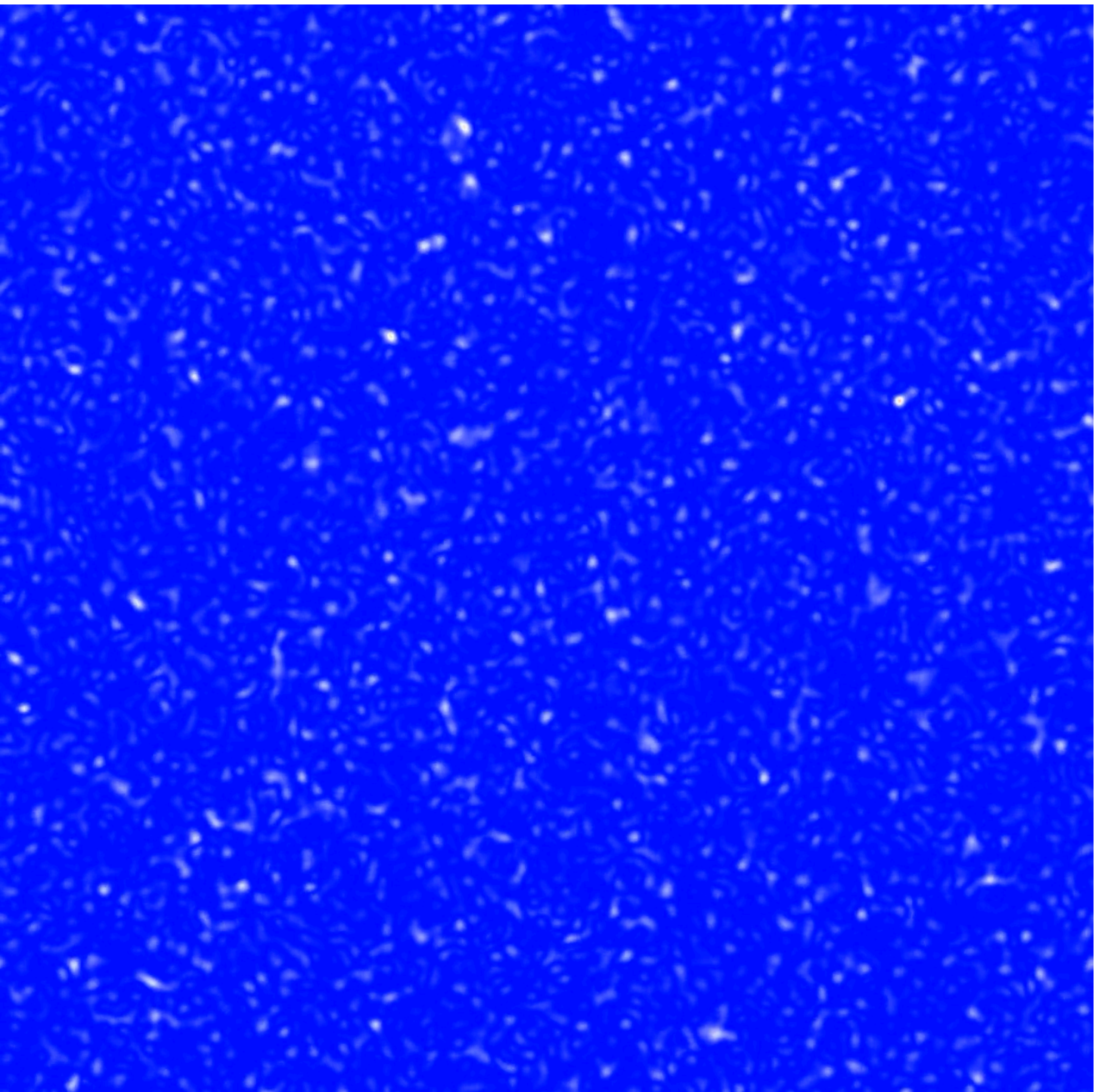
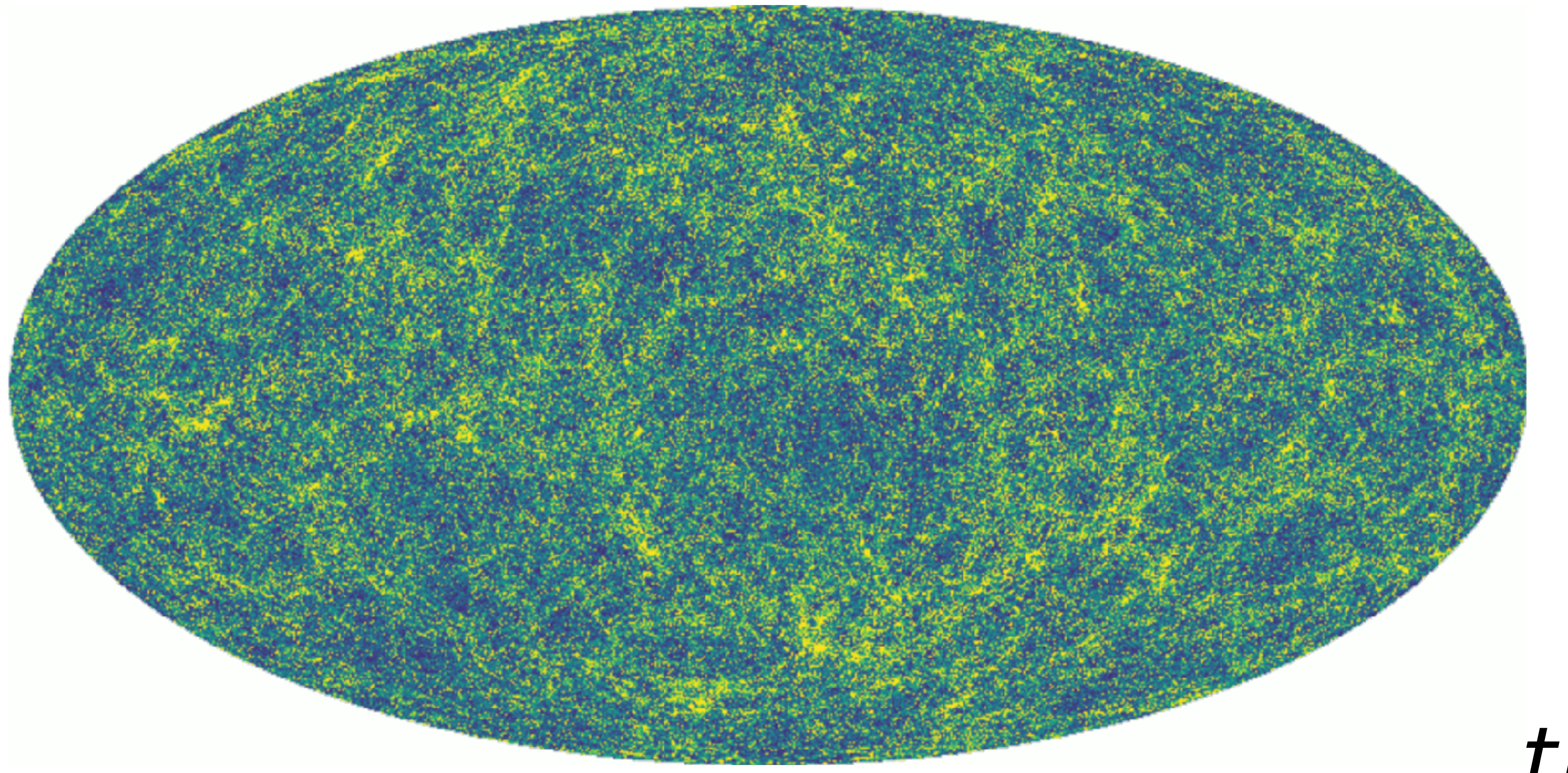

Flash Talks

GW Probes of the Early Universe

Alex Jenkins (acj46) | KICC/DAMTP | Office K01, Kavli Bldg.

