

# An explanation for the absence of secondary peaks in black hole light curve autocorrelations

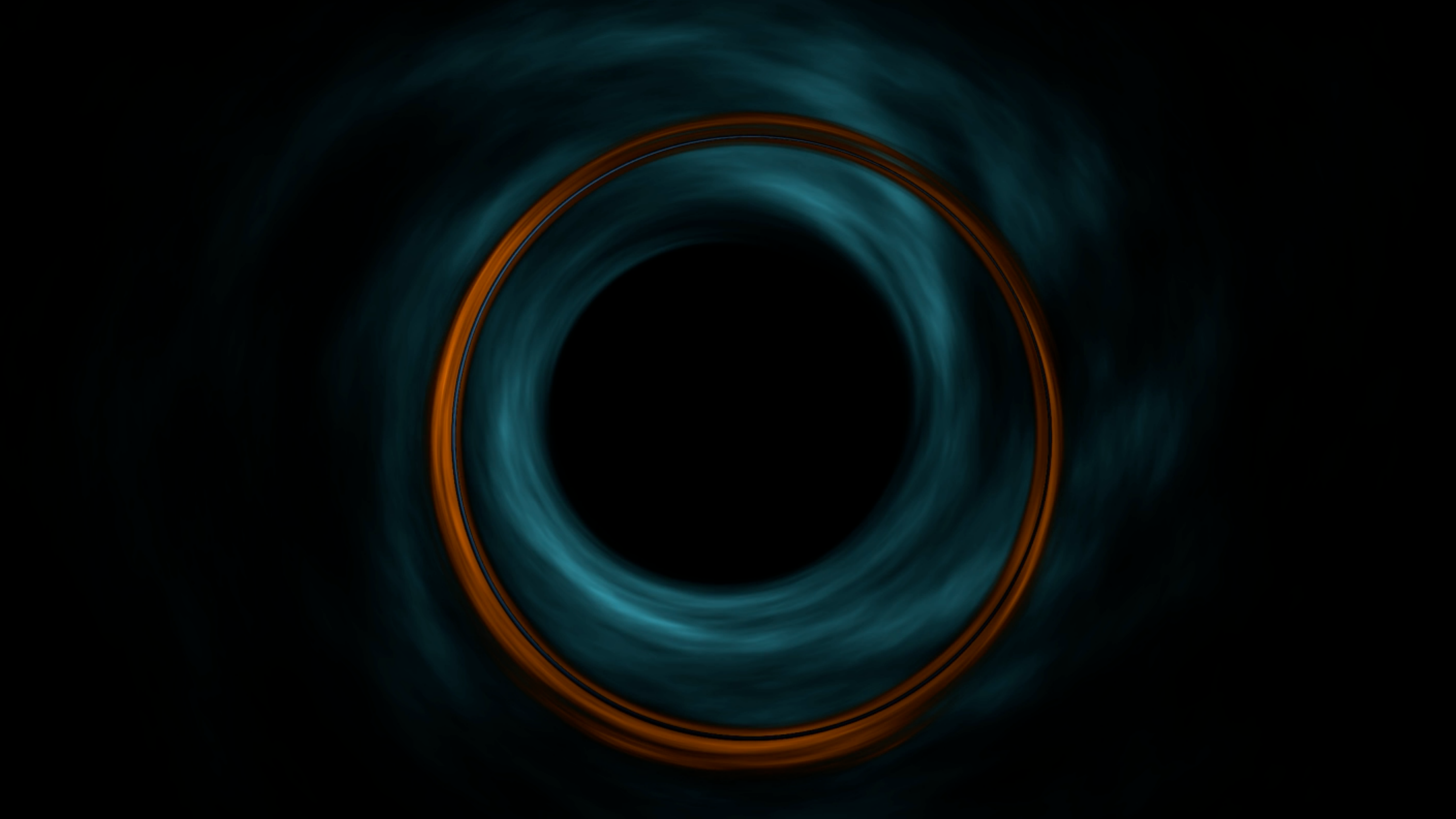
**Alejandro Cárdenas-Avendaño**

*Computational Physics and Methods (CCS-2) & Center for Nonlinear Studies (CNLS)*  
Los Alamos National Laboratory

