Topological BF description of 2D accelerated chiral edge modes

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Abstract:

We consider the topological abelian BF theory with radial boundary on a generic 3D manifold. Our aim is to study if, where and how the boundary keeps memory of the details of the background metric. We find that some features are topologically protected and do not depend on the bulk metric. These are the Kaç-Moody algebra formed by the conserved currents and its central charge, which is proportional to the inverse of the bulk action coupling constant. We then derive the 2D action holographically induced on the boundary, which depends on two scalar fields, and which can be decoupled in two Luttinger actions describing two chiral bosons moving on the edge of the 3D bulk. The outcome is that these edge excitations are accelerated, as a direct consequence of the non-flat nature of the bulk spacetime. The chiral velocities of the edge modes, indeed, acquire a local dependence through the determinant of the induced metric on the boundary. We find three possibilities for the motion of the edge quasiparticles: same directions, opposite directions and a single-moving mode. But, requiring that the Hamiltonian of the 2D theory is bounded by below, the case of edge modes moving in the same direction is ruled out: systems involving parallel Hall currents (for instance Fractional Quantum Hall Effect with $\nu = 2/5$) cannot be described by a BF theory with boundary, independently from the geometry of the bulk spacetime, because of positive energy considerations. We are therefore left with physical situations characterized by edge excitations moving with opposite velocities (examples are FQHE with $\nu = 1 - 1/n$, with n positive integer, and Helical Luttinger Liquids phenomena) or a single-moving mode (Quantum Anomalous Hall). A strong restriction is obtained by requiring Time Reversal symmetry, which uniquely identifies modes with equal and opposite velocities, and we know that this is the case of Topological Insulators. The novelty, with respect to the flat bulk background, is that the modes have local velocities, which corresponds to Topological Insulators with accelerated edge modes.