

Extending the Kerr–Bertotti–Robinson Spacetime Through Infinity

Yu-Sen Zhou

with Rong-Gen Cai, Li-Ming Cao, Liang-Bi Wu,
and Ming-Fei Ji, Wen-Tao Fu

University of Science and Technology of China

Based on: **2608.19136**
Forthcoming: **2609.xxxxx**

Kerr–Bertotti–Robinson (KBR) spacetime

$$ds^2 = \frac{1}{\Omega^2} \left[-\frac{Q}{\rho^2} (dt - a\Delta_x C d\varphi)^2 + \frac{\rho^2}{Q} dr^2 + \frac{\rho^2}{P\Delta_x} dx^2 + \frac{P\Delta_x}{\rho^2} (adt - \rho_0^2 C d\varphi)^2 \right].$$
$$\begin{aligned}\rho_0^2 &= r^2 + a^2, & \rho^2 &= r^2 + a^2 x^2, \\ Q &= (1 + B^2 r^2) \Delta, & \Delta &= Ar^2 - 2\mu r + a^2, \\ \Omega^2 &= (1 + B^2 r^2) - B^2 \Delta x^2, & \Delta_x &= 1 - x^2.\end{aligned}$$

► $x = \cos \theta$

► conicity C : $\varphi \in [0, 2\pi)$

Commonly regarded as a rotating black hole immersed in homogeneous magnetic universe

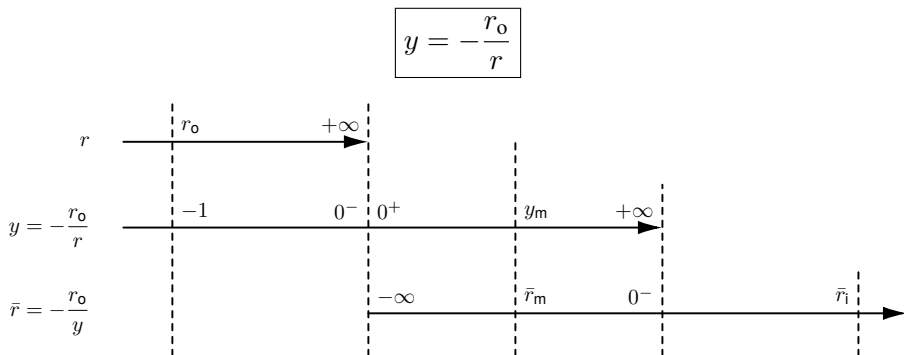
Podolský and Ovcharenko, Phys. Rev. Lett. 135, 181401 (2025), arXiv:2507.05199.

The $r = \infty$ surface

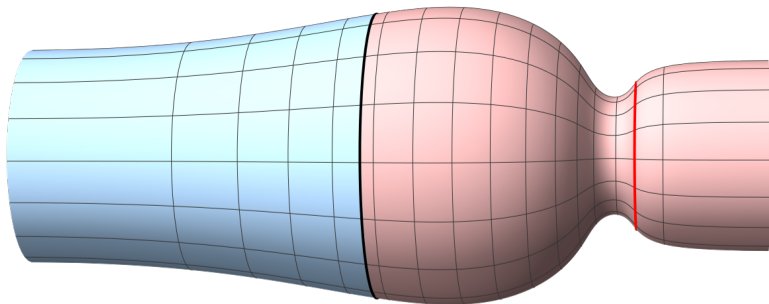
- ▶ Reachable by light rays;
- ▶ Reachable by timelike observers;
- ▶ nonvanishing Weyl curvature Ψ_2 .

What lies beyond $r = \infty$?

The Extension



The Isometric Embedding to $\mathbb{E}^3$

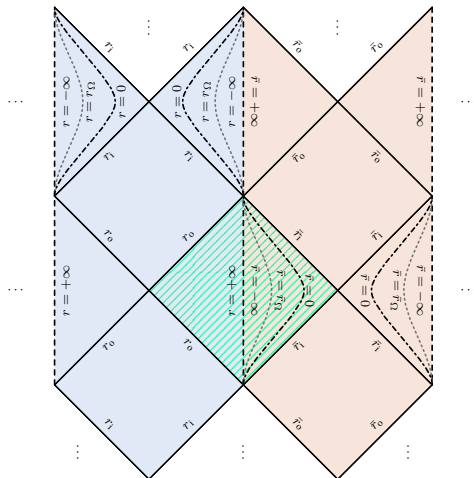


fixed- t, θ slice; black: gluing surface; red: $\bar{r} = 0$

► no matter shell

► no violation of the energy conditions

The Causal Structure



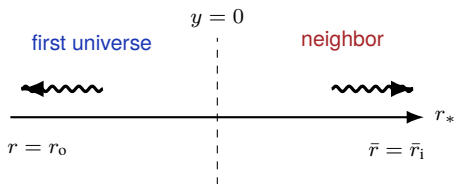
- ▶ minimal building block;
- ▶ $r = 0, \theta = \pi/2$: ring singularity not shielded by any horizon;
- ▶ $\theta = 0, \pi, r = r_\Omega$: where light can not reach.

