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I am a theoretical and computational physicist, specializing in the theory of quantum information, which uses the principles of quantum physics to store, manipulate and process data for advanced computing.

At the core of this work is a physical quantity called entanglement that is a known resource for quantum computing. In particular, my research group studies the intricate relationship among interactions, measurement fluctuations, and the amount of entanglement that can be extracted from low-dimensional systems like quantum dots and wires. The precise design and engineering of future quantum computers requires a complete understanding of this delicate interplay.

The representation of some of these low-dimensional quantum structures can sometimes take the form of a network of mathematical objects called tensors. Such networks, it turns out, share a great deal of similarity with the computing architectures used in modern artificial intelligence.

Some members of my group are exploring the possibility of applying the mathematical techniques developed for studying physical systems for carrying out calculations needed in machine learning tasks.

I also use a quantum-based technique called density functional theory to simulate the behavior of molecules and surfaces at the atomic level. Modern materials science workflows have integrated quantum theory-based modeling in the search for and design of new materials and processes. Some students in my group have been investigating the molecular basis of the interactions between small molecules like carbon dioxide and hydrogen sulfide and potential adsorbing materials.

The requirements of many of the needed computational tasks in these studies can exceed the capabilities of conventional CPUs. In addition to using theoretical optimizations to make these calculations manageable, some of my researchers are tasked to write parallel computing algorithms that take advantage of the GPUs in video cards to accelerate their work. The skills developed by these programmers are becoming increasingly valuable, especially as the next generation of tensor processing units (TPUs) become easier to access.

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