Project: Dynamics of edge modes at large N

Quantum field theories with boundaries have many applications ranging from statistical physics and condensed matter physic to string theory. In recent years the study of boundary conditions that preserve conformal symmetry has received renewed attention in the context of the conformal bootstrap program [1]. Using numerical bootstrap techniques, ref. [2] found rigorous non-perturbative constraints on the set of possible boundary conditions for the CFT of a massless scalar field in four dimensions.

It is natural to ask whether the boundary conditions found in [2] can be constructed more explicitly using renormalization group (RG) techniques. To achieve this one needs to consider interactions between edge modes localized on the boundary and the bulk scalar field, and explore whether it is possible to drive the whole system to criticality. This setup has also a natural realization in condensed matter [3] as a two-layered system of a topological insulator, which gives rise to the edge modes, coupled to a symmetry breaking bulk phase transition, which give rise to the massless scalar. In order to have analytic control over the RG some non-perturbative technique is needed, such as the large N limit. A study of the dynamics of large N edge modes coupled to a bulk scalar field was initiated in [4], which constructed the first explicit example of interacting conformal boundary condition for a 4d scalar field. In this example the dynamics of the edge modes is described by a U(1) Chern-Simons gauge theory coupled to bosonic matter in three dimensions.

The aim of this project is two-fold. The first goal is to further study the dynamics of the interacting boundary condition found in [4], and in particular to compute the observables that were used in the bootstrap study [2] in order to be able to compare. The second goal is to consider a more general type of dynamics for the edge modes, involving non-abelian gauge group U(N) in the limit of large N and large k with fixed ratio. Given the example found in [4], it is reasonable to expect that this will allow to construct a large family of interacting boundary conditions for the free scalar.

References

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[3] Y. Xu, X. Wu, C. Jian, C. Xu, "Topological Edge and Interface states at Bulk disorder-to-order Quantum Critical Points", Phys. Rev. B 101, 184419 (2020)
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