# Influence of the environment on electron capture decay: investigation of the microscopic nature of dark matter

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The search for sterile neutrinos is among the brightest possibilities in our quest for understanding the microscopic nature of dark matter. Sterile neutrinos, unlike the active neutrinos in the Standard Model (SM), do not couple to left-handed currents in the weak interaction and are best observed via their mass–generated effects that result from momentum conservation with SM particles. This can be done through high–precision measurements of electron capture (EC) nuclear decay where the final state only contains the neutrino and a recoiling atom. This approach is a powerful, model-independent method in the search for beyond SM scenarios since it relies only on the existence of a heavy neutrino admixture to the active neutrinos, which is a generic feature of neutrino mass mechanisms, and not on the model–dependent details of their interactions.

The BeEST (beast) experiment in which we are actively involved employs the decay–momentum reconstruction technique to precisely measure the $^{7}Be \rightarrow {}^{7}Li$ recoil energy spectrum in superconducting tunnel junctions (STJs) [1]. Very recently we succeeded for the first time in making direct measurements of the limits of the spatial extension of the wave function of a neutrino, one of the least understood fundamental particles of nature in physics [2,3].

It would appear that the process of EC is significantly dependent on the chemical nature of the material in which the radioactive atoms $^{7}Be$ are implanted. The aim of this PhD thesis is to study the influence of the supra conducting matrix (Ta, Al) on the electrons of the decaying atom. As these atomic electrons are themselves captured by the nucleus, their modification by the environment will modify the disintegration process. Within the framework of the BeEST collaboration this study will be carried out in close collaboration with quantum chemists and condensed matter physicists to describe the chemical and material environment and with nuclear physicists to describe the nuclear decay process [4].

[1] *The BeEST experiment: searching for beyond Standard Model neutrinos using $^{7}Be$ decay in STJs*, J. Low Temp. Phys. **209**, 796–803 (2022).
[2] *Direct Experimental Constraints on the Spatial Extent of a Neutrino Wavepacket, BeEst collaboration*, Nature **638**, 640–644 (2025).
[3] https://savoirs.unistra.fr/eclairage/une-nouvelle-avancee-dans-la-comprehension-des-neutrinos
[4] *Influence of atomic modeling on electron capture and shaking processes*, A. Andoche, L. Mouawad, P. -A. Hervieux, X. Mougeot, J. Machado, and J. P. Santos, Phys. Rev. A **109**, 032826 (2024).