Evolution of the CO-OO and AF ordering in the single-layer manganite $\text{Pr}_{1-x}\text{Ca}_{1+x}\text{MnO}_4$ near half doping

FENG YE, J. A. FERNANDEZ-BACA, Oak Ridge National Lab., SONGXUE CHI, PENGCHENG DAI, Univ. of Tennessee, Knoxville, J. W. LYNN, NIST Center for Neutron Research, R. MATHIEU, Y. KANEKO, ERATO-SSS, Y. TOKURA, Univ. of Tokyo — Manganese oxides have attracted considerable attention due to the CMR effect observed in the perovskite manganite $\text{A}_{1-x}\text{A'}_x\text{MnO}_3$ near $x = 0.3$. A peculiar charge/orbital (CO-OO) accompanied by antiferromagnetic (AF) order occurs when the carrier concentration is close to half doping ($x=0.5$). To understand the interplay between the charge, lattice and spin degrees of freedom in such insulating state, we used elastic neutron scattering to study the evolution of the CO-OO as well as the AF correlations in the single-layer manganite $\text{Pr}_{1-x}\text{Ca}_{1+x}\text{MnO}_4$ ($x = 0.40, 0.45$ and $0.50$). Upon cooling, all three samples exhibit long-range CO-OO near $300$ K. However, only the $x = 0.50$ system displays long-range AF order at low temperatures. The CE-type AF correlations are quickly suppressed and become short-ranged as more $e_g$ electrons are introduced to the MnO$_2$ plane. More interestingly, the CO-OO and AF order associated with Mn$^{3+}$ ions appears at incommensurate positions while the AF order associated with Mn$^{4+}$ ions remains commensurate. Our observations indicate that the orbital physics play an important role in the understanding of the electronic and magnetic properties of doped manganites.