Distinct Nature of Static and Dynamic Magnetic Stripes in Cuprate Superconductors

We present detailed neutron scattering studies of the static and dynamic stripes in an optimally doped high-Temperature superconductor, La$_2$CuO$_{4+y}$. We observe that the dynamic stripes do not disperse towards the static stripes in the limit of vanishing energy transfer. Therefore, the dynamic stripes observed in neutron scattering experiments are not the Goldstone modes associated with the broken symmetry of the simultaneously observed static stripes, and the signals originate from different domains in the sample. These observations support real-space electronic phase separation in the crystal, where the static stripes in one phase are pinned versions of the dynamic stripes in the other, having slightly different periods. Our results explain earlier observations of unusual dispersions in underdoped La$_{2-x}$Sr$_x$CuO$_4$ ($x=0.07$) and La$_{2-x}$Ba$_x$CuO$_4$ ($x=0.095$).