Shadows and accretion dynamics in charged black holes with spontaneous Lorentz symmetry breaking

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INTRODUCTION

Spontaneous Lorentz-symmetry breaking emerges in several extensions of General Relativity and can be realized through a Kalb–Ramond (KR) field.

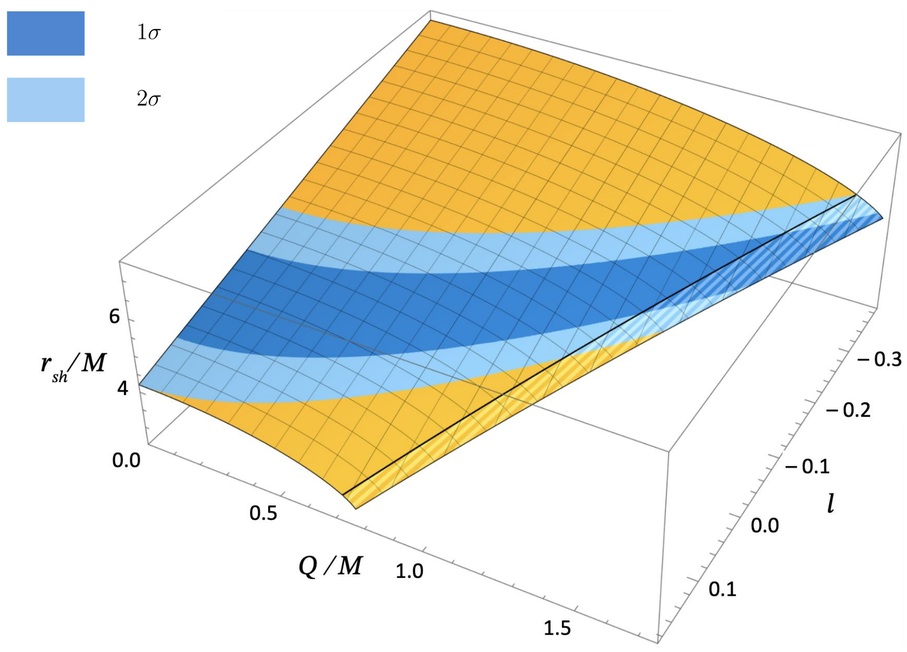
We consider a charged Kalb–Ramond black hole [1], characterized by the **charge Q** and **Lorentz-breaking parameter l**, and derive joint EHT shadow constraints in the (Q, l) parameter space before examining their effects on thin-disc emission and thick-disc equilibrium and stability.

$$g_{tt}(r) = -\left(\frac{1}{1-l} - \frac{2M}{r} + \frac{Q^2}{(1-l)^2 r^2}\right)$$

SHADOW

The 3D surface depicts the predicted shadow radius r_{sh}/M across the (Q, l) parameter space, where the **blue bands** mark the EHT-inferred 1σ and 2σ bounds for Sgr A* [2].