LA-UR-24-32136



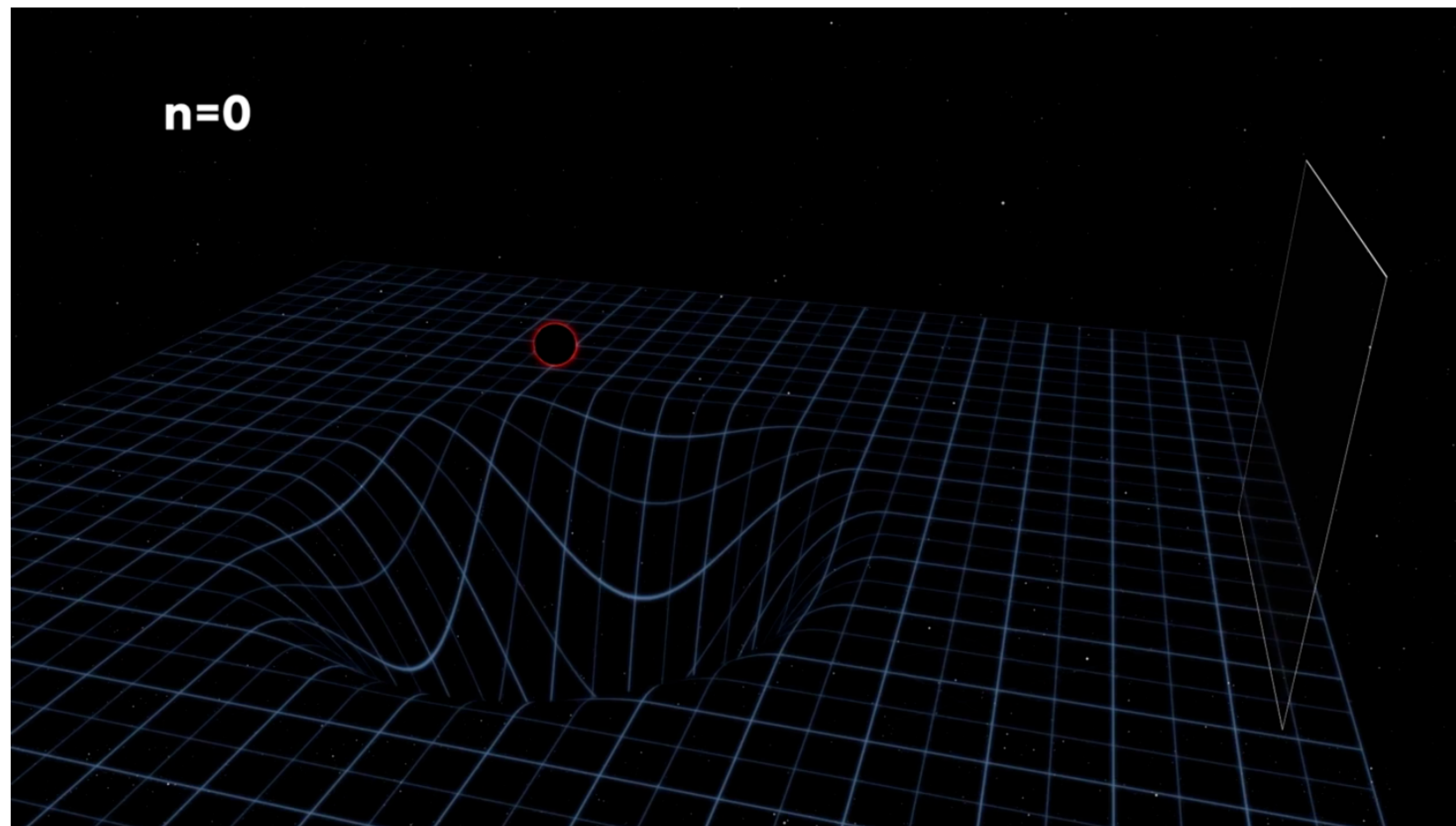
Managed by Triad National Security, LLC, for the U.S. Department of Energy's NNSA.



# The Black Hole Photon Shell:

A region where photons can move in **bound** orbits

e.g., Luminet, A&A, 75, 228 (1979); Ohanian, AJP 55, 428 (1987); Johnson, Lupsasca, Strominger, et al., (1907.04329)



Credit: Center for Astrophysics | Harvard & Smithsonian

**Three quantities** describe this behavior:

$\lambda$  • Instability of the nearly-bound orbits.  
• A **demagnification** by  $e^{-\lambda}$ .

$\delta$  • Change in the **azimuthal angle** over  
• a polar half-libration.

$\tau$  • The **period** of a polar half-libration.

