

# Isospectrality in Effective Field Theory Extensions of General Relativity

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Based on 2407.12080 w/ Marina David



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# Introduction

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2. **Bottom-up:** constrain EFT using physical requirements

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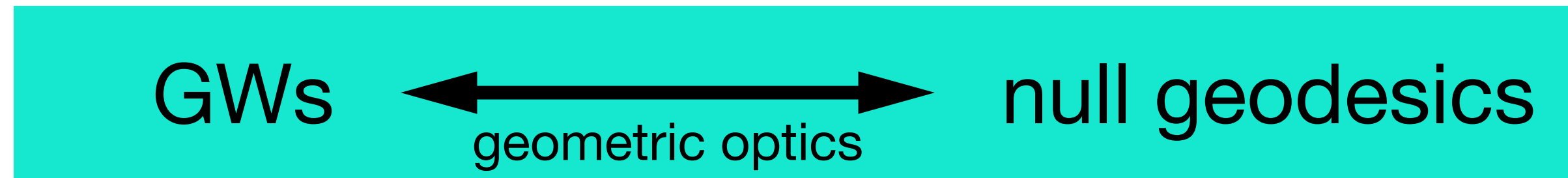
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In this talk: **new class of EFTs**  $\longrightarrow$  idea: preserve certain properties of GR

