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New axion haloscopes techniques to search for axion dark matter, high frequency gravitational waves and monopoles

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We introduce a systematic way to calculate the spectral sensitivity of an electromagnetic axion dark matter haloscope, so instrument comparison may be achieved independent of signal assumptions and only depends on the axion to signal transduction sensitivity and noise in the instrument [1]. Furthermore, it has been shown that electromagnetic axion haloscopes have proportional sensitivity to high-frequency gravitational waves based on the inverse Gertsenshtein effect. Thus, the calculation of the spectral sensitivity not only allows the comparison of dissimilar axion detectors independent of signal but also allows us to compare the order of magnitude gravitational wave sensitivity in terms of spectral strain sensitivity allowing comparisons to standard gravitational wave detectors based on optical interferometers and resonant-mass technology.

To calculate the sensitivity of axion haloscopes, we show Poynting theorem provides a systematic way of understanding power generation in a resonant haloscope [2]. For resonant haloscopes, it is optimum to impedance match, and the sensitivity is dictated by the real power flow in the system. In the quasi-static limit, the impedance must be mismatched to gain broadband sensitivity at the expense of resonant enhancement. In the quasi-static broadband case, we show the sensitivity may be calculated from the reactive power flow in the system.

Recently interactions between putative axions and magnetic monopoles have been revisited [3,4]. It has been shown that significant modifications to conventional axion electrodynamics arise due to these interactions so that the axion-photon coupling parameter space is expanded from one parameter g_{aγγ} to three (g_{aγγ}, g_{aEM}, g_{aMM}). We implement Poynting theorem in the resonant and quasi-static limits to determine how to exhibit sensitivity to g_{aEM} and g_{aMM} using various electromagnetic haloscopes techniques [5,6], allowing new ways to search for axions and a possible indirect way to determine if magnetically charged matter exists.

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[3] AV Sokolov, A Ringwald, Generic axion Maxwell equations: path integral approach, arXiv:2303.10170
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