

Title: Algebraic Approaches to Elementary Excitations in Media with Broken Spatial or Time-reversal Symmetry

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Abstract: Structural phase transitions with macroscopic symmetry breaking can be divided into 212 non-magnetic *species* according to the mutual spatial orientation of the point groups of both phases. Classification into the given species implies a set of universal transition properties such as the number of macroscopic domain states of the low-symmetry phase and their distinguishability by order parameter.

In this work, the distinguishability of macroscopic domain states by all order parameters which transform as vectors or vectorlike quantities (called bidirectors) was studied. For solving this task, a computer algorithm was designed which enabled an explicit listing of all vector and vectorlike order parameters, not only for the 212 non-magnetic species, but even for all 1602 magnetic species which includes transitions between crystallographic gray and bicolor point groups. In addition, irreducible representations of the 122 magnetic crystallographic point groups which transform as vectors or vectorlike quantities are given in character tables. The aim of this systematic analysis of irreducible representations of magnetic groups is to facilitate classification of long-wave elementary excitations. This work was used to identify phase transitions that allow the existence of so-called skyrmion phases.

Keywords: crystal symmetry, phase transitions, time-reversal symmetry, chirality