## IEEE UFFC Distinguished Lecturer

**Title:** Precision Metrology with Photons, Phonons and Spins: Answering Major Unsolved Problems in Physics and Advancing Translational Science

**Bio:** Professor Tobar leads the Quantum Technologies and Dark Matter Research Laboratory at the University of Western Australia (qdmlab.com). The lab is part of two nation-wide Australian Research Council Centres of Excellence, the Centre for Engineered Quantum Systems and the Centre for Dark Matter Particle Physics. His broad research interests encompass the disciplines of frequency metrology, precision and quantum measurements, low temperature, condensed matter and quantum physics. Over his career he has developed a variety of measurement tools, allowing investigations in many areas of Physics and Engineering, leading to many prestigious awards. In particular, he has developed technologies to undertake precise tests of fundamental physics and has also adapted such technology to the commercial sector, which includes 12 patents on precision radar and detectors and over 300 refereed journal publications. He also leads the well-known ORGAN axion Dark Matter detector collaboration co-funded by both Centres, and in 2019 his group become an official collaborator of the famous Axion Dark Matter eXperiment situated at the University of Washington, Seattle.

**Abstract:** The Quantum Technologies and Dark Matter research laboratory has a rich history of developing precision tools for both fundamental physics and industrial applications. This includes the development and application of novel low-loss and highly sensitive resonant photonic and phononic cavities, such as whispering gallery and re-entrant cavities, as well as photonic band gap and bulk acoustic wave structures. These cavities have been used in a range of applications, including highly stable low noise classical and atomic oscillators, low noise measurement systems, highly sensitivity displacement sensors, high precision electron spin resonance and spin-wave spectroscopy, high precision measurement of material properties and applications of low-loss quantum hybrid systems, which are strongly coupled to form polaritons or quasi-particles. Translational applications of our technology has included the realization of the lowest noise oscillators and systems for advance radar, the enabling of high accuracy atomic clocks and ultra-sensitive transducers for precision gravity measurements.

Meanwhile, there is currently a world-wide renascence to adapt precision and quantum measurement techniques to major unsolved problems in physics. This includes the effort to discover “Beyond Standard Model” physics, including the nature of Dark Matter, Dark Energy and the unification of Quantum Mechanics with General Relativity to discover the unified theory of everything. Thus, the aforementioned technology has been adapted to realize precision measurement tools and techniques to test some of these core aspects of fundamental physics, such as searches for Lorentz invariance violations in the photon, phonon and gravity sectors, possible variations in fundamental constants, searches for wave-like dark matter and test of quantum gravity. This work includes: 1) Our study and application of putative modified physical equations due to beyond standard model physics, to determine possible new experiments: 2) An overview of our current experimental program, including status and future directions. This includes experiments that take advantage of axion-photon coupling and axion-spin coupling to search for axion dark matter. High acoustic Q phonon systems to search for Lorentz violations, high frequency gravity waves, scalar dark matter and tests of quantum gravity from the possible modification of the Heisenberg uncertainty principle.