Abstract Submitted
for the EGLSF21 Meeting of
The American Physical Society

Phase transitions, critical behavior, and emergent order in systems of musical harmony[1] HUAY DIN, JESSE BEREZOVSKY, Case Western Reserve University — The emergence of order in a thermodynamic system can be understood as a temperature dependent trade-off between minimizing energy and maximizing entropy of the system. We posit that the ordered arrangement of musical pitches that constitute a system of musical harmony arises from an analogous trade-off. We show that by quantifying these factors, a system of harmony can be formulated as an XY model governed by an effective free energy. Methods from statistical mechanics can then be applied that serve to minimize free energy, reproducing familiar structures of Western and non-Western harmony. Numerical simulation of quenched tones on a 3D lattice shows a transition with a divergence of correlation length and relaxation time, consistent with the expected critical exponents for a 3D XY model. Furthermore, the resultant topological defects, frozen vortex strings, are as predicted by the Kibble-Zurek mechanism. These topological defects can be interpreted as musical chords, and the branching network of strings as chord progressions. These results provide a new approach for understanding, appreciating, and composing music from first principles

[1]H.D. and J.B. acknowledge support from the CWRU Expanding Horizons Initiative. H.D. acknowledges support from the Bruce Rakay Summer Fellowship Scholarship and the CWRU Coding Scholars program. This work made use of the High Performance Computing Resource in the Core Facility for Advanced Research Computing at CWRU

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Date submitted: 09 Nov 2021 Electronic form version 1.4