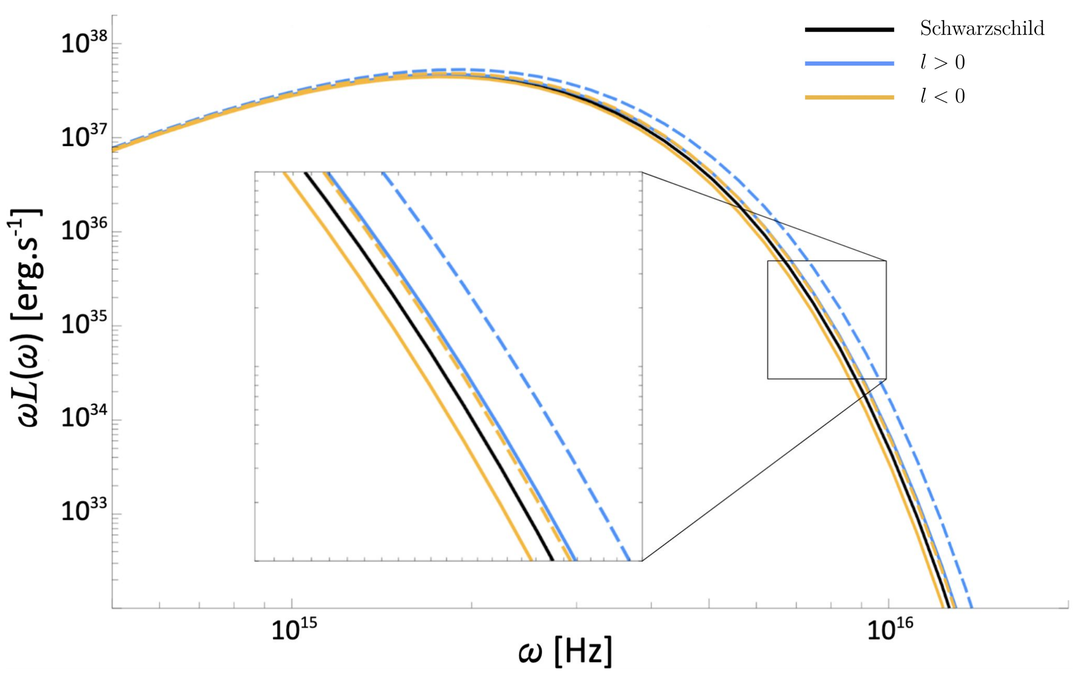
- Charge broadens the compatible l parameter range to $-0.3900 \leq l \leq 0.1898$, with multiple ($Q$, l) configurations producing the same shadow radius.



THIN ACCRETION

Within the Novikov–Thorne framework [3], spectral energy distributions $\omega L(\omega)$ for neutral (**solid**) and charged (**dashed**) configurations reveal the impact of l on the high-frequency emission:

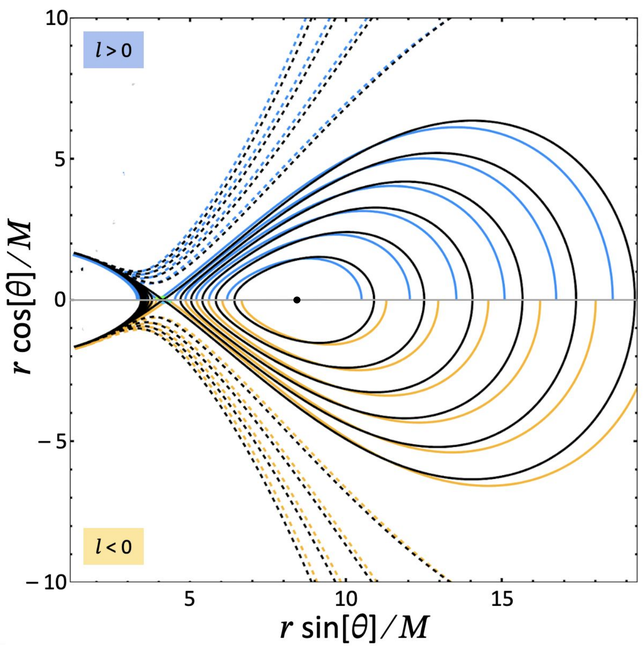
- $l > 0$ extends the spectrum to higher frequencies
- $l < 0$ produces an earlier fall-off
- Q amplifies the spectral effects of Lorentz-symmetry violation



THICK ACCRETION

Comparison of Reissner–Nordström (**black**) and charged KR (**coloured**) tori with the same fluid topology, leveraging equatorial symmetry to show $l > 0$ and $l < 0$ in the upper and lower halves, respectively.

- We consider constant-angular-momentum thick tori, following the standard relativistic equilibrium framework [4].
- **$l > 0$ (top)**: the cusp and torus centre shift inward, producing a more compact configuration
- **$l < 0$ (bottom)**: the cusp and torus centre shift outward, expanding the torus radially.



CONCLUSION

Compared with existing neutral-KR constraints [5], electric charge enlarges the EHT-compatible l parameter space to $-0.3900 \leq l \leq 0.1898$ and introduces a $Q - l$ degeneracy in the shadow radius. The same parameters leave distinct imprints on thin- and thick-disc accretion, providing complementary observational signatures beyond the shadow size alone.

References:

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