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geometric optics

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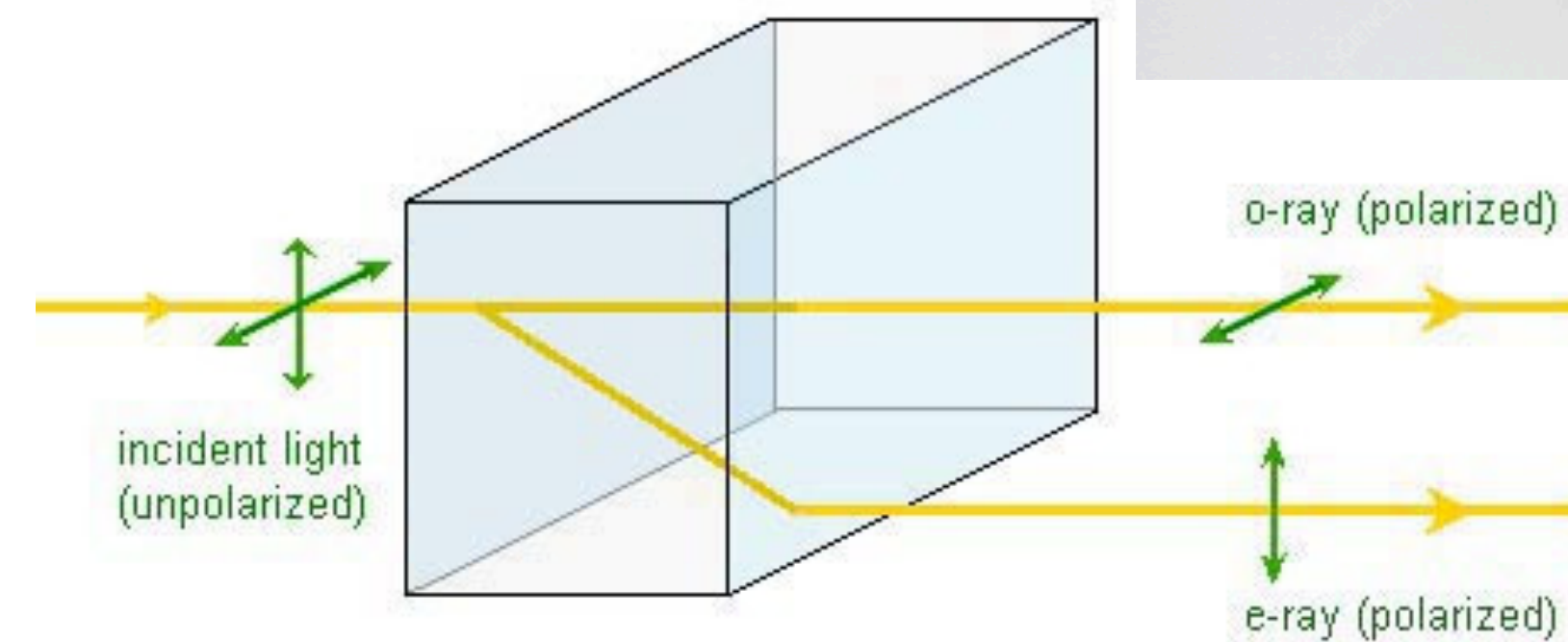
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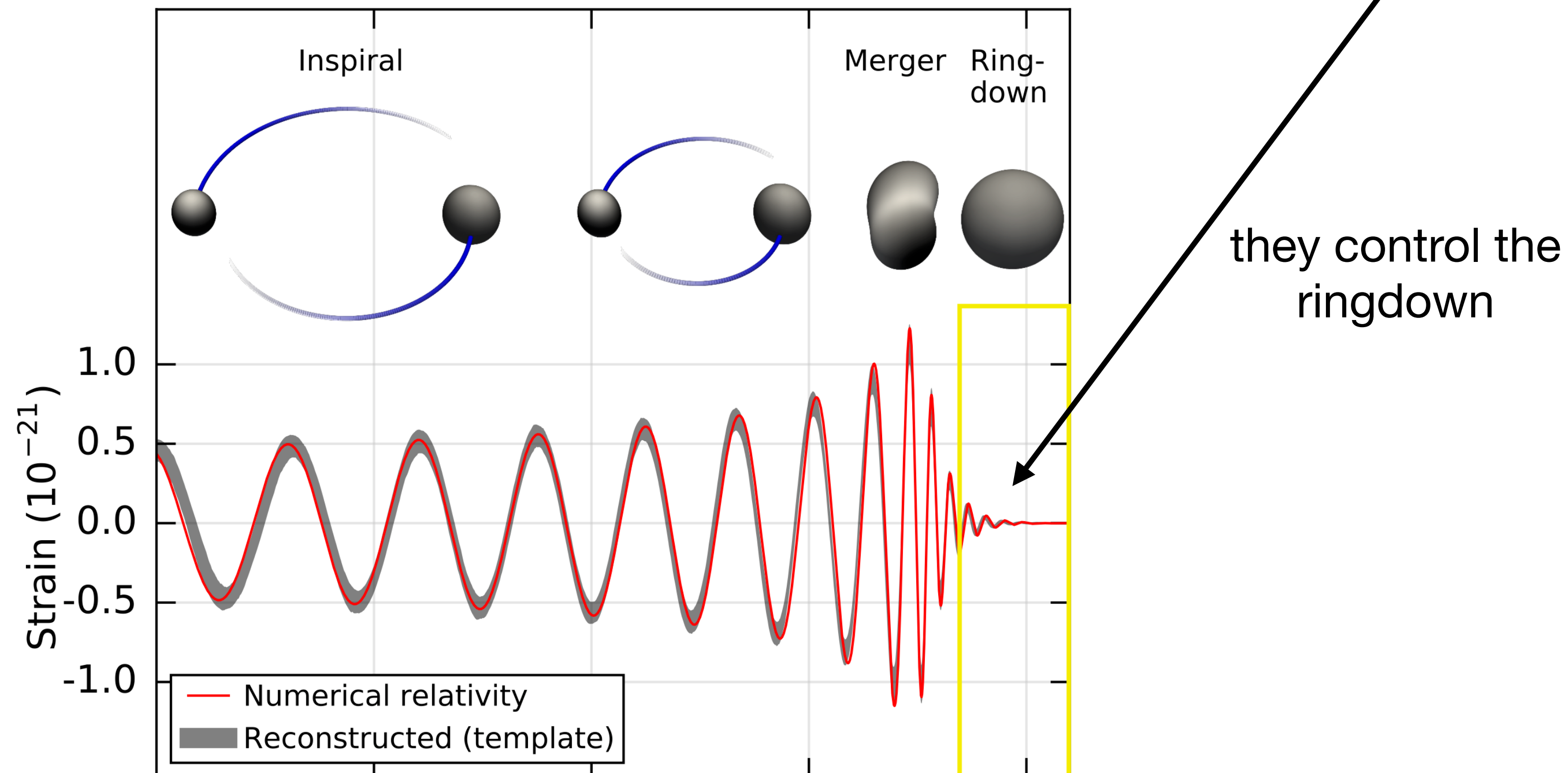
Beyond GR:

