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Phase Competition and Magnetotransport Phenomena in Manganite Films and Mesoscopic Structures

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The importance of competition between ferromagnetic metallic (FMM) and charge-ordered insulating (COI) phases in the physics of bulk manganites has been established through a wide variety of techniques. One exotic consequence of this phase competition is step-like features in magnetotransport observed in bulk and single-crystals of $Pr_{0.65}(Ca_ySr_{1-y})_{0.35}MnO_3$ (PCSMO) with $0.7 \leq y \leq 0.8$. The length-scale of the phase coexistence is $\sim$1 micron, motivating a study of structures with dimensions similar to this natural length scale where phenomenology distinct from that of bulk counterparts is expected. Toward that end, we have synthesized films and laterally confined mesoscopic bridges of PCSMO and studied their magnetotransport properties. In particular, we observed: (1) *Intrinsic* ultrasharp magnetization steps below 5 K in both bulk and film samples and their dependence on the *extrinsic* measurement protocols; (2) Spontaneous jumps of resistance during both the ramping of magnetic field and the relaxation after the field cycle; (3) I-V curves exhibiting negative differential resistance (NDR) in certain ranges of temperature and magnetic field. All of these phenomena can be explained in the context of interconversion between the COI phase and the FMM phase. As expected, this interconversion can be triggered by external magnetic field, as found in the case of the magnetization and resistance steps. Alternatively, in the mesoscopic structures with dimensions similar to the size of the competing FMM and COI domains, a local Joule heating-induced annihilation of conducting filaments causes the anomalous NDR.