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Generalizing Noether: the metric from energy-momentum non-conservation

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I show that a manifold's geometry can be reconstructed from its vibrational spectrum—provided one also measures the rates at which resonant modes nonlinearly excite one another under strong driving. Applied to spacetime, this yields a generalized Noether theorem: the specific pattern of energy-momentum non-conservation in quantum field theory on curved backgrounds, encoded in the scattering matrix, is sufficient to reconstruct the spacetime metric. In the context of quantum gravity, this suggests that the familiar dichotomy of spacetime versus matter can emerge from an information-theoretic framework based on only one concept: correlators. When higher-order correlators (n>2) are approximately jointly diagonalizable, they admit a representation as correlation functions of a local QFT on a curved background, allowing both spacetime and matter to emerge as effective constructs. However, at Planckian energies, this diagonalizability may break down, yielding a pre-geometric regime in which the correlators remain well-defined but lack an interpretation in terms of spacetime and local quantum fields.

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