- **GWs not null nor geodesic**
- **Birefringence:** speed of propagation depends on the polarization



# Beyond GR effects: BH quasinormal modes

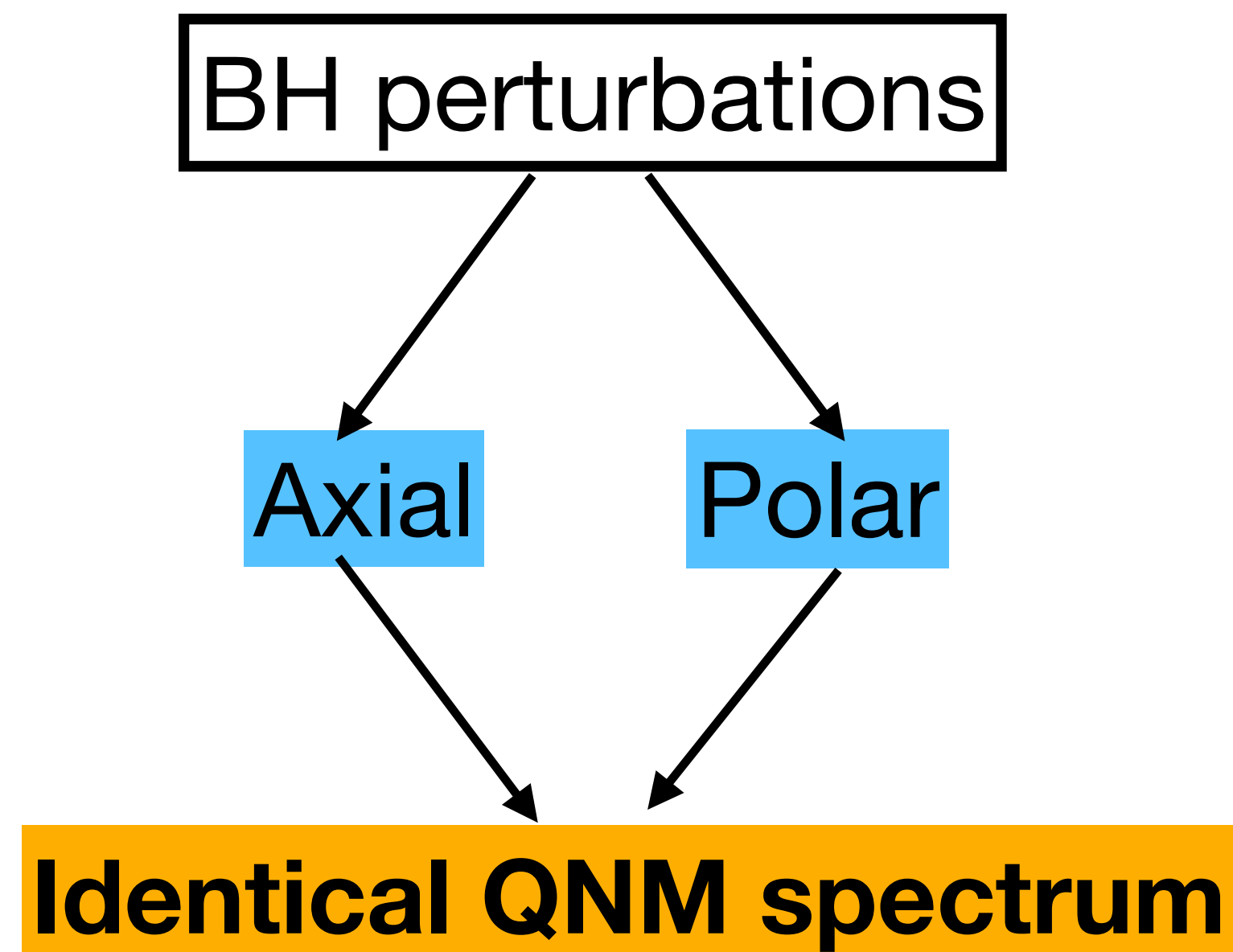
