Search for $B^+ \to K^{*+}\tau^+\tau^-$ with hadronic tagging at Belle II

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The Standard Model of particle physics (SM) is the most precise and detailed theory in the field of elementary particle physics. Although it explains only three of the four fundamental forces of the universe, it has achieved groundbreaking success over the past 50 years through its accurate predictions of high-precision measurements. However, it fails to explain many physical phenomena beyond gravity: it lacks adequate descriptions of the baryon asymmetry, the existence of dark matter, as well as the observed neutrino oscillations. This incompleteness provides the basis for numerous investigations of physics beyond the SM. One approach is the direct search for new phenomena by measuring well-known SM processes with the highest possible precision. Such measurements make it possible to identify inconsistencies in the SM description.

Flavor physics, in particular processes involving flavor-changing charged and neutral currents (FCCCs & FCNCs), is considered one of the most promising areas for new physics. These interactions are highly suppressed in the SM, which makes potential new phenomena experimentally observable. In the field of FCCCs, the ratios $\mathcal{R}(D^{(*)})$ and $\mathcal{R}(J/\psi)$ have been studied extensively in recent years with respect to possible violations of lepton flavor universality (LFU). A significant deviation of 3.2 sigma has been observed.

Based on this observation, a large LFU deviation is also expected in the FCNC process $b \to s\tau\tau$. Theoretical predictions in this area anticipate an enhancement of the branching ratio by three orders of magnitude (from 10^{-7} to 10^{-4}).

In the past, experimental limits on the sensitivity to such processes were set by experiments like BaBar and Belle, but these could not rule out the presence of new phenomena. To substantially advance research in this direction, the Belle II experiment offers a unique opportunity to study such decays, in particular the decay $B^+ \to K^{*+}\tau\tau$.

Compared to its predecessor experiments, Belle II provides numerous improvements, ranging from enhanced detector components to more efficient reconstruction software. In addition, a much larger dataset of collision events is expected (around a factor of 50-100 compared to BaBar and Belle), which will significantly reduce the statistical uncertainty for this rare process.
The goal of this work is the experimental determination of the branching ratio of $B^+ \to K^{*+}\tau\tau$, with a view toward the sensitivity to new physics.