# An equation of state for a hard homonuclear diatomic fluid derived from the integral equation method

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**ABSTRACT**
It has been shown that an improved prediction of an equation of state for hard homonuclear diatomic fluid can be done with an interpolation scheme that relates the pressure of the hard sphere to that of tangent hard spheres at the same density. The Boubl´ıkMansoori-Carnahan-Starling-Leland (BMCSL) formula, which is based on the virial and compressibility pressures obtained as a solution of an integral equation, is used for hard sphere fluid. For homonuclear diatomic fluid, the BMCSL formula employing pressures obtained with free energy and compressibility routes has been used. Calculations are performed for hard homonuclear diatomics with reduced separations of 0.1 to 1 at the reduced densities of 0.2 to 0.9. Our findings for the equation of state from the Martynov-Sarkisov approximation present good agreement with available accurate data, having maximum deviations of 10.2% over the separation and density ranges of the calculation.

***Keywords:*** *Pressure, Interpolation scheme, Integral equation, Diatomic liquid*

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# The formation of a vortex in a Bose-Einstein condensate

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**ABSTRACT**

In this work, we have studied the formation of a vortex in a Bose-Einstein condensate (BEC). One way to create numerically a vortex in BEC, that trapped in magnetic harmonic potential is the introducing of an angular momentum operator to the Hamiltonian. Time dependent GP equation calculated by means of time splitting method. The creation of vortex in BEC depends on rotational speed of trap $\Omega$ and interaction term
$\beta$. Critical value of rotation speed of trap $\Omega_c$ beginning to form of vortex defined from results calculation procedure.

***Keywords:*** *Gross-Pitaevskii equation, ground state, excited state, symmetry state vortex, rotation speed*

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# Photoelectron momentum distribution of Helium atom

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**ABSTRACT**

In this article, we present a numerical study of the interaction between a helium atom and a strong laser field. We solved the time-dependent Schrödinger equation using the Coulomb discrete variable representation method. For the single active electron of the helium atom, we calculated and compared the photoelectron momentum distributions using two different forms of effective potentials. Our computational results indicate that the ionization probability is higher when employing the effective potential discussed in Reiff''s work [1] compared to the potential proposed by Borbely's work [2]. It also illustrates the photoelectron momentum distribution.

***Keywords:*** *Laser pulse, Ionization probability, Single active electron approximation,*

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# DFT Study of $BaFe_{12}O_{19}$-$MgFe_2O_4$ Nanocomposites: Thickness-Dependent Structural, Magnetic, and Charge Analysis

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**ABSTRACT**

This study explores the structural, magnetic, and electronic properties of $BaFe_2O_{19}$–$MgFe_2O_4$ nanocomposites using Density Functional Theory (DFT) with the VASP software. The composite system was modeled by interfacing the (001) surface of $BaFe_2O_{19}$ with the (111) surface of $MgFe_2O_4$, comprising over 400 atoms. To investigate thickness-dependent effects, we varied the proportions of $BaFe_2O_{19}$ and $MgFe_2O_4$ across four distinct thickness configurations. Structural analysis revealed enhanced stability at the interface, driven by Fe–O bonds, with energy calculations indicating a more stable configuration compared to individual components. The results highlight significant differences in magnetic saturation (Ms) between $BaFe_2O_{19}$ and $MgFe_2O_4$, alongside notable charge variations at the interface, with strong ionic interactions. These findings suggest that thickness-dependent $BaFe_2O_{19}$–$MgFe_2O_4$ nanocomposites hold promise for tailored magnetic applications, such as recording media, with ongoing calculations aimed at further elucidating electronic and magnetic properties.

# Stark resonance parameter for atomic hydrogen revisited

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**ABSTRACT**

We revisit the Stark effect for atomic hydrogen, for which the Schrodinger equation in spherical coordinates has been solved in ¨ terms of a hybrid approach using a pseudospectral method. The Stark resonance parameter for the ground state of the atom in a static electric field has been determined by adding a complex absorbing potential to the Hamiltonian. Our findings for resonance parameter are more accurate than those obtained by a mapped two-dimensional Fourier grid method combined with a complex absorption in a previous work [Ts. Tsogbayar and M. Horbatsch, Few-Body Syst. 54 (2014), 431], by presenting good agreements with available data in literature. Moreover, we discuss a localized wave function for the state.

