

calculate $\Lambda \rightarrow p \ell^- \nu \ell$ semileptonic decay in lattice QCD

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This work presents a non-perturbative lattice-QCD study of the semileptonic decay $\langle \Lambda \rightarrow p \ell \bar{\nu}_{\ell} \rangle$, where $\ell = e, \mu$. The main objective is to calculate the hadronic transition matrix element

$$\langle p | \bar{u} \gamma^\mu (1 - \gamma_5) s | \Lambda \rangle$$

and extract the corresponding vector and axial-vector form factors.

Two-point and three-point correlation functions are constructed on the lattice. Excited-state contamination is reduced using the summation method, correlated global fits, and jackknife resampling. The momentum-transfer dependence of the form factors is described using a model-independent z -expansion with the appropriate kinematic constraints.

The extracted form factors are then used to calculate the differential and total decay rates,

$$\Gamma_\ell = \int_{m_\ell^2}^{(m_\Lambda - m_N)^2} dq^2 \frac{d\Gamma_\ell}{dq^2},$$

and to determine the CKM matrix element

$|V_{us}|$

Using experimental baryon masses, the resulting muon-to-electron decay-rate ratio is

$$R_{\mu/e} = 0.16464(18),$$

while the extracted values of

$|V_{us}|$

are

$$V_{us,e} = 0.2438(21), V_{us,\mu} = 0.2557(161).$$

The study demonstrates the feasibility of determining Λ -baryon semileptonic form factors from lattice QCD. Further calculations with multiple lattice spacings, improved mass tuning, and continuum extrapolation are required for a precision determination of $|V_{us}|$.

$\langle p | \bar{u} \gamma^\mu (1 - \gamma_5) s | \Lambda \rangle$

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