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Editorial Office
Chaos: An Interdisciplinary Journal of Nonlinear Science
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Dear Editors,

I am pleased to submit the manuscript entitled "**Dimension Matching in Multiscale Chaotic Systems: When Correlations and Spectra Coincide**" for consideration as a Regular Article in *Chaos*.

Summary. This paper establishes a framework for understanding when independently defined complexity measures—correlation dimension and harmonic dimension—agree in multiscale stochastic systems. Drawing on recent mathematical advances in Gaussian multiplicative chaos (GMC), we show that dimension matching reflects a coherence condition: cross-scale consistency maintained by martingale-like balance. When this consistency holds, low-dimensional projections faithfully represent high-dimensional dynamics; when it fails near criticality, such projections become unreliable.

Key contributions:

1. We interpret the recently-proven Garban-Vargas conjecture (on GMC dimension matching) as a coherence condition with broad applicability to chaotic systems.

2. We develop a game-theoretic interpretation where dimension matching corresponds to a cooperative equilibrium among scales—no scale can "defect" profitably from the martingale budget.

3. We demonstrate that dimension matching breakdown serves as a universal diagnostic for regime collapse, with applications to neural dynamics, cellular coordination, and multi-agent systems.

4. We clarify the distinction between coherence (high-dimensional constraint maintenance) and phase-locking (dimensional collapse), showing these are fundamentally different phenomena.

Relevance to Chaos. This work directly addresses core concerns of nonlinear dynamics: when do simplified descriptions capture essential structure, and when do they fail? The dimension-matching framework provides both theoretical insight (connecting geometry and harmonics via martingales) and practical diagnostics (measurable early-warning indicators for transitions). The game-theoretic framing offers a novel perspective on multiscale coordination that should interest researchers across the journal's interdisciplinary scope.

Technical validation. The paper includes numerical simulations of GMC measures, agent-based coordination games, and synthetic neural time series analysis. All code is available for reproducibil-

ity.

This manuscript has not been published elsewhere and is not under consideration by another journal. All authors have approved the manuscript and agree with its submission.

I suggest the following potential reviewers with relevant expertise:

- Vincent Vargas (University of Geneva) — co-author of the Garban-Vargas conjecture
- Dietmar Plenz (NIH) — neural criticality and multiscale dynamics
- James Crutchfield (UC Davis) — computational mechanics and complexity measures

Thank you for considering this submission.

Sincerely,

Ian Todd
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