Antiferromagnetism, structural instability, frustration, and quantum critical point in intermetallic AFe_4X_2 systems

N. Mufti[a], T. Dellmann[b], H.-H. Klauβ[b], T. Woike[c], T.T.M. Palstra[d], H. Rosner[a], and C. Geibel[a]

[a]MPI for Chemical Physics of Solids, Dresden, Germany
[b]Institute of Solid state Physics, Dresden University of Technology, Dresden, Germany
[c]Institute for Structural Physics, Dresden University of Technology, Dresden, Germany
[d]Zernike Institute for Advanced Materials, University of Groningen, Groningen, The Netherlands

Magnetic systems with reduced dimensionality or frustration are attracting strong interest because these features lead to an increase of quantum fluctuations which can induce very unusual properties. The quantum fluctuations can drive such systems from a magnetically ordered to a non-magnetic ground state across a Quantum Critical Point (QCP), a hot topic in condensed matter physics nowadays. Here we present a detailed study of the magnetic, thermodynamic, and structural properties of intermetallic AFe_4X_2 compounds (A = Sc, Y, Lu, Zr; X = Si, Ge) crystallizing in the $ZrFe_4Si_2$ structure type, in which Fe atoms form chains of edge-linked tetrahedra along the tetragonal c axis, a configuration which is prone for frustration and low dimensional fluctuations. Our results indeed evidence this family of compounds to cover the whole regime from frustrated antiferromagnetic (AFM) order with associated structural transition, up to an AFM quantum critical point. T_N as well as the relation between structural and magnetic transitions strongly depend on X element and trivalent A element, while tetravalent Zr results in a strong suppression of the AFM order, putting $ZrFe_4Si_2$ close to a QCP.