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Solitonic symmetry beyond homotopy: invertibility from bordism and non-invertibility from TQFT

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Solitonic symmetry is believed to follow the homotopy-group classification of topological solitons. Here, we point out a more sophisticated algebraic structure when solitons of different codimensions coexist in the spectrum. We uncover this phenomenon in a concrete quantum field theory, the 4d $\mathbb{C}P^1$ model. This model has two kinds of solitonic excitations, vortices and hopfions, which would follow two $U(1)$ solitonic symmetries according to homotopy groups. Nevertheless, we demonstrate the nonexistence of the hopfion $U(1)$ symmetry by evaluating the hopfion charge of vortex operators. We clarify that what conserves hopfion numbers is a non-invertible symmetry generated by 3d spin topological quantum field theories (TQFTs). Its invertible subgroup is just $\mathbb{Z}_2$, which we recognize as a spin bordism invariant. Compared with the 3d $\mathbb{C}P^1$ model, our work suggests a unified description of solitonic symmetries and couplings to topological phases.

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