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Superfluid Frequency Tuning of Superconducting Cavities for Axion Dark Matter Search

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The Center for Axion and Precision Physics Research (CAPP) has introduced a new generation of axion haloscopes by developing high quality factor ($> 10^7$) superconducting cavities even in the high magnetic field, utilizing high-temperature superconducting (HTS) tapes. In order to practically utilize superconducting cavities in axion haloscopes, the tuning mechanism should not compromise the cavity's quality factor or the geometrical factor. CAPP has developed an advanced frequency tuning mechanism that uses superfluid liquid helium (SLHe) to precisely control the amount of liquid helium in the cavity at the nanoscale level. This tuning method can adjust the resonant frequency of the cavity by up to 3%, while maintaining the quality and form factors within 10%, even when the quality factor is much larger than the axion quality factor. In addition, the use of SLHe eliminates the need for mechanical movement, resulting in thermally stable frequency tuning. A commissioning axion search experiment is underway utilizing a HTS cavity with an ultra-high quality factor ($> 10^7$) and a SLHe tuning method. We aim to present our preliminary findings at the upcoming workshop.

Primary authors: BYUN, HeeSu (CAPP-IBS); KWON, Ohjoon (Center for Axion and Precision Physics Research of Institute for Basic Science); CHUNG, Woohyun (Institute for Basic Science, Center for Axion and Precision Physics Research)

Presenter: BYUN, HeeSu (CAPP-IBS)

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