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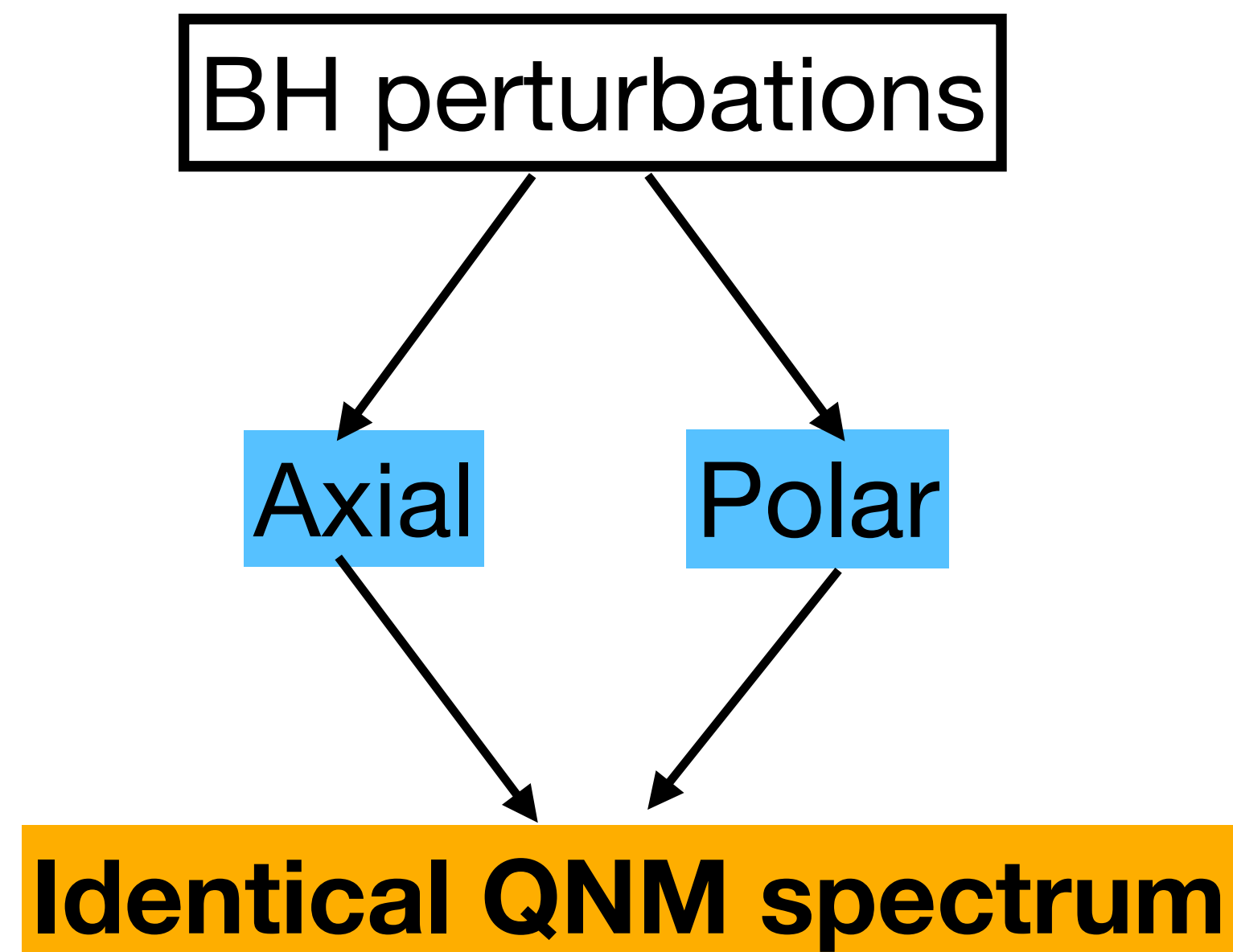
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