

Polarised unstable nuclei: from nuclear physics to life sciences

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When the nuclear spins of an ensemble of unstable nuclei are polarised, their decay radiation – be it beta or gamma decay – shows an asymmetry in space. This unique feature can be used in a variety of research fields, starting from fundamental physics, passing through nuclear physics, going all the way to chemistry, biology, and medicine.

In this presentation I will cover the techniques and science of several research projects, in which we polarise and further use short- and long-lived unstable nuclei, most of which are produced at the ISOLDE facility. At the VITO-ISOLDE beamtime we use the asymmetry in beta decay of laser-polarised short-lived nuclei to perform beta-decay detected nuclear resonance (beta-NMR), with up to a billion times higher sensitivity compared to conventional NMR. We have used the approach to push the limit in accuracy of magnetic moments on short-lived isotopes by two orders of magnitude. We now aim to use it to determine the distribution of nuclear magnetisation, and through it the distribution of valence neutrons in selected short-lived nuclei, relevant. We also start performing studies of angular correlations between emitted beta particles, gamma-radiation, and neutrons, with the aim to determine spins and parities of excited states in neutron-rich nuclei.

In chemistry and biology, we use beta-NMR on short-lived Na and K isotopes to investigate ionic liquids which are interesting for energy storage and determine the feasibility of investigating DNA G-quadruplex structures. Finally, within the gamma-MRI project, with several European partners, we work towards a novel molecular imaging modality, which aims at employing gamma-emitting long-lived Xe isotopes for improved lung and brain imaging.