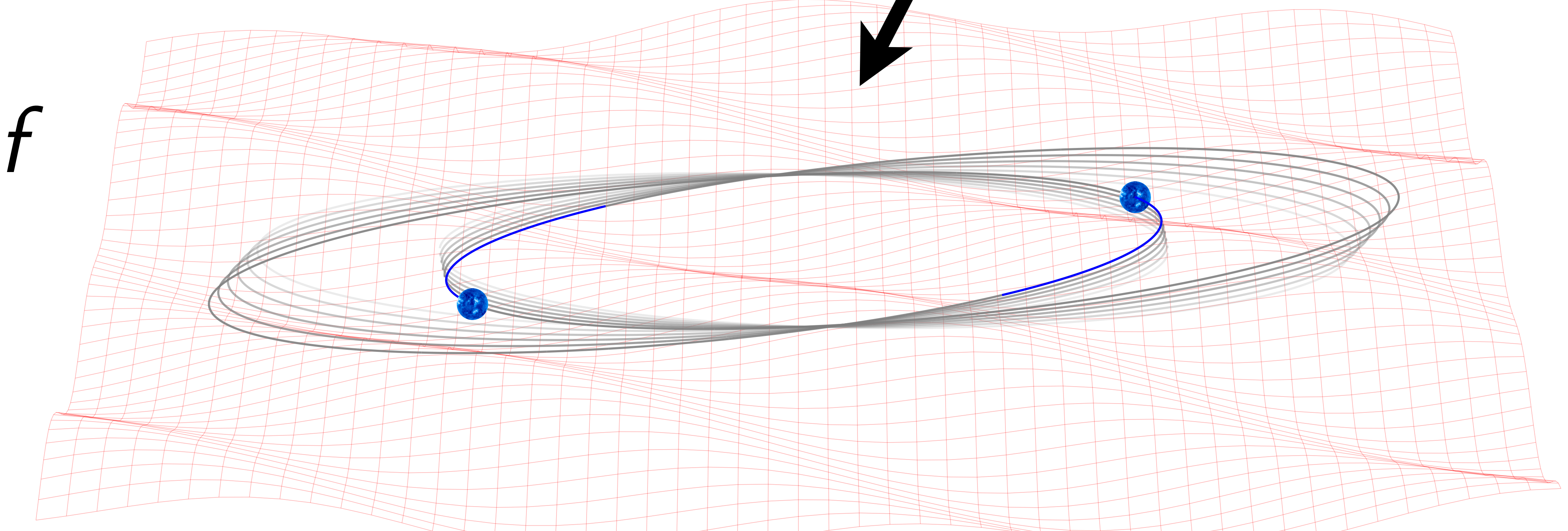
GWs from cosmological phase transitions





GW sources as tracers of cosmic structure

Detecting GWs via their effects on binaries



Mathematical and Computational Challenges in GW Astronomy

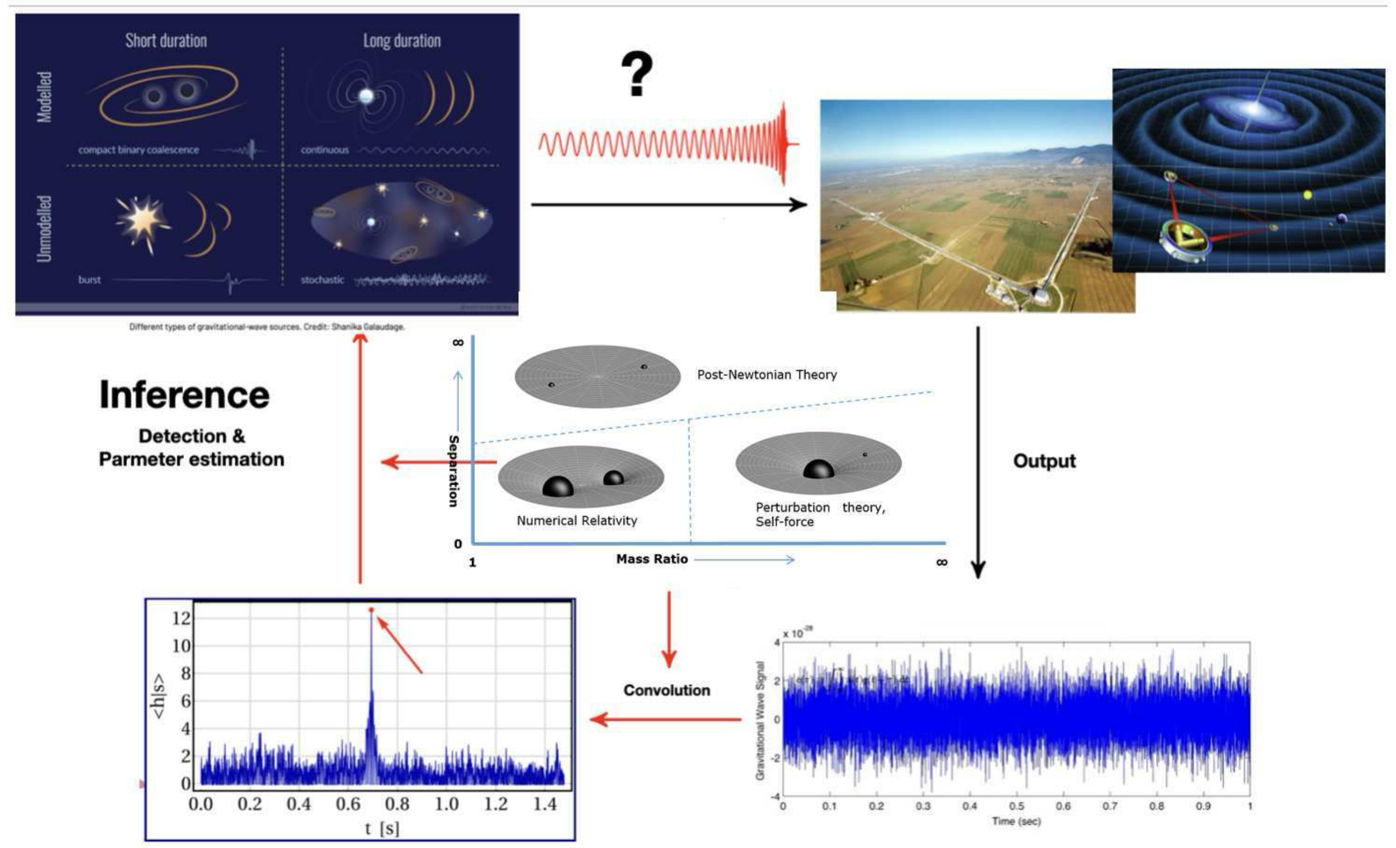
Objective: Contributing to ongoing efforts to maximize the capabilities of GW detectors and their scientific return. My focus is on two key aspects:

Modelling

- EMRI Dynamics: Exploiting the Hamiltonian formulation of binary evolution, incorporating the conservative self-force to consistently integrate orbits and extract GW waveforms.

Inference

- GW characterization and compression to enhance signal analysis and parameter estimation, particularly for the LISA global fit.
- Developing more informative priors for inference using data fusion techniques.



An Open Effective Field Theory for Gravitational Waves

Lennard Dufner, Thomas Colas & Enrico Pajer (DAMTP)

Motivation:

- Gravitational waves propagate through medium (dark matter, dark energy, …)
- Medium fills spacetime and has unknown microphysics
- Open effective field theory approach necessary to parametrise our ignorance

Objectives:

- Describe the propagation of GWs by an open & local effective field theory
- Derive phenomenological implications (dissipation, birefringence, noise, modified speed):

$$\ddot{\gamma}_{ij} + (3H + \Gamma)\,\dot{\gamma}_{ij} + c_T^2 k^2 \gamma_{ij} + \beta \epsilon_{ijl} \gamma_{ij} k_l = 0$$

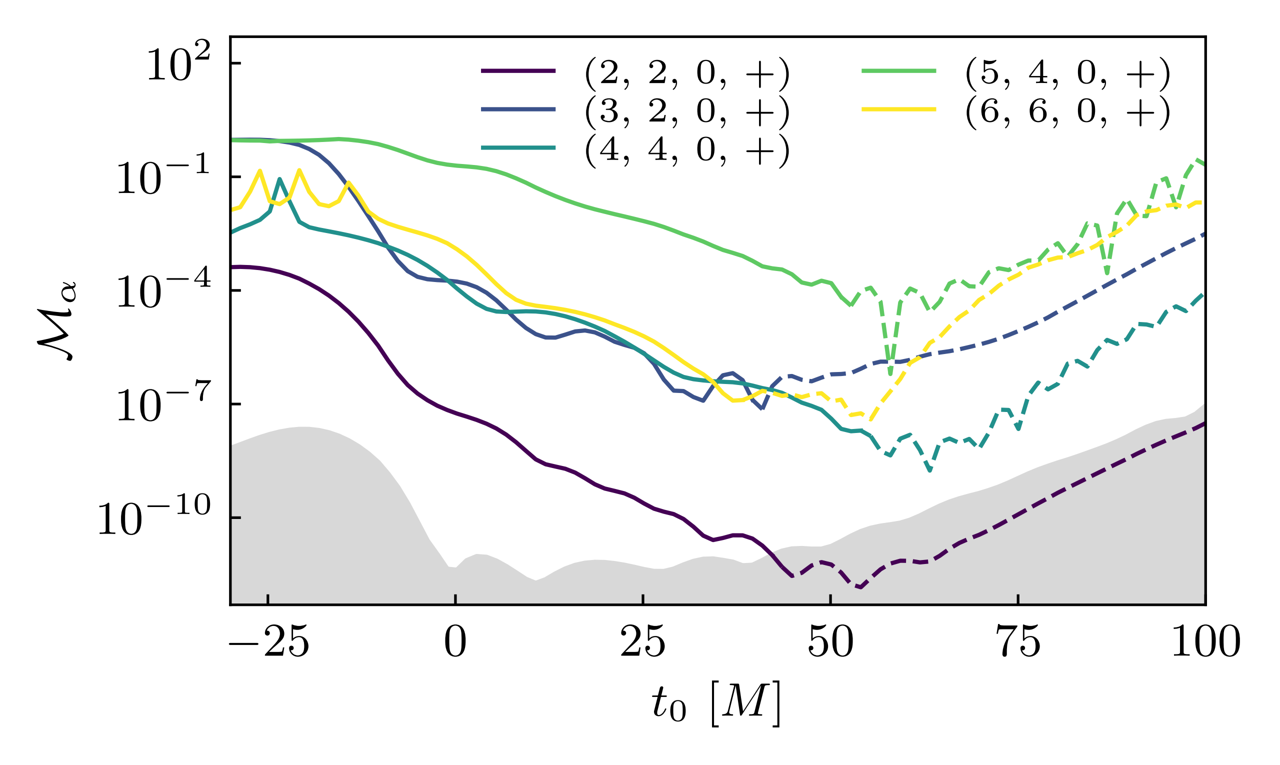
- Match to known & new microphysical theories

Novel Approaches to Black Hole Ringdown Fits

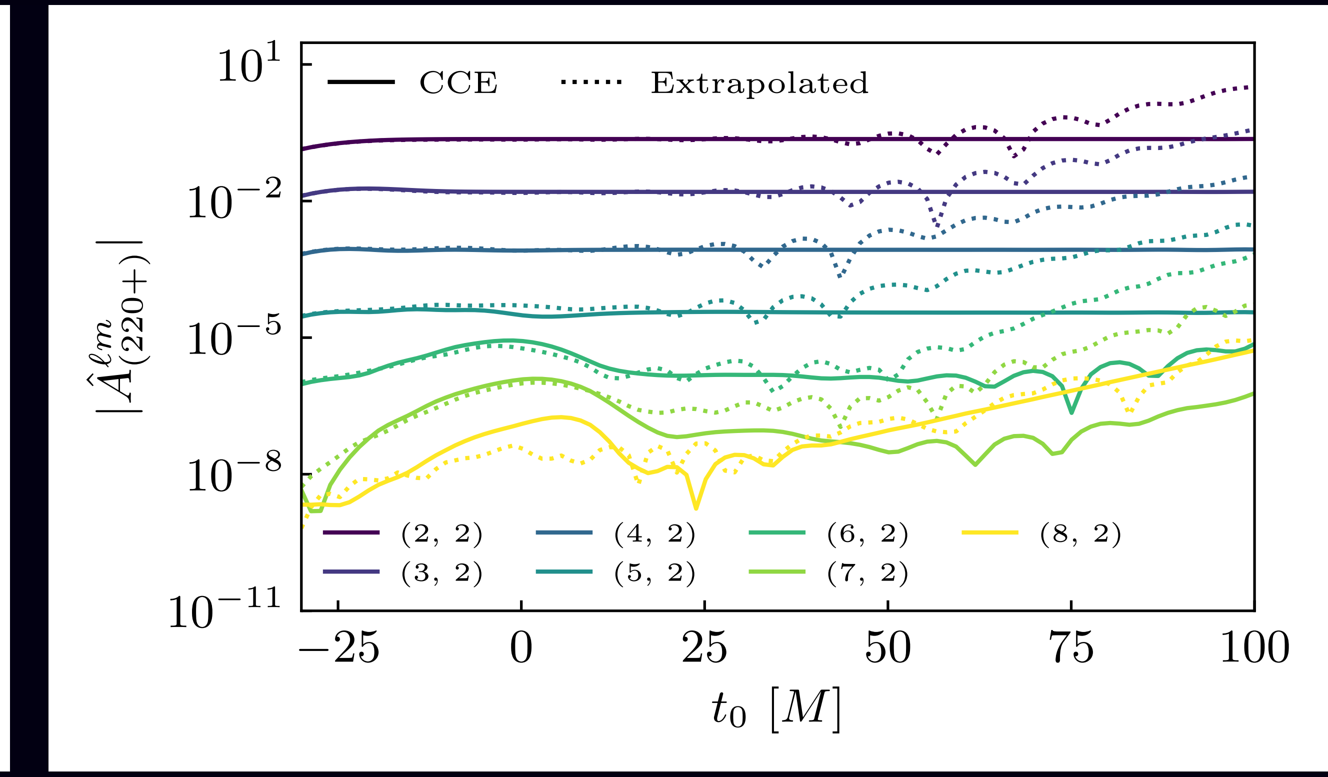
Richard Dyer | Institute of Astronomy | rvnd2

Black Hole Cartography:

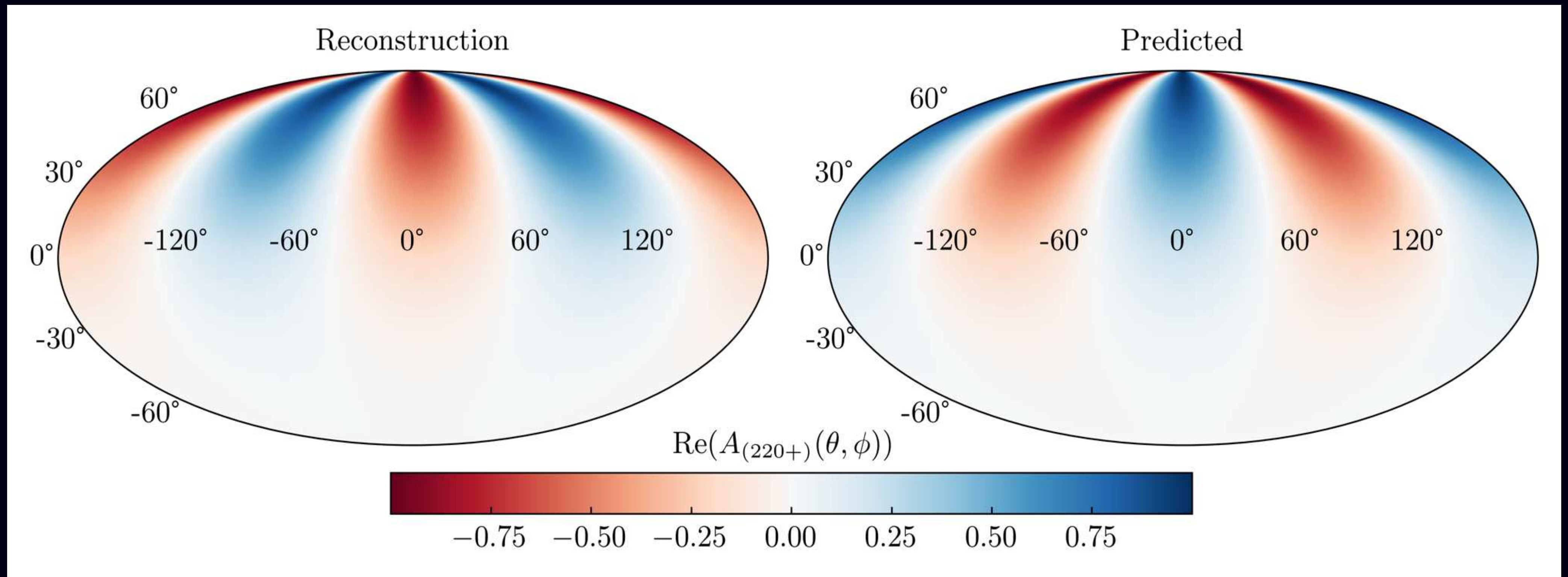
Dyer & Moore (2025)



Spatial Mismatch



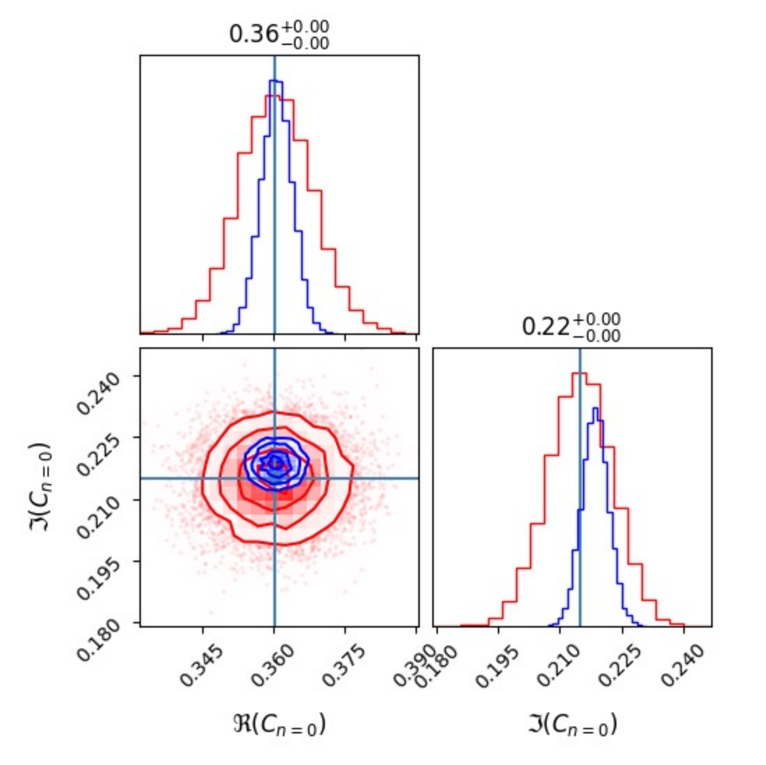
CCE vs Extrapolated NR Simulations



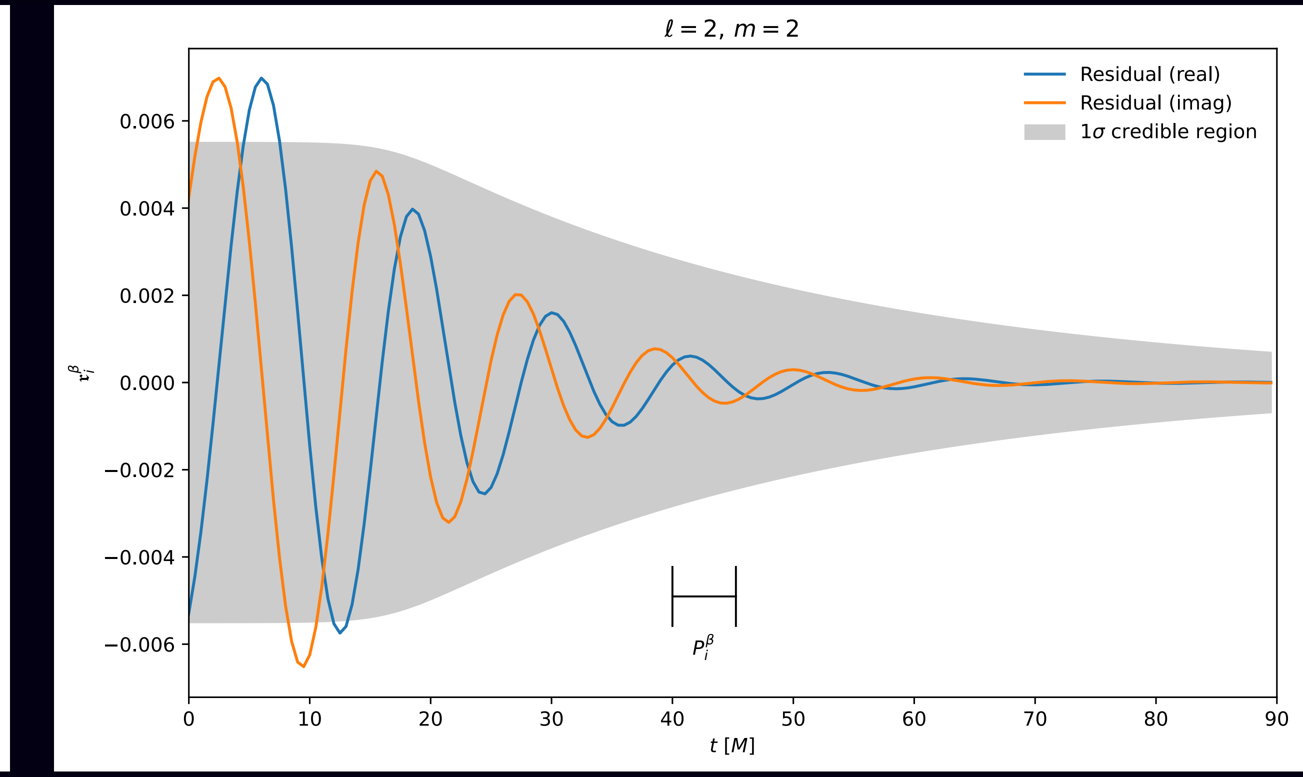
Spatial Mapping

Gaussian Process QNM Fits:

Preliminary Results



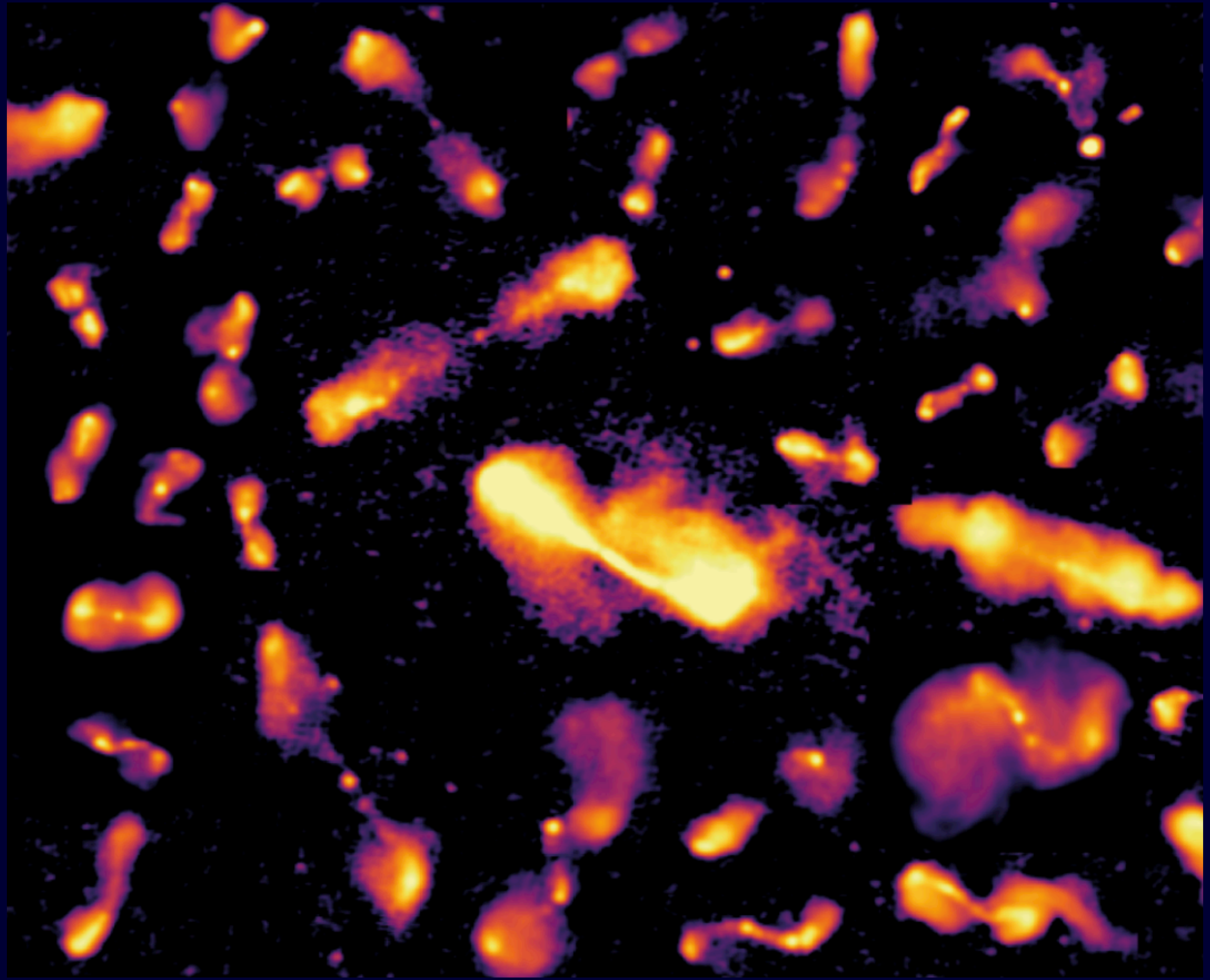
Bayesian QNM Fit



CCE Noise Kernel

Questions:

- What QNMs are detectable in the ringdown, and when?
- Are overtones and nonlinear features present?
- Are quadratic QNMs related to memory?