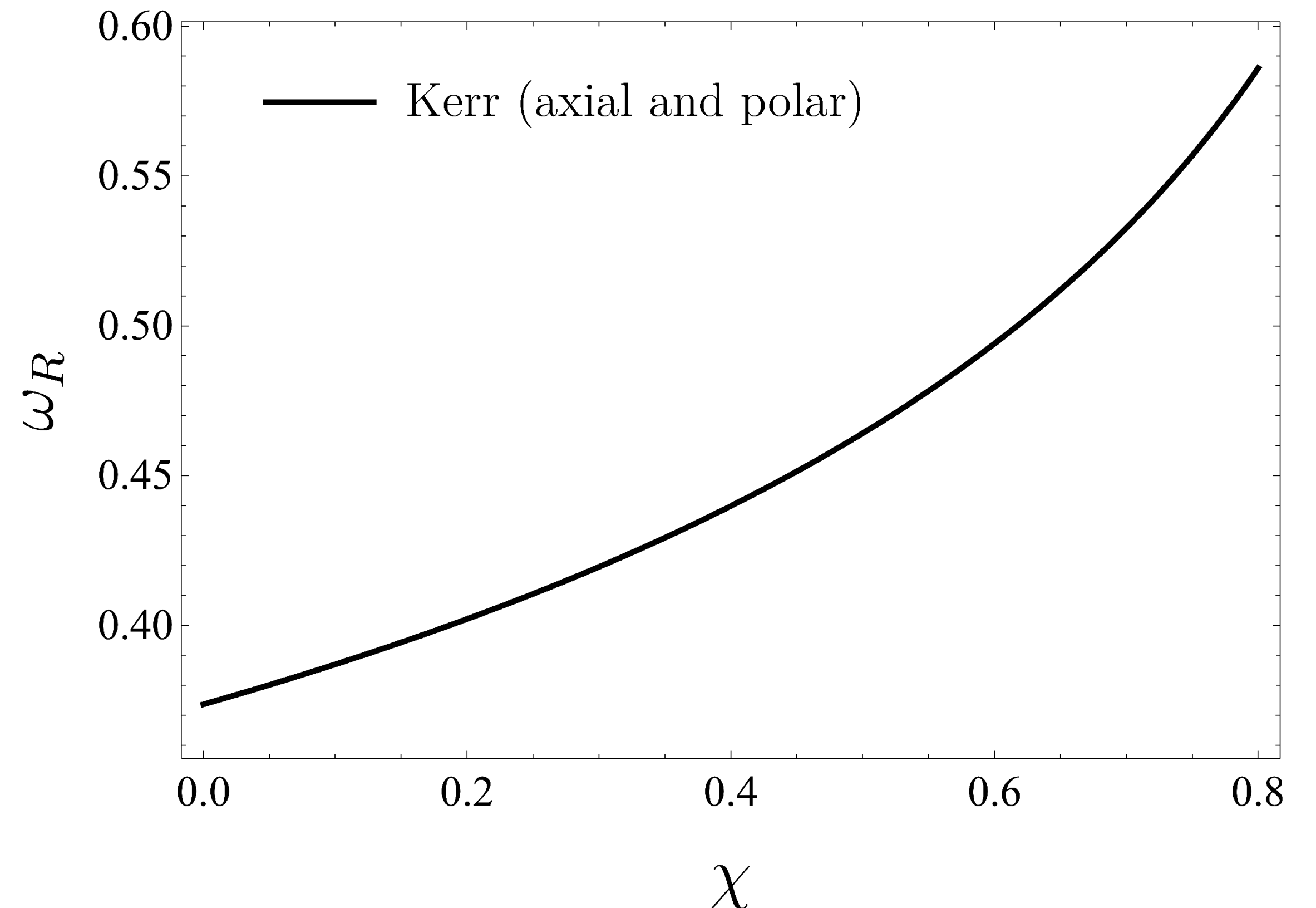
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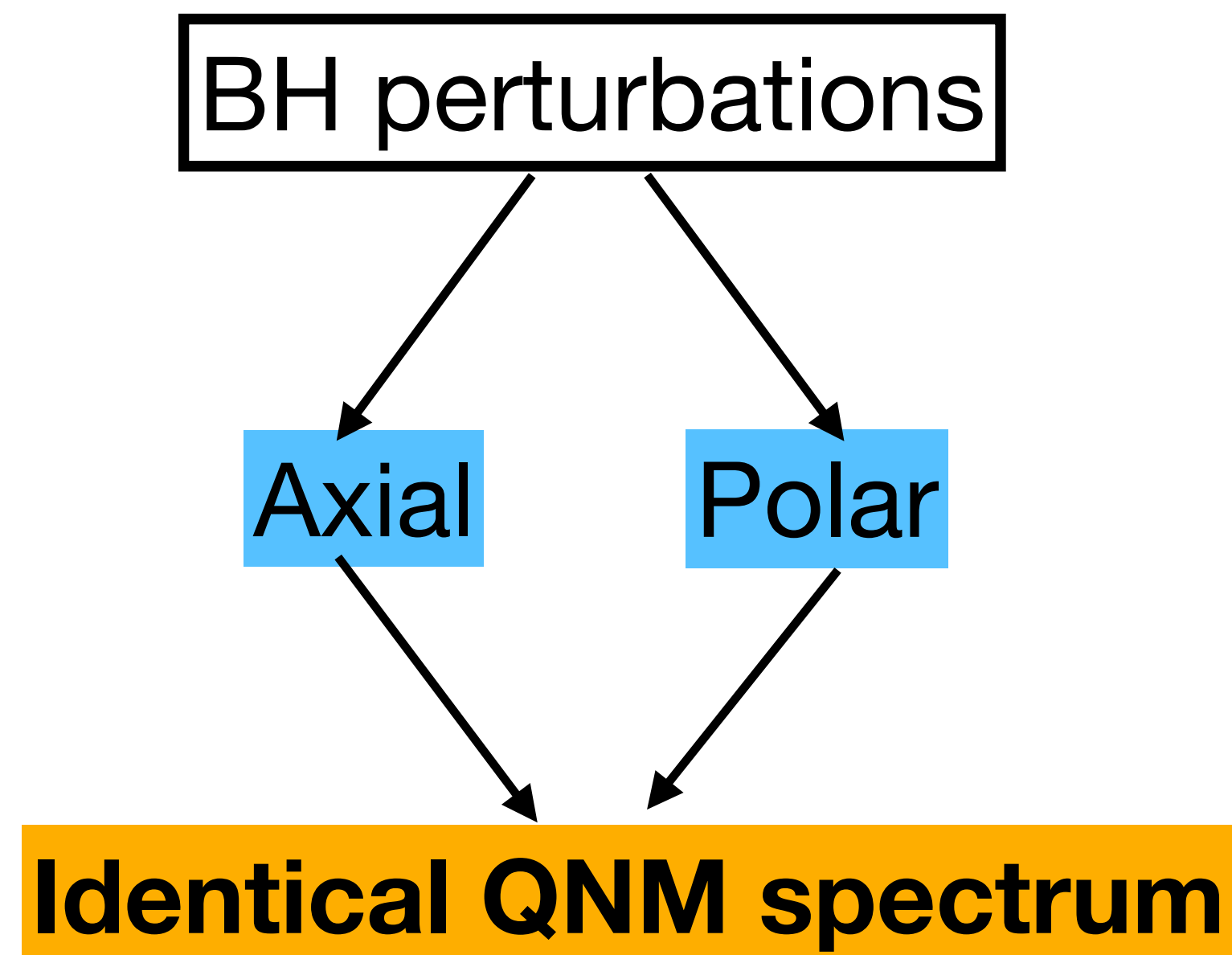
Isospectrality in GR



