

The Penrose Tiling is a Quantum Error-Correcting Code

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The Penrose tiling (PT) is an intrinsically non-periodic way of tiling the plane, with many remarkable properties. A quantum error-correcting code (QECC) is a clever way of protecting quantum information from noise, by encoding the information with a sophisticated type of redundancy. Although PTs and QECCs might seem completely unrelated, in this paper we point out that PTs give rise to (or, in a sense, $\{\backslash$ it are $\}$) a remarkable new type of QECC. In this code, quantum information is encoded through quantum geometry, and any local errors or erasures in any finite region, no matter how large, may be diagnosed and corrected. We also construct variants of this code (based on the Ammann-Beenker and Fibonacci tilings) that can live on finite spatial tori, in discrete spin systems, or in an arbitrary number of spatial dimensions. We discuss connections to quantum computing, condensed matter physics, and quantum gravity.