Observation of non-exponential decay of x-ray and γ lines from Co-57 on steel plates

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At ICCF20 we proposed an excitation transfer experiment [1] based on relativistic phonon-nuclear coupling [2]. The idea was to put a matched radioactive source on a metal plate, where the decay results in a nuclear excited state of an isotope present in the metal, and then stimulate with vibrations to transfer the nuclear excitation to other stable nuclei. Excitation transfer could result in spatial delocalization in the emission, in an angular anisotropy of the emission, or in other effects. An overview of the initial experimental effort was presented at ICCF20 [3].

We reported at the 2017 ISCMNS Asti workshop on a preliminary observation of non-exponential decay seen in the first excitation transfer experiment in May, where radioactive Co-57 (which decays to produce excited nuclear states in Fe-57) was evaporated on a steel plate [4]. Stimulation by MHz vibrations was not observed to produce a prompt response as had been hoped. Instead we saw a non-exponential decay of the Fe K_α and Fe-57 14.4 keV gamma peaks which resulted from mechanical stress associated with tightening clamps at the start of the experiment.

The current picture is that the stress results in dislocation movement in the steel, which primarily scatters but also generates high frequency phonons in the THz region, which theory suggests are much more effective in mediating excitation transfer. A dynamic delocalization of the source could result in a non-exponential decay effect, which is enhanced by transmission through a coarse aluminum mesh.

In this talk we describe non-exponential decay effects seen in some of the early experiments. In August we found that it was possible to induce the non-exponential decay effect using a thermal stimulation. Highlights of recent results and observations will be presented.

[1] P. L. Hagelstein and I. U. Chaudhary, "Coupling between the center of mass and relative degrees of freedom in a relativistic composite and applications," J. Condensed Matter Nuclear Science, vol. 24, pp. 114-122, 2017.
[2] P. L. Hagelstein, "Quantum composites: A review and new results for models for Condensed Matter Nuclear Science," J. Condensed Matter Nuclear Science, vol. 20, pp. 139-225, 2016.
[3] F. Metzler, P. L. Hagelstein and S. Lu, "Developing phonon-nuclear coupling experiments with vibrating plates and radiation detectors," J. Condensed Matter Nuclear Science, vol. 24, pp. 98-113, 2017.
[4] F. Metzler, P. L. Hagelstein and S. Lu, "Observation of non-exponential decay in x-ray and γ lines from Co-57," submitted to J. Condensed Matter Nuclear Science.