nuclei have similar inner structure and only differ by their valence nucleons. The entrance channels for both the reactions also consist of scattering of spin-$\frac{1}{2}$ particle with a spin-0 particle [7].

The scattering process is crucial for understanding the structure of the nucleus and the nature of interaction. Scattering phase shifts (SPS) indicate the strength of the interaction, and the scattering cross-section reveals the

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PARTIAL DIFFERENTIAL EQUATIONS

Algorithm to Obtain Inverse Potentials for α–α Scattering Using Variable Phase Approach

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Abstract—An algorithm has been developed with the purpose of obtaining inverse potentials, where the Riccati-type non-linear differential equation, also called phase equation, has been kept in tandem with the Variational Monte Carlo method. The optimization of Gaussian function parameters is achieved such that the experimental phase shifts are reproduced. The obtained SPS for various ℓ channels has been compared with experimental ones with mean absolute percentage error (MAPE) as a measure. The model parameters have been optimized by suitable optimization technique by looking for minimum value of MAPE. The results for $\ell = 0^+$, 2^+, and 4^+ partial waves have been obtained, to match with experimental SPS, with MAPE values of 2.9, 4.6, and 6.2, respectively, for data up to 23 MeV, while for higher states 6^+, 8^+, and 10^+ has MAPE of 3.2, 4.5, and 5.9, respectively, for data from 53–120 MeV. On extrapolation for data in range $E_{\ell ab} = 23–120$ MeV, using the optimised parameters, the SPS are found to be in close agreement with experimental ones for the first three channels.

Keywords: inverse potentials, alpha-alpha scattering, variable phase approach (VPA) or phase function method (PFM), scattering phase shifts, Double Gaussian potential

DOI: 10.1134/S096554252470129X

1. INTRODUCTION

As stated by Kabanikhin in the 1950s, the first publication about inverse problems emerged in fields like physics (electrodynamics, quantum scattering theory, and acoustics), geophysics (electro-, seismo-, and geomagnetic exploration), and astronomy [1]. With the advent of powerful computers, these problems found use in almost every academic area that uses mathematical models, including medicine, industry, ecology, economics, linguistics, and social sciences. In recent years, there has been a growing interest in the study of heavy ion collisions and scattering problems, driven by their relevance in various fields of physics. Several computational approaches have been developed to tackle the complex nature of these problems, ranging from symbolic-numerical algorithms to numerical solutions. One notable contribution comes from Gusev et al. (2023) [2], who proposed a symbolic-numerical algorithm implemented in Maple for solving the inverse problem in the optical model for scattering in heavy ion collisions. Another important reference is the work by Puzynina and Vo Trong Thach [3], which offers a numerical solution for both direct and inverse scattering problems across various potentials. The core purpose of this paper is to investigate scattering of alpha particles which are in relative motion for all partial waves using an inverse approach. Rutherford and Chadwick were the first who experimentally studied α–α scattering in the year 1927 and since then a large amount of experimental data is available given by (i) Afzal et al. [4], (ii) S. Chien and Ronald E brown [5], (iii) Igo [6], (iv) Darriulat, Igo, Pug, Holm [7], (v) Nilson [8] and others. Alpha-alpha problem has been extensively studied both experimentally and theoretically with alpha particle having some sole properties like (i) zero spin and isospin (ii) tight binding energy of 28.3 MeV having property to form cluster-like states for lighter nuclei (^{6,7}Li, ^{9}Be, ^{12}C, and ^{16}O are α-structured) with alpha particle being the core nuclei in the cluster (iii) small root mean square radius of 1.44 fm.

In the 1940's for α–α scattering experiments, only naturally occurring α-sources like polonium, thorium and radium were used, which did not result in very accurate results from experiments. Later on, with the advancement of technology, accelerators were used in scattering processes and highly accurate phase

Simulation Study of Arbitrary 1D Periodic Potentials by Modified Marsiglio's Matrix Approach using Gnumeric Spreadsheet*

Aditi Sharma, Arushi Sharma and O S K S Sastri

In this paper, we present a structured approach to solving the quantum mechanical problem of a particle in 1D periodic square well potential to obtain energy eigenvalues. Here, we utilize the modified Marsiglio's matrix mechanics method to obtain energy eigenvalues for the potential. The method is implemented in a Gnumeric spreadsheet environment, a free open source software that has an in-built eigensolver, to gain clarity regarding each of the steps involved by choosing a smaller-sized H-matrix. The resultant eigenvalues obtained using the simulation are plotted with respect to *k* values to visualize the band structure diagrams arising from various periodic potentials such as a harmonic oscillator, inverted harmonic oscillator, and linear well potential. This implementation strategy helps us study the physical system in a more systematic and simpler way, pedagogically.

Aditi Sharma is an Assistant Professor at Chandigarh Group of Colleges, Jhanjeri, Mohali, Punjab. She completed her PhD in Physics from Central University of Himachal Pradesh, Dharamshala. This article presents part of work carried by her during PhD under Prof. O S K S Sastri.

Arushi Sharma is currently pursuing a PhD at the Central University of Himachal Pradesh under Prof. Sastri. Her study focuses on producing inverse potentials for nuclear charge configurations.

Sastri is a Professor at the Central University of Himachal Pradesh. His specialization includes computational physics, nuclear structure studies of actinides and superheavy nuclei, and specifically in physics education research.

1. Introduction

The study of periodic potentials is essential in many branches of physics, including solid-state physics, quantum mechanics, and condensed matter physics. Understanding how particles or waves behave in periodic potentials allows us to learn about material properties, electronic band structures, and transport phenomena. While analytical solutions exist for simple periodic potentials [1], studying more complicated and arbitrary potentials frequently necessitates numerical approaches and computational tools. The matrix method, notably Marsiglio's matrix approach [2], is a popular numerical approach that has been widely utilized to in-

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ELEMENTARY PARTICLES AND FIELDS
Theory

Real and Imaginary Phase Shifts for Nucleon–Deuteron Scattering Using Phase Function Method

Shikha Awasthi[1)] **and O. S. K. S. Sastri**[1)*]

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Abstract—The neutron–deuteron (nd) and proton–deuteron (pd) scattering are the simplest nucleon–nucleus scenario which throws light on understanding few body systems. In this work, real and imaginary parts of scattering phase shifts (SPS) for nd- and pd-scattering are obtained using complex potential, with Malfliet–Tjon (MT) model of interaction, by phase function method (PFM). The SPS for doublet $^2S_{1/2}$ and quartet $^4S_{3/2}$ states of nd- and pd-systems have been obtained for real and imaginary parts separately by solving the phase equation for $\ell = 0$, using Runge–Kutta 5^{th} order technique for laboratory energies up to 19 MeV. The obtained (real, imaginary) SPS for $^2S_{1/2}$ and $^4S_{3/2}$ states are matching with standard data with mean absolute error (MAE) of (1.32, 0.06) for $^2S_{1/2}$ state and (0.19, 0.06) for $^4S_{3/2}$ state of nd-scattering, (0.95, 0.28) for $^2S_{1/2}$ state and (0.58, 0.21) for $^4S_{3/2}$ state of pd-scattering.

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1. INTRODUCTION

One of the most crucial methods for determining the nature of interactions between various particles or systems of particles, which in turn would give information about their internal structure, is scattering experiments. The scattering phase shifts (SPS) obtained from phase wave analysis carry the specifics of the interaction for various ℓ-channels and are used to determine the differential and total scattering cross-sections (SCS). Quantum mechanically, the interaction potential between two particles is modeled and the corresponding time independent Schrodinger equation (TISE) is solved to obtain the wavefunction. The obtained wavefunction is matched with asymptotic free particle wavefunction, to determine SPS. A correct match between the obtained and experimental phase shifts validates the model of interaction potential.

Study of nucleon–deuteron scattering is one of the extensive fields of research and many research groups have studied it both theoretically and experimentally [1–5] over the years. For neutron–deuteron (nd) system, the SPS have been obtained using different phenomenological potentials such as Manning–Rosen [6] and Hulthén [7]. Alternatively, Faddeev equations have been solved for the three-body problem using AV18 nucleon–nucleon (NN) potential [8] and Malfliet–Tjon [9] potential [1, 5, 9]. The research on nd- and pd-systems has been focused both below [1–3, 5] and above the deuteron break up threshold of 3 MeV. G.L. Payne [1] et al. in 1980 solved Faddeev equations in configuration space to obtain ground state properties of Triton by considering NN interaction model of Malfliet–Tjon [9]. C.R. Chen et al. [2] solved configuration-space Faddeev equations for the nucleon–deuteron scattering below three-body breakup threshold to obtain scattering phase shifts and scattering parameters for doublet $^2S_{1/2}$ and quartet $^4S_{3/2}$ states of nd- and pd-systems.

Further, Ishikawa [5] studied interaction between proton and deuteron by a modified version of Faddeev equation to accomodate the Coulomb interaction and by considering Malfliet–Tjon [9] I–III NN-potential to obtain scattering phase shifts of nd- and pd-systems for lab energies ranging between 0.0015–3.27 MeV for nd-scattering and between 0.15–3.0 MeV for pd-scattering. A. Kievsky et al. [3] did critical phase shift analysis for nucleon–deuteron scattering for incident nucleon energy range from 1 to 3 MeV. For energies above deuteron breakup threshold, Kievsky et al. [10] applied complex Kohn variational principle and the hyperspherical harmonics technique and compared elastic nucleon–deuteron cross section with experimental data at several energies.