A. C-A, et al, (2406.04176)

M. D Johnson et. al, (incl. A.C-A) (2406.12917)

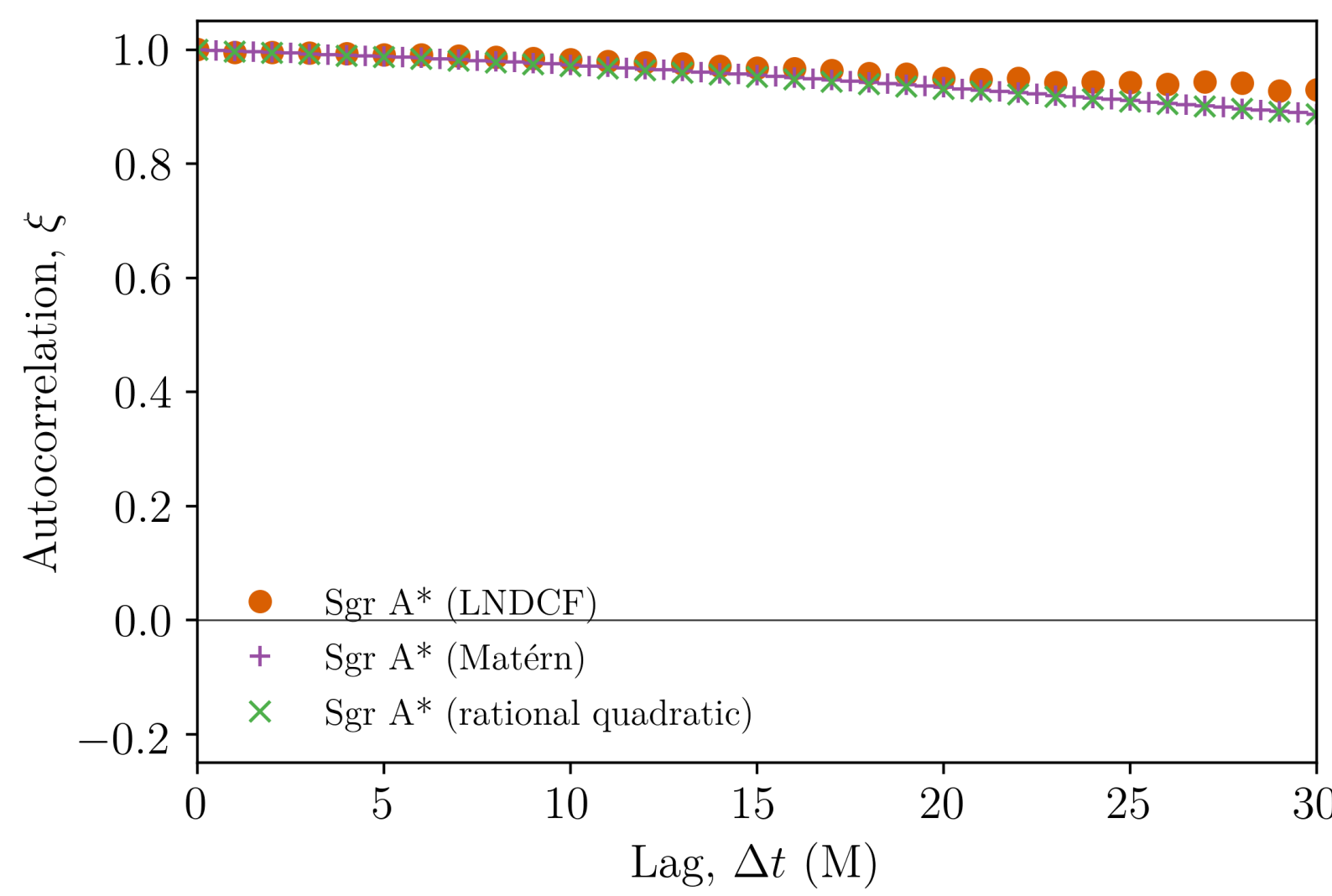
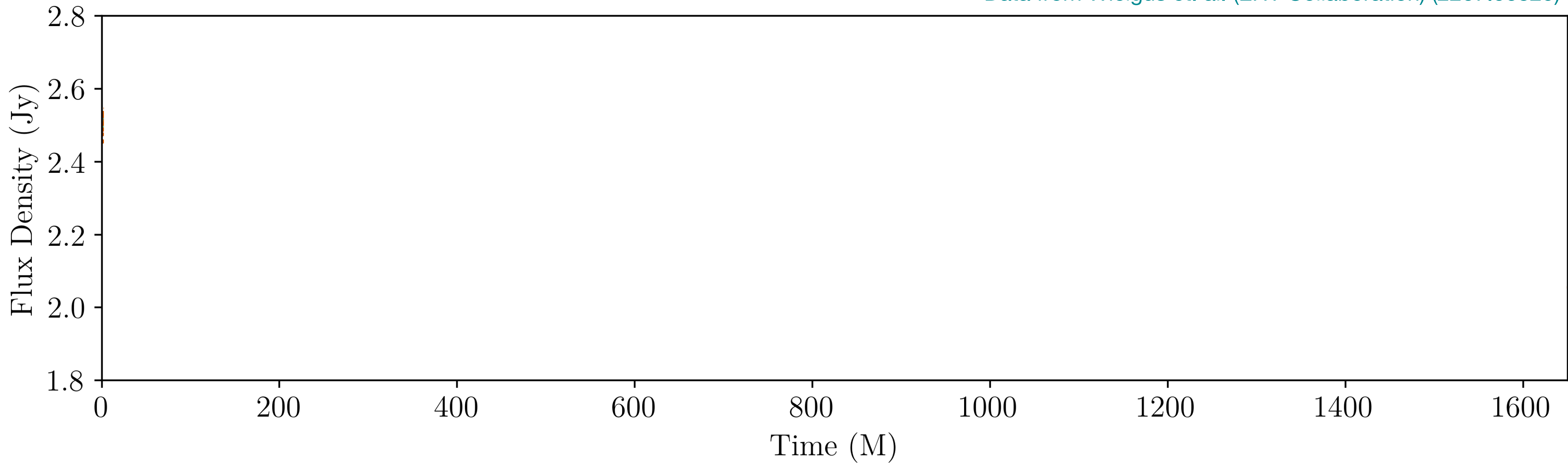
A. Lupsasca, A. C-A, et al, (2406.09498)



