Dynamical magnetoelectric coupling in axion insulator thin films

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Introduction

Topological Insulator:

Low Energy Action:

$$S = S_{Maxwell} + S_{Axion}$$

$$S_{Axion} = \frac{\theta}{2\pi}\frac{e^2}{2\pi\hbar c}\int d^3x dt \boldsymbol{E}\cdot\boldsymbol{B} = \hbar\theta N$$

$\theta = \pi$: Topological Magnetoelectric Coupling

Orbital Effect (Band Effect).

Axion Insulator:

Axion Electrodynamics:

$$-\frac{1}{c^2}\frac{\partial \mathbf{E}}{\partial t} + \nabla\times\mathbf{B} = \frac{\alpha}{\pi c}\left(\dot{\theta}\mathbf{B} + \nabla\theta\times\mathbf{E}\right)$$

$$\nabla\cdot\mathbf{E} = -\frac{\alpha c}{\pi}\nabla\theta\cdot\mathbf{B}$$

TME Current:

$$\mathbf{j} = \frac{e^2}{2\pi h}\left[\nabla\theta\times\mathbf{E} + \partial_t\theta\mathbf{B}\right]$$

For Axion insulator thin film, the θ is not quantized and depends on thickness and surface gap.

$$1 - \frac{\theta(d)}{\pi} = \frac{\beta(\Delta_s)}{d} + o\left(\frac{1}{d^2}\right)$$

$$\eta \equiv (d/\pi)(\partial\theta/\partial\Delta_s)$$

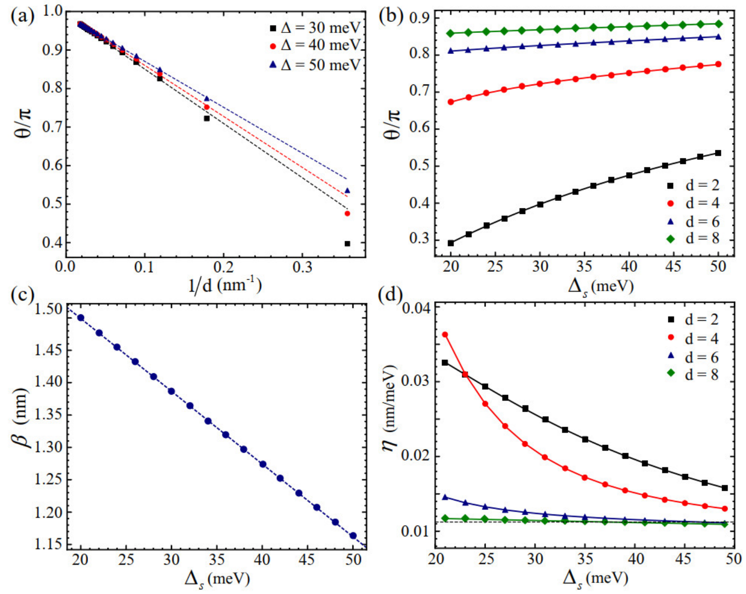
Dynamics on surface gap would give θ time dependence.

$$\partial_t\theta = \frac{\partial\theta}{\partial\Delta_s}\frac{\partial\Delta_s}{\partial t}$$

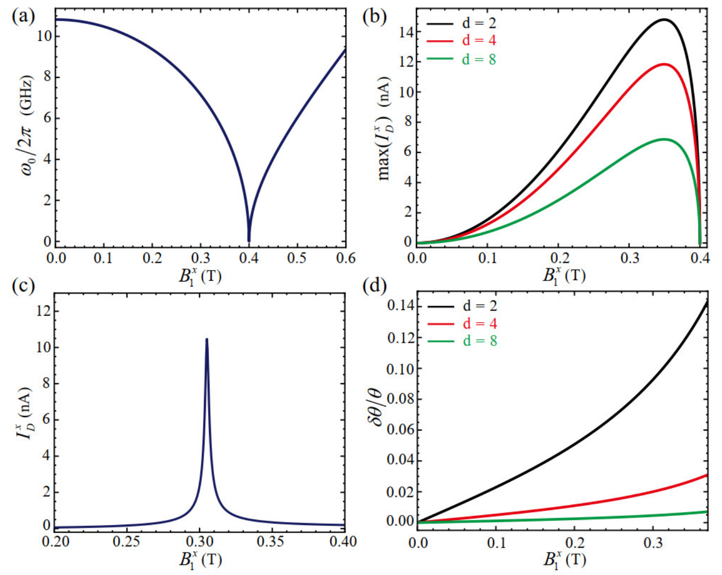
Surface magnetic resonance induced surface gap dynamics.

$$\mathcal{J}_D = \mathcal{J}_D^x\hat{\mathbf{x}} = \frac{e^2}{2h}\eta g_M \partial_t \delta M_z\left(B_1^x + B_2^x\cos(\omega t)\right)\hat{\mathbf{x}}$$

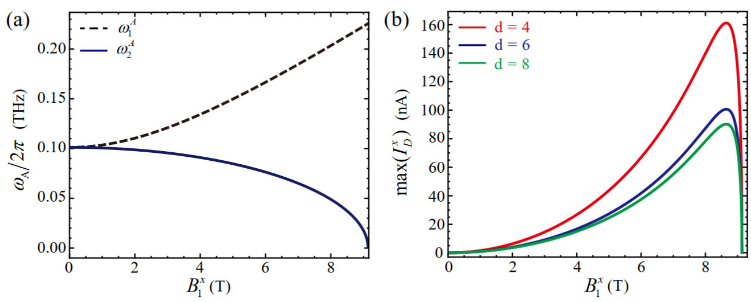
Results



FMR



AFMR



Conclusion

The surface magnetic resonance can induce dynamical magnetoelectric current in Axion insulator thin film.

Reference

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[2] X.-L. Qi, T. L. Hughes, and S.-C. Zhang, Phys. Rev. B78, 195424 (2008)
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