***Keywords:*** *Static electric field, complex absorbing potential, hydrogen atom*

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# Air pollution and health of vulnerable groups in Mongolia: A review of existing studies

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**ABSTRACT**

Air pollution in Mongolia, particularly in Ulaanbaatar, poses severe health risks, especially to vulnerable groups such as children, elderly, pregnant women, and individuals with preexisting conditions. This study supports the association of air pollution and health outcomes, analysing the effects of both indoor and outdoor air pollution. This review synthesizes over 50 peer-reviewed articles on the health impacts of key pollutants, including PM2.5, PM10, NO2, SO2, CO, and O3 linking exposure to respiratory and cardiovascular disorders, birth outcome, childhood development, and cancer risk in Mongolia. Among the studies, the most investigated health outcomes are respiratory effects of children followed by birth outcomes and reproductive health. PM, SO2, and NO2 are the main pollutants mentioned in this review causing respiratory, cardiovascular disease, defect reproductive system and even affect neurodevelopment of children such as behavioural, cognitive and autistic performances. Furthermore, volatile organic compounds (VOCs), and polycyclic aromatic hydrocarbons (PAHs) (mostly indoor) are the pollutants causing lung and liver cancer highlighting a desperate need for indoor air quality standard. CO provokes direct poisoning and even leading to death upon high exposure. Children living in Ulaanbaatar has lower lung function compared to the rural children mostly due to high exposure of carbon monoxide. Moreover, blood lead levels of children living in both non-apartment dwellings and apartment have a high level of lead concentration exceeding reference level but children in non-apartment have shown lower lung function values than apartment living children. It is shown that high blood lead level affects the academic performance of children. For the adults, bronchial asthma, chronic obstructive pulmonary disease, and cardiovascular disease exhibited higher prevalence among 40–60-year-olds. Last but not least, air pollution in Ulaanbaatar significantly impacts not only health but also overall quality of life of residents, particularly through its effects on labour supply, school attendance, and life satisfaction. Despite growing research, gaps remain in long-term studies. Strengthening policies and healthcare responses is important to mitigating health risks for vulnerable populations.

***Keywords:*** *Air pollution, Public health, Vulnerable groups, Mongolia.*

# Investigation of environmental radiation dispersion during uranium mining in Mongolia: Impacts and mitigation strategies

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**ABSTRACT**

As electricity demand continues to grow and climate change accelerates, low-carbon energy generation has become a global priority. Nuclear and renewable energy sources complement each other, collectively helping to reduce carbon emissions even as global energy demand is expected to double. However, uranium mining and processing can lead to the dispersion of radiation through various pathways, such as the release of radioactive dust, radon gas, and contamination of soil, water, and air, which poses potential risks to human health and the environment. Therefore, it is crucial to adopt environmentally friendly methodologies for uranium mining. In this study, the radioactivity associated with uranium mining (Ra-226, Th-232, K-40, Cs-137) was assessed based on air, water, and soil samples collected from monitoring boreholes in Badrakh Energy mining site in Mongolia. Gamma spectrometry was utilized to measure radiation levels in the samples, analyze their environmental and human health impacts, and compare the results with both international standards and Mongolian national regulations. The modified Gaussian plume equation was used to estimate the average dispersion of radon released from a point source, and a numerical distribution map was created based on the modeling results. This study will serve as a fundamental scientific study in controlling the effects of radiation caused by uranium mining and ensuring environmental sustainability.

