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Dielectric tuning of cavities

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Haloscope-based axion searches are typically planned around a single, costly superconducting magnet. As a corollary to this design constraint, the number of cavities that can be fit into a fixed magnet bore will increase as the targeted axion mass increases, i.e. as the haloscope cavity radius decreases. Mechanically tuning an array of N cavities, where N is large, introduces a suite of physics and engineering challenges collectively referred to as "the Swiss watch problem". Non-mechanical tuning strategies would relieve some constraints on the mechanical tolerance requirements of cavity dimension and tuning rod precision, as well as reducing the heat load from simultaneous actuation of many tuning motors. We have demonstrated cavity tuning on the order of a linewidth by loading a 4-GHz cavity with a strontium titanate (STO) crystal – a ferroelectric material. The permittivity of this material varies under the application of an external DC voltage. Changing the dielectric strength of a small fraction of the cavity volume allows the cavity frequency to be tuned non-mechanically. We present a first demonstration of this tuning strategy, as well as recommendations for future work based on our results.

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