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Locality and entanglement in bandlimited quantum field theory
JASON PYE, University of Waterloo, WILLIAM DONNELLY, University of California Santa Barbara, ACHIM KEMPF, University of Waterloo — We consider a model for a Planck scale ultraviolet cutoff which is based on Shannon sampling. Shannon sampling originated in information theory, where it expresses the equivalence of continuous and discrete representations of information. When applied to quantum field theory, Shannon sampling expresses a hard ultraviolet cutoff in the form of a bandlimitation. This introduces nonlocality at the cutoff scale in a way that is more subtle than a simple discretization of space: quantum fields can then be represented as either living on continuous space or, entirely equivalently, as living on any one lattice whose average spacing is sufficiently small. We explicitly calculate vacuum entanglement entropies in 1+1 dimensions and we find a transition between logarithmic and linear scaling of the entropy, which is the expected 1+1 dimensional analog of the transition from an area to a volume law. We also use entanglement entropy and mutual information as measures to probe in detail the localizability of the field degrees of freedom. We find that, even though neither translation nor rotation invariance are broken, each field degree of freedom occupies an incompressible volume of space, indicating a finite information density.

Jason Pye
University of Waterloo

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