Z.M. Chen et al. [8] performed phase shift analysis for proton–deuteron for proton lab energies up to 22.7 MeV using AV18 NN-potential. Pisa group

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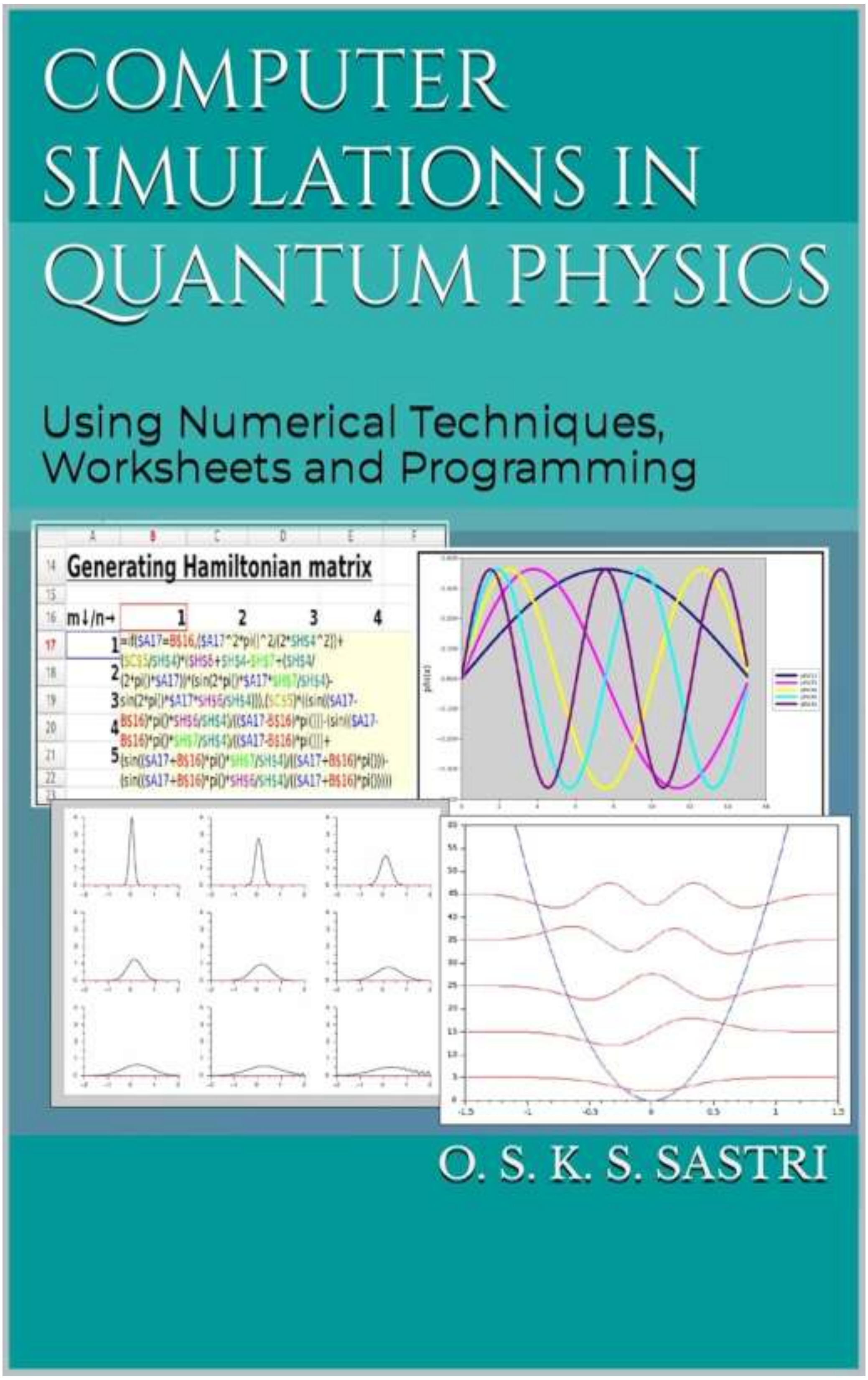
Annexure :2


COMPUTER SIMULATIONS IN QUANTUM PHYSICS
Using Numerical Techniques, Worksheets and Programming
Generating Hamiltonian matrix
O. S. K. S. SASTRI

<u>Annexure 3</u>

PAS 8109H: Research Work – 4 Credits

Research abstracts of all three B.Sc. (Physics) students were published in the DAE-HEP Conference Proceedings, December 2024.

1. Awasthi, A., Thakur, T., & Sastri, O. S. K. S. (2024). *Energy-dependent inverse potentials for neutron-proton elastic scattering at energy up to 1050 MeV using a piecewise Morse function.* Presented at the XXVI DAE-BRNS High Energy Physics Symposium, December 2024.

Energy-Dependent Inverse Potentials for Neutron-Proton Elastic Scattering at energy up to 1050 MeV Using a Piecewise Morse Function

Author: Ayushi Awasthi[1]

Co-authors: Tanisha Thakur [2]; O.S.K.S Sastri [2]

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In this study, we have constructed the inverse potentials for s-wave neutron-proton (n-p) elastic scattering in the 1S0 and 3S1 channels, utilizing a piecewise Morse function as the reference function within the phase equation framework. We have optimized the model parameters of the reference function by minimizing the mean absolute percentage error (MAPE) between the simulated and expected phase shifts within a machine learning paradigm. The phase shifts were calculated independently for two distinct energy ranges, up to 350 MeV and 1050 MeV, by solving the phase equation using a fifth-order Runge-Kutta (RK5) method. This approach enabled us to systematically construct the inverse potential, tailored specifically for each energy limit, allowing for detailed analysis of the energy-dependent characteristics of the n-p interaction. The constructed potentials for 1S0 and 3S1 state exhibit distinct profiles across the examined energy ranges. For the 350 MeV case, the potential displays a well-defined attraction at short distances, with a depth Vd =−101.67 MeV at a distance of rd= 0.88 fm, aligning with observed phase shifts at lower energies. In contrast, the potential constructed for 1050 MeV exhibits a more pronounced well depth of Vd = −114.56 MeV at rd=0.83 fm, indicating an increased attractive interaction with rising energy in the 1S0 state. For the 3S1 state, the potential depth is Vd=−107.83 MeV at rd=0.94 fm for energies up to 350 MeV, while for energies up to 1050 MeV, the depth increases to Vd=−136.31 MeV at a distance of rd=0.86 fm. This variation in the depth and shape of the potential well highlights the sensitivity of the interaction to higher energy scales, as the increased kinetic energy of the scattering particles requires a deeper potential to reproduce the observed phase behavior accurately. These findings not only suggest that the piecewise Morse function serves effectively as a reference in constructing accurate inverse potentials that capture the energy-dependent dynamics of s-wave n-p elastic scattering but also underscore the methodology's relevance to high-energy physics, where precise modeling of scattering interactions at energies up to the GeV scale is essential. The methodology and results thus provide a refined framework for modeling nuclear scattering potentials, enhancing our understanding of elastic scattering processes across a wide energy range, including those relevant to high-energy physics.

Field of contribution:

Theory

2. Sharma, A., Rathore, G., & Sastri, O. S. K. S. (2024). *Optical inverse potentials for proton-proton scattering up to 1 GeV*. Presented at the XXVI DAE-BRNS High Energy Physics Symposium, December 2024

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Optical inverse potentials for Proton-Proton scattering up to 1GeV

Authors: Arushi Sharma Arushi[1]; Gargi Rathore[None]; O.S.K.S. Sastri O.S.K.S. Sastri[2]

[1] *Research Scholar*

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Background: Phase shift analysis of nucleon-nucleon elastic scattering has been conducted up to 350 MeV by various research groups, employing realistic interaction potentials based on pion and meson exchange.
Purpose: Objective of this research is to develop inverse potentials for both real and imaginary scattering phase shifts by utilizing the optical potential for proton-proton interactions up to 1 GeV.
Methodology: A combination of various smoothly connected Morse components over different regions of interaction is selected as the reference potential. The reference potential comprises of two regular Morse functions to account for short- and medium-range interactions and an inverse Morse function to represent long-range interactions. Such a combination ensures that one need not include the long-range coulomb interaction separately. The potential parameters are optimized by solving the phase equation using the RK-5 method iteratively, in order to minimize the mean squared error between the calculated and experimental phase shifts using genetic algorithm.
Results: The final real and imaginary scattering phase shifts obtained using our methodology demonstrates excellent agreement with the expected ones up to 1GeV.

3. Awasthi, A., Walia, S., Sharma, A., & Sastri, O. S. K. S. (2024). *Isospin-Dependent Inverse Potentials for Elastic Pion-Nucleon Scattering in the S_{11} and S_{31} Channels.* Presented at the XXVI DAE-BRNS High Energy Physics Symposium, December 2024.

Isospin-Dependent Inverse Potentials for Elastic Pion-Nucleon Scattering in the S11 and S31 Channels

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Co-authors: Sanyam Walia [2]; Arushi Sharma [2]; O.S.K.S Sastri [2]

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Background: The study of pion-nucleon scattering is essential in particle and nuclear physics due to the complexities introduced by strong interactions and isospin-dependent dynamics. The analysis of pion-nucleon scattering provides insights into resonance behavior and the underlying forces between pions and nucleons.
Purpose: In this work, we construct inverse potentials for pion-nucleon scattering by choosing a piece-wise smooth Morse function as a reference, focusing on single channel scattering processes. Our study specifically targets the S11 (isospin T = ½) and S31 (isospin T = 3/2) states to capture the isospin-dependence in the scattering interaction.
Methodology: The phase equations for ⊠ = 0 channel are solved using the fifth-order Runge-Kutta method, enabling the calculation of scattering phase shifts across a range of energies up to 310 MeV. Model parameters of the reference function were optimized by minimizing the mean squared error (MSE) between the computed and expected scattering phase shifts, providing an accurate description of the pion-nucleon interaction for both isospin states.
Results: The inverse potentials for pion-nucleon scattering, were successfully constructed with MSE equal to 0.12 and 0.0004 for S31 and S11 respectively. For the S11 state, the inverse potential analysis reveals a strong attractive potential with a depth of Vd = −384.86 at a short range of rd = 0 .55 fm. This state also exhibits a moderate Coulomb barrier of VCB=9.85 at a distance of rCB = 1.59 fm, reflecting the repulsive effect of the pion's charge at close proximity to the nucleon. In contrast, for the S31 state, we observe a significantly shallower potential depth of Vd = −121.818 MeV, extended to rd = 0.78 fm, indicating a weaker but more extended interaction range. The Coulomb barrier for this state is minimal at VCB = 0.0003 MeV and rCB = 5.56 fm, suggesting a reduced repulsive influence in this isospin channel. These results underscore the isospin-dependent nature of the pion-nucleon interaction, highlighting distinct scattering behaviors in the S11 and S31 channels.

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Conclusion: The constructed inverse potentials accurately describe the isospin-dependent dynamics of pion-nucleon scattering in the S11 and S31 channels, as reflected in the low MSE values of 0.0004 and 0.123, respectively. These results offer valuable insights into the strength and range variations of pion-nucleon interactions across different isospin states, supporting further exploration of resonance and scattering phenomena in particle physics.

Annexure 4

PAS 9106: Literature Review and Research Proposal – 4 Credits 1.

Two papers published in DAE-BRNS 2023 Annual Symposium in Nuclear Physics

1. Kant, I., Barbie, Sharma, J., & Sastri, O. S. K. S. (2023). Viola-Seaborg coefficients for partial alpha half-lives based on latest NNDC data. Proceedings of the DAE Symposium on Nuclear Physics, 6.
2. Awasthi, A., & Sastri, O. S. K. S. (2023). Optimum number of parameters for np interaction using reference potential approach. *Proceedings of the DAE Symposium on Nuclear Physics, 67*.