***Keywords:*** *Environmental radiation, Uranium mining, Radioactive contamination, Gamma spectrometry, sustainable mining practices*

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# Comparative study of insulation materials for cost-effective and energy-efficient private residential buildings

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**ABSTRACT**

Climate change imposes significant challenges globally, with Mongolia experiencing impacts nearly threefold greater than the global average due to its severe continental climate. Winter temperatures frequently fall below −30 °C, highlighting the critical need for effective thermal insulation solutions to enhance energy efficiency and indoor thermal comfort in residential buildings. This study comprehensively evaluates the structural, thermal, mechanical, and environmental performance of Mongolian sheep wool insulation, specifically sourced from Eco Wool House Co., Ltd., as a sustainable and locally available alternative for cold-climate construction. Key physical and mechanical properties—including moisture content, density, thermal conductivity, and water absorption—were quantified in accordance with established national and international standards (MNS ISO 29470:2010, MNS 380:2007, EN ISO 10534-1, EN 29052-1, MNS 4115:1991, MNS 4999:2000). Comparative analyses with imported German sheep wool insulation revealed that the Mongolian product exhibits significantly higher density (35.1 kg/m³ versus 28.7 kg/m³), elevated sulfur content indicative of greater fiber purity (73.6 wt%), and a distinctive porous hollow fiber morphology. These attributes confer superior thermal performance, demonstrated by a reduced thermal conductivity coefficient of 0.036 W/m·K. Structural and compositional assessments via Scanning Electron Microscopy (SEM) and Energy-Dispersive X-ray Spectroscopy (EDS) corroborated these findings. In situ thermal performance evaluation through infrared thermography indicated minimal thermal bridging within buildings insulated with Eco Wool. The test structure attained a Category B energy efficiency classification, with an annual energy consumption of 9,827 kWh, reflecting a 49% reduction in energy demand and an associated 0.4-ton annual decrease in $CO_2$ emissions relative to conventional foam insulation. Complementary socio-economic analysis, aligned with Mongolia's National Housing Program, identified a 60 m² dwelling as the optimal balance of affordability and energy efficiency, with subsidized mortgage payments feasible for the average household. Collectively, these results substantiate Mongolian sheep wool insulation as an effective, sustainable, and economically viable material for advancing energy-efficient housing in harsh cold climates, thereby contributing to national climate adaptation and green building strategies.

***Keywords:*** *Sheep wool insulation material, Climate change, indoor air quality, building heat loss*

# Mathematical modelling of anthropogenic loads based on satellite data

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**ABSTRACT**

The purpose of this study is to develop a model for determining the land load index related to geological environment changes and anthropogenic loads in the entire territory of the Ugii Lake Basin based on satellite data. We used correlation analysis and multivariate analysis in our study. We developed five categories of anthropogenic loads in the Ugii Lake Basin taking into account regional characteristics. The results of the August average data of the MODIS 2000-2023 satellite NDVI, the long-term change relationship of 46 parameters including anthropogenic loads and climatic parameters were calculated and a nonlinear model of NDVI was developed. Based on this NDVI model, a new nonlinear model was developed to determine the land load index related to anthropogenic loads in the entire region. The results developed using the land load index model were verified by overlapping the ground measurement points of roads, cities, mines, and agricultural fields. The land load index model has a determination coefficient of R=0.79 with ground measurement values. The spatial distribution of land degradation was determined using a model for calculating the land load index, and the results were divided into 7 categories. Looking at the land load index map, the eastern part of the basin is more heavily loaded and the load index falls into the category of weak to strong. The model results agree well with the ground measurement data, so it is considered that the model can be used for the entire area of the Ugii Lake basin.

***Keywords: geological changes, land load index, lake basin***

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# Effect of Nd doping on FeCo composite

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**ABSTRACT**
The development of rare-earth (RE)-free permanent magnets remains a key challenge in materials science. This study explores the impact of neodymium (Nd) doping on FeCo alloys, demonstrating its ability to induce tetragonality and enhance magnetic properties. Through systematic doping optimization, we achieve a coercivity of 63 Oe and a saturation magnetization of 163 emu/g in Nd-doped FeCo isotropic magnets. These findings provide valuable insights for optimizing FeCo-based materials for advanced magnetics applications.

***Keywords:*** *FeCo alloy, Nd doping, tetragonality, coercivity, saturation magnetization, permanentmagnets*

# A curriculum quality assurance using performance indicators

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**ABSTRACT**
In this paper, we discuss about the experience in assessing the attainment level of Program Learning Outcomes (PLOs) for undergraduate programs through the use of performance indicators (PIs), which serve as quantifiable measures to evaluate curriculum effectiveness. We outline our defined PIs and associated rubrics designed to fairly evaluate students' achievements in knowledge, skills, and attitudes. Additionally, we explore the role of PIs in curriculum quality assurance, emphasizing their development, implementation, and analysis. The study highlights best practices and challenges in using PIs to drive continuous improvement in PLO performance and overall educational outcomes, demonstrating the effectiveness of this approach in aligning education with institutional goals, student needs, and societal expectations.