The **Black Hole Explorer**

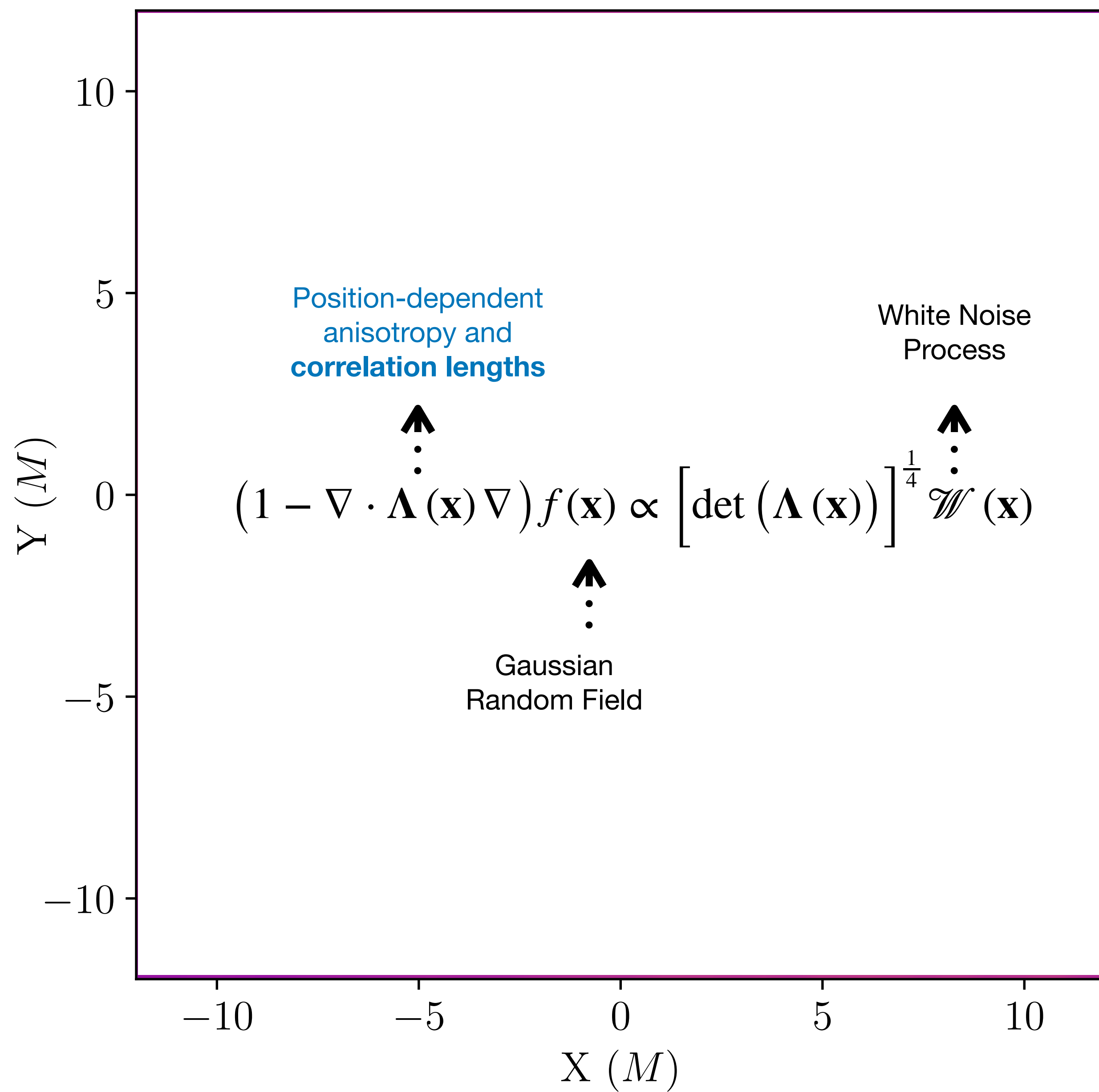
# Observed light curves from the Galactic Center

Data from Wielgus et. al. (EHT Collaboration) (2207.06829)