Viola-Seaborg Coefficients for Partial Alpha Half-lives Based on Latest NNDC Data

Ishwar Kant, Barbie†, Jyoti Sharma† and O.S.K.S Sastri[1]*
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Central University of Himachal Pradesh,
Dharamshala, 176215,H.P., Bharat(India)

Introduction

The Geiger-Nuttall law is an empirical relationship that describes the behavior of alpha particle emission rates for heavy atomic nuclei. It reveals a straight line with a slope of A_Z and an intercept of B_Z when plotting the logarithmic graph of α half-life of given isotopes vs. the inverse square root of effective α energy. Viola-Seaborg (VS) coefficients, which are obtained from the graph between different atomic number nuclei and A_Z & B_Z, can be generalized into a single formula that can be used to calculate the α half-life of heavy nuclei.

In this work, we have recalculated the Viola-Seaborg coefficients[1] by observing total of 104 α-decay favoured nuclei for atomic number range of Z = 88 to 98, using the latest NNDC data[2], incorporating the effects of alpha transition intensity and electron screening correlation[3].

Methodology

In 1911, Geiger-Nuttel (GN) established a relationship between α-decay and partial half-life as follows:

$$\log_{10} T^{\alpha}_{\frac{1}{2}} = \frac{A_z}{\sqrt{E^*_\alpha}} + B_z$$

Here, A_z and B_z are Z-dependent coefficients, and $T^{\alpha}_{\frac{1}{2}}$ is the experimental half-life of α-decay and E^*_α is effective α-decay energy and is given by:

$$E^*_\alpha = \frac{A}{A-4} E_\alpha + \Delta E_{SC}$$

Here, ΔE_{SC} is the electron screening correction[4] and is expressed as:

$$\Delta E_{SC} = (6.5 \times 10^{-5}) Z_D^{\frac{7}{5}} \,\mathrm{MeV}$$

Here, Z_D is atomic number of daughter nuclei. The partial half-life $T^{\alpha}_{\frac{1}{2}}$ of isotopic nuclei is given as:

$$T^{\alpha}_{\frac{1}{2}} = \frac{T_{\frac{1}{2}}}{\mathrm{B.R.} \times I_\alpha}$$

Here, $T_{\frac{1}{2}}$ is the total half-life, B.R. is the branching ratio for α-decay and I_α is intensity of ground state to ground state transition. Viola-Seaborg(VS) generalized the GN law to the Viola-Seaborg Formula (VSF) in 1966 by observing straight and nearly parallel lines:

$$\log_{10} T^{\alpha}_{\frac{1}{2}} = \frac{aZ + b}{\sqrt{E^*_\alpha}} + (cZ + d) + h_{log}$$

Here a, b, c, and d are VS coefficients obtained from even-even nuclei, and $h_{\log}$ is the hindrance factor calculated for unpaired nucleons.

Result and Discussion

In this work, A_z and B_z were obtained by observing a regression line graph between $(E^*_\alpha)^{-\frac{1}{2}}$ and $\log T^{\alpha}_{\frac{1}{2}}$ for forty even-even nuclei (including their α-decay favoured isotopes) as

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Alpha preformation probability from Cluster Formation Model using AME-2020

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[1] *Department of Physics and Astronomical Sciences,
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Dharamshala, 176215,H.P., Bharat(India)*

Introduction

Alpha decay, one of the most common decay modes of heavy and superheavy nuclei, has received a lot of attention since it can be used as a probe to examine unstable nuclei and it is the sole means to identify newly synthesized superheavy nuclei [1]. Recently, Cluster Formation Model (CFM), a quantum mechanical technique for determining preformation factor$P\alpha$ using binding energy differences of parent and daughter nuclei was presented, and it was successful in reproducing the microscopic calculation results for ^{212}Po [2]. Ahmed et al. successfully determine the α cluster preformation probability in even-even nuclei using this technique. Despite the fact that this has been expanded for odd-odd and odd A nuclei , as well as the study of α-decay, the analysis is limited to shell closures and does not reveal the relative stability of odd-N nuclei in comparison to their neighboring even-N nuclei. P.C. Sood et.al. [3] proposed a criterion for determining the relative longevity of odd-N nuclei in the actinide region as follows: *If three or more consecutive members of an isotopic sequence lying at or near the β-stability curve have α-emission as their dominant decay mode and if an intense favoured decay is available for the odd-N parent, then the odd-N member of the isotopic triad has generally a longer half-life than that of its even-N neighbour on either side, irrespective of Z being even or odd.* In this work, we will examine the alpha-cluster preformation factors for the actinide region to confirm the relative longevity of odd N nuclei compared to their even-N neighbors using experimental BEs from the atomic mass evaluation in AME2020 [4].

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Theoretical Framework

In CFM, a nucleus with energy E consists of a daughter nucleus and an alpha particle with a formation energy of $E_{f\alpha}$, the α preformation factor can be expressed as $P_\alpha = \frac{E_{f\alpha}}{E}$. The Formation Energy of Cluster $E_{f\alpha}$ for different nuclei type are given as follows [5]:

Case 1: For Even Z - Even N nuclei

$$E_{f\alpha} = 3B(A, Z) + B(A-4, Z-2) \\ -2B(A-1, Z-1) - 2B(A-1, Z)$$

Case 2: : For Even Z - Odd N nuclei

$$E_{f\alpha} = 3B(A-1, Z) + B(A-5, Z-2) \\ -2B(A-2, Z-1) - 2B(A-2, Z)$$

Case 3: For Odd Z - Even N nuclei

$$E_{f\alpha} = 3B(A-1, Z-1) + B(A-5, Z-3) \\ -2B(A-2, Z-2) - 2B(A-2, Z-1)$$

Case 4: For Odd Z - Odd N nuclei

$$E_{f\alpha} = 3B(A-2, Z-1) + B(A-6, Z-3) \\ -2B(A-3, Z-2) - 2B(A-3, Z-1)$$

By using these formulae, one can calculate P_α using experimental Binding energies, which are taken from the latest atomic mass evaluation in AME2020.

Study of 2^+ Resonance in $^4He(d,d)^4He$ using Reference Potential Approach

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Department of Physics and Astronomical Science,
Central University of Himachal Pradesh, Himachal Pradesh, Bharat(India)

Introduction

Scattering studies between light nuclei is the only way by which one can understand the level structure of the nucleus with small Z values. Analyzing $^4He(d,d)^4He$ elastic scattering data by considering energy-dependent phase shifts gives rise to the energy levels of ^6Li nuclei. Deuteron-alpha (dα) scattering is also of interest in connection with the problem of measuring the spin polarization parameters characterizing deuteron beams. Over the past few decades, $^4He(d,d)^4He$ scattering has been extensively investigated for the low-lying levels of ^6Li, both experimentally and theoretically [1, 2]. In this study, we determine the underlying interaction potential for the resonance states of $^3D_1$ and $^3D_2$ of the dα system by utlizing the reference potential approach[3]. The obtained scattering phase shifts from the underlying potentials are utilized to calculate the respective partial cross-sections and resonance energies.

Methodology

The phase equation for $^3D_1$ and $^3D_2$, with $\ell = 2$, is given by

$$\delta_2'(k,r) = -\frac{U(r)}{k}[-\sin(\delta_2 + kr) - \frac{3\cos(\delta_2 + kr)}{kr} + \frac{3\sin(\delta_2 + kr)}{kr^2}]^2 \qquad (1)$$

where one needs to provide a mathematical function to represent the form for the potential U(r). This will be constructed as a combination of three Morse functions over three different regions of interaction, with the third Morse function being negative to account for the Coulomb interaction [3], connected in a piece-wise smooth manner. Each Morse function comprises of 4 parameters which results in 12 parameters in addition to two boundary points. By applying the continuity conditions for the three Morse functions and their derivatives at the two boundaries, one can solve the resulting four equations and obtains 4 of the parameters to be dependent on other parameters. Hence, the total number of the model parameters is reduced to 10. Varying the two boundary points further provides flexibility and hence greater variety. The 10 parameter reference potential is given as input to solve the phase equation, (eqn. ref1), numerically using RK-5 method with the initial condition as $\delta_2(k,0) = 0$. The final integration distance can be chosen as far as possible. The phase equation is solved by updating the model parameters in each iteration, using a genetic algorithm[3], so as to minimize mean absolute percentage error (MAPE) between the obtained and expected scattering phase shifts.

Results and Discussion

Varying the parameters of the reference function will produce a wide range of curves in the sample space. While, the inverse potential that best matches the expected phase shifts is determined by optimizing the reference function's parameters to minimize a cost function.

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Study of $p-^{12}$C at Astrophysical Energies Using Phase Function Method

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[1]*Department of Physics and Astronomical Sciences, Central University of Himachal Pradesh, Bharat(India)*

Introduction

The p-^{12}C reaction is crucial for energy production in stars, particularly through the CNO cycle [1]. Studying this reaction in the astrophysical energy range (0–10 keV) provides key insights into stellar processes. In this work, we model the interaction potential for proton energies between 400 keV and 1000 keV in the elastic region, focusing on scattering from the $^2S_{1/2}$ ($\ell = 0$) resonant state, which predominantly contributes to the astrophysical S-factor. The inverse potentials are constructed using the phase function method (PFM), which directly obtains phase shifts from the potential without relying on the wave function. The nuclear interaction between the proton and ^{12}C is modeled using the Morse potential, while the screened Coulomb interaction is described by the atomic Hulthén potential.

Methodology

A. Modeling the Interactions

The nuclear part of the $p-^{12}$C interaction, is modeled by Morse potential and the long-range Coulomb interaction, which gets typically screened in experimental scenario, is taken to satisfy the Atomic Hulthén form of the potential [2]. hence, the net model of interaction is given by

$$V(r) = V_0\left(e^{\frac{-2(r-r_m)}{a_m}} - 2e^{\frac{-(r-r_m)}{a_m}}\right) + V\frac{e^{-r/a}}{1-e^{-r/a}}$$

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where V_0 represents the nuclear potential strength, a_m is the shape parameter, r_m is the equilibrium distance, V is the strength of the Coulomb barrier and a is the screening parameter. V and a are related to the Sommerfeld parameter η as:

$$aV = 2k\eta = \frac{2Z_1Z_2e^2\mu c^2}{\hbar^2c^2} = 0.384\ \text{fm}^{-1}$$

B. Phase Function Method (PFM)

The second order time-independent Schrödinger equation for $\ell = 0$ is transformed into nonlinear Riccati equation, given as:

$$\delta_0'(k, r) = -\frac{U(r)}{k}\sin^2[kr + \delta_0(r)]$$

where $k = \sqrt{E_{c.m}/(\hbar^2/2\mu)}$. The Runge-Kutta method is employed to solve this equation using the initial condition $\delta_0(k, 0) = 0$.
Mean Absolute Percentage Error (MAPE) is used as the cost function in the optimization procedure driven by Genetic algorithm [3], which is given as:

$$\text{MAPE} = \frac{1}{N}\sum_{i=1}^{N}\left|\frac{\delta^i_{inp} - \delta^i_{sim}}{\delta^i_{inp}}\right| \times 100$$

where δ^i_{inp} represents the expected phase shift values[1], and δ^i_{sim} represents the calculated values from our simulation procedure.

