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Quantum melting of the hole crystal in the spin ladder of $Sr_{14-x}Ca_xCu_{24}O_{41}$[1]

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The "spin ladder" is a reduced-dimensional analogue of the t-J model that has been shown theortically to exhibit close competition between d-wave superconductivity and a "hole crystal" (HC) phase in which the carriers form a static lattice. An example of a real doped spin ladder is the cuprate $Sr_{14-x}Ca_xCu_{24}O_{41}$, which exhibits superconductivity at $x = 13.6$ (under pressure) and a commensurate HC at $x = 0$. In this talk I will present a resonant soft x-ray scattering (RSXS) study of the effects of discommensuration on this HC, i.e. how it evolves with the hole density. As x is varied the HC forms only with the commensurate wave vectors $L = 1/5$ and $L = 1/3$; for incommensurate values it "melts." A simple scaling between L and temperature is observed, $\tau_{1/3}/\tau_{1/5} = 5/3$, indicating an inverse relationship between the interaction strength and the HC period. Our results suggest that the HC consists of hole pairs crystallized through an interplay between lattice commensuration and a poorly screened Coulomb interaction. I will discuss the relationship between the HC and the static "stripe" phase that has been observed in the closely related system $La_{2-x}Ba_xCuO_4$.

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