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Nanoscale devices can exhibit memory effects that must be accounted for in applications. In the last decade, there has been a lot of interest in resistors with a memory, also called memristors. While the origin of the effect can be both classical and quantum, the signature of the resistive memory is a pinched hysteresis in the I-V diagram. After a description of the phenomenology of memristive devices, this talk discusses the intricate effects arising from dense circuits made of memristors. In this talk we provide some background on the physical properties of the memristors (various physical origins and some recent attempts to describe quantum filamentary switching), to then focus on emergent and classical properties of circuits of memristors. Specifically, we will discuss an exact equation for the evolution of the memory of a generic circuit and the collective phenomena that arise. We will conclude by discussing what we call rumbling transition, a chaotic switching phenomenon occurring in voltage-controlled coctios, and that has been possibly measured recently in neuromorphic nanowire circuit experiments. We interpret the switching as a symmetry breaking phenomenon.

**Short Bio**

Francesco is interested in equilibrium and non-equilibrium statistical mechanics. He began his research career studying Quantum Gravity as a PhD student at UWaterloo/Perimeter Institute but moved to Complex Systems during his postdocs at University of Oxford and University College London. He has been interested in the properties of dynamical graphs and in statistical mechanics since his PhD, a topic that he continues to investigate since joining Los Alamos National Laboratory in 2017.

Recently, his attention is focused on the properties of memristors and their collective behavior, and in particular on neuromorphic circuits. Memristors are 2-port passive devices which have characteristics similar to a resistance but exhibit a very nonlinear dynamical behavior. Neuromorphic circuits are, in general, interesting for many reasons. These provide in fact a valid alternative to the von Neumann architecture at the classical level (analog computation), in particular in view of the need of building low-power circuits. Dr Caravelli studies the relaxation properties of the circuits under various conditions (AC or DC controlled) and exact solutions and the use of statistical mechanics to understand their asymptotic behavior. In collaboration with Massimiliano Di Ventra and Fabio L. Traversa he derived an exact equation for the internal memory dynamics of purely memristive circuits, which he uses to derive formal results and connection to both ordered and disordered Statistical Physics.