Result and Discussion

The available scattering phase shift data for the S-state of $p-^{12}$ C ranges a little below 400 keV to 1 MeV. There are only six data points that capture the sharp variation in phase shifts from 400 to 500 keV and the rest of the 25 data points which are closely spaced between 500 to 1000 keV fall almost on a horizontal line with an extremely small negative slope. Trying to consider all the points in the data during optimization leads to poor convergence in the rising part of the phase

Annexure 5

PAS 9207: Publication – 2 Credits 1.

Four M.Sc (Physics) projects, from 2022-2024 batch, presented research work in an International Conference on Physics for Sustainable Development at Central University, Jammu.

1. **Barbie:** Study of alpha - 12 Carbon Elastic Scattering using Phase Function Method.
2. **Simran:** Study of p-12 Carbon elastic scattering at astrophysical energies using phase function method. **[published in DAE SNP 2024]**
3. **Jyoti:** Phase Shift Analysis of Deutron-Alpha Elastic Scattering 2+ Resonance. **[published in DAE SNP 2024]**
4. **Yogesh:** Phase shift analysis of p-16 O elastic scattering at astrophysical energies using phase function method. **[Submitted book chapter to Springer]**

Annexure : 6

CENTRAL UNIVERSITY OF HIMACHAL PRADESH

[ESTABLISHED UNDER THE CENTRAL UNIVERSITIES ACT 2009]
PO BOX: 21, DHARAMSHALA, DISTRICT KANGRA - 176215 (HP)
www.cuhimachal.ac.in

Course Code: PAS 9106C
Course Name: **Theoretical Nuclear Physics**
Course Instructor: Prof. O. S. K. S. Sastri
Course Duration: 15 weeks
Credits Equivalent: 4 Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; Reading/listening to self-learning modules, literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives: The course is designed to study the following:

1. Interaction of nuclear radiation like charged particles, neutrons, gamma and positron with matter and how these radiations are detected.
2. Study of decay laws, theory and use in the structure exploration of nuclei.
3. Study of Nucleon-Nucleon and Nucleus-Nucleus scattering
4. Nuclear Models

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in the examination.

Evaluation Criteria:

1. Mid Term Examination: 20%
2. End Term Examination: 60%
3. Continuous Internal Assessment: 20%

COURSE CONTENTS:

Unit 1: Interaction of nuclear radiation with matter ` (12 hours)

- Interaction of charged particles with matter
- Interaction of neutrons with matter: energy loss and energy distribution after collision
- Interaction of gamma radiation with matter: attenuation of gamma rays, Compton Effect, photoelectric effect and pair production.
- Interaction of positron with matter

Unit 2: Radioactive Decay (12 hours)

- Radioactive decay law, Quantum theory of radiative decays, production and decay of radioactivity, Growth of Daughter activities.
- Alpha decay: energetic, decay constant, hindrance factors, alpha particle spectra
- Fermi theory of β-decay: nuclear structure information.
- Theory of γ-decay, internal conversion and nuclear structure information

Unit 3: Nucleon-Nucleon and Nucleus-Nucleus Scattering (12 hours)

- Elastic scattering and method of partial waves
- Relationship between differential and scattering amplitude.
- Phase function method
- Study of np and pp scattering by simple potentials:
    - Yukawa
    - Malfiet-Tjohn
- Theory of resonance: Breit-Wigner formula

Unit 4: Nuclear Models (12 hours)

- Shell model: Derivations for Harmonic Oscillator and Woods-Saxon potentials using Nikiforov-Uvarov (NU) method
- Introduction to Nilsson model

Lecture Plan

Unit 1: Interaction of Radiation with matter

Lecture 01 Introduction to Nuclear Radiations

Lecture 02 Interaction of charged particles with matter

Lecture 03 Interaction of neutrons with matter

Lecture 04 Energy loss and distribution after collission

Lab 05: Priciple of GM Counter

Lab 06: Application of GM Counter

Assignment01: Numerical Problems

Lecture 07: Interaction of gamma radiation with matter: attenuation of gamma rays

Lecture 08: Compton Effect

Lab 09: Principle of alpha spectrometer

Assignment 02: Numerical Problems

Lecture 10: Pair production.

Lecture 11: Principle of gamma spectrometer

Tutorial 12: Numericals based on Compton, photoelectric effect and Pair production

Unit 2: NN and Alpha-Alpha Scattering

Lecture 01 Introduction to Scattering: Method of Partial Waves

Lecture 02 Phase Function Method

Lecture 03 Study of np scattering using Yukawa and MT potentials

Lecture 04 Demonstration of RK-2 method for Yukawa potential

Lab 05: Implementation of np scattering by students using RK-4 for Yukawa

Lab 06: Implementation of np scattering by students using RK-4 for MT potential

Assignment01: Implementation of np scattering using RK-4 with Morse potential

Lecture 07: Study of pp scattering using MT with Hulthen function as Screened Coulomb Potential

Lecture 08: Demonstration of pp scattering using RK-4 method in python

Lab 09: Implementation of pp scattering by students using RK-4 for MT potential using python

Assignment 02: Implementation of pp scattering using RK-4 with Morse potential using python

Lecture 10: Study of alpha-alpha scattering

Lecture 11: Demonstration of alpha-alpha scattering using RK-4 method in python

Lab 12: Implementation of alpha-alpha scattering using RK-4 method in python

Unit 3: Alpha, Beta and Gamma Decays

Lecture 01 Demonstration of alpha spectrum

Lecture 02: Gamov's theory of alpha decay

Lecture 03: GN law verification using ground state to ground state alpha decay tranistions in even-even nucleus

Assignment 01: Obtain the co-efficients for GN law for various even-even nucleus

Lecture 04: Partial alpha half lives, Viola Seaborg formula and Cluster formation model

Lab 05 & 06 Determination of Viola-Seaborg co-efficients for alpha decay

Assignment 02: Determine the partial alpha half lives using CFM

Lecture 07: Fermi's theory of Beta Decay

Lab 08 Fermi-Kurie plot

Lecture 08: log ft values for beta transitions and nuclear structure

Lecture 09: log ft analysis and selection rules

Lecture 10 Demonstration of Gamma spectrum

Lecture 11 Gamma decays and nuclear structure

Lecture 12 Gamma transitions and selection rules

Unit 4: Nuclear Models

Lecture 01 Solving Radial TISE for 3D harmonic Oscillator using Nikafarov-Uvarov (NU) method

Assignment 01: Solving Radial TISE for 3D harmonic Oscillator along with spin-orbit term using Nikafarov-Uvarov (NU) method

Lecture 02: Solving Radial TISE for Woods-Saxon (WS) potential along with spin-orbit tem using Nikafarov-Uvarov (NU) method

Lecture 03: Numerical Simulation of radial TISE using WS potential with and without spin-orbit term

Lab 04 & 05 Implementation of radial TISE using WS potential along with Spin-Orbit term in Gnumeric worksheets

Assignment 02: Determination of magnetic moments and Quadrupole moments using Shell model

Lecture 06: LDM and least squares minimisation

Lab 08 Solving LDM with corrections for asymmetry and pairing terms

Lecture 08: Generalised Liquid Drop Model

Lecture 09: Introduction to Nillson Model

Lecture 10 Nillson orbitals

Lecture 11 Selection rules for beta decay

Lecture 12 Application of Nillson model to setup selection rules for beta decay

Prescribed Text Books:

1. Introductory Nuclear Physics, K. S. Krane, John Wiley& Sons Ltd
2. An Introduction to Nuclear Physics, W. N. Cottingham, D. A. Greenwood, Cambridge University Press.
3. Elements of Nuclear Physics, Walter E. Meyerhof, McGraw-Hill Book Company.

Suggested Extra Readings:

1. Fundamentals In Nuclear Physics from Nuclear Structure to Cosmology Jean-Louis Basdevant, James Rich, Michel Spiro, Springer
2. B.R. Martin, Nuclear and Particle Physics, John Wiley& Sons Ltd.
3. R.R. Roy and B.P. Nigam, Nuclear Physics: Theory and experiment, New age International (P) limited, Publishers.

Annexure 7

PAS 7107: Innovation Project – 4 Credits

Innovation Projects:

1. **Application of Vein Viewer for Medical Purposes**

Group : Kanika & Tanisha Thakur , Hitesh & Sanyam Waliya

2. **Reducing Friction -Air Tracker**

Group- Ayush Chambyal, Ranveer Kaswan, Gargi Rathore, Abhay Singh Katnoria

3. **Generation of EMF by change of magnetic flux**

Group: Kartik and Amit Jaswal

4. **Transmission of torsional waves**

Group: Akanksha and Vanshita

5. **Demonstration of Standing Waves Using Speaker**

Group: Ananya and Sanya Wardhan

6. **Demonstration of 2D Crystal Structure in Macroscopic Level.**

Group: Khushi and Shivani

8. **Demonstration of Bohr's Orbit**

Group : Disha , Payal

9. **Air Canon**

Group: Sakshi, Shivangi

10. **Demonstration of Coupled Oscillator**

Group: Janvi, Aryan

11. **Demonstration of Doppler Effect**

Group : Harshik, Dikshay

Project Regarding Visits:

1. Rainbow International School, Nagrota Bagwan. (Two times)

Date: Sept 2023

2. Government Degree College, Dharamshala

Annexure : 9

Course Name: **Quantum Mechanics**

Course Code: **PAS 8404 A**

Course Instructor: **Prof. O. S. K. S. Sastri**

Course Type: **Core Compulsory**

Credits: **4**

Course Objectives:
The students would learn the following:

1. Postulates of Quantum Mechanics (QM)
2. Operators in QM and matrix methods
3. Hamiltonian Formulation of Supersymmetric (SUSY) QM
4. Time Independent Perturbation Theory, Variational method and WKB Method.
5. Solving Time Independent Schrodinger Equation (TISE) for various potentials both analytically and using numerical techniques based on Central Divivded Difference, Matrix Numerov Matrix Method and Matrix Methods using Sine basis

Course Contents

Unit 1: Fundamentals of Quantum Physics: (15 hours)