Radio galaxies showing multiple "precession indicators" are most likely to host supermassive black hole binaries

RESEARCH GOAL:

TO USE A COMBINATION OF HIGH-RESOLUTION SIMULATIONS, STATISTICAL MODELLING AND LARGE SURVEYS TO IDENTIFY HOST GALAXY CANDIDATES FOR FUTURE CONTINUOUS GRAVITATIONAL WAVE DETECTION

KEY RESULTS:

RADIO EMISSION FROM AGN CAN SHOW CLOSE SUPERMASSIVE BINARIES
PREVALENCE OF "PRECESSION INDICATORS" LINKED TO GALAXY MASS
APPROX 250 SMBHB CANDIDATE HOST GALAXIES IDENTIFIED
FOLLOW-UP STUDIES AT HIGH FREQUENCIES CAN IMPROVE MODELLING

FUTURE WORK:

USE GALAXY MASS, REDSHIFT AND MORPHOLOGY TO PREDICT BINARY SEPARATION
GW MODELLING FOR REALISTIC DETECTIONS FOR FUTURE INSTRUMENTATION

Searching for Large-Scale Signatures of Supermassive Black Hole Binary Candidates

MAYA A HORTON (MAH241@CAM.AC.UK)

Kilonova Seekers

The GOTO project for real-time citizen science in time-domain astrophysics

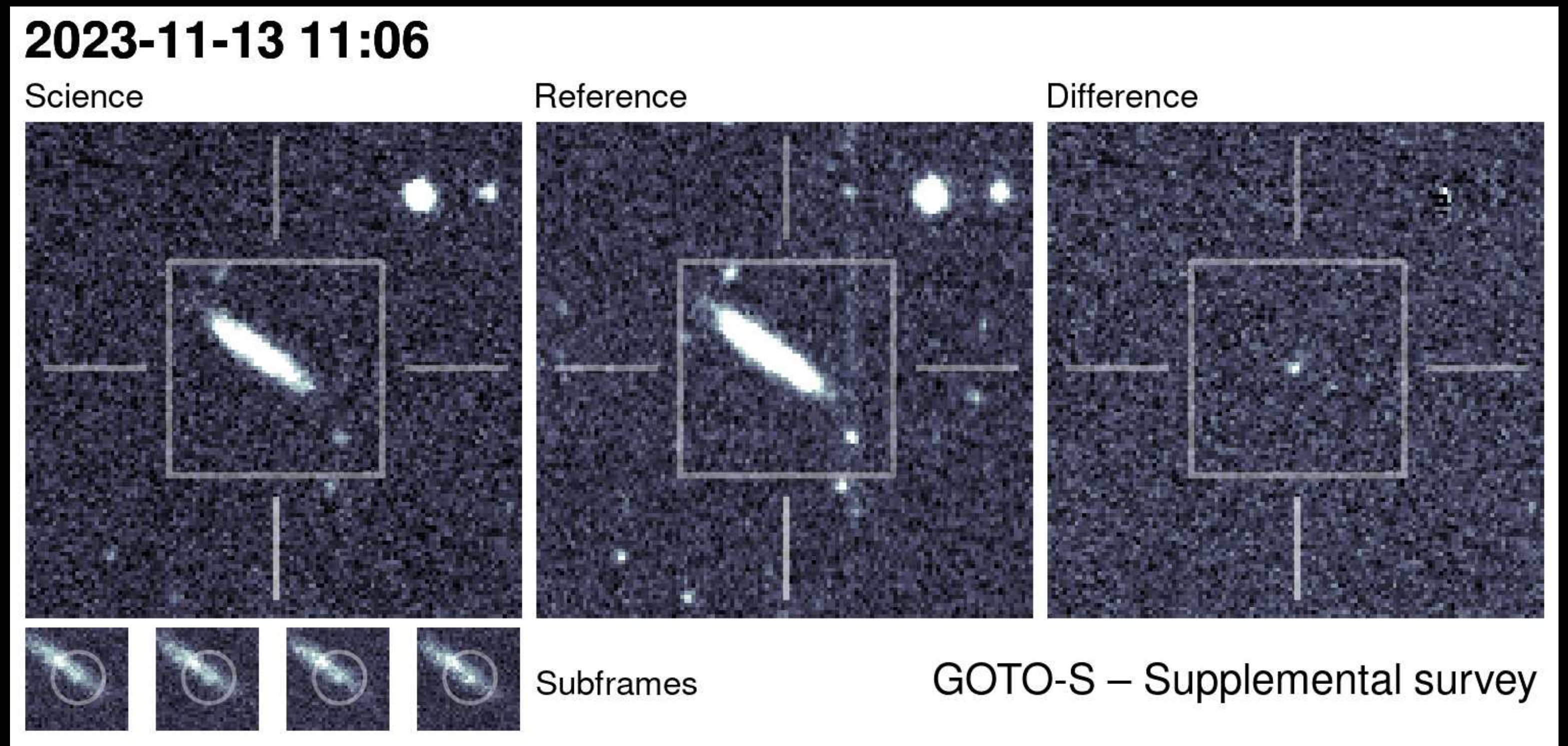
Leads: Lisa Kelsey and Tom Killestein

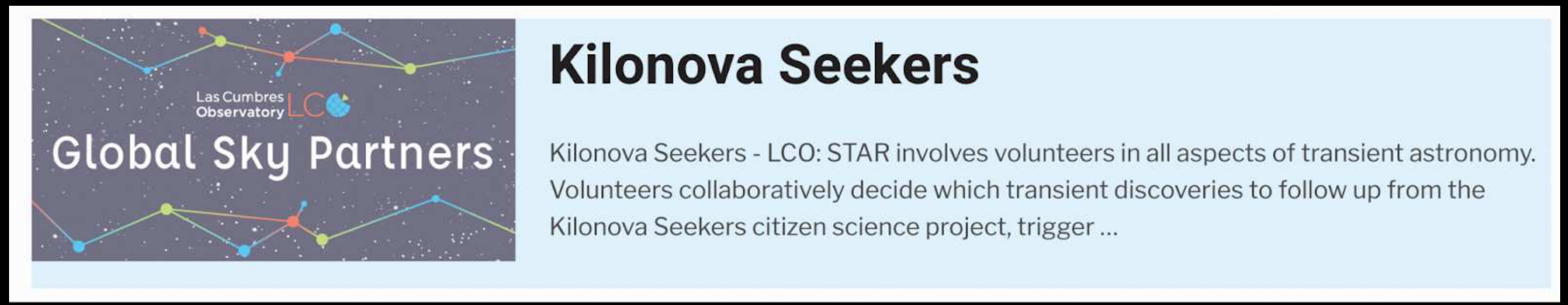
GRAVITATIONAL-WAVE OPTICAL TRANSIENT OBSERVER

- GOTO designed for optical follow-up of gravitational-wave events
- Kilonova Seekers involves members of the public in these searches in real-time - new data every 15mins
- Focusing on candidates where the real-bogus classifier is uncertain – searching for exciting new transients
- Key numbers:
  - > 3000 volunteers
  - In 105 countries around the world
  - > 2,000,000 classifications
  - > 170,000 human-labelled subjects

kilonova-seekers.org

Read the paper:

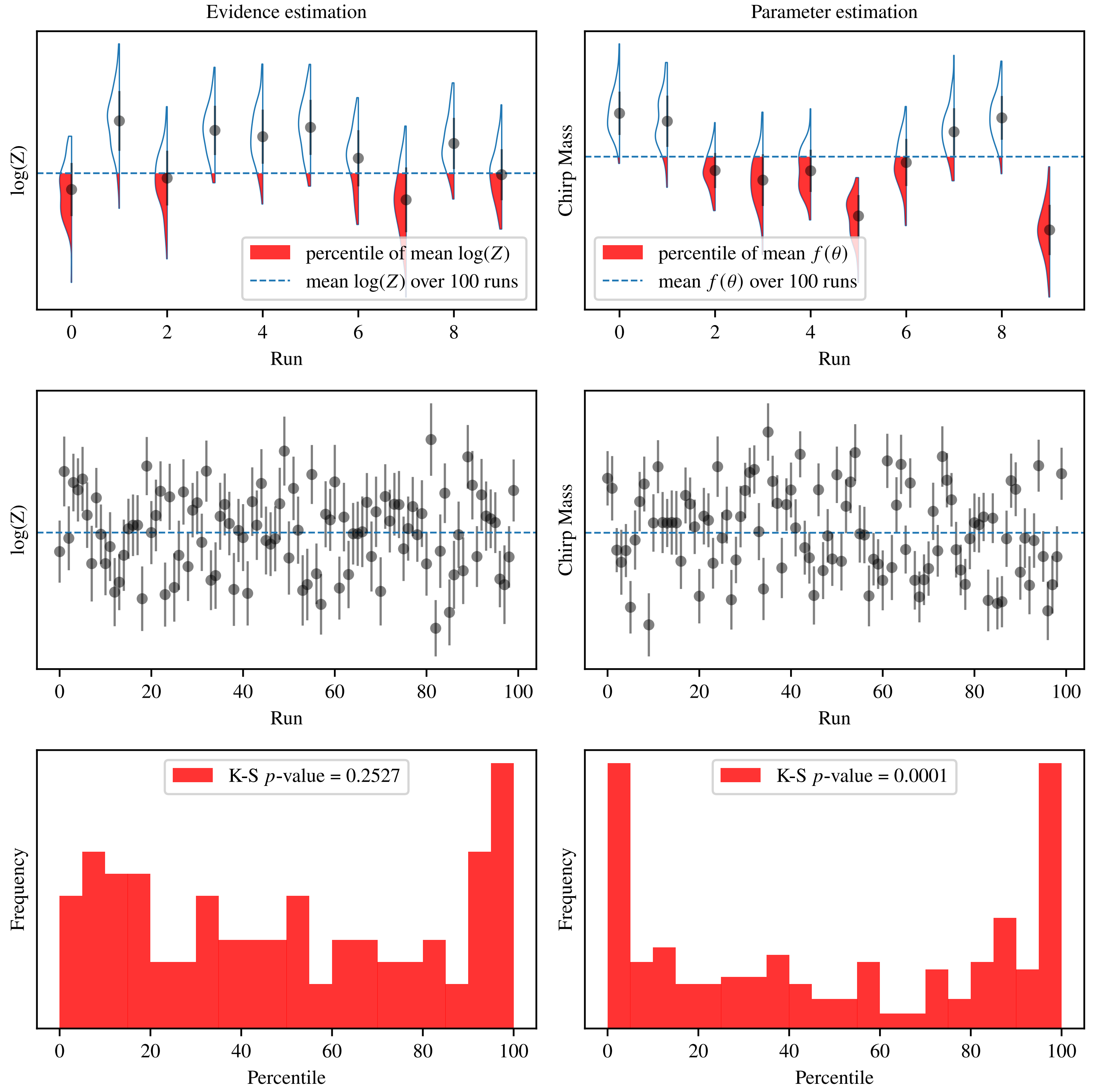




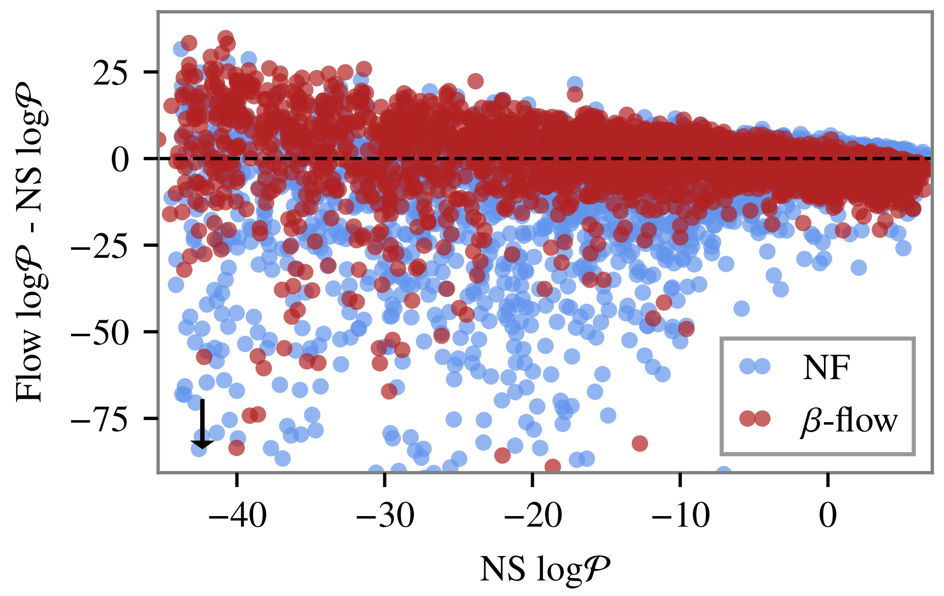
Expanded to LCO Global Sky Partners Program: Kilonova Seekers - LCO: STAR (Surveying Transients with Amateur Researchers)

