Contribution ID: **48** Type: **Oral**

Axion Haloscope Experiments at the University of Western Australia

Monday 3 June 2019 16:50 (20 minutes)

At UWA we have funded axion detection programs for several mass ranges. The research program includes:

1) The Oscillating Resonant Group AxioN (ORGAN) experiment [1], to search the mass range 0.06 to 0.21 mev using a 14 Tesla magnet, dilution fridge, novel microwave cavity designs [2] and readout systems based on cross correlation to combine more than one cavity [3].

2) Ferromagnetic Axion Haloscope with Strongly Coupled Cavity-Magnon Polaritons to broaden the bandwidth of such experiments [4].

3) New experiments which interfere two highly stabilized photon modes and search for frequency or phase perturbations in these modes caused by galactic halo axions [5].

4) New low mass broad band and resonant schemes based on lumped LC elements for very low-mass ALPS [6,7], which promise enhanced sensitivity below a micro-eV.

After a general overview of the work at UWA, an update of the ORGAN experiment will be given. The magnet and dilution fridge will be delivered this year along with a laboratory upgrade, with the experiment expected to begin in 2020.

Following this a detailed look at our low-mass Haloscope experiments using lumped LC components will be presented. In particular a reformulation of axion modified electrodynamics is presented, which is shown to be of similar form to odd-parity Lorentz invariance violating background fields in the photon sector of the Standard Model Extension. When a DC B-field is applied an oscillating background polarization is induced at a frequency equivalent to the axion mass. In contrast, when a large DC E-field is applied, an oscillating background magnetization is induced at a frequency equivalent to the axion mass. We then go on to show that these terms are equivalent to impressed source terms, analogous to the way that voltage and current sources are impressed into Maxwell's equations in circuit and antenna theory [8]. The impressed source terms represent the conversion of external energy into electromagnetic energy due to the inverse Primakoff effect converting energy from axions under a DC magnetic field into photons. It is shown that the impressed electrical DC current that drives the solenoidal magnetic DC field of an electromagnet, induces an impressed effective magnetic current (or voltage source) parallel to the DC electrical current, oscillating at the Compton frequency of the axion. The effective magnetic current drives a voltage source through an electric vector potential and also defines the boundary condition of the oscillating axion induced polarization (or impressed axion induced electric field) inside and outside the electromagnet. This impressed electric field, like in any voltage source, represents an extra force per unit charge supplied to the system, which also adds to the Lorentz force and allows low-mass experiments based on lumped elements to achieve a greater sensitivity than what is currently thought to be.

[1] BT McAllister, G Flower, EN Ivanov, M Goryachev, J Bourhill, ME Tobar, The ORGAN experiment: An axion haloscope above 15 GHz, Physics of the Dark Universe, vol. 18, pp. 67–72, 2017.

[2] BT McAllister, G Flower, LE Tobar, ME Tobar, Tunable Super-Mode Dielectric Resonators for Axion Haloscopes, Phys. Rev. Applied, vol. 9, 014028, 2018.

[3] BT McAllister, S Parker, EN Ivanov, ME Tobar, Cross-correlation Signal Processing for Axion and WISP Dark Matter Searches, IEEE Trans. on UFFC, vol. 66, no. 1, 2019.

[4] Broadening Frequency Range of a Ferromagnetic Axion Haloscope with Strongly Coupled Cavity-Magnon Polaritons. (To be presented by G. Flower at PATRAS 2019)

[5] M Goryachev, BT McAllister, ME Tobar, arXiv:1806.07141 [physics.ins-det] (To be presented by M. Goryachev at PATRAS 2019)

[6] ME Tobar, BT McAllister, M Goryachev, arXiv:1809.01654 [hep-ph]

[7] ME Tobar, BT McAllister, M Goryachev, arXiv:1803.07755 [physics.ins-det]

[8] ME Tobar, BT McAllister, M Goryachev, arXiv:1904.05774 [physics.class-ph]

Author: Prof. TOBAR, Michael (University of Western Australia)

Co-authors: Mr MCALLISTER, Ben (University of Western Australia); Dr GORYACHEV, Maxim (University of Western Australia)

Presenter: Prof. TOBAR, Michael (University of Western Australia)

Session Classification: Afternoon 12