Contribution ID: **7** Type: **not specified**

High-precision tests of the Pauli Exclusion Principle in proton-nucleus interactions using the SPES Cyclotron

Introduction & Scientific Motivation: The Pauli Exclusion Principle (PEP) is one of the fundamental tenets of quantum mechanics, dictating the behavior of identical fermions within a system. While extensively tested (by us) for electrons within the VIP (VIolation of the Pauli exclusion principle) experiment using high-precision X-ray spectroscopy [1], its validity for nucleons remains an open question, with potential implications for beyond Standard Model (BSM) physics. Recently we put forward the study of possible PEP violations at similar precision level in nuclear reactions [2], leveraging proton beams to introduce protons into nuclear systems under controlled conditions.
Building on these approaches, we propose an experimental study using the SPES Cyclotron at LNL-INFN to search for PEP-violating nuclear transitions. This experiment aims to refine existing limits and investigate whether non-Paulian nuclear states can be induced through controlled proton interactions, further probing quantum statistics and their foundational principles.

Experimental Setup & Feasibility: The proposed experiment plans to employ the high-intensity proton beam of the SPES Cyclotron. An optimized nuclear target, such as carbon-12, will be bombarded to induce potential non-Paulian (p, p') transitions, in analogy with pioneering studies conducted at LNL in '90s [3]. The experimental setup described in attached file.

By making use of the high-intensity proton beam of SPES, this experiment will significantly improve the sensitivity to possible PEP violations in nuclear reactions, far beyond previous limits.

Expected Outcomes & Impact: The results of this study will set new constraints on the possible violation of the Pauli Exclusion Principle for protons, providing a direct test of providing a direct test of quantum statistical laws in nuclei. If evidence of PEP violation is observed, it could signal new physics beyond the Standard Model, including scenarios related to quantum gravity, extra dimensions, and fundamental symmetry violations [4]. Additionally, the methodological advancements in high-precision nuclear spectroscopy could contribute to broader applications in nuclear physics and astrophysics.

References: [1] F. Napolitano et al., Testing the Pauli Exclusion Principle with the VIP-2 Experiment Symmetry 14 (2022) 5, 893 [2] C. Curceanu et al., PANTHEON: Towards High-Precision Tests of the Pauli Exclusion Principle in Nuclear Reaction as a Testbed of Theories Beyond the Standard Model, Acta Physica Polonica B Proceedings Supplement 17, 1-A6 (2024); [3] D. Miljanić et al., Experimental Search for Pauli Exclusion Principle Violation in Nuclear Reactions, Phys. Lett. B 252, 487 (1990). [4] K. Piscicchia et al., Strongest Atomic Physics Bounds on Noncommutative Quantum Gravity Models,Phys.Rev.Lett. 129 (2022) 13, 131301

Primary author: CURCEANU, Catalina Oana (Istituto Nazionale di Fisica Nucleare)

Session Classification: Fourth Session: Nuclear Physics