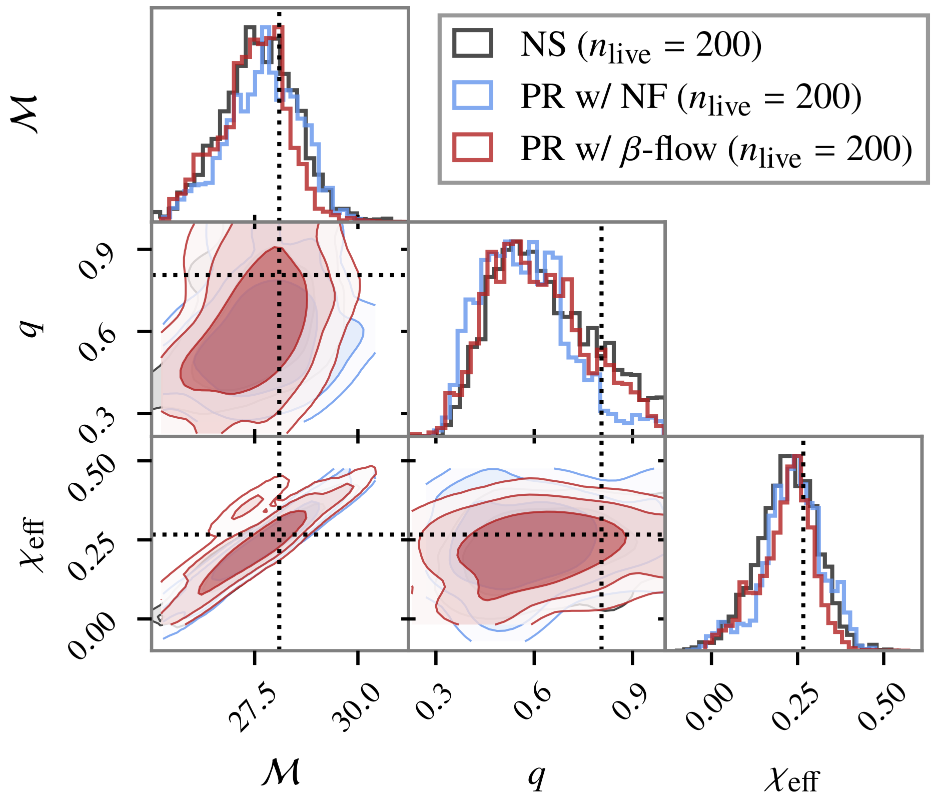
- 3rd year PhD student supervised by Will Handley
- Work on Bayesian numerical method development in context of GWs

Error quantification in NS PE:

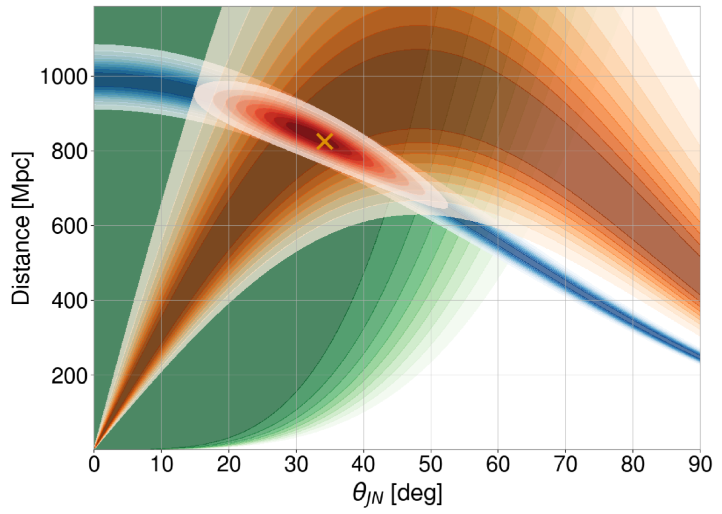


Accelerating NS w/ β-flows

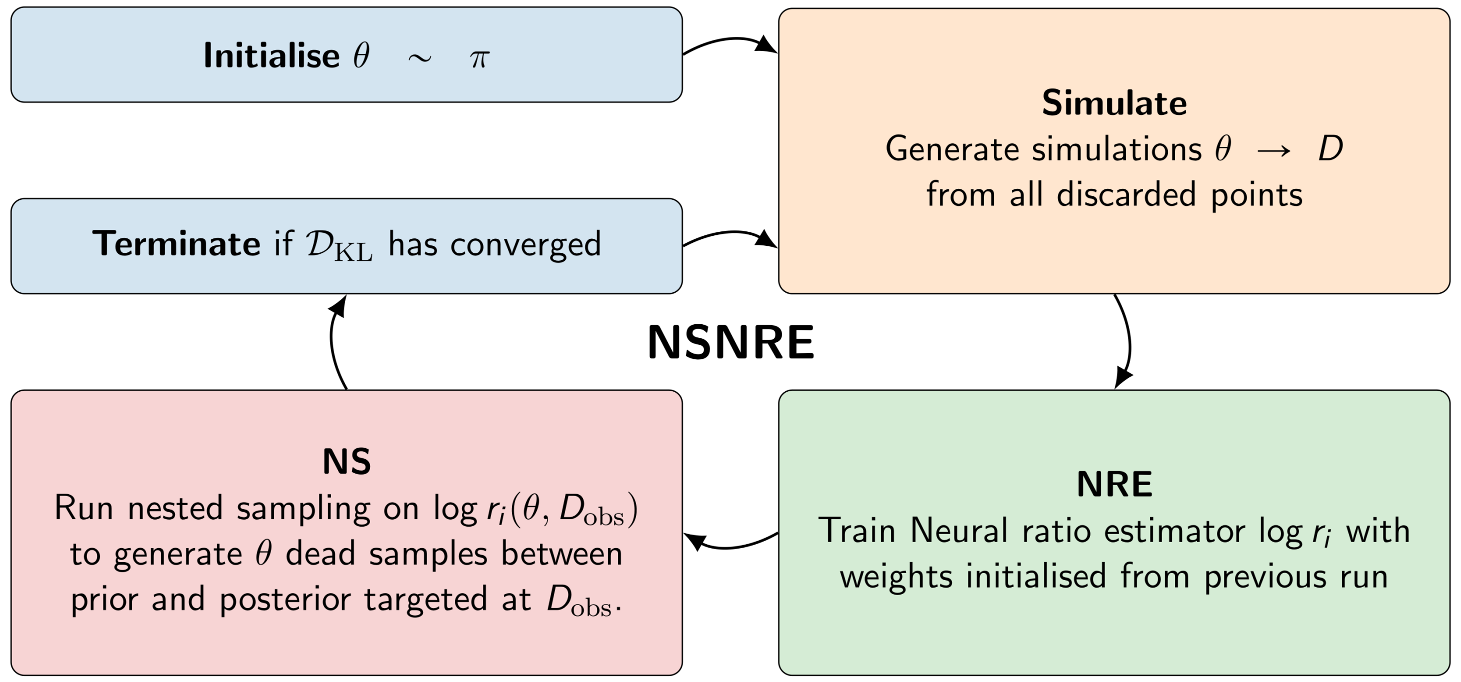




SIMPLE-PE + accelerated NS



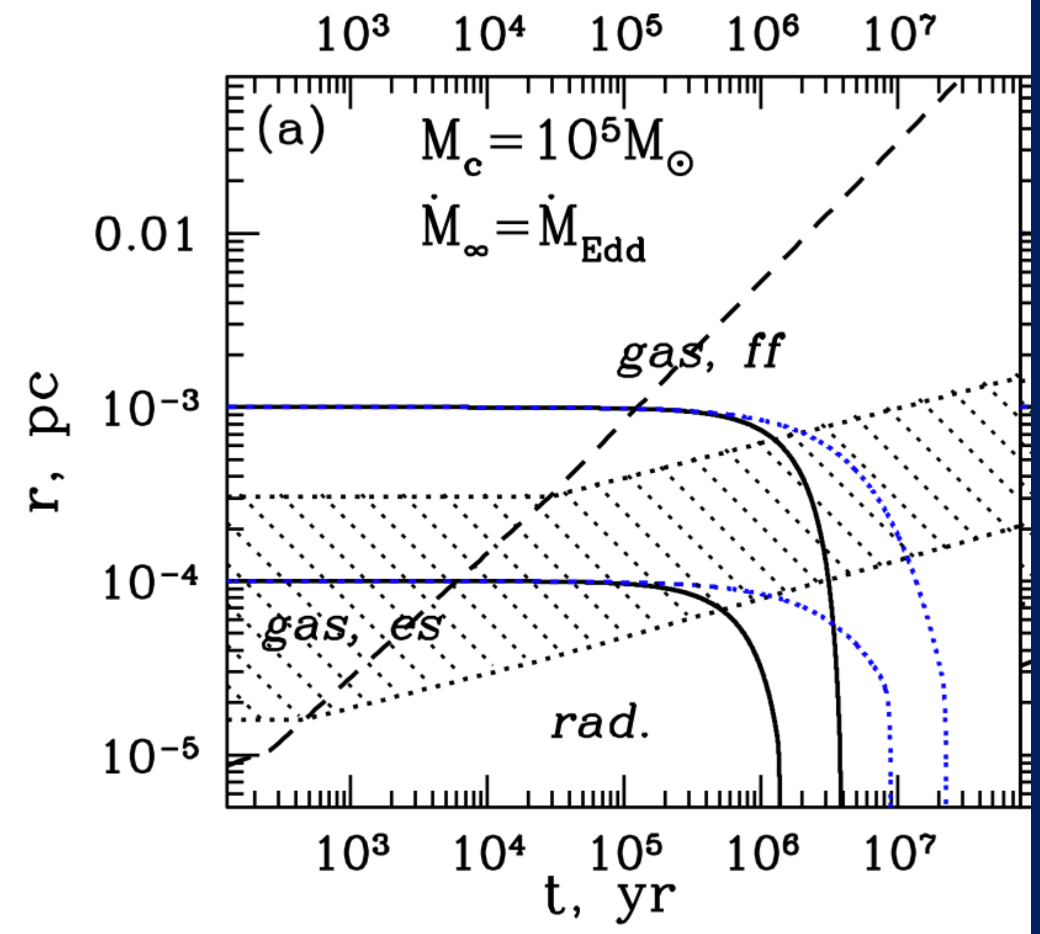
PolySwyft/NSNRE for GWs

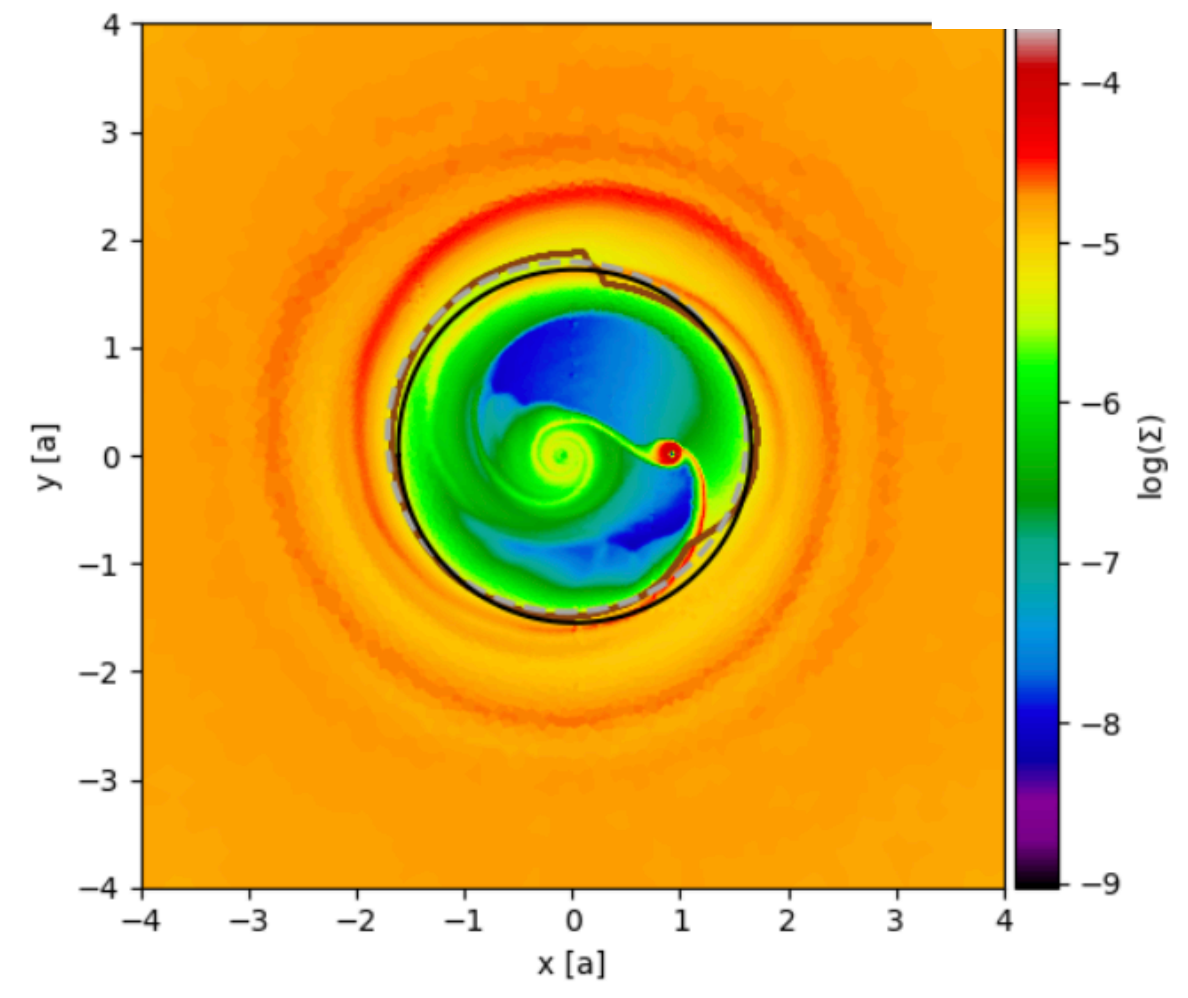


Prof Roman Rafikov
Astro group, DAMTP

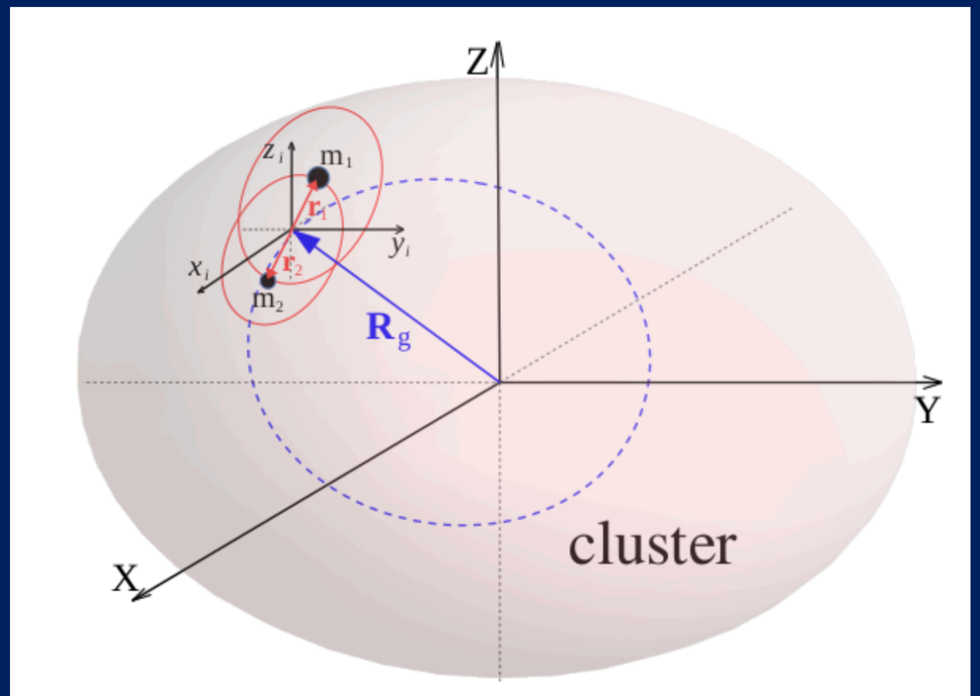
LISA: orbital evolution of SMBH binaries

Gravitational interaction of a SMBH binary with a circumbinary disk and its evolution (RR 2013,2015)



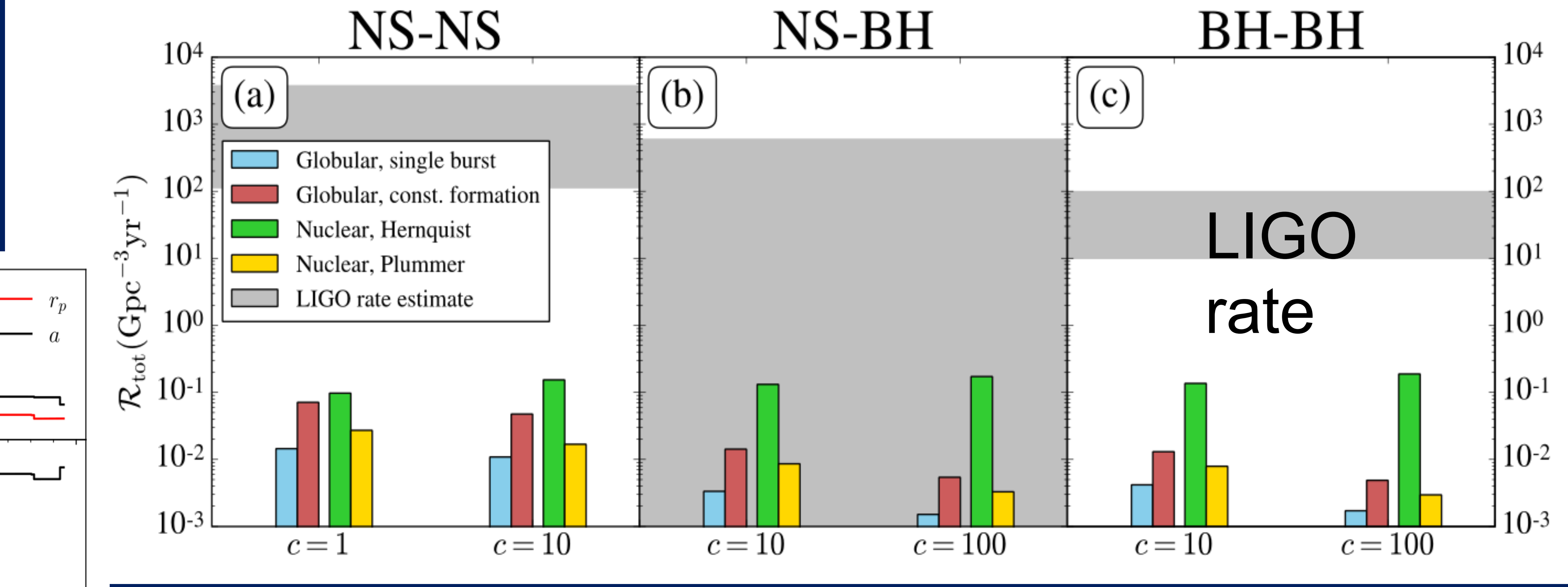


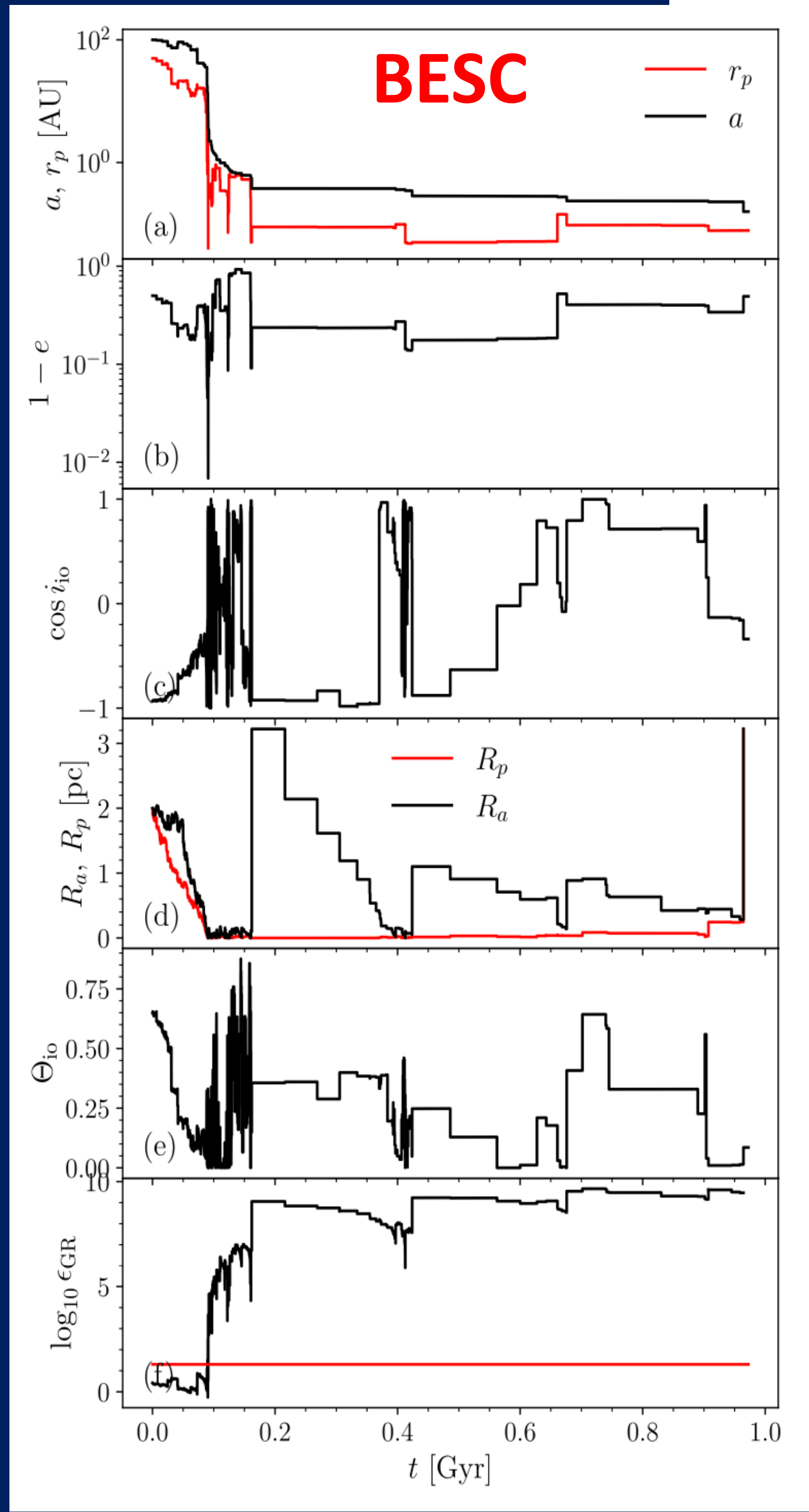
Physical properties of circumbinary disks, observational signatures (Ju+2013, Wang+ 2017, Cimerman & RR 2024, DeLaurentiis+ in prep)



