論文の内容の要旨

Measurement of the Flavor Changing Neutral Current Decays $B \to K\ell^+\ell^-$ at the Belle II Experiment

(Belle II 実験におけるフレーバー変換中性カレント崩壊 $B \to K\ell^+\ell^-$の測定)

氏名：MORA GRIMALDO JOHNNY ALEJANDRO

モラ グリマルド ジョニー アレハンドロ

Flavor Changing Neutral Currents (FCNC) constitute excellent probes for physics beyond the Standard Model, since their branching fractions can be affected by the presence of new, heavy particles as mediators. Of special interest are the $B \to K\ell^+\ell^-$ decays—where B is either a B^0 or a B^+ meson, K is either a K^+ or a K^0, and ℓ is either a μ or an e— given their relatively high branching fraction and smaller theoretical uncertainties (in comparison with other FCNC), and the multiple new couplings they can test. Great efforts have been put into measuring the value of R_K, defined as

$$R_K = \frac{\mathfrak{B}(B \to K\mu^+ \mu^-)}{\mathfrak{B}(B \to K e^+ e^-)}$$

since it is theoretically very clean, and recent measurements show tension with the Standard Model predicted value of 1.

These decays are extremely rare, and as such, their uncertainties are dominated by the size of the data sample used to study them. New particle accelerators, focused on extreme luminosities, have the potential to narrow these uncertainties and to provide more precise measurements. The Belle II Experiment, which started recording physics events from the summer of 2019, aims for an integrated luminosity of 50 ab^{-1}, by achieving a new record of instantaneous luminosity ($\sim 8 \times 10^{35}\mathrm{cm}^{-2}\mathrm{s}^{-1}$). Since it is operating at the SuperKEK-B, a B meson factory, its reconstruction efficiency for these decays is higher than more general experiments such as the LHC; thus, it represents an ideal setup for a moreprecise study of the $B \to K\ell^+\ell^-$ transitions.

The current work is the first analysis of the $B \to K\ell^+\ell^-$ decays using the Belle II experiment data accumulated in its first physics runs up to March of 2020. It consists of 11.5 fb^{-1} of collisions recorded at a Center of Mass Energy equal to the Υ(4S) mass; besides the novelty of being the first study of these processes at the Belle II Experiment, this analysis also introduces a new, improved algorithm for Bremsstrahlung recovery, uses Boosted Decision Trees as multivariate classifiers in order to reduce the different background components in the data samples, and applies the technique of *boosting to flatness* in order to avoid introducing bias through the multivariate classifiers' outputs. In the study, the ratio R_K is measured for the dilepton invariant mass regions corresponding to the *J/ψ* and *ψ(2S)* resonances to be

$$\frac{\mathfrak{B}(B \to KJ/\psi[e^+e^-])}{\mathfrak{B}(B \to KJ/\psi[\mu^+\mu^-])} = 0.99 \pm 0.09(\text{stat}) \pm 0.01(\text{sys}),$$
$$\frac{\mathfrak{B}(B \to K\psi(2S)[e^+e^-])}{\mathfrak{B}(B \to K\psi(2S)[\mu^+\mu^-])} = 1.03 \pm 0.41(\text{stat}) \pm 0.01(\text{sys}).$$

The decay mode $B^+ \to K^+e^+e^-$ is observed with a significance of 1.35 and a 90% C.L. upper bound on its branching fraction is measured to be

$$\mathfrak{B}(B^+ \to K^+e^+e^-) < 3.5 \times 10^{-6}$$

The other three decays are not observed; the 90% C.L. upper bound on their branch- ing fractions are:

$$\mathfrak{B}(B^0 \to K^0\mu^+\mu^-) < 3.2 \times 10^{-6}$$
$$\mathfrak{B}(B^+ \to K^+\mu^+\mu^-) < 9.9 \times 10^{-7}$$
$$\mathfrak{B}(B^0 \to K^0e^+e^-) < 2.3 \times 10^{-6}$$

All of these are consistent with measurements by previous experiments, and with the predictions made by the Standard Model.

We also perform a sensitivity projection for both the branching fractions and the R_K ratio at higher luminosities, and show that the improvements in the detector performance are required to meet previous expectations for the R_K ratio at Belle II –derived from extrapolations of the Belle measurements–; based on these projections, and pending on the improvements mentioned, we predict that the Belle II experiment will be able to settle the R_K anomaly with a 5σ significance at 35 ab^{-1}.