**Probabilistic Computing With p-Bits: Optimization, Machine Learning and Quantum Simulation**

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The slowing down of Moore's Law growth has coincided with escalating computational demands from machine learning and artificial intelligence. An emerging trend in computing involves building physics-inspired computers that leverage the intrinsic properties of physical systems for specific domains of applications. Probabilistic computing with probabilistic bits (p-bits) has emerged as a promising candidate in this area, offering an energy-efficient approach to probabilistic algorithms and applications [1]-[4].

Several implementations of p-bits, ranging from standard complementary metal oxide semiconductor (CMOS) technology to nanodevices, have been demonstrated. Among these, the most promising p-bits appear to be based on stochastic magnetic tunnel junctions (sMTJs) [2]. Such sMTJs harness the natural randomness in low-barrier nanomagnets to create energy-efficient and fast fluctuations, up to gigahertz frequencies [4]. In this talk, I will discuss how magnetic p-bits can be combined with conventional CMOS to create hybrid probabilistic-classical computers for various applications. I will provide recent examples of how p-bits are naturally applicable to combinatorial optimization, such as solving the Boolean satisfiability problem [3], energy-based generative machine learning models like deep Boltzmann machines, and quantum simulation for investigating many-body quantum systems. Through experimentally informed projections for scaled p-bit computers using sMTJs, I will demonstrate how physics-inspired probabilistic computing can lead to graphics-processing-unit-like success stories for a sustainable future in computing.

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**Bio**

Kerem Çamsarı received the Ph.D. in Electrical and Computer Engineering from Purdue University in 2015, where he continued as a postdoctoral researcher before becoming Assistant Professor at the Department of Electrical and Computer Engineering at the University of California Santa Barbara in 2020. His doctoral work established a modular approach to connect a growing set of emerging materials and phenomena to circuits and systems, a framework adopted by others. In later work, he used this approach to establish the concept of p-bits and p-circuits as a bridge between classical and quantum circuits to design efficient, domain-specific hardware accelerators for the "beyond-Moore" era of electronics. He is a founding member of the Technical Committee on Quantum, Neuromorphic, and Unconventional Computing within the IEEE Nanotechnology Council where he currently leads the Unconventional Computing section. For his work on probabilistic computing, he has received the IEEE Magnetics Society Early Career Award, a Bell Labs Prize, an Office of Naval Research Young Investigator Award, and a National Science Foundation CAREER award. He is a senior member of the IEEE.