

## All spin-1 topological phases in a single spin-2 chain

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**Author(s):**

Augustine Kshetrimayum, Hong-Hao Tu, and Roman Orus

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<http://journals.aps.org/prb/abstract/10.1103/PhysRevB.91.205118> [2]

Here we study the emergence of different Symmetry-Protected Topological (SPT) phases in a spin-2 quantum chain. We consider a Heisenberg-like model with bilinear, biquadratic, bicubic, and biquartic nearest-neighbor interactions, as well as uniaxial anisotropy. We show that this model contains four different effective spin-1 SPT phases, corresponding to different representations of the  $(Z_2 \times Z_2) + T$  symmetry group, where  $Z_2$  is some  $\pi$ -rotation in the spin internal space and  $T$  is time-reversal. One of these phases is equivalent to the usual spin-1 Haldane phase, while the other three are different but also typical of spin-1 systems. The model also exhibits an  $SO(5)$ -Haldane phase. Moreover, we also find that the transitions between the different effective spin-1 SPT phases are continuous, and can be described by a  $c=2$  conformal field theory. At such transitions, indirect evidence suggests a possible effective field theory of four massless Majorana fermions. The results are obtained by approximating the ground state of the system in the thermodynamic limit using Matrix Product States via the infinite Time Evolving Block Decimation method, as well as by effective field theory considerations. Our findings show, for the first time, that different large effective spin-1 SPT phases separated by continuous quantum phase transitions can be stabilized in a simple quantum spin chain.

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