***Keywords:*** *CDIO approach, Program Learning Outcomes, Performance Indicators, Rubrics.*

# Using physics experiments to support “Monozukuri” skills

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**ABSTRACT**

Developing students' creative thinking, fostering independent knowledge construction, problem-solving, entrepreneurial and engineering mindsets are essential goals of science education—particularly physics. One of the most effective ways to achieve these objectives is by engaging students in hands-on, creative activities. This study explores the implementation of the “Monozukuri” methodology in secondary school physics lessons to enable students to construct knowledge through experience and better understand physical phenomena. The research also examines the development of students’ cognitive knowledge, affective competencies. The experimental study involved 160 students and employed a quasi-experimental design, including both control and experimental groups. Qualitative and quantitative data were collected and analyzed. Statistical analysis using the t-test showed that there was a significant improvement ($p < 0.05$) in the cognitive, affective domains of the students who participated in the experimental group, indicating the effectiveness of the “Monozukuri” approach in fostering engineering-oriented learning.

***Keywords:*** *Monozukuri, cognitive knowledge, affective competencies, engineering thinking.*

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# Preparation of carbon porous material from coal as a raw material

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**ABSTRACT**

Coal, after undergoing a chemical procedure, can be converted into porous materials through simple high-temperature pyrolysis, demonstrating significant potential for application in energy storage and environmental remediation. This study uses coal as a raw material to produce porous carbon materials via high-temperature pyrolysis, in our case, it is up to 900°C. The structure and properties of the resulting materials were systematically characterized using X-ray diffraction (XRD), scanning electron microscopy (SEM), Brunauer-Emmett-Teller (BET) surface area analysis, thermogravimetric analysis (TG), and Fourier-transform infrared spectroscopy (FTIR). The results indicate that original raw material, such as coal, is structurally being optimized, having porous not only on the surface but also in the body. SEM images confirm a honeycomb-like porous morphology on the material surface, with pore size distribution ranging from 1 to 20 μm, attributed to volatile release and carbon skeleton contraction. XRD patterns show that two characteristic peaks at approximately which correspond to the 001 and 100 planes of disordered graphite lattices. The result indicates partial graphitization of the initial material. FTIR spectra showed a significant reduction in oxygen-containing functional groups (-OH, C=O) after pyrolysis, while the characteristic aromatic C=C peak (1600 $cm^{-1}$) decrease, confirming deoxygenation and aromatization reactions.

***Keywords:*** *coal, porous carbon material, XRD，FTIR，SEM*

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# Layer number identifications of the mechanical exfoliated TMDs

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**ABSTRACT**

In this work, an investigation of the mechanically exfoliated TMDs under the influence of heat treatment was carried out. Optical and atomic force microscopy techniques were applied to determine the number of layers. Resonant Raman investigation was performed, which clearly showed systematic layer-dependent spectral features. The surface morphology of TMDs was investigated with the STM. Atomic-resolution images of TMDs is were obtained. Three types of atomic defects were identified as substitutions of donor and acceptor atoms in the Mo atomic layer below the topmost dichalcogenide layer.

***Keywords:*** *2D materials, TMDs, layer identification, exfoliation, resonant Raman spectroscopy.*

# Liquid phase exfoliation of MoS2 nanosheets in IPA and NMP solutions

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**ABSTRACT**

In this work, the liquid phase exfoliation (LPE) method was investigated to produce a large quantity of 2D $MoS_2$. The introduction of ultrasound into IPA and NMP solutions containing bulk $MoS_2$ resulted in exfoliation of the $MoS_2$. The suspensions were centrifuged at various rotation speeds (2000-8000 rpm) to collect supernates. The determination of the layers of LPE-$MoS_2$ was performed by optical microscopy, atomic force microscopy, non-resonant Raman spectroscopy and XRD. Flakes with few layers were detected by AFM and resonant Raman investigations. The yield can potentially be further improved by adjusting the concentrations of the $MoS_2$ powder and solutions and the processing parameters such as sonication time and centrifugation speed.

