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Electron-phonon coupling in $\text{Mn}_{1-x}\text{Fe}_x\text{Si}$

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The interplay of ferromagnetic exchange, Dzyaloshinsky-Moriya interaction and crystal potential results in the complex phase diagram of the chiral magnet MnSi ($T_C \approx 30$ K). In $\text{Mn}_{1-x}\text{Fe}_x\text{Si}$, long-range magnetic order is suppressed and helimagnetic correlations vanish at $x \approx 0.2$ along with a redistribution of d states at the Fermi energy.

Here, we present a study of the lattice dynamical properties of $\text{Mn}_{1-x}\text{Fe}_x\text{Si}$ with $0 \leq x \leq 0.22$. Employing time-of-flight neutron spectroscopy and high energy resolution inelastic x-ray scattering, we investigate the doping dependence of phonon energies, E_{phon} , and line widths, Γ_{phon} ($\Gamma_{phon} \propto 1/\text{life time}$). In contrast to the general trend of slightly increasing energies with doping because of the reduced lattice constant, we find a significant softening and broadening of a phonon mode propagating along the [111] direction, which is also the direction of the magnetic ordering wave vector in MnSi. Ab-initio lattice dynamical calculations based on density-function theory predict an increasingly strong electron-phonon coupling for this particular mode linked to changes of the Fermi surface geometry upon doping.

Primary author: WEBER, Frank (Karlsruhe Institute of Technology)

Co-authors: BAUER, Andreas (Technische Universität München); Dr SAID, Ayman (Argonne National Laboratory); PFLEIDERER, Christian; Dr VONESHEN, David (Rutherford Appleton Laboratory); KHAN, Nazir (Karlsruhe Institute of Technology (KIT)); DE LA PENA-SEAMAN, Omar (Benemerita Universidad Autonoma de Puebla); HEID, Rolf (Karlsruhe Institute of Technology)

Presenter: WEBER, Frank (Karlsruhe Institute of Technology)

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