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The Earth Mover's Distance as a Measure of CP Violation

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We introduce a new unbinned two sample test statistic sensitive to CP violation utilizing the optimal transport plan associated with the Wasserstein (earth mover's) distance. The efficacy of the test statistic is shown via two examples of CP asymmetric distributions with varying sample sizes: the Dalitz distributions of $B^0 \rightarrow K^+\pi^-\pi^0$ and of $D^0 \rightarrow \pi^+\pi^-\pi^0$ decays. The test statistic is shown to have comparable sensitivity to CP violation as the commonly used energy test statistic, but also retains information about the localized distributions of CP asymmetry over the Dalitz plot. Additionally, we introduce two alternative test statistics with similar sensitivities to CP violation but improved time and space complexity scalings. Finally, generalizations and applications to time dependent and flavor asymmetries are discussed.

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