MatFyz CONNECTIONS 2025

Wednesday, November 26, 2025 - Wednesday, November 26, 2025

Book of Abstracts

On Monday, October 9, 2023, 20:23 CEST, an earthquake with a local magnitude of 4.9 occurred in Eastern Slovakia with an epicenter near the village of Ďapalovce. The epicentral macroseismic intensity reached 8° EMS-98. It was the strongest earthquake on the territory of Slovakia in more than 100 years (since earthquake on the night of January 9-10, 1906 near the municipality Dobrá Voda, nowadays Trnava region). The macroseismic effects were reported from more than 540 municipalities and damage was verified to 80 sites.

Looking at the earthquake catalogue for the territory of Slovakia, the location of the epicenter and the magnitude of October 9, 2023 earthquake are not surprising in terms of the historical seismic activity of the Vranov nad Topľou and Humenné regions (a series of three earthquakes between 1778-1779 with a magnitude of around 5.0, earthquakes in 1885, 1890, 1893, 1914, 1932, 1941 with magnitudes between 4.5 and 5.0). The 2023 earthquake undoubtedly contributed to the increased interest in studying the historical and recent seismic activity of eastern Slovakia and raised the need to update the seismic hazard map of the territory of Slovakia.

ID:110# Reflection-enhanced gain in traveling-wave parametric amplifiers and plasma oscillation phase matching

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Traveling-Wave Parametric Amplifiers (TWPAs) are essential tools for ultra-sensitive measurements, particularly in quantum systems. Their performance, however, is often limited by challenges in impedance and phase matching. Conventional phase-matching techniques, such as periodic impedance modulation or the use of resonators and phase shifters, complicate circuit design and increase impedance mismatch. We show that reflections caused by such mismatches significantly alter both gain and phase-matching conditions in TWPAs 1. To capture this behavior, we extend standard coupled-mode theory, which typically assumes only forward-propagating waves, by including reflected waves. This leads to a corrected gain formula that more accurately reflects real device performance. To overcome these limitations, we propose a simpler and more integrated solution: leveraging tunable dispersion in a Josephson junction array waveguide [2]. The desired dispersion is engineered through a metamaterial structure, achieved by periodically adding a parallel capacitor to every n-th Josephson junction. This design enables efficient phase matching in the three-wave mixing regime. Our analytical framework is supported by numerical simulations that account for the complex nonlinear dynamics present in realistic devices

ID:118# Non-Thermal Plasma-Assisted VOC Decomposition: Influence of Catalyst Type, Electron Energy, and Gas Residence Time

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Volatile organic compounds (VOCs) such as toluene are major air pollutants, contributing to photochemical smog and posing severe environmental and health risks. Conventional abatement methods often require high operating temperatures or show poor efficiency for intermittent emissions. In this study, non-thermal plasma (NTP) assisted VOC decomposition was investigated using a dielectric barrier discharge (DBD) reactor integrated with different catalyst materials (TiO_2, Ag/TiO_2, $BaTiO_2$, and γ-Al_2O_3). The effects of discharge characteristics, gas residence time, and catalyst type on toluene degradation, energy efficiency, and by-product formation were systematically examined. Experiments were performed in an N_2/O_2 (50:50) atmosphere at applied voltages of 12 - 16.5 kV and flow rates of 0.5 - 2.0 L min^{-1}. Infrared spectroscopy analysis identified CO_2, CO, HCOOH, and O_3 as

major oxidation products, indicating partial mineralisation of toluene. Among the tested catalysts, $BaTiO_3$ exhibited superior degradation performance and energy efficiency at lower specific input energy (SIE), emphasising the role of high-dielectric materials in enhancing plasma–catalyst interactions. The Ag/TiO_2 catalyst demonstrated further improvement in mineralisation efficiency due to enhanced electron transfer and plasmonic activity of Ag nanoparticles, facilitating deeper oxidation of intermediate species. Additionally, the mean electron energy and reduced electric field (E/N) were calculated for different plasma-catalyst combinations, revealing that plasma-only conditions exhibited higher values compared to plasma-catalyst configurations, consistent with the voltage distribution and energy dissipation across the dielectric materials. These findings provide valuable insights into optimising plasma-catalyst systems for energy-efficient VOC abatement and highlight their potential for scalable, low-temperature air purification applications.

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ID:29#Towards the minimal effective theory for leptogenesis, dark matter, and neutrino masses

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We present a bottom-up approach to an effective theory that simultaneously explains the matter–antimatter asymmetry via leptogenesis, the dark matter relic abundance via freeze-in or freeze-out mechanisms, and neutrino masses via the Weinberg operator. We show that, in the minimal scenario, only two new particles and a single portal operator coupling the visible and dark sectors are sufficient beyond the Standard Model. This contribution is primarily based on arXiv:2504.15164.

ID:55#The study of nuclear structure in collaboration with ISOLDE

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The ISOLDE facility at CERN is one of the world's leading centers for the investigation of exotic nuclei and their structure. Thanks to large production yields and element-selective laser ionisation, ISOLDE provides access to a broad range of radioactive isotopes far from stability. Various experimental techniques, for example, laser or decay spectroscopy, are used to probe properties of these nuclei, including their shapes, the presence of isomeric states, or rare decay modes, such as the process of β-delayed fission. In this contribution, we present recent results obtained through a collaboration between a local research group specializing in nuclear structure studies and the ISOLDE facility.

ID:25#Robust edge states in stacked Al/Ni-based multilayers

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Topological phases emerge from the global properties of electronic band structures, stabilized by time-reversal or mirror symmetries. Their hallmark is the presence of gapless boundary states that are robust against perturbations and enable charge transport without backscattering. To realize a