**Where are the  
echoes/delays?!**

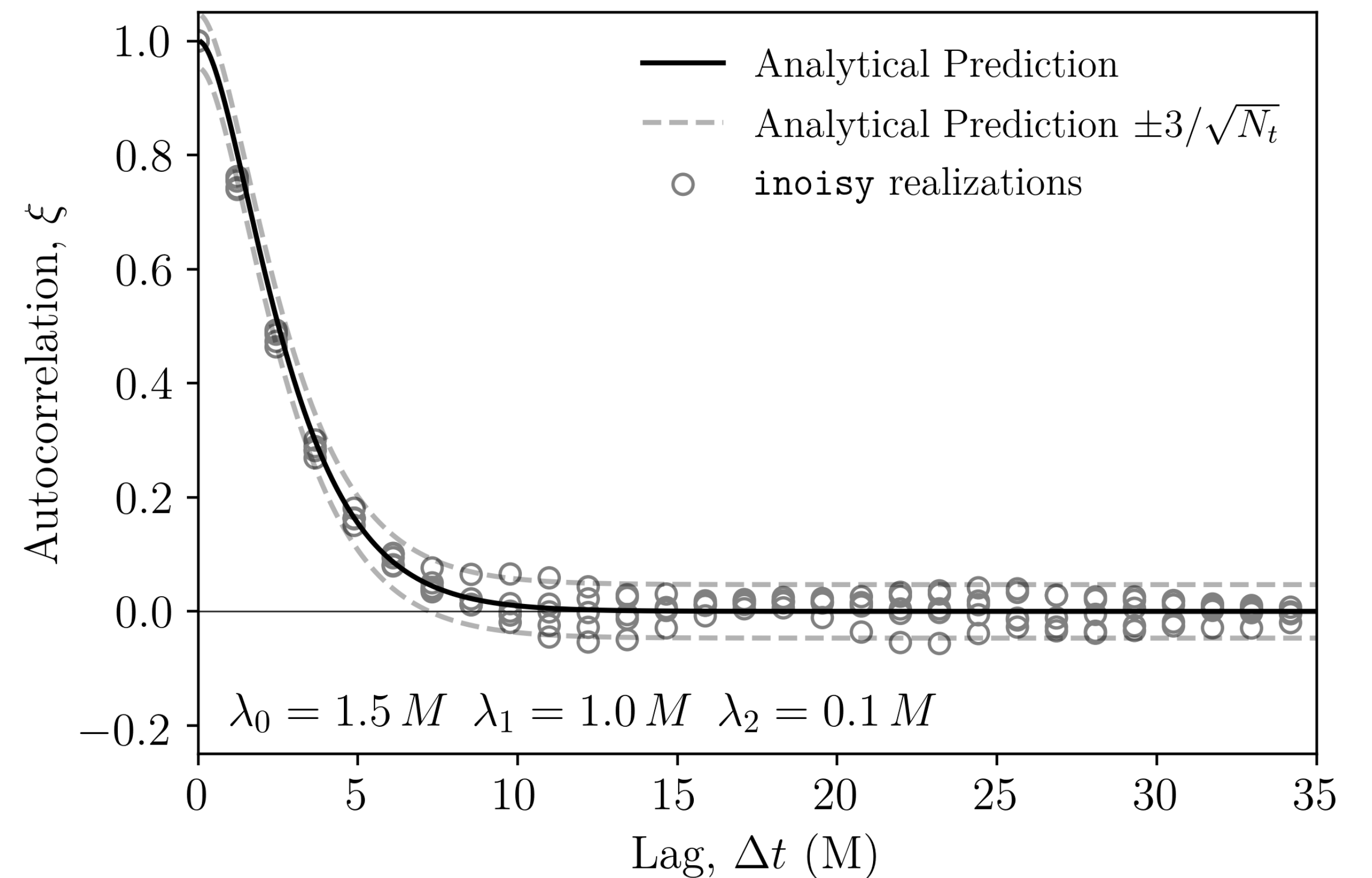