***Keywords:*** *2D materials, TMDs, ultrasonication, exfoliation, solvent, supernatant*

# The calculation of ground states of noble gas atoms using quantum fluid density functional approach

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**ABSTRACT**

We present a study on the calculation of ground-state properties of noble gas atoms using the Coulomb Wave Function Discrete Variable Representation (CWDVR) method within the framework of quantum fluid density functional theory (QFDFT). A Wigner-type local correlation energy functional is employed to incorporate electron correlation effects. The CWDVR method provides an optimal, non-uniform spatial grid for solving the time-dependent quantum fluid dynamical equation. This equation is numerically solved using an imaginary time propagation approach, which efficiently converges to the ground state of the system. Ground-state energies for helium, neon, argon, krypton, and xenon are computed and show excellent agreement with high-precision theoretical and experimental results, demonstrating the accuracy and Effectiveness of the CWDVR method in electronic structure calculations.

***Keywords:*** *Atomic electron structure, Quantum fluid density functional theory, Discrete variable representation, Exchange-correlation energy, Noble gas atoms*

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# Analysis of system dynamics model for policy impacts on solid waste management in Ulaanbaatar city

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**ABSTRACT**
Mongolia's long-term development strategy promotes a 3R (Reduce, Reuse, Recycle) waste management approach aimed at integrating waste into the economic cycle to reduce generation and enhance recycling. This study employs a system dynamics model to analyse of urban solid waste management in Ulaanbaatar, evaluating the impact of policy interventions across six strategic scenarios. Among these, the All-Policy Scenario (Scenario 2)—which integrates economic growth, population control, waste segregation at source, and comprehensive treatment policies—emerges as the most effective. Simulation results reveal that Scenario 2 significantly reduces total waste generation, boosts waste sorting rates to 40% by 2030, and limits landfill use to 36% by 2035 through increased recycling and incineration for energy recovery. This holistic approach not only alleviates landfill pressure but also emphasizes the critical need for infrastructure development in food waste composting. The findings demonstrate the interconnected effects of economic, demographic, and environmental policies and provide a roadmap for sustainable waste management, offering valuable insights for policy planning across Mongolia's provinces.

***Keywords:*** *Waste management, system dynamics, scenario analysis, Ulaanbaatar, policy intervention, recycling*

# Thickness identification of two-dimensional $MoS_2$ layers using X-ray powder diffractometer

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**ABSTRACT**
Two-dimensional (2D) transition metal dichalcogenide have attracted much attention in recent years. Furthermore, determining the thickness of two-dimensional materials is not only helpful in understanding their thickness-dependent physical properties, but also in scientific research and applications. In this paper, we determined the thickness of mechanically exfoliated $MoS_2$ materials using powder X-ray diffractometer and Raman spectrometry. Based on the intensity and full width at half maximum (FWHM) of the main peaks with Miller index (002) in the X-ray diffraction pattern, the crystallite size and the number of layers of each of these exfoliated samples were determined using the Scherrer equation. Also, the $A_{1g}$ and $E_{2g}$ peaks were recorded in the Raman spectrum, and the intensity of these peaks decreases depending on the thickness of $MoS_2$ and these two peaks approach each other, which is consistent with the results described by the Scherrer equation. This method is fast and easy to perform, and furthermore, determining the thickness of 2D materials will be of help in basic research and future applications.

***Keywords:*** *2D material, Molibdenum Dichalcogenide, XRD, Scherrer equation, number of layer*

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# Structural properties of Al-doping of $Bi_5Ti_3FeO_{15}$ thin films

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**ABSTRACT**
Al-doped $Bi_5Ti_3FeO_{15}$ thin films were synthesized using the sol-gel method. The effects of Al doping on the crystalline structure were investigated by X-ray diffraction and Raman spectroscopy. The surface morphology and grain size of the $Bi_5Ti_3Fe_{1-x}Al_xO_{15}$ thin films were studied by AFM and SEM.

***Keywords:*** *Al doping, sol-gel method, Raman spectra, XRD, thin films*