The search for new physics with rare kaon decays at the CERN SPS

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Abstract

Precise measurements of the branching ratios (BRs) for the flavor-changing neutral current decays $K \to \pi\nu\bar{\nu}$ can provide unique constraints on CKM unitarity and, potentially, evidence for the existence of new physics. The NA62 experiment at the CERN SPS was designed to measure BR($K^+ \to \pi^+\nu\bar{\nu}$) with a precision of about 10%. The key features of the experiment include ultrafast tracking for both beam and secondary particles, redundant particle identification, hermetic photon vetoes, and high-performance electromagnetic calorimetry. The experiment took data from 2016–2018 before LHC Long Shutdown 2, obtaining a measurement of BR($K^+ \to \pi^+\nu\bar{\nu}$) in agreement with the Standard Model prediction, establishing the existence of the decay at the 3.4σ level and providing new constraints on models for physics beyond the Standard Model. The data collected in 2016–2018 correspond to 20% of the expected total; the experiment restarted data taking in July 2021 and will be completed in 2024. Over the longer term, the continued availablility of the primary proton beam from the CERN SPS through at least 2036 provides an opportunity for an integrated program for precise measurements of rare kaon decays, both charged and neutral, to give clear insight into the flavor structure of new physics. This program will make use of a significantly upgraded NA62-like setup with detectors that can be reconfigured and reused in various experimental stages, including a measurement of BR($K^+ \to \pi^+\nu\bar{\nu}$) to ∼5%, a measurement of BR($K_L \to \pi^0\nu\bar{\nu}$) to ∼20% (KLEVER), and a program with a neutral beam and downstream detectors for tracking and particle identification to allow the study of decays such as $K_L \to \pi^0\ell^+\ell^-$. In this seminar, the recent results from NA62 will be reviewed, and future directions for the kaon program at CERN will be described.

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