

# Neutron Resonance Spin Echo or how to get a high-energy resolution in a triple-axis spectrometer.

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Neutron scattering spectroscopy is an advanced method for studying the dynamics of condensed matter. In physics, the study of dispersive excitations such as phonons and magnons is an important experimental data in many materials (HTc superconductors, thermoelectric, magnetic systems). These dispersive excitations are traditionally studied by inelastic neutron scattering on three-axis spectrometer (TAS), as well their lifetime which is given by the inverse of the width of the measured excitation. Accessible widths are typically of the order of 0.5 to 1 meV, which corresponds to lifetimes of a few picoseconds, i.e relatively short lifetimes. In order to measure much longer lifetimes, a new method, combining the neutron resonance spin-echo technique (NRSE) and TAS, has been developed over the past fifteen years. This method of spin-echo focusing, proposed by F. Mezei[1], makes possible to measure the widths of the dispersive excitations in the solids throughout the Brillouin zone with a resolution of a few  $\mu\text{eV}$ , thus improving the typical TAS resolution of about 2 orders a magnitude. On IN22, it has made possible to improve the energy resolution from 1.1meV to  $1\mu\text{eV}$  for non-dispersive excitations and to  $10\mu\text{eV}$  for dispersive excitations, thus allowing access to lifetimes on the order of one hundred pico-second, much more interesting for the physics of condensed matter. During the presentation, we will show what it has been possible to measure by this technique that can not be achieved by other techniques. In particular, the measurement of acoustic phonon lifetimes in an intermetallic clathrate  $\text{Ba}_{7.81}\text{Ge}_{40.67}\text{Au}_{5.33}$ , finding large values of phonon lifetime which spectacularly falsify the theoretical expectation[3].

- [1] F. Mezei ed. Neutron Spin Echo, Lecture Notes in Physics, Volume **128**, Berlin Heidelberg New York, Springer Verlag, (1980)
- [2] Direct measurement of individual phonon lifetimes in the clathrate compound  $\text{Ba}_{7.81}\text{Ge}_{40.67}\text{Au}_{5.33}$ , P.-F. Lory et al., Nat. Commun. **8**, 491 (2017)

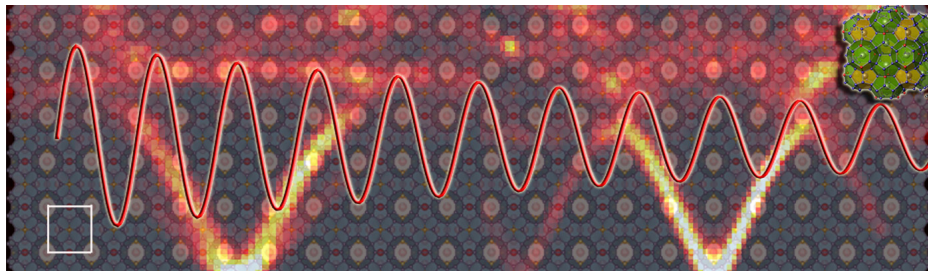


Figure 1: Illustration of the phonon lifetime in a Clathrate. The red-white colour illustrates the measured phonon dispersion relationship, whereas the red sinusoid illustrates an acoustic phonon decaying with time for a mean free path of 25 nm