The birth of quantum mechanics last century led to the first quantum revolution and technology such as the transistor and the laser. Our current era marks a second quantum revolution where the fundamental strangeness of quantum mechanics, exemplified by phenomena such as entanglement and superposition, is being exploited towards breakthrough advances in computing, communication and sensing. In this talk, I will focus on the latter and give a brief introduction to the world of quantum metrology and how its basic principles can be understood through quantum noise, i.e., the apparent fuzziness of the microscopic realm that is encapsulated by the uncertainty principle. I will discuss some of the outstanding challenges facing the development of state-of-the-art quantum-enhanced sensors, such as the fragility and complexity of dealing with entangled quantum states. I will introduce some potential solutions in the context of a pair of exemplary quantum-enhanced sensing platforms based on atomic and optical components: Trapped-ion crystals and cavity-QED. The former have been demonstrated as unparalleled sensors of weak forces (as small as yocto-newtons) and electric fields (as weak as nanovolts/meter), while the latter has been proposed as the basis for the construction of next-generation entangled atomic clocks for state-of-the-art timekeeping.

“Quiet quantum sensing: Taming quantum noise in spin-boson systems”

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