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Lattice Results for the $K^+ \to \ell^+ \nu_\ell \ell'^+ \ell'^-$ Form Factors and Branching Ratios

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We study, with lattice QCD, the radiative leptonic decays $P \to \ell \nu_\ell \ell'^+ \ell'^-$, where P is a charged pseudoscalar meson and ℓ and ℓ' are charged leptons. These processes are mediated by the emission of a virtual photon and, in addition to the "point-like" contribution in which the virtual photon is emitted either from the lepton or the meson treated as a point-like particle, four structure-dependent (SD) form factors contribute to the amplitude. We present a strategy for the extraction of the SD form factors and implement it in an exploratory lattice computation of the decay rates for the four channels of kaon decays ($\ell, \ell' = e, \mu$). The lattice computation has been performed employing only one gauge ensemble, with simulated pion and kaon masses equal to 320 and 530 MeV, respectively.
It is the SD form factors which describe the interaction between the virtual photon and the internal hadronic structure of the decaying meson, and in our procedure we separate the SD and point-like contributions to the amplitudes. The form factors are extracted with good precision and used to reconstruct the branching ratio values, which are compared with the available experimental data.
These are very suppressed processes, which thus provide an excellent test of the Standard Model, and provide a useful avenue for the search for signatures of new physics.

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