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Phonons and magnetism in FeSi

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The interactions of spin, lattice and electronic degrees of freedom in materials are at the origin of complex phase diagrams resulting in new emergent phenomena and technical applications. The coupling between lattice and electronic degrees of freedom is well understood, and the interaction between spin and electronic excitations has been investigated intensely, e.g., in the research on high-temperature superconductivity. However, only little is known about the dynamic interactions between spin and lattice excitations, apart from the well-established magneto-elastic coupling. Noncentrosymmetric FeSi is known to undergo a transition from insulating to metallic behavior with increasing temperature, and exhibits strongly temperature dependent phonon energies. Here we show by detailed inelastic neutron scattering measurements that the phonon renormalization in FeSi is in fact linked to its unconventional magnetic properties. In combination with ab-initio calculations, we demonstrate that two different mechanisms cause the unusual behavior: Electronic states mediating conventional electron-phonon coupling are only activated in the presence of strong magnetic fluctuations. Secondly, phonons are damped via a dynamic coupling to the temperature-induced magnetic moment with the highest impact on phonons having strongly varying Fe-Fe distances. Our findings highlight FeSi as one of the rare materials with direct spin-phonon coupling and a prime example for multiple interaction paths.

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