State Space Renormalization in 1+1 CDT

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Attempts to quantize a field theory (such as General Relativity) typically start with some kind of *discretization, truncation or cut-off*. This reduces the theory to finitely many degrees of freedom, making it amenable to standard and well-understood quantization procedures (e.g. geometric quantization, path-integrals,...).

These truncated theories, while maybe technically challenging to work with, should pose little conceptual difficulties. Serious issues however resurface as one strives to remove the regulator. The *renormalization* techniques inherited from ordinary flat-background QFT are geared toward the determination of a *uniquely singled-out vacuum state*, from which the entire continuum quantum theory is to be *reconstructed* (e.g. by means of the Osterwalder–Schrader theorem). The mathematical assumptions which make this reconstruction possible are however crucially dependent on a *static spacetime background*.

An alternative is to turn our classical system of truncations into a *quantum coarse-graining scheme* [1]. We can then employ *projective techniques* [2, 3] to assemble an exhaustive space of *untruncated* quantum states. Because this state space naturally comes with its own notion of *convergence*, which targets the *transition amplitudes* between quantum states (as opposed to vacuum-vacuum expectation values), we get a renormalization paradigm in which the *quantum state space* (as opposed to a single vacuum state) takes centre stage and the reconstruction question mentioned above is sidestepped.

Causal Dynamical Triangulations in 1+1 dimensions [4] offer a fully solvable model in which to test this approach, and, since its continuum limit can be easily constructed using a direct ansatz, a known reference against which to compare our results. At the same time, the strategy developed here could provide a new route to probe the continuum limit of CDT in higher (and more interesting...) dimensions.

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[2] J. Kijowski, "Symplectic Geometry and Second Quantization," *Rep. Math. Phys.*, vol. 11, pp. 97–109, 1977.

[3] A. Okołów, "Construction of Spaces of Kinematic Quantum States for Field Theories via Projective Techniques," *Class. Quant. Grav.*, vol. 30, p. 195003, 2013.

[4] J. Ambjorn, A. Görlich, J. Jurkiewicz, and R. Loll, "Nonperturbative Quantum Gravity," *Physics Reports*, vol. 519, pp. 127–210, 2012.