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Electron-phonon coupling in $Mn_{1-x}Fe_xSi$

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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 $Mn_{1-x}Fe_xSi$, 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 $Mn_{1-x}Fe_xSi$ 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} ($\Gamma_{phon} \propto 1$/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.

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