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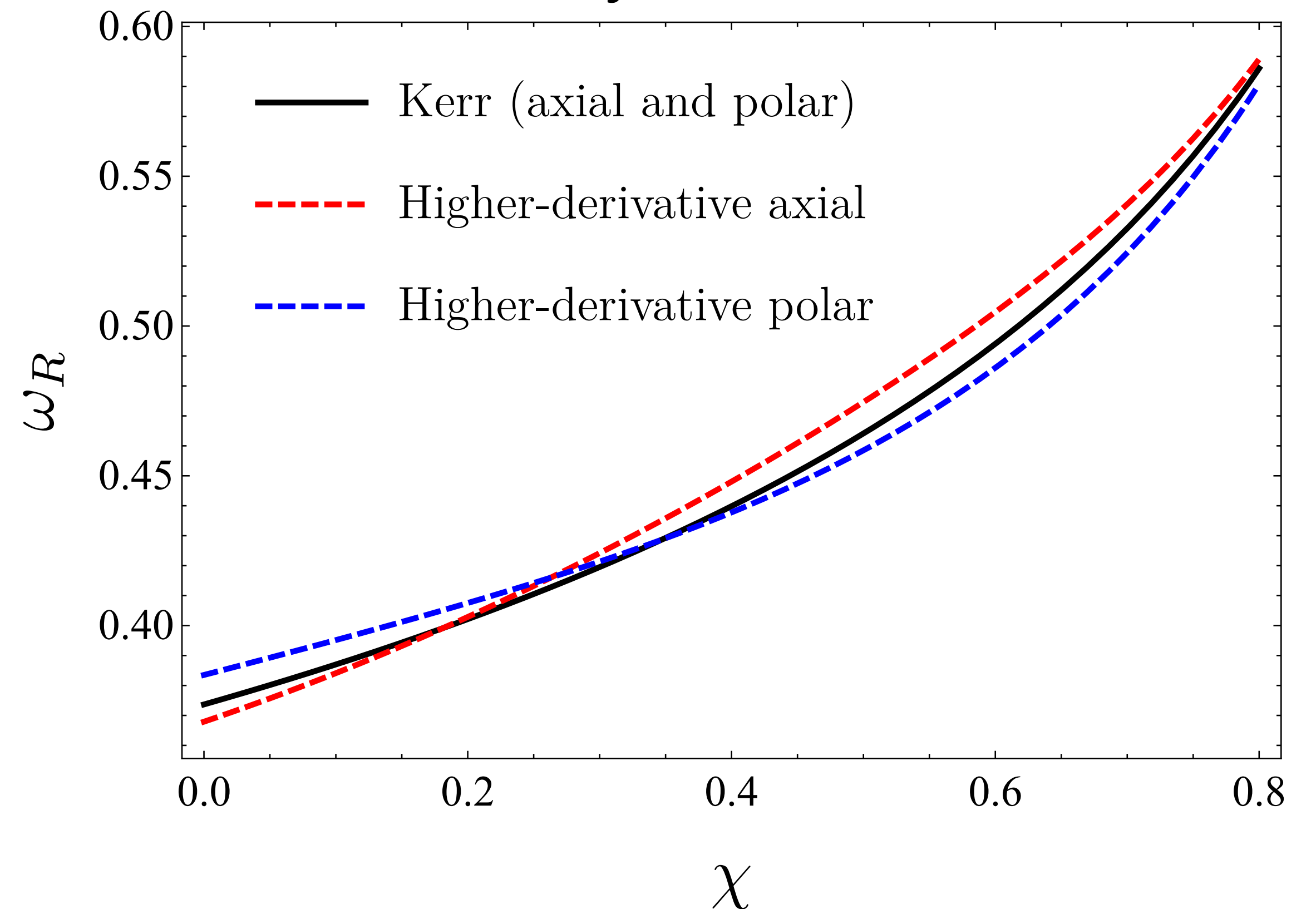
**QNM spectrum:** set of **characteristic frequencies** of black holes

