Phonon lifetime and lattice thermal conductivity of the i-AlPdMn icosahedral quasicrystal

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The lattice thermal conductivity of the icosahedral i-AlPdMn phase is very similar to the one of glasses with an umklapp peak that is replaced by a broad plateau in the temperature range 20 to 300 K and a value of the thermal conductivity of the order 1-2 $wK^{-1}m^{-1}$ in this temperature range [1]. This is also very similar to what is found in structurally complex materials such as Ge based clathrates for instance [2].

Several explanations have been given for this behaviour. The first one is a generalised umklapp process, related to the existence of several pseudo-Brillouin zone boundaries in a quasicrystal acting as Bragg plane reflexion [3]. On the other hand, in the context of structurally complex materials, a simple model was designed, pointing out to the restricted energy range for which acoustic modes do exist [4], following an idea of Slack [5]. Since in quasicrystal the acoustic regime is also restricted [6; 7], this model could be extended to quasicrystals. However, testing those predictions requires the measurement of phonon dispersion together with phonon lifetime, a challenging task from the experimental point of view.

Recently using the neutron resonant spin-echo technic, we have found surprisingly large phonon lifetime and phonon mean free path in the Ge-Ba-Au clathrate, contradicting the 'phonon glass' picture usually associated to such materials [2]. Indeed close to the Brillouin zone boundary and for transverse acoustic phonon energies about 4 meV, mean free path equal to 20 nm have been measured, much larger than the interatomic distance expected in the phonon glass picture. This result can in fact be understood in the framework of a simple lattice gas model, once the heat carrier phonon are restricted to the three acoustic modes, with an energy cut-off.

We will present the results obtained on a large single grain of the i-AlPdMn phase with the NRSE technic. The temperature and energy dependence of transverse acoustic phonon lifetime have been measured from 100K to 600K. Results point to a phonon scattering process that is different from a simple umklapp one. This will be compared to the experimental lattice thermal conductivity using a simple lattice gas model.

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