Time-dependent description of proton-emitting radioactivity

Tomohiro Oishi*

*Yukawa Institute for Theoretical Physics, Kyoto University, Japan.

In this presentation, I will introduce a recent study [1], in which the time-dependent Dirac equation is applied to one-proton radioactive emission. Relativistic energy-density functional (REDF) theory has been developed and utilized for self-consistent mean-field calculations of atomic nuclei. The proton-emitting radioactivity can provide a suitable reference to improve the predicting ability of REDF especially on the proton-drip line. However, the relativistic quantum tunneling, which is necessary to explain the radioactive process, has been less investigated compared with the nonrelativistic case. I develop the time-dependent (TD) Dirac-spinor calculation to simulate the 1p emission [1]. By utilizing the relativistic Hartree-Bogoliubov (RHB) calculation, the single-proton potentials for the time-dependent Dirac spinor are determined. This method is applied to the 1p emissions from the Sc-37 and Sc-39 nuclei, which can be well approximated as the valence proton and the proton-close-shell cores. Remarkable sensitivity of 1p-emission energy and decaying width to the mass number is concluded. The calculated 1p energy and decaying lifetime are roughly consistent to the experimental limitation. The present TD-Dirac calculation is expected as applicable widely to proton-rich nuclides in order to improve the REDF by utilizing the 1p-emission data.

When available, I will also present the recent progress on time-dependent calculations of the two-proton radioactive emissions [2]. Since the simplest case of time-dependent multi-nucleon system appears, observable quantities of two-proton radioactivity can provide the knowledge on the nuclear pairing interaction, quantum entanglement, and/or limit of stable nuclides. Dynamics of proton pair with quantum entanglement, which is indeed sensitive to the pairing interaction [2], will be discussed.

References

[1] Tomohiro Oishi, Phys. Rev. C **107**, 034301 (2023).

[2] Tomohiro Oishi, Markus Kortelainen, and Alessandro Pastore, Phys. Rev. C **96**, 044327 (2017).