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Up and down quark masses and corrections to Dashen's theorem from lattice QCD and quenched QED

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We present a determination of the corrections to Dashen's theorem and of the individual up and down quark masses from a lattice calculation based on quenched QED and $N_f = 2 + 1$ QCD simulations with 5 lattice spacings down to 0.054 fm. The simulations feature lattice sizes up to 6 fm and average up-down quark masses all the way down to their physical value. For the parameter which quantifies violations to Dashen's theorem we obtain $\epsilon = 0.73(2)(5)(17)$, where the first error is statistical, the second is systematic, and the third is an estimate of the QED quenching error. For the light quark masses we obtain, $m_u = 2.27(6)(5)(4)$ MeV and $m_d = 4.67(6)(5)(4)$ MeV in the \overline{MS} scheme at 2 GeV and the isospin breaking ratios $m_u/m_d = 0.485(11)(8)(14)$, $R = 38.2(1.1)(0.8)(1.4)$ and $Q = 23.4(0.4)(0.3)(0.4)$. Our results exclude the $m_u = 0$ solution to the strong CP problem by more than 24 standard deviations.

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