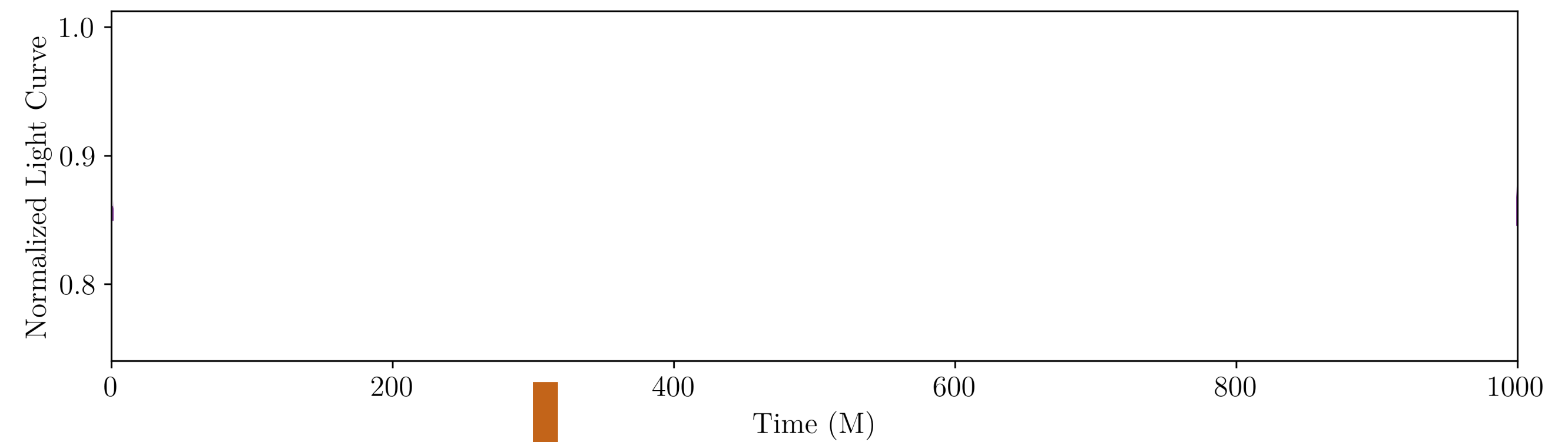
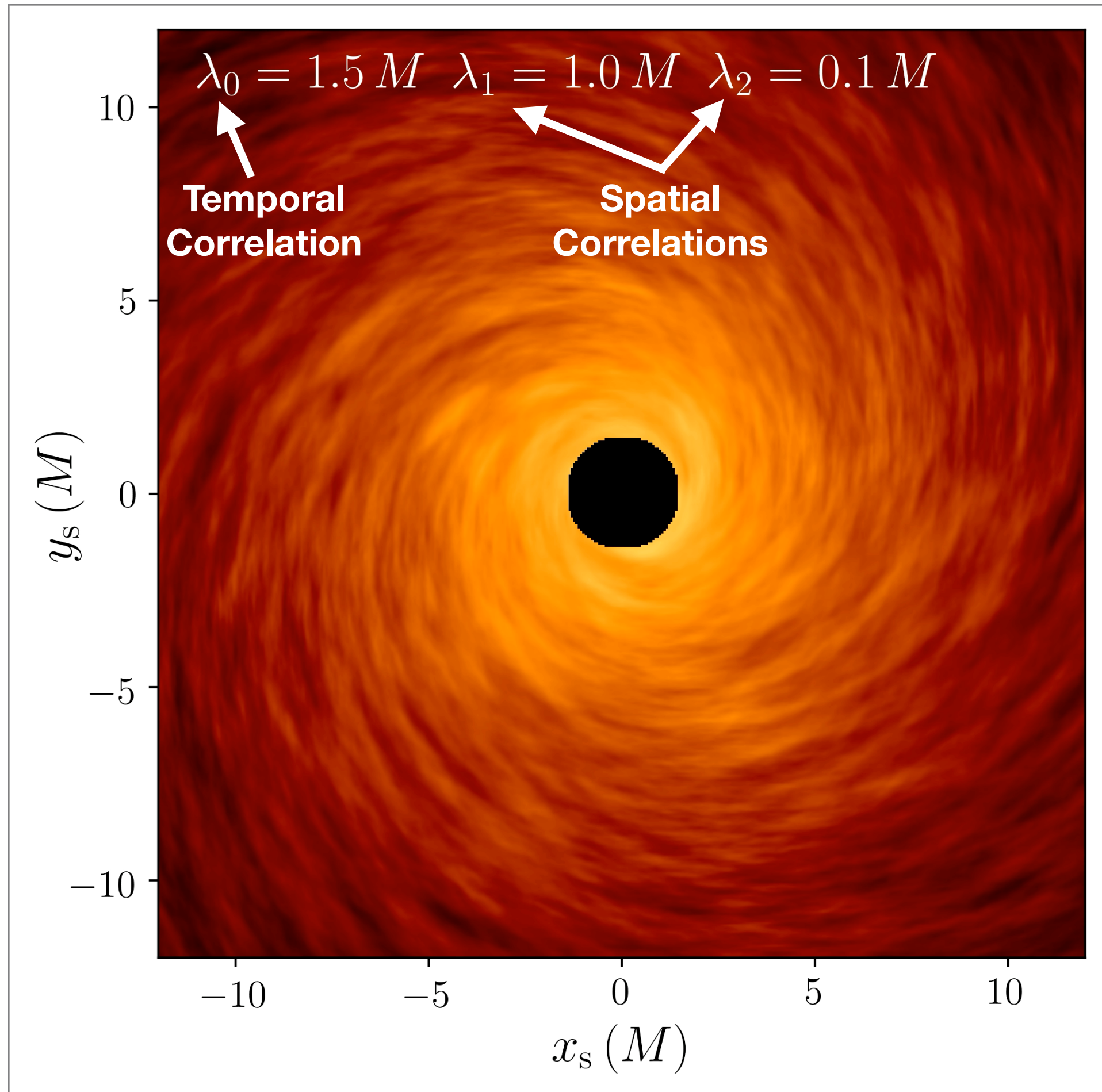
# *inoisy*



