Contribution ID: **84** Type: **Talk**

Quantum logic and precision measurements with atoms and molecules

Thursday 6 July 2023 16:05 (35 minutes)

The extreme precision and accuracy of state-of-the-art optical atomic clocks can be used to look for very small deviations from the predictions of the Standard Model, offering a tool to search for beyond Standard Model (BSM) physics complementary to particle accelerators. These searches are based on measuring the frequency ratio of two transitions that depend differently on interactions with BSM particles or fields. In this talk, I will present frequency ratio measurements between atomic clocks based on Al+, Hg+, Sr, and Yb atoms at NIST and JILA in Boulder, Colorado, and the use of these measurements to constrain the coupling of ultralight scalar dark matter candidates to the Standard Model particles and fields. Next, I will describe how the quantum-logic spectroscopy techniques first developed for Al+ clocks have enabled quantum control and precision measurements of molecular ions, with a variety of applications. Finally, I will conclude with a brief discussion of new experiments being set up at UCLA in Los Angeles, California based on different atomic, molecular, and nuclear transitions with much higher sensitivity to BSM physics in a variety of sectors.

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Session Classification: Ions