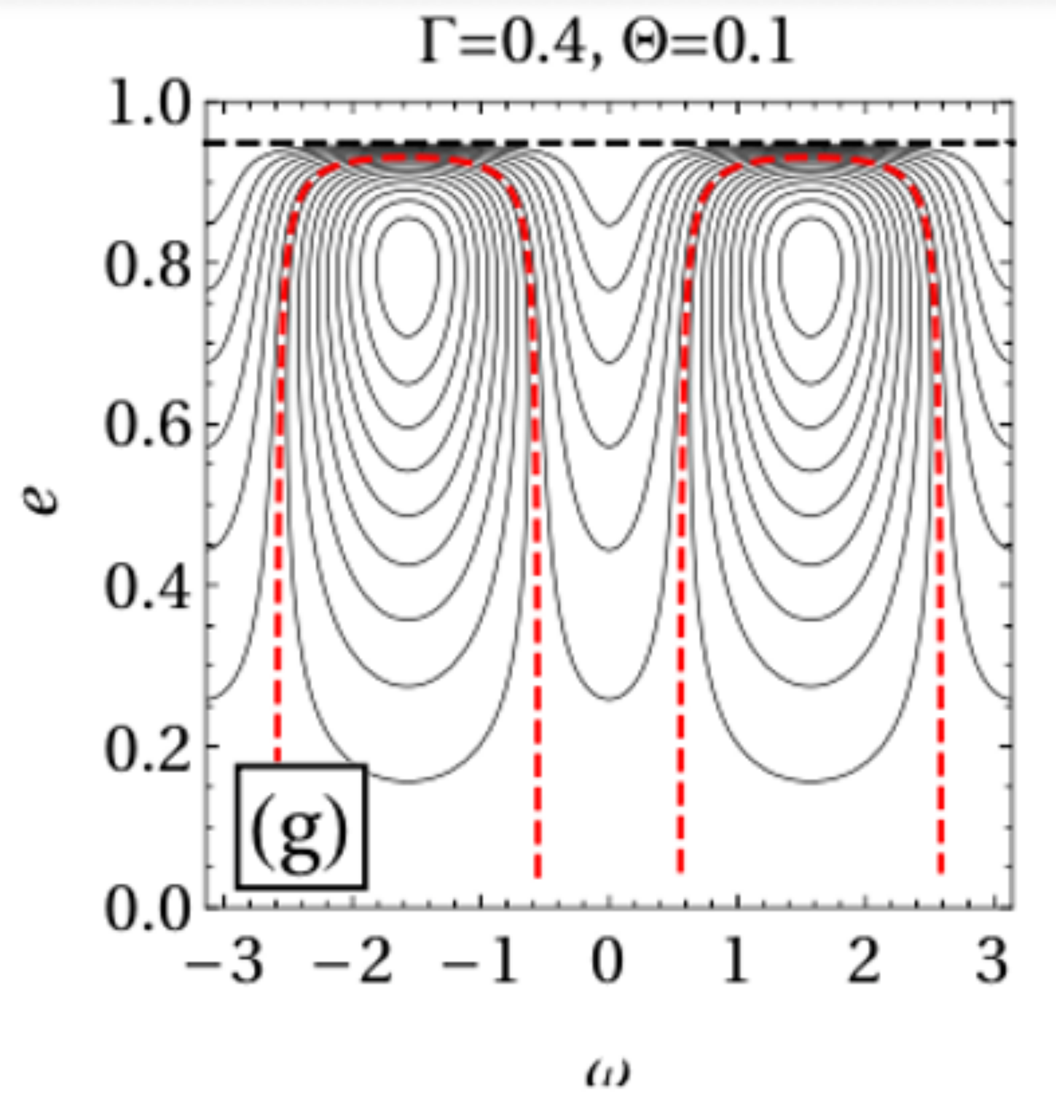
LIGO: dynamical origin of the mergers

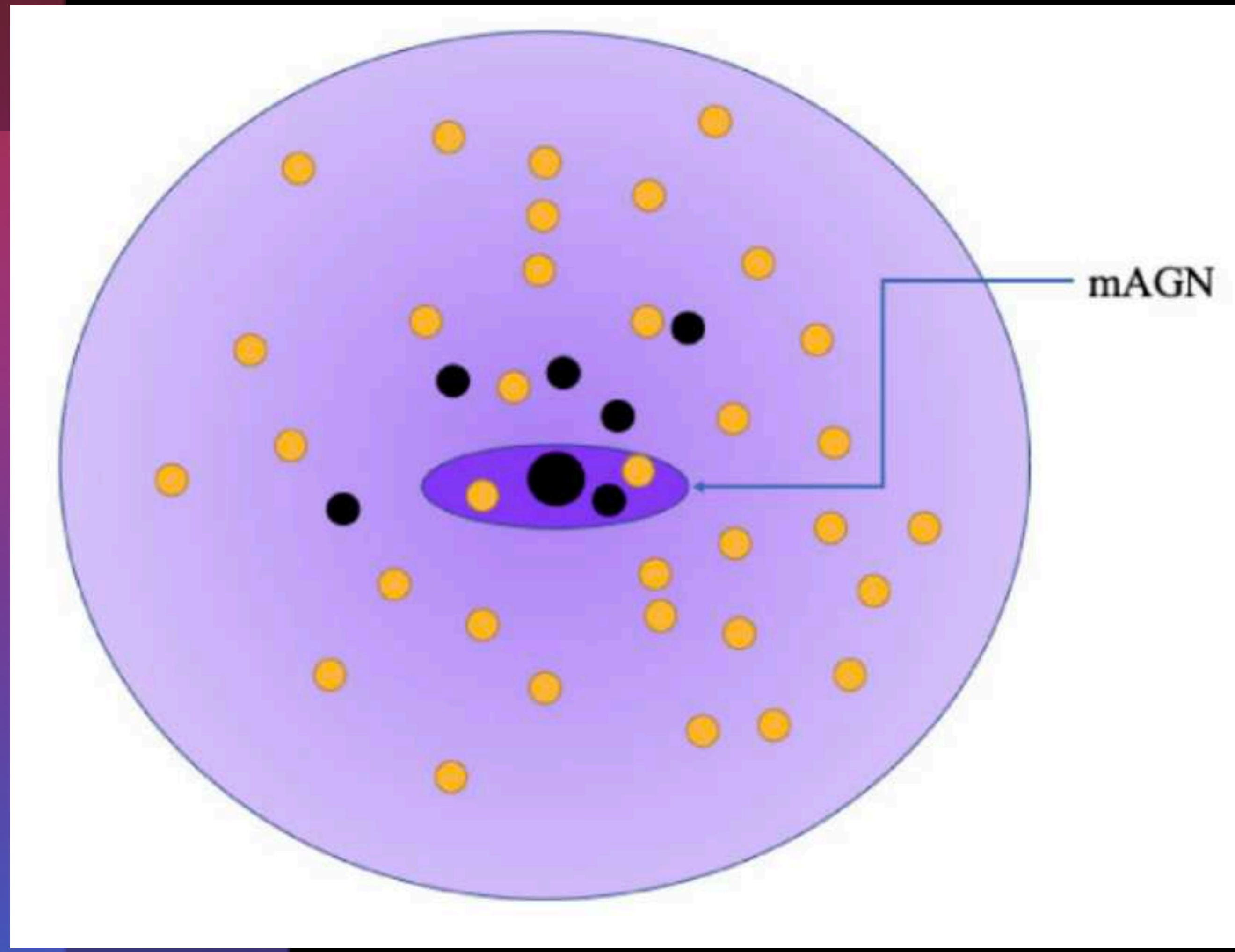
Secular orbital evolution (with GW emission) of relativistic binaries in stellar clusters driven by the gravitational tidal field of the cluster as a whole, a la Lidov-Kozai (Hamilton & RR 2019a,b,c,2021,2022,2024)



