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Systematic evolution of magnetism with doping in AFe_2As_2 superconductors[1]

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The AFe_2As_2 (A=Ba,Sr,Ca) based superconductors (SC) are antiferromagnetic (AFM) metals with a layered crystal structure. Electron or hole doping suppresses the AFM transition and leads to the appearance of a SC phase in the presence of AFM spin fluctuations. We have studied the evolution of static magnetic order and spin excitations as a function of doping in $Ba(Fe_{1-x}Co_x)_2As_2$ using neutron and x-ray scattering. The spin wave spectra in the AFM parent compounds (A=Ca) reveal large magnetic exchange within the Fe layers and weaker interlayer exchange. Spin fluctuations in the optimally doped SC compositions (x > 7%), with no long-range AFM order, are more two-dimensional (2D) in character and highlighted by a 2D magnetic resonance feature that develops below T_C. Within a narrow compositional range (3 < x < 6%) at the onset of SC, AFM and SC can actually coexist and compete with each other. This competition is revealed by a strong suppression of the AFM order parameter below T_C. The spin excitations in the underdoped compositions are notably more 3D than optimally doped compositions, including a magnetic resonance that has strong c-axis dispersion. Overall, the results suggest that the approach to SC in $Ba(Fe_{1-x}Co_x)_2As_2$ coincides with competing weak magnetic order and a crossover in the dimensionality of the system.

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