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Color-kinematics duality for Chern-Simons theory

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Many gauge theories possess a hidden duality between color and kinematics in
their on-shell scattering amplitudes. An open problem is to formulate an off-shell realizationof the duality, thus manifesting a kinematic algebra. We show that 3D Chern-Simons (CS) theory in Lorenz gauge obeys off-shell color-kinematics duality. This holds both for the CS field and the BRST ghosts, and the duality is manifest in the Feynman rules. A kinematic algebra emerges through the second-order differential operator in the propagator-numerator, and it corresponds to the algebra of diffeomorphism of functions in the Lorenz gauge. We consider several admissible 3D off-shell double-copy constructions. While the double copy is in principle well formulated off shell, the scattering amplitudes vanish due to the topological nature of CS theory.

To obtain non-vanishing amplitudes, we deform Chern-Simons theory by including adjoint matter, which we take to be maximally supersymmetric. This gives a formulation of a $N = 4$ CS-matter theory, whose double-copy with itself corresponds to maximally supersymmetric $N = 8$ Dirac-Born-Infeld theory.

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