Special property in GR: **isospectrality**



Not true in extensions of GR!

Isospectrality **breaking**  
beyond GR



**Is there any extension of GR that preserves isospectrality and/or non-birefringence?**

# Results

Found new class of theories such that

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- } *Isospectral EFTs*

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# Lowest order isospectral correction

$$S_{\text{iso}} = \frac{1}{16\pi G} \int d^4x \sqrt{-g} \left\{ R + \gamma \left[ \left( R_{\mu\nu\rho\sigma} R^{\mu\nu\rho\sigma} \right)^2 + \left( R_{\mu\nu\rho\sigma} \tilde{R}^{\mu\nu\rho\sigma} \right)^2 \right] + \dots \right\}$$

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4. **Matches String Theory prediction**  $S_{\text{iso}} = S_{II}^{\text{string theory}}, \quad \gamma = \frac{\zeta(3)}{256} \alpha'^3$

Supersymmetry? Duality? Born-Infeld-like gravity?

# Conclusion

- Identified a new class of isospectral extensions of GR
- These are theories with non-birefringent dispersion relation, implying isospectral eikonal QNMs
- This might be a key feature of quantum gravity
- Future directions: generalizations, phenomenology and understanding the connection to string theory

**Thank you for your attention**

# Bonus: eikonal QNMs and photon sphere

In GR eikonal QNMs are related to **unstable photon sphere geodesics**

QNM frequency  $\longleftrightarrow$  Orbital frequency  
Damping time  $\longleftrightarrow$  Lyapunov exponent

Beyond GR: Generalized correspondence

QNMs  $\longleftrightarrow$  Unstable **GW orbits** (not geodesic!)

**Isospectrality**  $\longleftrightarrow$  **non-birefringence**