- <u>Lectures 01 and 02:</u> Feynman's double slit experiment with electrons: Modeling the electron's wavepacket; It's Statistical interpretation and normalisation;
- <u>Activity 01:</u> Canned experiment of double slit using electrons: Analysis using Tracker video analysis software
- <u>Lecture 03 and 04:</u> Construction of wavepacket: It's Mathematical formulation as Fourier transform; Concept of Measurement in QM: ensemble average and uncertainty;
- <u>Problem Session 01:</u>
  - Fourier transform of rectangular and gaussian amplitude functions in k-space leading to construction of wavepackets in position space;
  - Determination of width of gaussian wavepacket in both position and momentum space and Heisenberg's uncertainty product
- <u>Activities 02 and 03:</u>
  - Numerical Simulation of Fourier superposition of waves;
  - Numerical Simulation of wavepacket construction using superposition of waves and Fourier transform
- <u>Lecture 05:</u> Derivation of operator expression for momentum in position space; Expectation values of operators; Time dependent Schrodinger equation (TDSE).
- <u>Lecture 06:</u> Time independent Schrodinger equation (TISE); Particle in 1-D Box
- <u>Problem Session 02:</u> Stationary and non-stationary states, normalisation and probability current densities
- <u>Activity 04:</u> Numerical simulation of TISE using central divided difference (CDD) technique in gnumeric worksheet environment and Scilab/Python
- <u>Lecture 07:</u> Evolution of Gaussian wavepacket and the importance of measurement in QM
- <u>Activity 05:</u> Numerical simulation of evolution of Gaussian wavepacket using Crank-Nicholson method for solving TDSE

Unit 2: Postulates of Quantum Mechanics: (15 hours)

- Lecture 08 and 09: Operators in QM:
  - Linear and Hermitian properties and consequences; Commutators; Adjoint operator; Parity operator; Simultaneous eigenstates; Eigenstates and measurement; Expansion postulate;
- Problem Session 03: Commutation relations involving position and momentum operators
  - Dirac Bracket notation; Compatible and incompatible observables; Generalised Heisenberg's uncertainty principle; Conserved quantities and Constants of motion; Time development of an expectation value; Ehrenfest's theorem;
- Lectures 10 and 11: Expansion and Reduction Postulate:
  - The generalised Born interpretation and
  - Role of measurment in QM
- Lecture 12: Expanding square well: An example
- Problem Session 04: Energy measurements on non-stationary states and variations of expanding square well
- Lecture 13: Finite square well (FSW)
- Activity 06: Obtaining eigen values for FSW using Bisection and Newton-Rapson method
- Activity 07: Numerical simulation of Finite square well using Numerov matrix method (NMM)
- Lecture 14: Matrix methods of QM
- Activity 08: Numerical solution of Finite square well using matrix methods with sine basis (MMS)

Unit 3: Supersymmetric (SUSY) Quantum Mechanics Technique: (15 hours)

- Lecture 15: Hamiltonian Formulation of Supersymmetric (SUSY) QM
  - Factorisation and Hirerachy of Hamiltonians
- Lecture 16: Linear Harmonic Oscillator (HO) using SUSY
- Problem Session 05: Expectation values and uncertainty product
- Activity 09: Numerical solution of HO using CDD, NMM and MMS
- Lecture 17 and 18: 3D problems in Cartesian and spherical polar coordinates
  - Square well
  - Rigid rotator and
  - Harmonic oscillator
- Lecture 19: Angular Momentum Operators and their algebra
- Lecture 20: Eigenvalues and Eigenfunctions for angular momentum operators
- Activity 10: Numerical Simulation of Molecular vibrations and rotations
- Lecture 21: Hydrogen atom, Radial equation and it's solution using SUSY
- Activity 11: Numerical solution of Hydrogen atom using CDD, NMM and MMS
- Lectures 22 and 23: Normal Zeeman Effect and Stark Effect.
- Activity 12: Numerical solution of applying external electric field to square well

Unit 4: Approximation methods: (15 hours)

- Lectures 24 and 25: WKB Method,
  - Connection Formula
  - Validity of WKB Method
- Lecture 26: Tunnelling through a Barrier and alpha decay.
- Lecture 27: Supersymmetric WKB Approximation
- Problem Session 06: Applications of WKB to obtain energy eigen values and eigen states for various potentials
- Lecture 28: Time Independent Perturbation Theory
- Activity 13: Numerical Solution of Anharmonic Oscillator using MMS
- Lecture 29: Degenerate Perturbation Theory

- Lecture 30: The Variational Method or Rayleigh-Ritz method
- Activity 14: Application to AHO and Hydrogen ground states
- Lecture 31: Hamiltonian for Helium atom and self-consistent formalism
- Lecture 32: Ground state of Helium
- Activity 15: Obtaining the ground state of He using variational method numerically

Lecture Notes and Lab manual, 2022:
O. S. K. S. Sastri, Quantum Physics Simulations using Gnumeric and Scilab,
Available on https://dpas.saivyasa.in/

Prescribed Textbooks:

1. Michael A Morrison, Understanding Quantum Physics-A User's Manual, Vol 1, {rentice Hall Inc, 1990
2. Amit Goswami, Quantum Mechanics, Second Edition, Waveland Press Inc, 1997
3. Avinash Khare, Frederick M Cooper and Uday P Sukhatme, Supersymmetry in Quantum Mechanics, World Scientific, 2001
4. G. Aruldhas, Quantum Mechanics, PHI Learning, Eastern Economy Edition 2013.
5. W. Greiner, Quantum Mechanics-An Introduction, Springer-Verlag, Germany.
6. David J. Griffiths, Introduction to Quantum Mechanics, Pearson Prentice Hall, Inc.
7. N. Zettili, Quantum Mechanics: Concepts and Applications, Wiley, 2009

Other Resources/Reference books:

1. A K Ghatak and S Lokanathan, Quantum Mechanics, Trinity, 6th edition, 2022.
2. Ashok Das, Quantum Mechanics, Tata McGraw Hill (2007).
3. Leonard. I. Schiff, Quantum Mechanics, 3 rd edition, Tata McGraw-Hill 2010.
4. J. J. Sakurai, Modern Quantum Mechanics, Addison-Wesley ISBN 0-201-06710-2).
5. R. Shankar, Principles of Quantum Mechanics, Second edition, Plenum Press, New York.E.
6. Marzbacher, Quantum Mechanics, Wiley Student Edition, 2011.
7. Mathews and Venkateshan, Quantum Mechanics, Tata McGraw-Hill 2010.
8. P.A.M. Dirac, The Principles of Quantum Mechanics, Snowball Publishing.
9. A. Messiah, Quantum Mechanics, Dover Books on Physics.

Annexure : 10

Course Name: **Advanced Quantum Mechanics**

Course Code: **PAS 8202 A**

Course Instructor: **Prof. O. S. K. S. Sastri**

Course Type: **Core Compulsory**

Credits: **2**

Course Objectives:

The students would learn the following:

1. ***Identical particles***
2. ***WKB approximation and Time dependent perturbation theory***
3. ***Elementary theory of Scattering***
4. ***Relativistic quantum mechanics***

Course Content

Unit 1: Identical Particles **4 hours**

- Meaning of identity and consequences;
- Symmetric and antisymmetric wavefunctions;
- Slater determinant;
- Symmetric and antisymmetric spin wavefunctions of two identical particles;

Unit 2: WKB and Time-dependent Perturbation Theory **6 hours**

- WKB: Connection formula and validity
- Time dependent perturbation theory
- Interaction picture
- Constant and Harmonic perturbations: Fermi's Golden rule;

Unit 3: Elementary Theory of Scattering Theory **6 hours**

- Laboratory and centre of mass frames,
- Scattering amplitude, Differential and total scattering cross-sections
- Scattering by spherically symmetric potentials: Partial wave analysis and phase shifts; Ramsauer-Townsend effect;
- Scattering by an attractive square well potential;
- Relation between sign of phase shift and attractive or repulsive nature of the potential;

Unit 4: Relativistic Quantum Mechanics **8 hours**

- Geometric Algebra of 3D space and Pauli vectors
- Geometric Algebra of 4D Space-time and Dirac vectors
- Klein-Gordon equation
- Dirac equation
- Interpretation of negative energy states and concept of antiparticles;
- Spin and magnetic moment of the electron

Prescribed Text Books:

1. Amit Goswami, Quantum Mechanics, Second Edition, Waveland Press Inc, 1997

2. G. Aruldhas, Quantum Mechanics, PHI Learning, Eastern Economy Edition 2013.

3. W. Greiner, Quantum Mechanics-An Introduction, Springer-Verlag, Germany.

4. N. Zettili, Quantum Mechanics: Concepts and Applications, Wiley, 2009.

5. David Hestenes, Space-Time Algebra, Springer, 2015.

Other Resources/ Reference Books:

1. J. J. Sakurai, *Modern Quantum Mechanics*, Addison-Wesley.
2. *R. Shankar, Principles of quantum mechanics, Plenum Press.*
3. D. J Griffiths, *Introduction to particle physics*, Pearson Prentice Hall.

