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Universal Properties of the C_4 Magnetic Phase in Hole Doped Ternary Superconducting Pnictides[1]

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AFe$_2$As$_2$ (A=Alkali Earth) superconductors exhibit phase diagrams that are remarkably similar when substitutions are made at any of the available crystallographic sites. In recent work, we demonstrated that some hole-doped compositions with low temperature orthorhombic structures exhibit universal phase reentrance back to the tetragonal symmetry with the formation of a previously unknown magnetic C_4 phase facilitated by the recovery of magnetic degeneracy coupled with spin reorientation from the in-plane to the out-of-plane c-axis direction. Using neutron diffraction and Mossbauer spectroscopy, we unraveled the nature of this new phase as being a rare double-Q magnetic structure in which two orthogonal spin density waves combine to produce the tetragonal magnetic symmetry with a checkerboard –like Fe sublattice in which half the sites are magnetic (magnetic moment nearly doubled) while the other half are not. Our results give strong evidence for the electronic itineracy of the system and provide a definite proof that the structural and magnetic transitions are driven by magnetic fluctuations rather than other mechanisms. The exact location and shape of the C_4 phase space have somewhat remained until recently a mystery as the phase shifted together with the superconducting dome to different doping levels in various phase diagrams but with no any clear trends. Noting the complete absence of this phase in any known electron or isovalent-substituted analog, it has become clear that detailed mapping of the phase properties requires hole-doped systems that go beyond the customary binary diagrams. In this talk, I will present and discuss the properties of a two dimensional map in a broad range of compositions that extend between binary end-members of elaborate ternary phase diagrams. This work establishes the universality of the C_4 phase, its robustness and provides a quantitative relationship between the magnetic properties and the A-site ionic size and internal structural parameters.

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