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Constraints on MeV Axion Models from Kaon Decays with KTeV Data

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The QCD axion is a compelling mechanism for solving the strong CP problem. Most studies have focused on axion models with a large decay constant, f_a
$gtrsim 10^9$, GeV. However, recent work has pointed out that viable axion models may also exist in the low-scale regime, $f_a \sim \mathcal{O}(1)$, GeV, corresponding to an axion mass in the MeV range.

In this mass range, the axion can be produced in kaon decays such as $K_L \to \pi^0\pi^0 a$, followed by the prompt decay $a \to e^+e^-$. As a result, the final-state signature coincides with that of the rare decay $K_L \to \pi^0\pi^0 e^+e^-$. The KTeV experiment has placed a stringent upper bound on this channel, $\mathrm{Br}(K_L \to \pi^0\pi^0 e^+e^-) < 6.6 \times 10^{-9}$, which can therefore be directly reinterpreted as a strong constraint on MeV-scale QCD axion models. In our work, we perform a dedicated analysis of this reinterpretation and derive stringent limits on the axion parameter space from kaon decay measurements.

Presenter: IWAI, Takaya

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