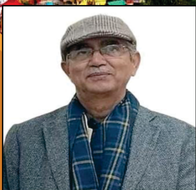
Annexure: 11

Ruby Jubilee Celebrations

The 38th Annual Convention of Indian Association of Physics Teachers (IAPT)

16th - 18th October, 2024

CHIEF PATRON
PROF. S.P. BANSAL
Hon'ble Vice Chancellor
Central University of
Himachal Pradesh, Dharamshala
&
Himachal Pradesh University, Shimla



Prof. P. K. AHLUWALIA
President
IAPT

DR. REKHA GHORPADE
General Secretary
IAPT

Prof. O. S. K. S. Sastri
Chairman
IAPT, Convention

Organized by :-

- Central University of Himachal Pradesh
- National Institute of Technology, Hamirpur
- Govt. Degree College, Dharamshala
- Govt. Post Graduate Degree College, Nagrota Bagwan
- IAPT RC-03

Annexure : 12

PRE-CONVENTION WORKSHOP

1. Innovative Experiments using ExpEYES : **Er. V. V. V. Sathyanarayana**, IUAC New Delhi
2. Shell Model Simulations using worksheets: **Dr. Swapna Gora** and **Shikha Awasthi**
3. Simulations using XCOS: **Dr Anil Khachi**, Chandigarh Group of Colleges and Mr **Lalit Kumar**, G. B. Pant Memorial Govt. College, Rampur
4. Research Based Pedagogical Tools: **Dr Vandna Luthra**, Delhi University
5. Computer Simulations in Quantum Physics using Worksheets: **Dr Pawan Sharma** Principal, Govt. Degree College, Shri Renukaji Sirmour District and **Dr Sapna Verma**
6. Video and Image Analysis using Tracker: By **Dr Jyothi Bharadwaj** and **Dr Aditi Sharma**, Chandigarh Group of Colleges
7. Statistics Physics Simulations: By **Dr Vandana Sharada** and **Ms Ayushi Awasthi**
8. Innovative Experiments and Demonstrations in Physics: **Prof. Y K Vijay**, IIS deemed to be University Jaipur
9. Physics a Thought- Let us develop it: **Dr Arun Sharma**, Govt. College, Bilaspur
10. Telescope Making Workshop: **Tushar Purohit**, IUCAA

To register visit the link: Registration and Abstract Submission Form (google.com)

अन्तर–विश्वविद्यालय त्वरक केन्द्र
INTER- UNIVERSITY ACCELERATOR CENTRE
(Formerly Nuclear Science Centre)
(विश्वविद्यालय अनुदान आयोग का स्वायत्त केन्द्र)
(An Autonomous Centre of UGC)

Annexure-14

Prof. Avinash Chandra Pandey
Director

Ref: IUAC/0.21-A/ 3420

30th April, 2023

Dr. O.S.K.S. Sastri
Professor of Physics, Department of Physics & Astronomical Sciences
Central University of Himachal Pradesh
TAB, Shahpur, Kangra, H.P. - 176206
Phone no: 9418030901

Dear Prof. Sastri,

In continuation of recommendations of the Committee for Academic Affairs (CAA) dated 15/04/2019 read with the approval of Governing Board in its meeting dated 18/04/2023, it gives me great pleasure to inform you that it has been decided to offer you Visiting Associate-ship and Convener of the Board of Examiners. You may be provided flatlet accommodation in the campus and all the secretarial assistance required for the purpose during the training module besides the other assignments as enumerated in IUAC/0.25AA/2051 dated 03/05/2019.

It is pertinent to mention that the concept of trainee scientists and conditions of absorption in service is borrowed from DAE recruitment rules but IUAC does not have a full-fledged training school like DAE system due to sporadic and a smaller number of trainees in a recruitment year. Recently, IUAC has selected 14 Scientists, 07 Engineers, and 05 Junior Engineers in various disciplines, and an offer of appointment to the selected candidates has already been issued. Under these circumstances and keeping in view the requirement of trained and skilled manpower to operate, maintain & repair the facilities without much dependency on imports, the trainees need to be properly skilled and oriented towards the mandate of IUAC for which the following arrangements are being made for the training: -

- formative assessment, maintenance of confidential records, and remedial measures for differential learning with special reference to skilling in desired areas to ensure that the rigorous skilling/ training sessions for newly recruited Trainee-Scientists of IUAC are organized in a blended mode drawing expert in cognate fields from across the world.
- all the lectures shall be recorded for MOOCs in Accelerator-based physics/Radiation Biology/Geo Sciences possibly to be offered from the SWAYAM portal.
- syllabus of the training module shall comprise a systematic body of knowledge for accelerator-based Physics, Radiation Biology, and Geo Sciences and shall be as per a learning outcome-based framework with Course Outcome (CO), Programme Outcome (PO) & Program Educational/Specific Outcome (PE/SO).
- any other pedagogical input that may be recommended by the Board of Examiners for making the training effective and exemplary.

You may kindly contact the undersigned during your stay at IUAC.

Kindly give your acceptance to this officer. We look forward to your visit to IUAC.

With regards,

Yours sincerely,

(Avinash C. Pandey)

Copy to: S.A.O./A.O. (P)/ A.O. (F&A)/ A.O. (Estate)/Academic Cell to facilitate as per the recommendations 11.10 (C) 74th GB of IUAC held on 18/04/2023.

अरुणा आसफ अली मार्ग, नई दिल्ली – 110 067 (भारत)
Aruna Asaf Ali Marg, New Delhi- 110 067 (India)
Phone : 011-2412 6036 (Dir.), 2412 6018, 2412 6022, 2412 6024, 2412 6025
Fax : 011-2412 6004 • E-mail : acpandey@iuac.res.in, prof.acpandey@gmail.com
Website : www.iuac.res.in

अन्तर-विश्वविद्यालय त्वरक केन्द्र
INTER-UNIVERSITY ACCELERATOR CENTRE
(Formerly Nuclear Science Centre)
(विश्वविद्यालय अनुदान आयोग का स्वायत्त केन्द्र)
(An Autonomous Centre of UGC)

Annexure: 15

Date: 21-02-2024

Dr. Ambuj Tripati
Scientist H
email: ambujtripathi2023@gmail.com

To
Prof. O. S. K. S. Sastri
Central University of Himachal Pradesh
Dharamsala

Sub: Invitation for delivering Special lecture as part of National Science Day Celebrations

Dear Prof Sastri

It gives me great pleasure to invite you as special lecture for the Inaugural session of National Science Day celebrations being held at IUAC, New Delhi. The program is going to be attended by all the IUAC faternity and students from nearby schools and colleges of Delhi. You are requested to give a talk on this year's theme for National Science Day, which is

Indegenous Technologies for Vikisit Bharat

We will provide TA/DA as per the rules of the center and accommodation at the guest house shall be booked for you.

Look forward to your talk.

Dr. Ambuj Tripati
Scientist- H

पोस्ट बाक्सः 10502 अरूणा आसफ अली मार्ग,
Post Box No. 10502, Aruna Asaf Ali Marg,
नई दिल्ली - 110 067 (भारत)
New Delhi - 110 067 (India)

दूरभाष :/Telephone : 011-26893955
011-26892601
तार :/Telegram : NURCEN
फैक्स :/Fax : 011-26893666
वेबसाइट :/Website : www.iuac.ernet.in

Gmail

Annexure - 16

Sastri Osks <sastri.osks@gmail.com>

Invitation to Serve as Chief Guest and Plenary Session Chair at the International Conference on Recent Advances in Materials and Biological Sciences

Sanjauli College <principalsanjauli@gmail.com> Tue, Nov 12, 2024 at 3:08 PM
To: "sastri.osks@hpcu.ac.in" <sastri.osks@hpcu.ac.in>, Sastri Osks <sastri.osks@gmail.com>
Cc: Kirti Singha <kirtisingha09@gmail.com>

Dear Sir

We are honored to invite you to serve as the Chief Guest at the Valedictory Ceremony of the International Conference on Recent Advances in Materials and Biological Sciences, organized by Govt. College Sanjauli, Shimla, on November 20, 2024. Your presence and insights would be invaluable as we conclude this gathering of esteemed researchers, educators, and industry professionals.

Additionally, we would be privileged if you would also chair a Plenary Session on November 19, 2024. Your expertise and perspective would greatly enrich the discussions and inspire participants from around the globe.

Please find the conference brochure, agenda and session details attached for your review. Should you have further suggestions or specific needs, feel free to reach out to us at following contact details.

We look forward to welcoming you to Shimla for what promises to be a fruitful and inspiring event.

Warm regards,

Principal
Organizing Committee/ Conference Coordinator
Centre of Excellence, Government College Sanjauli
Shimla-06, Himachal Pradesh, India
For further information, please contact:
Conference coordinator:
Dr.KirtiSingha: +91 9418470909/ 7018358537
International Conference
RAMBS - 2024

P कृपया धरती को बचायें. अति आवश्यक होने पर ही प्रिंट करें"

निवेदन: कागज़ बचाएँ, पेड़ बचाएँ. जब तक आवश्यक न हो इस दस्तावेज़ का प्रिंट न लें।

Please don't print this e-mail unless you really need to. Save Paper, Save Ink and Save environment too.

2 attachments

International Conference Brochure - 2024.pdf
570K

Itinerary (3).pdf
248K

Annexure : 17

Report on

Training Program on Computer Interfaced Science Experiments using ExpEYES

Venue: Ph. D. Classroom

अंतर विश्वविद्यालय त्वरक केंद्र
Inter-University
Accelerator Centre - (IUAC)

Aruna Asaf Ali Marg, Near Vasant Kunj,
New Delhi, 110067, INDIA

Program Schedule

Day 1: Monday 9th October, 2023

9:30 – 10:00	**Registration**	
10:00-11:00	**Introduction of the Participants**	
11:00-11:30	**Tea**	
11:30-12:15	**Session-1** **Design of Experiments**	**Prof O.S.K.S.Sastri,** CUHP, Dharamshala
12:15-13:00	**Session-2** **Introduction to ExpEYES**	**Er. V.V.V.Satyanarayana** IUAC, New Delhi
13:00-14:00	**Lunch**	
14:00-15:30	**Session-3** **Electronics Experiments using ExpEYES** (Demonstration & Hands-on)	**Er. V.V.V.Satyanarayana** IUAC, New Delhi **Dr Praveen Patil** GSS College, Belgaum
15:30-16:00	**Tea**	
16:00-16:45	**Hands-on Experiments** (Continued)	**Dr Praveen Patil** GSS College, Belgaum **Er. V.V.V.Satyanarayana** IUAC, New Delhi
16:45-17:30	**Session-4** **Introduction to Tracker for Video and Image Analysis**	**Prof O.S.K.S.Sastri,** CUHP, Dharamshala

