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Observation of CP-violation in an amplitude analysis of the $B^+ \to \pi^+\pi^+\pi^-$ decay

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In the Standard Model, CP violation originates from a single irreducible phase in the Cabibbo-Kobayashi-Maskawa matrix. For the manifestation of CP violation in decay, two separate interfering decay amplitudes are required, with differing CP-violating and CP-conserving phases. Previous analyses of the $B^+ \to \pi^+\pi^+\pi^-$ decay have hinted at large CP violation in specific regions of the three-body phase space. Here a recent analysis by the LHCb experiment is described, where the decay amplitude is modelled explicitly. Particular attention is paid to the large spin-0 component, which is modelled using three separate approaches that exhibit good agreement. Here, the largest CP asymmetry ever for a quasi-two-body decay is observed. Furthermore, unprecedented insight is gained into how CP violation manifests in practice, and, for the first time, is observed in the interference between resonant structures. This confirms the importance of resonance dynamics in the generation of the strong-phase differences required for CP violation in decay, and informs further searches for CP violation in similar decays.

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