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Opening up the Quantum Three-Box Problem with Undetectable Measurements RICHARD GEORGE, University College London, LUCIO ROBLEDO, TU Delft, OWEN MARONEY, University of Oxford, MACHIEL BLOK, HANNES BERNIEN, TU Delft, DANIEL TWITCHEN, MATTHEW MARKHAM, E6, JOHN MORTON, University College London, ANDREW BRIGGS, University of Oxford, RONALD HANSON, TU Delft — One of the most striking features of quantum mechanics is the profound effect exerted by measurements alone. Sophisticated quantum control is now available in several experimental systems, exposing discrepancies between quantum and classical mechanics whenever measurement induces disturbance of the interrogated system. In practice, such discrepancies may frequently be explained as the back-action required by quantum mechanics adding quantum noise to a classical signal. Here we implement the 'three-box' quantum game (Aharonov, et al. 1991) by utilising state-of-the-art control and measurement of the nitrogen vacancy centre in diamond. In this protocol, the back-action of quantum measurements add no detectable disturbance to the classical description of the game. Quantum and classical mechanics then make contradictory predictions for the same experimental procedure, however classical observers are unable to invoke measurement-induced disturbance to explain the discrepancy. We quantify the disturbance of our measurements and obtain data ruling out any classical model by 7.8 sigma, excluding state-definiteness from our system. Our experiment is then equivalent to a Kochen-Spekker test of quantum non-contextuality that successfully addresses the measurement detectability loophole.

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