# Autocorrelations:

## No relativistic effects

A C-A, Gammie & Lupsasca (2406.04176)

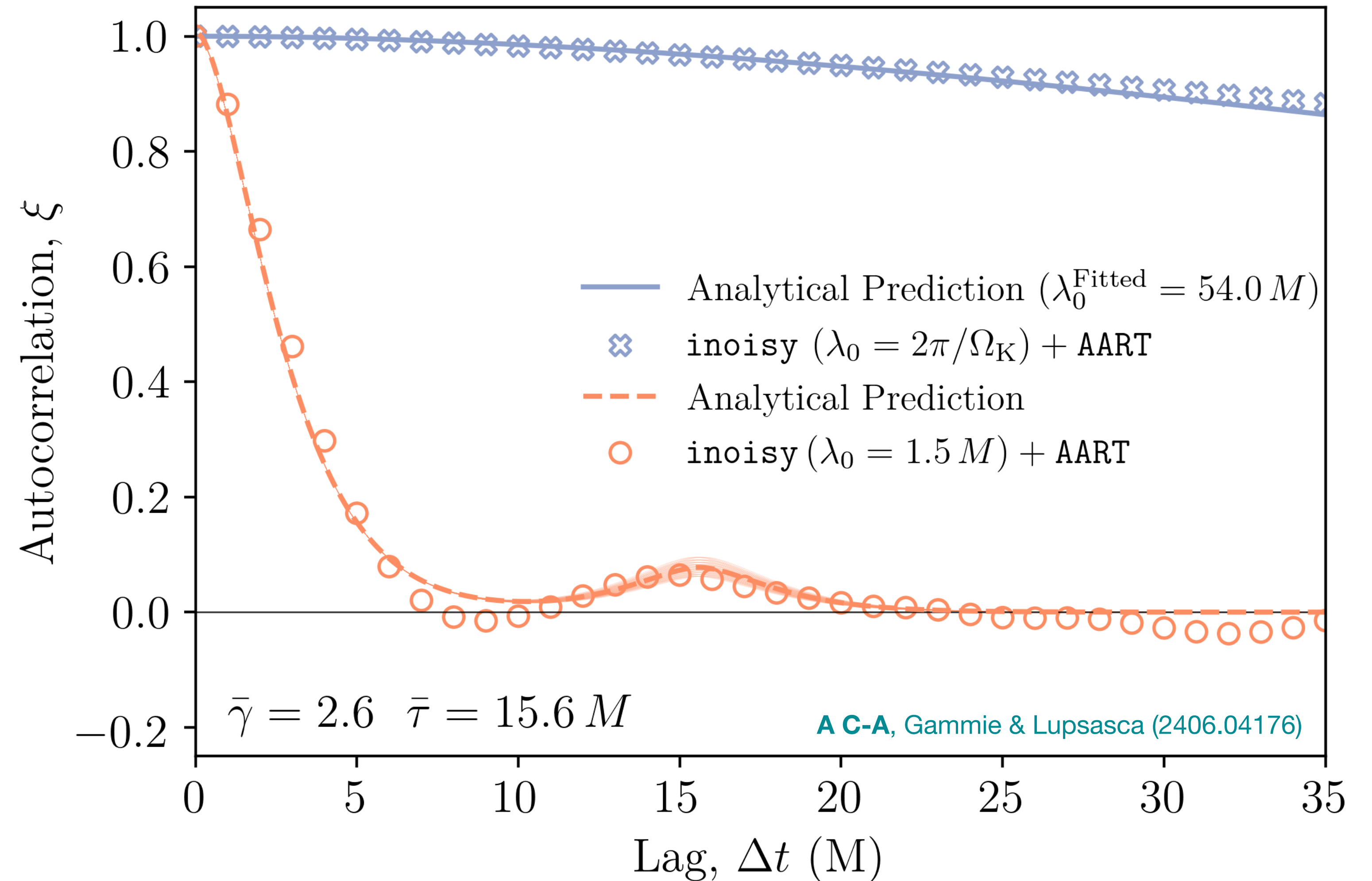


# Autocorrelations:

## Relativistic effects

**Spin:**  
 $a/M = 0.94$

**Observers' inclinations:**  
 $\theta_o = 20^\circ$

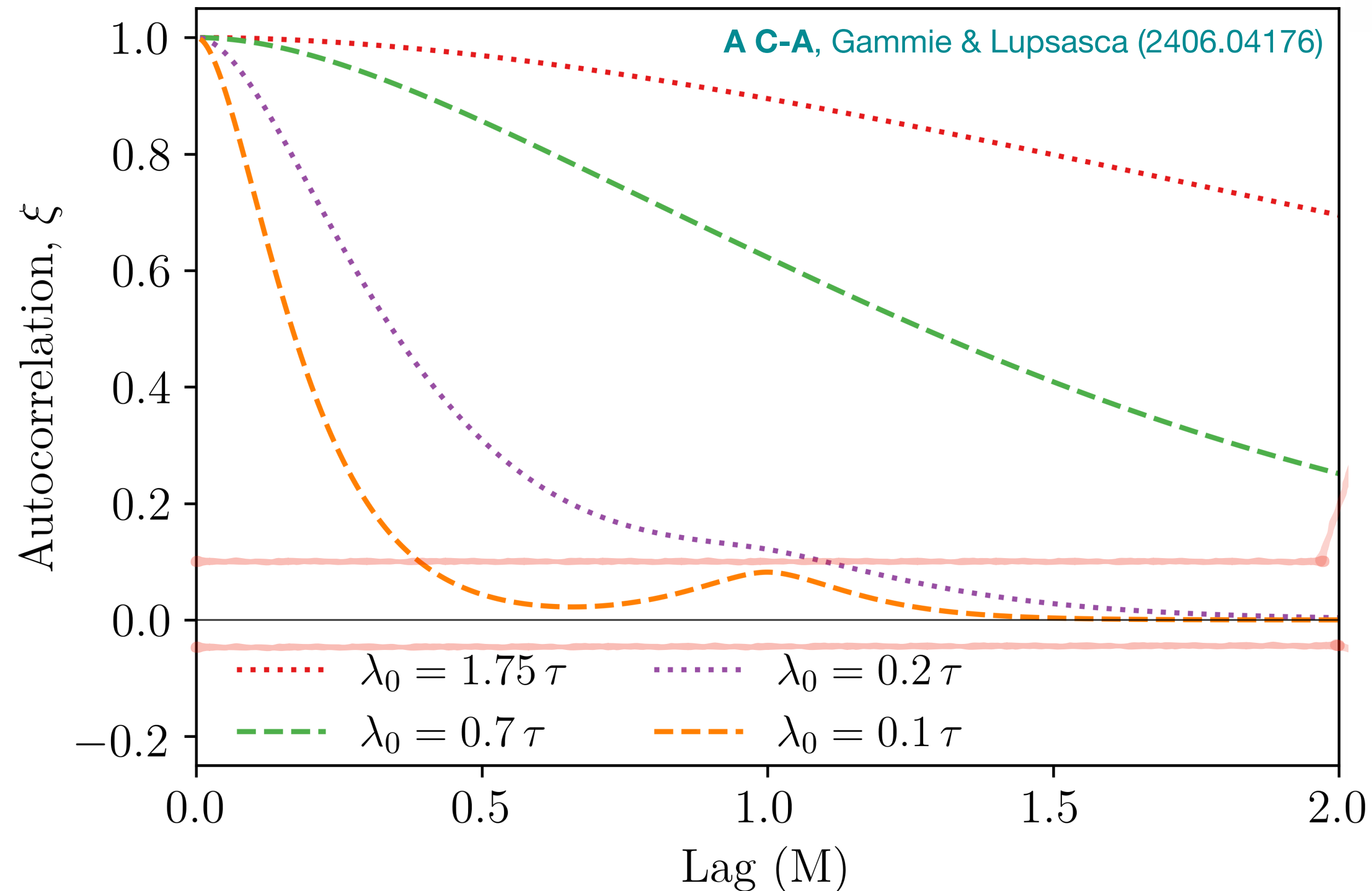


# An analytical model for the autocorrelation

$$\xi \propto f_1 [\text{Emission parameters}] + f_2 [\text{Emission parameters}, \gamma(a, \theta_o), \tau(a, \theta_o)]$$



