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# Quark-Hadron Duality Violations and Higher-Order $1/m_b$ Corrections in Inclusive Semileptonic $B$ Decays

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The Heavy Quark Expansion (HQE) is one of the leading tools for calculating decay rates and kinematic moments of inclusive semi-leptonic B-meson decays ($B \to X_c\, \overline{\nu}\, l$). The HQE is an Operator Product Expansion (OPE) in terms of the inverse of the mass of the heavy bottom quark ($1/m_b$). It introduces nonperturbative HQE parameters which can be determined using data. Using the HQE, the Cabibbo-Kobayashi-Maskawa (CKM) matrix element $|V_{cb}|$ has been extracted at percentage level precision from the moments of inclusive semi-leptonic B meson decays ($B \to X_c\, \overline{\nu}\, l$). This matrix element is a key ingredient in our understanding of the Standard Model of Particle Physics (SM). The calculations upon which the theoretical estimates rely are done in terms of quarks and gluons. These are, however, not accessible for experiments. Quark Hadron Duality (QHD) allows for a translation of theoretical predictions at the quark level to experimental observables at the hadron level. Since the increased accuracy in HQE predictions up to order of $1/m_b^5$, violation of the QHD may start to become the limiting factor in reaching higher precision. When QHD is violated, the OPE upon which the HQE relies is no longer a valid expansion. I will show how we derive a model for the Quark Hadron Duality Violation (QHDV) and how the violation enters different kinematic moments of the $B \to X_c\, \overline{\nu}\, l$ decays. Furthermore, we construct new observables designed to be sensitive to QHDV and extract a first constraint on QHDV using data.

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