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Encoding field theories into gravities

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We propose a method, which encodes the information of a d dimensional quantum field theory into a $d + 1$ dimensional gravity in the $1/N$ expansion. We first construct a $d + 1$ dimensional field theory from the d dimensional one via the gradient flow equation, whose flow time t represents the energy scale of the system such that $t \rightarrow 0$ corresponds to the ultra-violet (UV) while $t \rightarrow \infty$ to the infra-red (IR). We then define the induced metric from $d + 1$ dimensional field operators.

We show that the metric defined in this way becomes classical in the large N limit, in a sense that quantum fluctuations of the metric are suppressed as $1/N$ due to the large N factorization property.

As a concrete example, we apply our method to the O(N) non-linear σ model in two dimensions.

We calculate the induced metric in three dimensions, which is shown to describe asymptotically De Sitter (dS) or Anti De Sitter (AdS) space in the UV limit.

We finally discuss several open issues in future studies.

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