$$\frac{\lambda_0}{\tau}$$



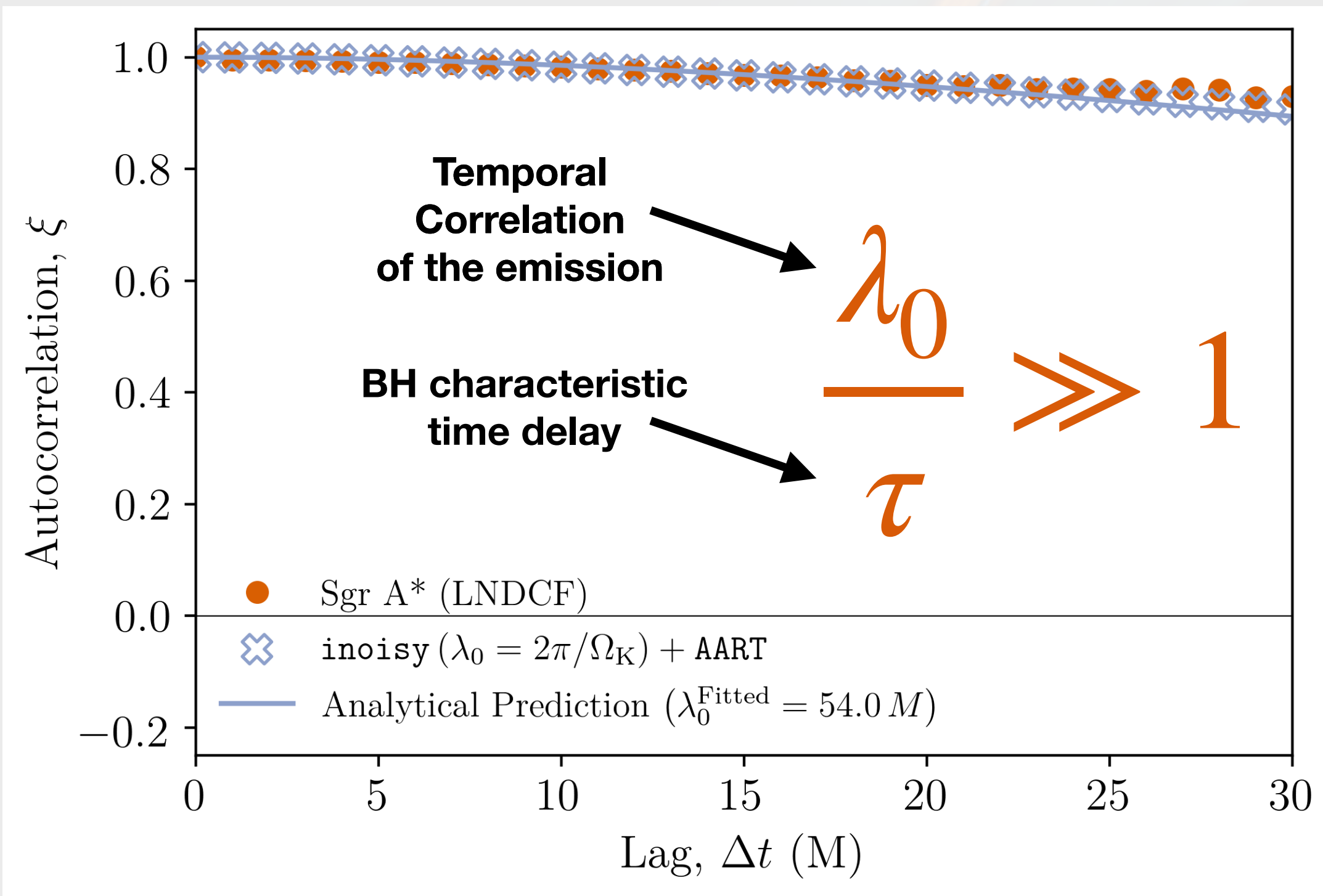
# Discussion

<https://github.com/iAART/aart>

`pip install aart`



More details: (arXiv:2406.04176)



We have **developed an analytical model** that provides insights into the complexities of separating the effects of plasma characteristics and spacetime geometry on emitted light.

We show that the time correlations inherent in the **emitting plasma** can mask the expected **signatures of spacetime geometry**, through light echoes, in observed data.

Wong, Medeiros, A. C-A & Stone (2410.10950)

Although **direct measurement of echoes** is hard, detecting their interferometric signature **may be feasible!**

**Thank you!**

[cardenas-avendano@lanl.gov](mailto:cardenas-avendano@lanl.gov)