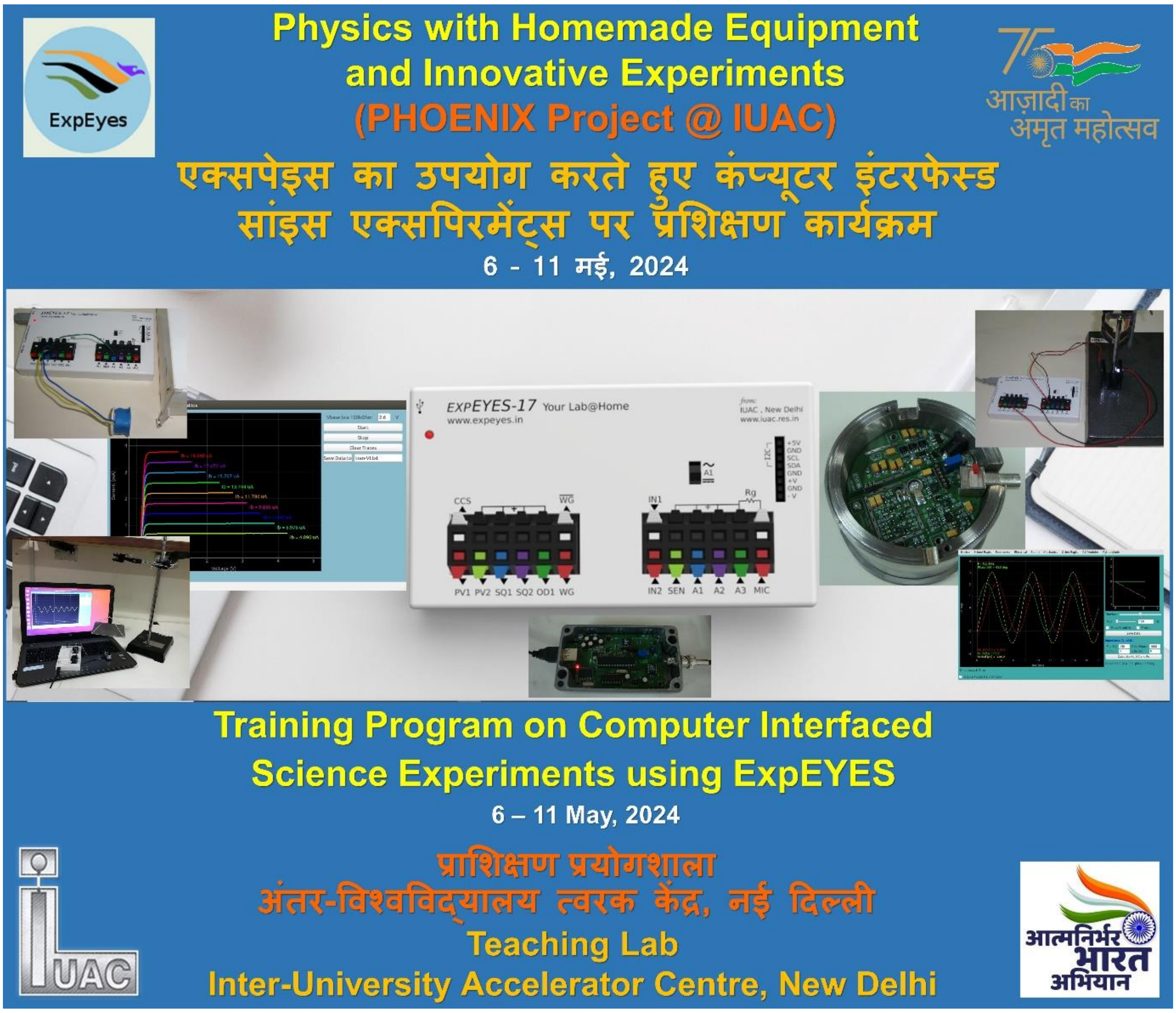
Day 2: Tuesday 10th October, 2023

09:30-11:00	**Session-5** **Classical Mechanics Experiments Demonstration**	**Prof O.S.K.S.Sastri,** CUHP, Dharamshala
11:00-11:30	**Tea**	
11:30-13:00	**Hands-On Experiments**	**Er. V.V.V.Satyanarayana** IUAC, New Delhi **Dr Praveen Patil** GSS College, Belgaum
13:00-14:00	**Lunch**	
14:00-15:30	**Session-6** **Optics Experiments** **Demonstration** **&** **Hands-On**	**Prof O. S. K. S. Sastri** CUHP, Dharamshala **Er. V.V.V.Satyanarayana** IUAC, New Delhi **Dr Praveen Patil** GSS College, Belgaum
15:30-16:00	**Tea**	
16:00-17:30	**Session-7** **Introduction to Python Programming Language** (Online)	**Dr Ajith Kumar B. P.** Ex IUAC, New Delhi

Annexure : 18

Report on

Training Program on Computer Interfaced Science Experiments using ExpEYES



Venue: Ph. D. Classroom

अंतर विश्वविद्यालय त्वरक केंद्र
Inter-University Accelerator Centre - (IUAC)

Aruna Asaf Ali Marg, Near Vasant Kunj,
New Delhi, 110067, INDIA

Program Schedule

Day 1: Monday 6th May, 2024

9:30 – 10:00	**Registration**	
10:00-11:00	**Inaugural Session** **Keynote Address by** **Prof. Avinash Chandra Pandey, Director, IUAC**	
11:00-11:30	**Tea**	
11:30-12:15	**Session-1** **Introduction to ExpEYES**	**Er. V.V.V.Satyanarayana** IUAC, New Delhi **Prof Vandna Luthra** Gargi College, New Delhi
12:15-13:00	**Session-2** **Electronics Experiments using ExpEYES** (Demonstration & Hands-on)	**Er. V.V.V.Satyanarayana** IUAC, New Delhi
13:00-14:00	**Lunch**	
14:00-15:30	**Session-3** **Electrical Experiments using ExpEYES** (Demonstration & Hands-on)	**Er. V.V.V.Satyanarayana** IUAC, New Delhi
15:30-16:00	**Tea**	
16:00-16:45	**Session-4** Invited talk on **ExpEYES in School Education** (Online)	**Dr Govinda Lakhotiya** Bajaj College of Science, Warda, Maharashtra.
16:45-17:30	**Session-5** **Hands-on Experiments**	**Er. V.V.V.Satyanarayana** IUAC, New Delhi

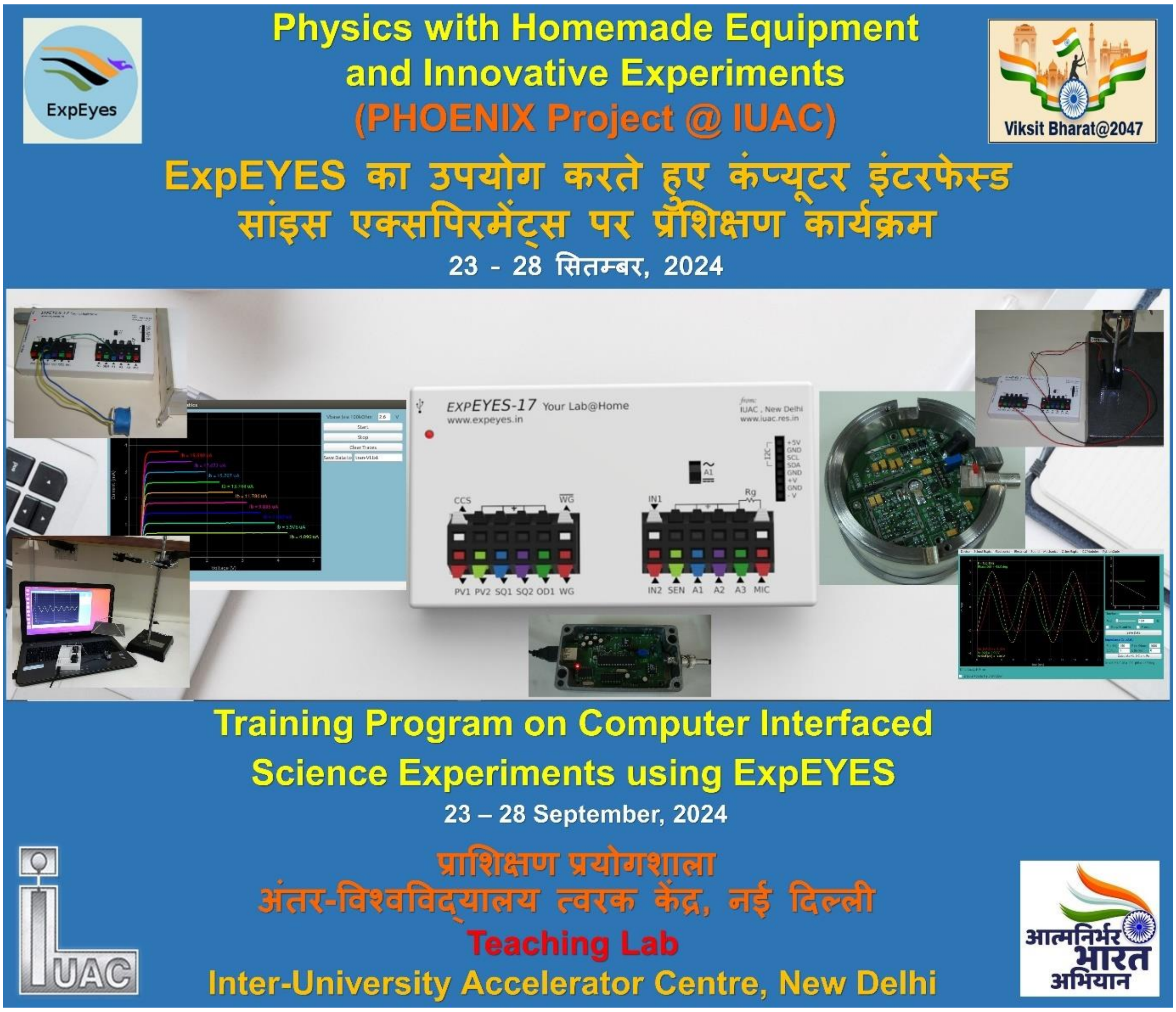
Day 2: Tuesday 7th May, 2024

09:30-11:00	**Session-6** **Sensor Based Data Acquisition Experiments**	**Prof O.S.K.S.Sastri,** CUHP, Dharamshala
11:00-11:30	**Tea**	
11:30-13:00	**Session-7** **Classical Mechanics Experiments Demonstration & Hands-On**	**Er. V.V.V.Satyanarayana** IUAC, New Delhi **Prof O.S.K.S.Sastri,** CUHP, Dharamshala
13:00-14:00	**Lunch**	
14:00-15:30	**Session-8** **Optics Experiments** **Demonstration & Hands-On**	**Prof O. S. K. S. Sastri** CUHP, Dharamshala **Er. V.V.V.Satyanarayana** IUAC, New Delhi
15:30-16:00	**Tea**	
16:00-16:45	**Session-9** **Introduction to Tracker for Video and Image Analysis**	**Prof O.S.K.S.Sastri,** CUHP, Dharamshala
16:45-17:30	**Hands-On and Projects Discussion**	

Annexure - 19

Report on

Training Program on Computer Interfaced Science Experiments using ExpEYES



Venue: Ph. D. Classroom

अंतर विश्वविद्यालय त्वरक केंद्र
Inter-University
Accelerator Centre - (IUAC)

