

Peer Review

Review of: "Scrambling in Charged Hairy Black Holes and the Kasner Interior"

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Overall assessment:

The paper investigates chaotic dynamics inside charged hairy black holes with axion fields and an Einstein–Maxwell–Scalar (EMS) coupling. By computing OTOCs and mutual information, it extracts the Lyapunov exponent, butterfly velocity, and scrambling-time delay as functions of a boundary deformation that drives the bulk toward a Kasner interior. The study is methodologically solid, numerically detailed, and offers physically interesting results—particularly the charged-shock-wave “bounce” and the distinct roles of the EMS coupling γ , axion strength ζ , and charge density ρ .

Strengths:

- 1) Extends standard shock-wave analyses by including electric charge, showing how γ and ρ strongly modulate the scrambling delay while ζ influences both chaos measures and interior geometry.
- 2) Provides a clear holographic setup, full equations of motion, and systematic numerical scans; the figures convincingly illustrate non-monotonic λ_L behavior and the drop in v_B with increasing deformation.
- 3) Highlights that λ_L can even exceed its axion-Reissner–Nordström benchmark under large deformations, raising fresh questions about chaos bounds.

Weaknesses & suggested revisions:

- Several plots lack detailed captions and parameter justification; a concise symbol table would greatly improve readability.
- The paper should clarify whether λ_L ever truly violates the MSS bound or if this is a normalization artifact.
- The physical meaning of the non-invertible $\lambda_L - p_t$ relation deserves deeper discussion, as does the rapid suppression of scrambling delay at large γ .

Minor issues include scattered cross-page equations and a few missing references on early charged shock-wave work.

Recommendation:

Accept after **major revision** addressing the above explanatory and presentation issues; the core results are novel and publishable once clarified.

Declarations

Potential competing interests: No potential competing interests to declare.