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Towards establishing the second b-flavored CKM unitarity triangle

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With the help of the generalized Wolfenstein parametrization of quark flavor mixing and CP violation, we calculate fine differences between the twin b-flavored unitarity triangles defined by $V_{ub}^* V_{ud} + V_{cb}^* V_{cd} + V_{tb}^* V_{td} = 0$ and $V_{ud}^* V_{td} + V_{us}^* V_{ts} + V_{ub}^* V_{tb} = 0$ in the complex plane. We find that apexes of the rescaled versions of these two triangles, described respectively by $\overline{\rho} + {\rm i}\overline{\eta} = -\left(V_{ub}^* V_{ud}\right) / \left(V_{cb}^* V_{cd}\right)$ and $\widetilde{\rho} + {\rm i}\widetilde{\eta} = -\left(V_{ub}^* V_{tb}\right) / \left(V_{us}^* V_{ts}\right)$, are located on a circular arc whose center and radius are given by $O = (0.5, 0.5\cot\alpha)$ and $R = 0.5\csc\alpha$ with α being their common inner angle. The small difference between $(\overline{\rho}, \overline{\eta})$ and $(\widetilde{\rho}, \widetilde{\eta})$ is characterized by $\widetilde{\rho} - \overline{\rho} \sim \widetilde{\eta} - \overline{\eta} \sim calO(\lambda^2)$ with $\lambda \simeq 0.22$ being the Wolfenstein expansion parameter, and these two apexes are insensitive to the two-loop renormalization-group running effects up to the accuracy of $calO(\lambda^4)$. We suggest that the second b-flavored unitarity triangle can be established with the observables from $B_u^{\pm}$ and B_s^0-$\bar{B}_s^0$ systems based on the high-precision measurements to be done at the upgraded LHCb and Belle II experiments, and a comparison between the twin b-flavor unitarity triangles will provide a consistency check of the CKM picture for CP violation and probe possible new physics in this connection.

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