Infinite chain of KBR regions.

Two-universe Wave Scattering

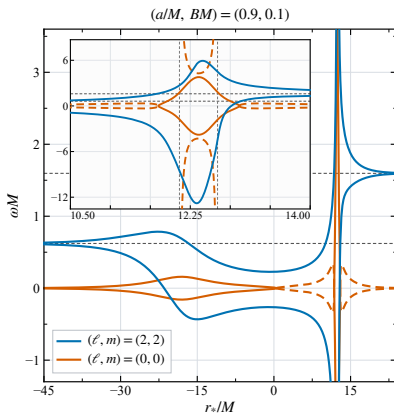
$$\square\Psi = 0.$$

$$\frac{d^2\Psi^{(r_*)}}{dr_*^2} + V\Psi^{(r_*)} = 0.$$



Effective Potential

$$\Psi^{(r_*)} \sim A_0 \exp \left[i \int k(r_*; \omega, \lambda) dr_* \right],$$



Roots ω_i such that $V(r_*; \omega_i, \lambda(\omega_i)) = 0$

$$\ell = m = 0$$

One can analytically prove that the existence of:

$$\omega = i\gamma, \quad \gamma > 0, \quad e^{-i\omega t} = e^{\gamma t}.$$

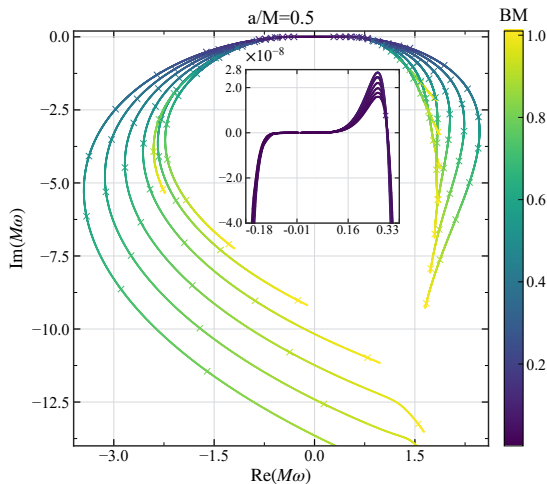
for every ℓ

CTC region $\sim$ trapping region

Caveat: no global hyperbolicity $\Rightarrow$ no standard Cauchy instability.

Method adapted from Dotti, Gleiser, and Ranea-Sandoval, CQG 29, 095017 (2012), arXiv:1111.5974.

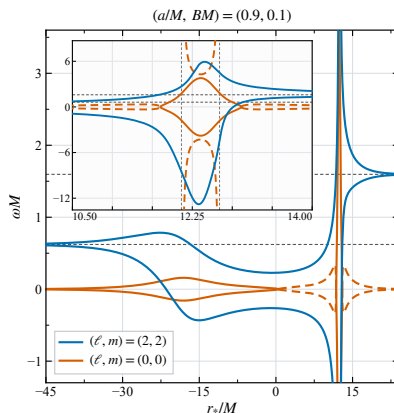
$(\ell, m) = (2, 2)$: rotational instability



Instability: high spin; weak B

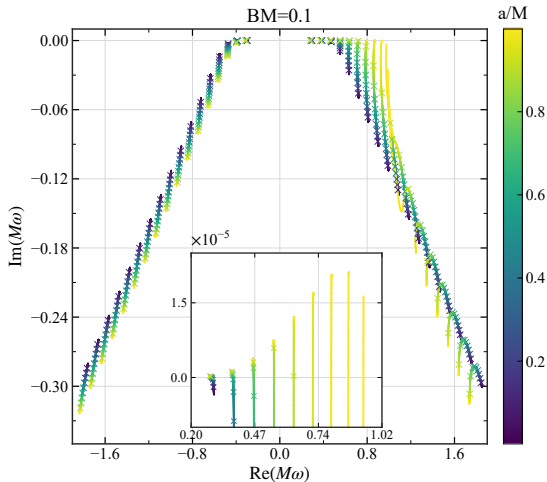
Effective Potential

$$\Psi(r_*) \sim A_0 \exp \left[i \int k(r_*; \omega, \lambda) dr_* \right],$$



Roots ω_i such that $V(r_*; \omega_i, \lambda_i) = 0$

Weakly damped echo modes



Conclusion

- ▶ Natural extension beyond $r = \infty$;
- ▶ Wormhole-like structure;
- ▶ Infinite KBR chain;
- ▶ Naked singularity;
- ▶ $m = 0$ instability: CTC-induced;
- ▶ $m = 2$ instability: black-hole-bomb-induced;
- ▶ Echo-like response.

Thank You

Questions and comments are welcome.

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