Aruna Asaf Ali Marg, Near Vasant Kunj,
New Delhi, 110067, INDIA

Program Schedule

Day 1: Monday 23rd September, 2024

9:30 – 10:00	**Registration**	
10:00-10:30	**Inaugural Program** **Keynote Address by** **Prof. Avinash Chandra Pandey, Director, IUAC**	
10:30-11:15	**Session-1** **Design of Experiments**	**Prof O.S.K.S.Sastri,** CUHP, Dharamshala.
11:15-11:30	**Tea**	
11:30-12:00	**Session-2** **Teaching Science through Experimentation and Exploration**	**Shri. V.V.V.Satyanarayana** IUAC, New Delhi
12:00-13:00	**Session-3** **Introduction to ExpEYES**	**Prof Vandna Luthra** Gargi College, New Delhi
13:00-14:00	**Lunch**	
14:00-14:45	**Session-4** **Experiments using ExpEYES** (Demonstration & Hands-on)	**Shri. V.V.V.Satyanarayana** IUAC, New Delhi **Prof O.S.K.S.Sastri,** CUHP, Dharamshala. **Prof Vandna Luthra** Gargi College, New Delhi
14:45-15:30	**Hands-On Experiments**	
16:00-16:45	**Session-5** Invited talk on **Evaluation of Planck's Constant using Light Emitting Diodes: A new approach** (Online)	**Ms. Bidisha Biswas** Bhairab Ganguly College, Kolkata.
16:45-17:30	**Projects – Discussions**	

Day 2: Tuesday 24h September, 2024

09:30-11:00	**Session-6** **Classical Mechanics Experiments Demonstration & Hands-On**	**Prof O.S.K.S.Sastri,** CUHP, Dharamshala **Shri. V.V.V.Satyanarayana** IUAC, New Delhi
11:00-11:30	**Tea**	
11:30-13:00	**Hands-On Experiments**	
13:00-14:00	**Lunch**	
14:00-14:45	**Session-7** **Introduction to Tracker for Video and Image Analysis**	**Prof O. S. K. S. Sastri** CUHP, Dharamshala
14:45-15:30	**Hands-On Experiments**	
15:30-16:00	**Tea**	
16:00-16:45	**Session-8** **Innovative Approach to Teaching Ray Optics in the Classroom**	**Prof Amit Garg,** Department of Electronics, Acharya Narendra Dev College, New Delhi.
16:45-17:30	**Hands-On Experiments**	

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Prof. OSKS Sastri
School of Physical and Materials Science
Central University of Himachal, Dharamshala

Subject: Invitation to deliver an invited talk at St. Bede's College Shimla

Respected Prof. Sastri

It gives me immense pleasure on behalf of Physics Department, St. Bede's College Shimla to invite you to deliver a talk in One day Hands-On Workshop on ***'Quantum Physics Simulations using Spreadsheets',*** on 29.09.2023 at 10.30 a.m. in the Physics department.

We look forward to your kind acceptance of our invitation.

With best regards

Yours sincerely

Dr. Sapna Sharma
Head of Department of Physics
St. Bede's College, Shimla

Annexure: 21

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Dated: 25.09.2024

To
OSKS Sastri
Professor of Physics,
School of Physical and Materials Science
Central University of Himachal, Dharamshala

Subject: Invitation to deliver a talk at Workshop on Simulations

Respected Prof. OSKS Sastri,

I hope this message finds you well.

On behalf of the Physics Department, St. Bede's College, Shimla, I am delighted to invite you to deliver a talk on **"Simulations using the XCos Tool of Scilab"** at our One-Day Workshop scheduled for October 3, 2024, at 10:30 a.m. in the Physics Department.

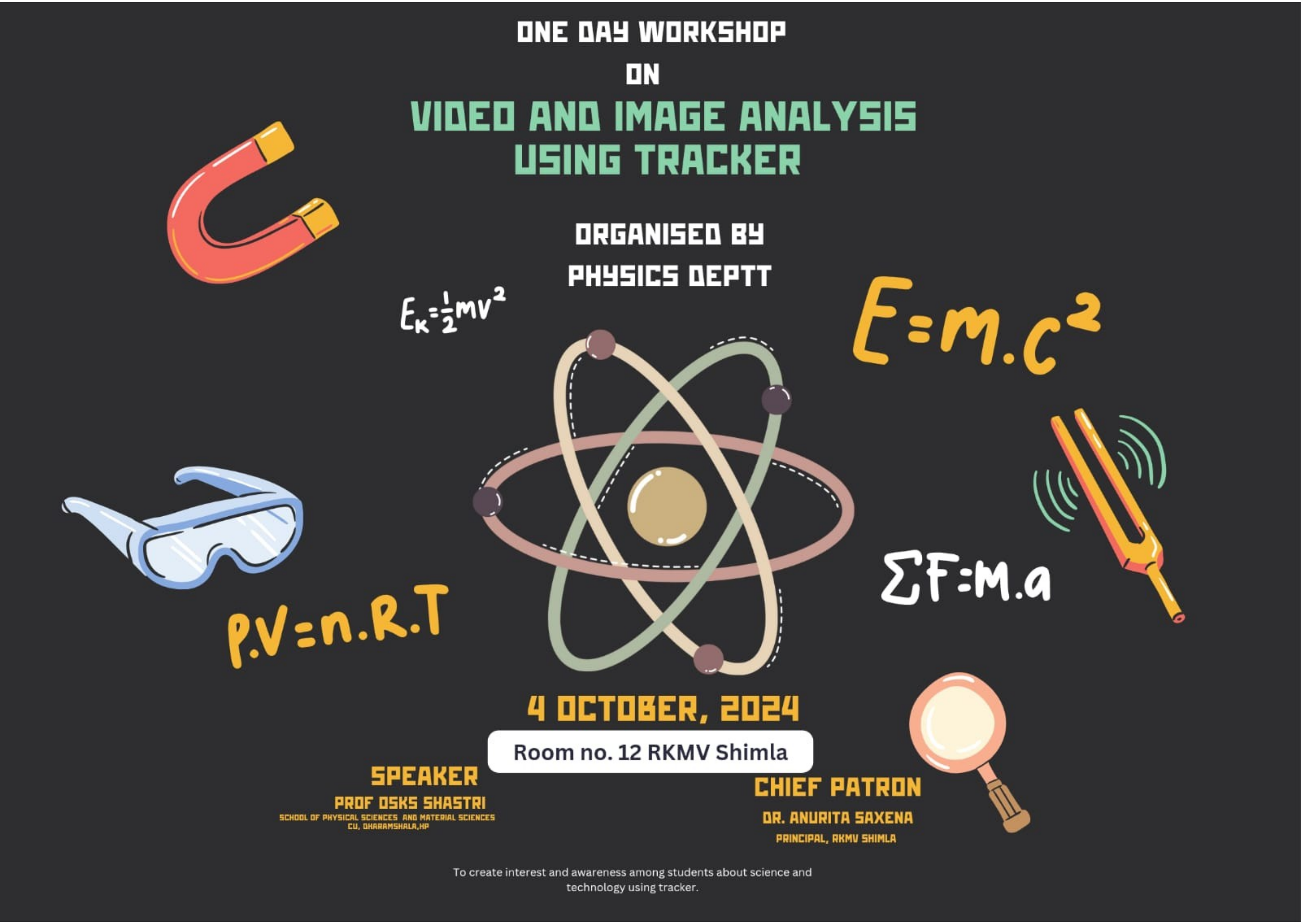
We would be honored to have you with us and look forward to your positive response.

Thanking you

Best regards,

Dr. Sapna Sharma
Head of Department of Physics
St. Bede's College, Shimla

Annexure: 22



ONE DAY WORKSHOP
ON
VIDEO AND IMAGE ANALYSIS USING TRACKER
ORGANISED BY
PHYSICS DEPTT
E=m.c²
ΣF=M.a
P.V=n.R.T
4 OCTOBER, 2024
Room no. 12 RKMV Shimla
SPEAKER
PROF OSKS SHASTRI
SCHOOL OF PHYSICAL SCIENCES AND MATERIAL SCIENCES
CU, DHARAMSHALA,HP
CHIEF PATRON
DR. ANURITA SAXENA
PRINCIPAL, RKMV SHIMLA
To create interest and awareness among students about science and technology using tracker.

Annexure - 23

GOD is Omnipresence, Omniscience and Omnipotence

A Comprehension based on the Concept of Fourier Transform

Prof. O. S. K. S. Sastri

Central University of Himachal Pradesh, Dharamsala, Bharat

Abstract

Purpose: In this paper, the mathematical concept of Fourier transform is being used to *draw a parallel* for developing a conceptual comprehension of the Omnipresence, Omniscience, and Omnipotence.

Background:

(i) *Mathematical Background:* The Fourier transform of a Gaussian function in the time and space domain results in a Gaussian function in the Fourier space of temporal and spatial frequencies. The widths of the Gaussian functions in both the domains are inversely related. That is, the smaller the width in the space-time domains the larger the width in their respective Fourier domains. When the width of the Gaussian function with unit area tends to zero with the total area under the curve remaining as unity, we call the resulting function a Delta function. The Fourier transform of such a Delta function would become a constant function in the Fourier domain.

(ii) *Vedantic Background:* Anantam means na antam, that which has no limits or is Infinite. In what sense? Typically, one finds that there are three kinds of limitations one observes:

- Spatial limitation: Every object in the Universe, however big it might be, has a certain limit. The Ocean and the Earth, even though they look limitless, have their limited sizes. All living and non-living things are also limited in size.
- Temporal limitation: Every entity similarly has a beginning and an end. Our body comes into existence at birth and goes out of existence at death and hence has a limited existence in time. Even the Universe is created and dissolved over a very large time frame but yet has this limitation in time.
- Identity limitation: Every object or entity is limited to be of only one type and can not be of another type. A pen can not be a book and vice-versa. So, each object has an identification based on its characteristics and is limited by those characteristics.

Hence, Brahman being Anantam, has no limits in space, time, or identity. That is,

- ब्रह्म (Brahman) is all-pervading or there is no place where ब्रह्म (Brahman) is not, which means Omnipresence. ब्रह्म (Brahman) is present at all times past, present, and future, which means ब्रह्म (Brahman) is Nitya or Eternal and hence is Omniscient.
- ब्रह्म (Brahman) is present in every entity irrespective of its identity. That is, there exists no entity that ब्रह्म (Brahman) is not. This means, ब्रह्म (Brahman) is Non-dual or अद्वैतम् (advaitam).

CERTIFICATE

Of Appreciation

This certificate is presented to

O. S. K. Subramanya Sastri (Seminar)

For Delivering Lectures in the School-cum-workshop on Low Energy Nuclear Astrophysics (SLENA-23), held from 7th to 10th November, 2023 at Saha Institute of Nuclear Physics, Kolkata.

Chairperson, SLENA-23
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NPTEL Coordinator
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Central University of Himachal Pradesh, Shahpur Campus, Himachal Pradesh

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Prof. Naveen K. Navani	Prof. Akshay Dvivedi	Prof. Meenakshi Rawat
Dean of Academic Affairs, IIT Roorkee	Dean, SRIC, IIT Roorkee	ADeAA-ITS & A, IIT Roorkee