PhD position in experimental nuclear physics

Time reversal invariance test in nuclear beta decay: Analysis of the data of MORA at JYFL

Description:
Why are we living in a world made of matter?

The "**M**atter's **O**rigin from **R**adio**A**ctivity" (**MORA**) experiment [1] is looking for answers. Appearing in the beta decay spectra of mixed Fermi and Gamow Teller transitions, the so-called *D* correlation is sensitive to Time reversal violation, and via the CPT theorem, to CP violation. CP violation is one of the three famous Sakharov conditions needed for explaining the matter – antimatter imbalance observed in the Universe [2]. The measurement of the *D* correlation in the decay of trapped, and laser polarized $^{23}Mg^{+}$ and $^{39}Ca^{+}$ ions, as proposed in the frame of MORA, complements the search for Electric Dipole Moments to look for new interactions, which can explain the imbalance [3, 4].

The MORA experiment is using an innovative polarization technique, which combines the high efficiency of ion trapping with the one of laser orientation. It is currently taking data using $^{23}Mg^{+}$ beams delivered by the IGISOL facility, at the Accelerator Laboratory of the University of Jyväskylä. A problem of beam contamination by stable $^{23}Na^{+}$ has so far hampered the measurement. However, recent experimental progress shows that the laser-polarization proof-of-principle is finally within reach. It enables measurements of *D* to the ~10^{-4} level, which will be competitive with the best limit obtained so far on a non-zero *D* correlation in neutron decay [5]. To attain such precision regime, several weeks of data taking are required along the coming years (2025-2027) at Jyväskylä, both for $^{23}Mg^{+}$ and $^{39}Ca^{+}$ beams. As for every precision measurement aiming at looking for New Physics, the analysis of data has to be undertaken in parallel with data acquisition, in order to control data quality and to investigate systematics effects potentially affecting the sensitivity of the measurement. The data analysis includes crosschecks and adaptation of existing simulations of individual detectors of MORA, performed with GEANT4 and PENELOPE Monte Carlo codes, and pursing the investigation of systematic effects using these simulations. Dissemination of the experimental data at national and international conferences will be part of the objectives of the PhD thesis.

Expected skills:

- Skills in numerical methods and data analysis, statistics
- General interest in developments in fundamental subatomic physics
- Knowledgeable in experimental methods in nuclear or particle physics
- Good communication skills
- Programming (C++/python/others)

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Bibliography

[1] P. Delahaye, E. Liénard, I. Moore, M. Benali, M. L. Bissel, L. Canete, T. Eronen, A. Falkowski, X. Fléchard, M. Gonzalez-Alonso, W. Gins, R. P. D. Groote, A. Jokinen, A. Kankainen, M. Kowalska, N. Lecesne, R. Leroy, Y. Merrer, G. Neyens et al., «The MORA project,» *Hyp. Int.,* vol. 240, p. 63, 2019.

[2] A. D. Sakharov, «Violation of CP invariance, C asymmetry, and baryon asymetry of the universe,» *JETP Letters,* vol. 5, p. 24, 1967.

[3] A. Falkowski et A. Rodriguez-Sanchez, «On the sensitivity of the D parameter to new physics", (2022),» *Eur. Phys. J. C,* vol. 82, p. 1134, 2022.

[4] P. Herczeg et I. B. Khriplovich, «Time-reversal violation in beta decay in the standard model,» *Phys. Rev. D,* vol. 56, p. 80, 1997.

[5] H. P. Mumm, T. E. Chupp, R. L. Cooper, K. P. Coulter, S. J. Freedman, B. K. Fujikawa, A. Garcia, G. L. Jones, J. S. Nico, A. K. Thompson, C. A. Trull, J. F. Wilkerson et F. E. Wietfeldt, «New Limit on Time-Reversal Violation in Beta Decay,» *Phys. Rev. Lett.,* vol. 107, p. 102301, 2011.