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## Understanding Ryu-Takayangi as entropy without invoking holography

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In appropriate semiclassical limits, the so-called Island Formula computes the entropy of non-gravitational quantum systems entangled with a gravitational theory. This is a special case in which the quantum-corrected Ryu-Takayanagi formula has been shown to compute a von Neumann entropy using only properties of the gravitational path integral and, in particular, without relying on the existence of a holographic dual field theory. It is thus natural to claim that a similar conclusion should hold more broadly, and that any asymptotically-AdS gravitational theory will define an algebra for any boundary region such that, in appropriate limits, the entropy of any state on that algebra is computed by the quantum-corrected Ryu-Takayanagi formula. Recent works by Chandrasekaran, Pennington and Witten have used the theory of von Neumann algebras to derive results of this form in various special contexts. We argue here that the above claim holds more generally, whenever the Euclidean path integral of the gravitational theory satisfies a set of standard axioms. We thus allow finite values of all coupling constants and do not require taking any special limits. Since our axioms do not restrict ultra-violet bulk structures, they may be expected to hold equally well for successful formulations of string field theory, spin-foam models, or any other approach to constructing a UV-complete theory.

### Keyword-1

Quantum Gravity

### Keyword-2

Gravitational Entropy

### Keyword-3

von Neumann algebras

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