Design considerations for future axion cavity searches

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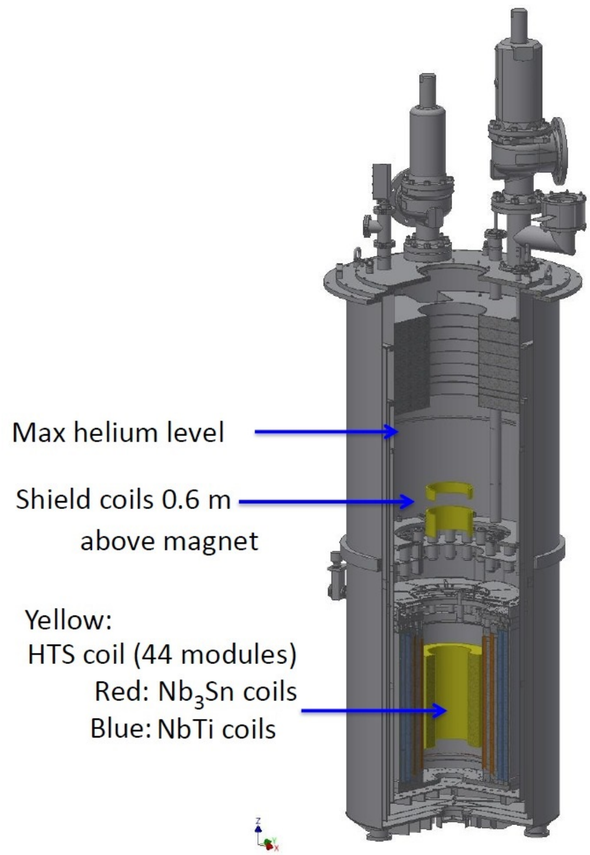
The objective of this project is to conduct a detailed design study for a third-generation axion cavity detector, optimized for searches for the case where the axion mass is above the range searched by ADMX. The generation-2 ADMX detector is the most sensitive dark matter detector in the world. It is designed to detect or rule out the existence of dark matter axions in the Galactic halo having masses in the 2 to 10 μeV range. This design project would study the factors governing the sensitivity of a detector in the 10 to 50 μeV mass range..



The conversion occurs when the cavity is resonant at the photon frequency f, making $hf = mc^2$ with m the axion mass. The power in the axion signal is governed by many parameters:

$$P \sim B^2 V C f \rho Q g^2$$

where B is the magnetic field strength, V is the cavity volume, C is a mode-dependent form factor, ρ the density of galactic halo axions at the Earth's location, Q is the loaded quality factor of the cavity, and g is the coupling strength of the axion to two photons. The dilemma for our design study is that cavity dimensions are comparable to the wavelength, so that the cavity becomes smaller as frequency goes up, making the cavity volume decrease as $1/f^3$. Thus, it seems inevitable that the design of a new detector should focus on smaller magnet volume.

The loss of sensitivity can be addressed by increasing the magnetic field strength; the gain goes as the square of the field. Hence, an increase from 8 T (the present ADMX magnet) to 24–26 T (as sketched above) can balance a 10 fold reduction in volume. The study underway will address at the conceptual level the design of such a detector, including the magnet, cavity or cavities, cryogenics, SQUID or JPA amplifiers, and other aspects of the detector.

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