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Theoretical Engineering of Integrable Models from Extra Dimensions

Integrable models are a special class of physical systems that have enough conserved charges and hence can be solved exactly. They provide invaluable data for e.g. understanding critical phenomena in condensed matter systems, and are useful stepping stones for analyzing generic non-integrable/chaotic systems.

In the past few years, a new framework has emerged to explain many of the existing results, as well as new ones, from a certain four-dimensional Chern-Simons-type quantum field theory. While we are interested in theories in two spacetime dimensions, it is useful to include two extra dimensions and consider everything from the four-dimensional perspective. The geometries of the extra dimensions are rich enough to "theoretically engineer" a class of integrable models and uncover their properties.

As an example of these results, we explain how to better understand relations between integrable lattice models and integrable quantum field theories, where the latter can be regarded as the low-energy limit of the former. Such studies are useful for the quantum simulation of two-dimensional integrable quantum field theories, and potentially for benchmarking noisy quantum devices in the future. Our discussion is "T-dual" to the relation between knot theory and the three-dimensional Chern-Simons theory, which relation is the theoretical basis for the topological quantum computation.

[1] K. Costello, E. Witten and M. Yamazaki, ICCM Not. 6, 46-119 (2018), arXiv:1709.09993 [hep-th]

[2] K. Costello and M. Yamazaki, arXiv:1908.02289 [hep-th]