Contribution ID: **86** Type: **5 min talk**

Precision Multi-Mode Microwave Characterisation of Single Crystal Calcium Tungstate for Dark Matter Searches

Tuesday, 17 September 2024 16:35 (5 minutes)

Scheelite, or calcium tungstate (CaWO4), is a scintillating dielectric material of significant interest for its potential application in a myriad of contexts. It plays a key role in detection of rare events such as neutrinoless double β-decay, radioactive decay of very long-living isotopes and searches for weakly interacting massive particles (WIMPs), a candidate for dark matter (DM). In addition to existing applications, we propose to use a large single crystal of CaWO4 configured as a microwave cavity bolometer for highly sensitive readout. This may be suitable for WIMP DM detection and offers scope for qubit-based sensing methods.

In this work, we investigate whether such detection schemes can be realised in a single crystal architecture at low temperatures, and what effects the residual impurity spin ensemble defects display. To that end, we report the findings of precision multi-mode microwave electron spin resonance (ESR) spectroscopy, as developed in, to identify the paramagnetic residual impurities present in a high-purity CaWO4 sample, as well as the crystal' s temperature dependent dielectric properties.

Dilute ion spin ensemble defects in the low-loss single crystal sample of CaWO4 were experimentally observed at 30 mK. A cylindrical resonator hosts whispering gallery modes with high Q-factors of up to 3 × 107 , equivalent to a loss tangent of ~ 3 × 10−8. Measurements of numerous high Q-factor photon-spin interactions between 7 to 22 GHz revealed the presence of Gd3+ , Fe3+, and another trace species, inferred to be rare-earth, at concentrations on the order of parts per billion.

The phonon coupling to microwave resonances was also explored in the pursuit of the development of a novel sensing approach, by parameterising the change in permittivity of the crystal with temperature. This innovative method of bolometry may be achieved by utilising the temperature dependence (O(300) MHz/K) of high-Q resonances. These findings motivate further exploration of prospective uses of this low-loss dielectric material for applications in precision and quantum metrology, as well as searches for dark matter.

Primary author: Dr HARTMAN, Elrina (Department of Physics, UWA)

Presenter: Dr HARTMAN, Elrina (Department of Physics, UWA)

Session Classification: Afternoon 2