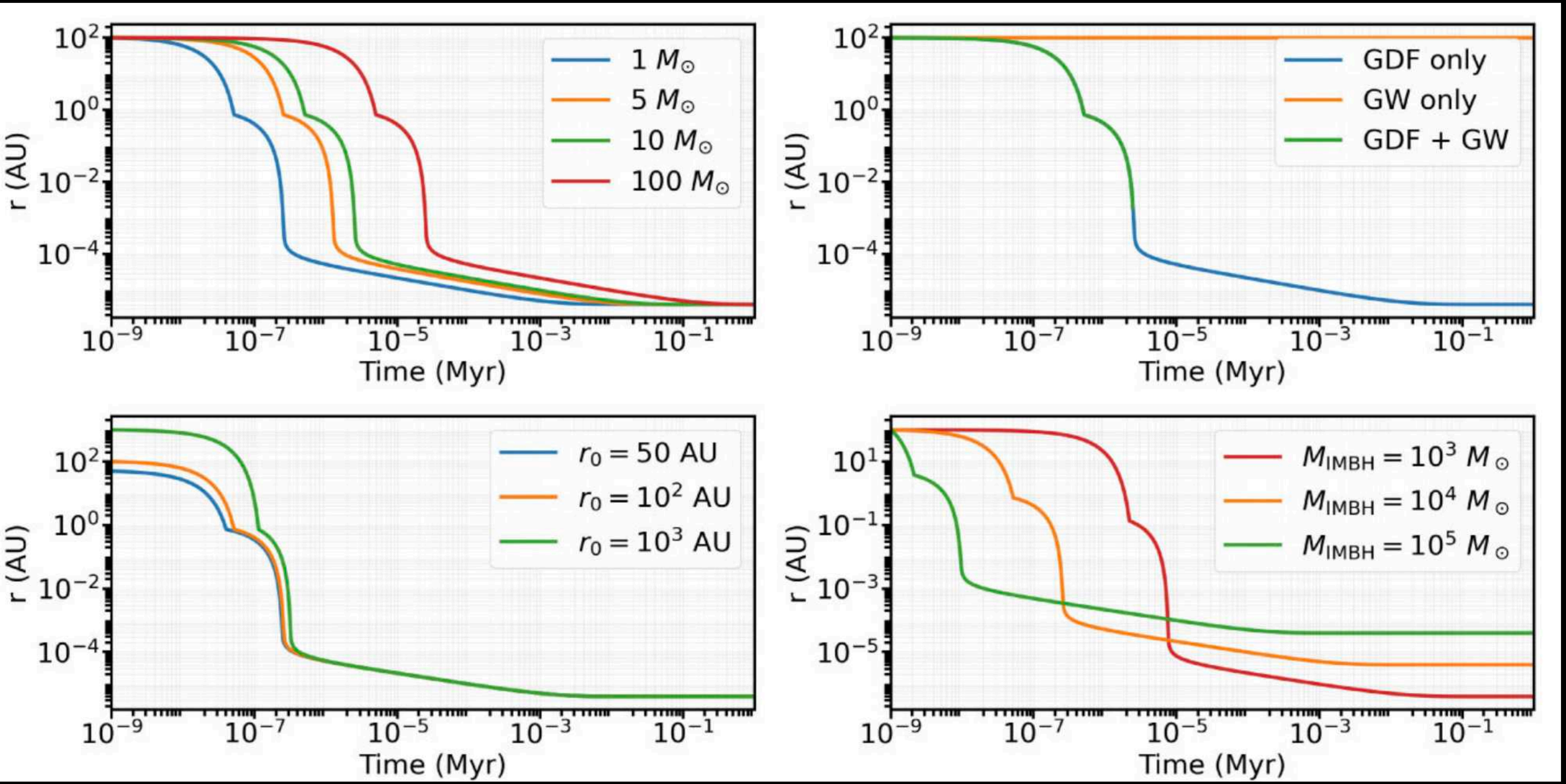


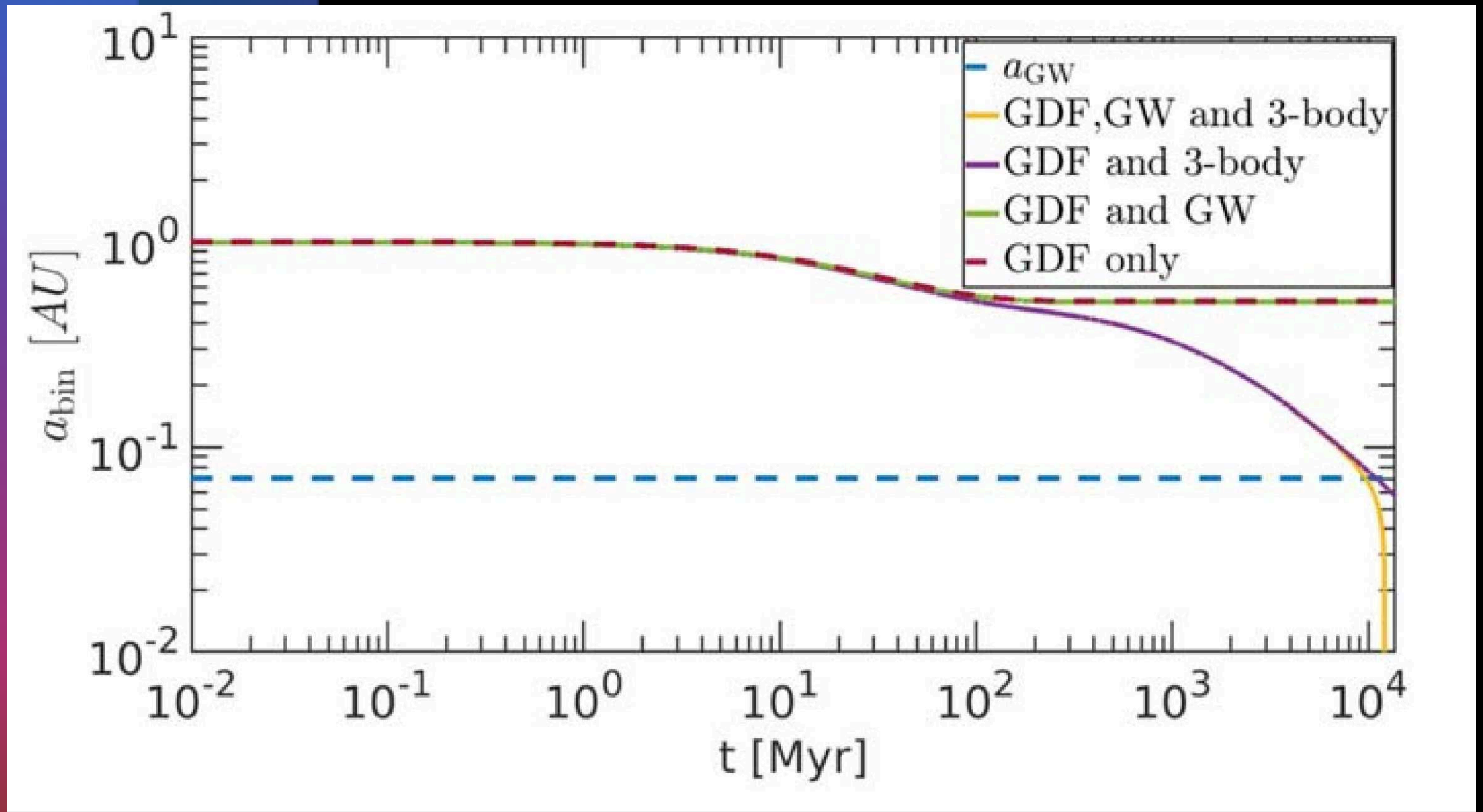
BESC (**B**inary **E**volution in **S**tellar **C**lusters) – a new computational framework to study evolution of compact binaries with cluster tides, stellar encounters, GW emission and GR precession (Rasskazov & Rafikov 2024)





Rozner et al 2025





Gravitational-wave mergers in gas-rich environments

Mor Rozner (H15)

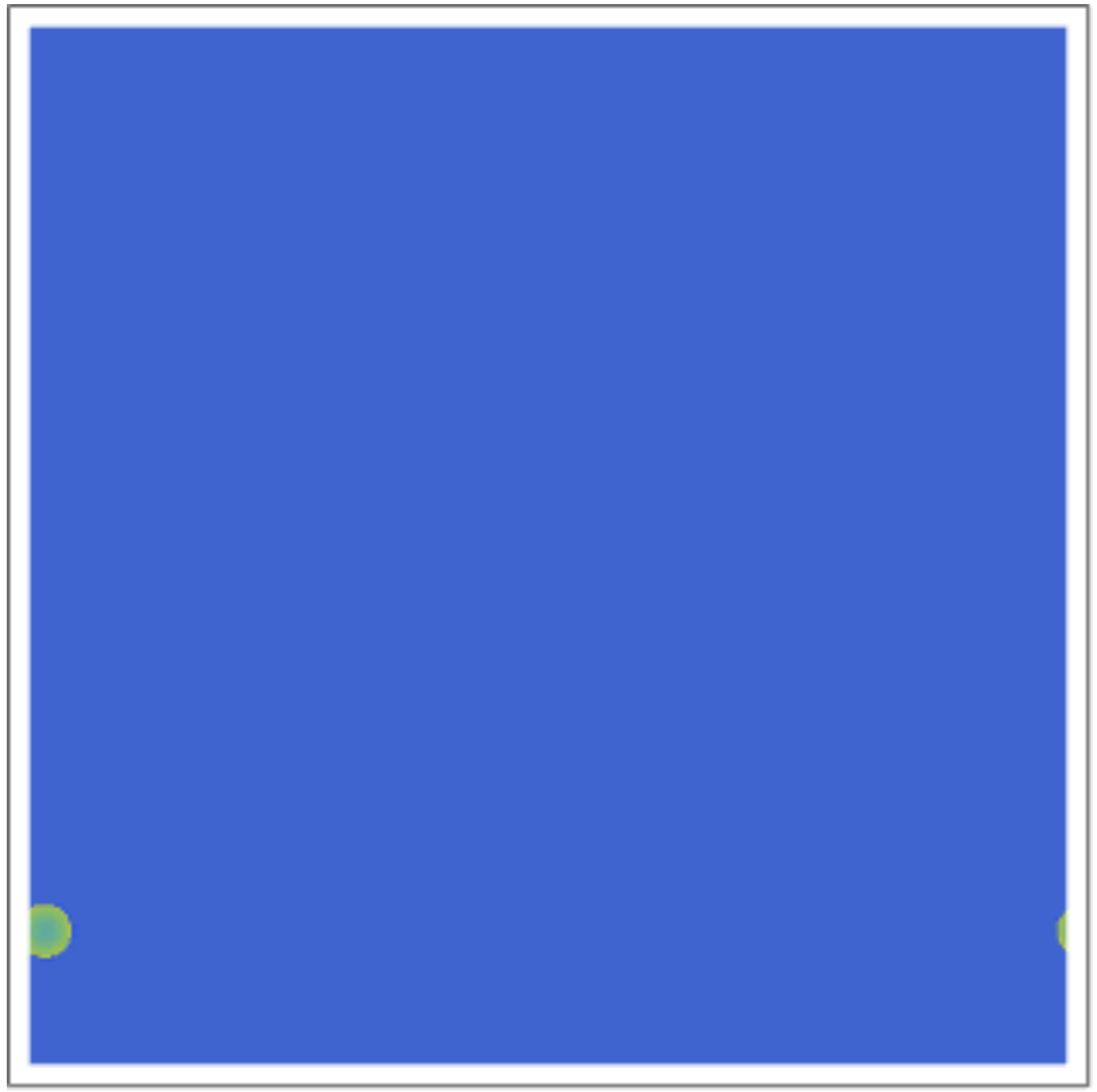
Rozner & Perets 2022

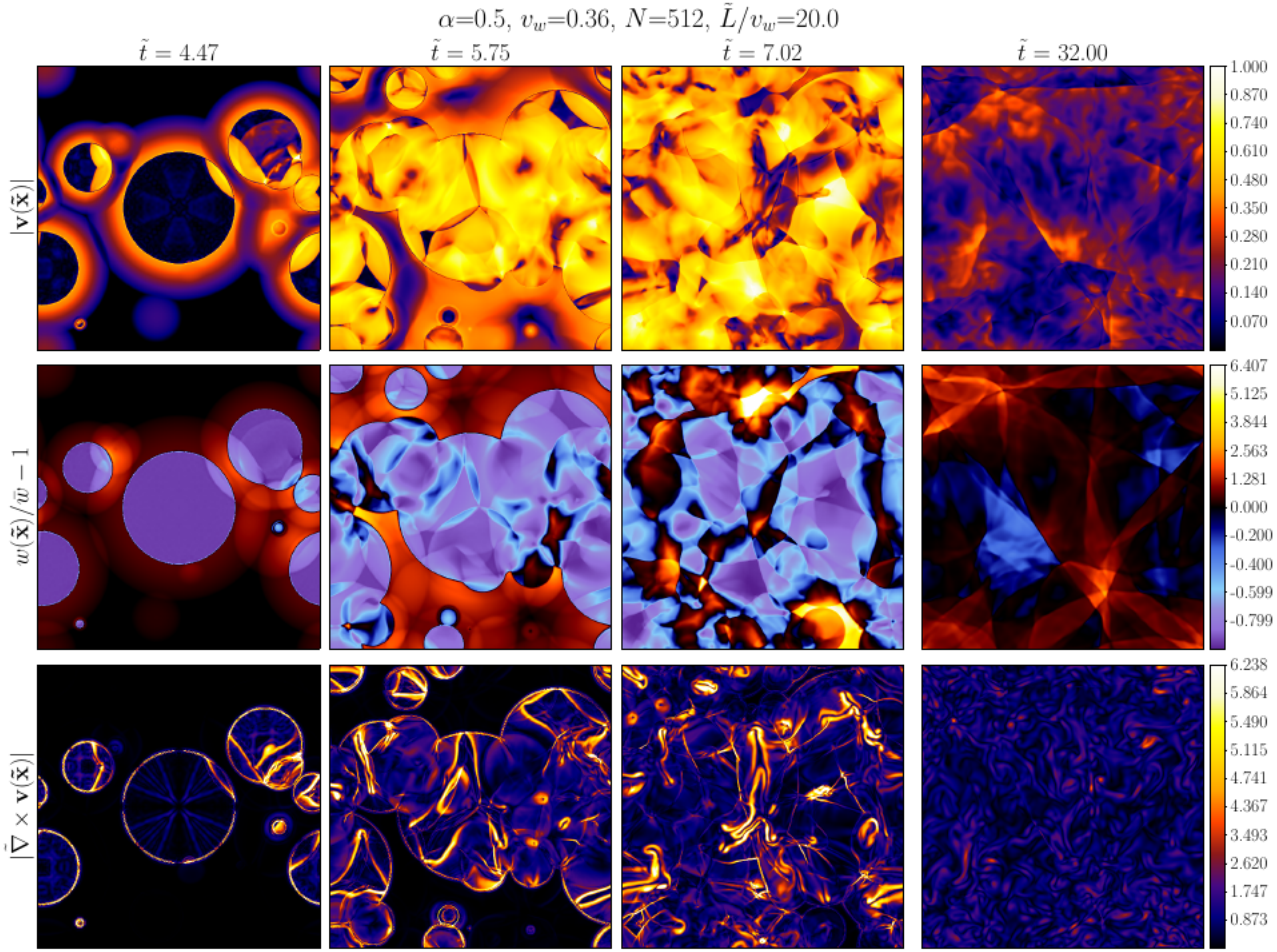
Henrique Rubira (Cambridge/LMU fellow)

In collaboration with: Simone Blasi, Chiara Caprini, Ryusuke Jinno, Thomas Konstandin, Alberto Roper Pol, Jorinde v.d. Vis, Isaac Stromberg

Simulating cosmological first-order phase transition:

- First time strong transitions
- "Higgsless simulations"



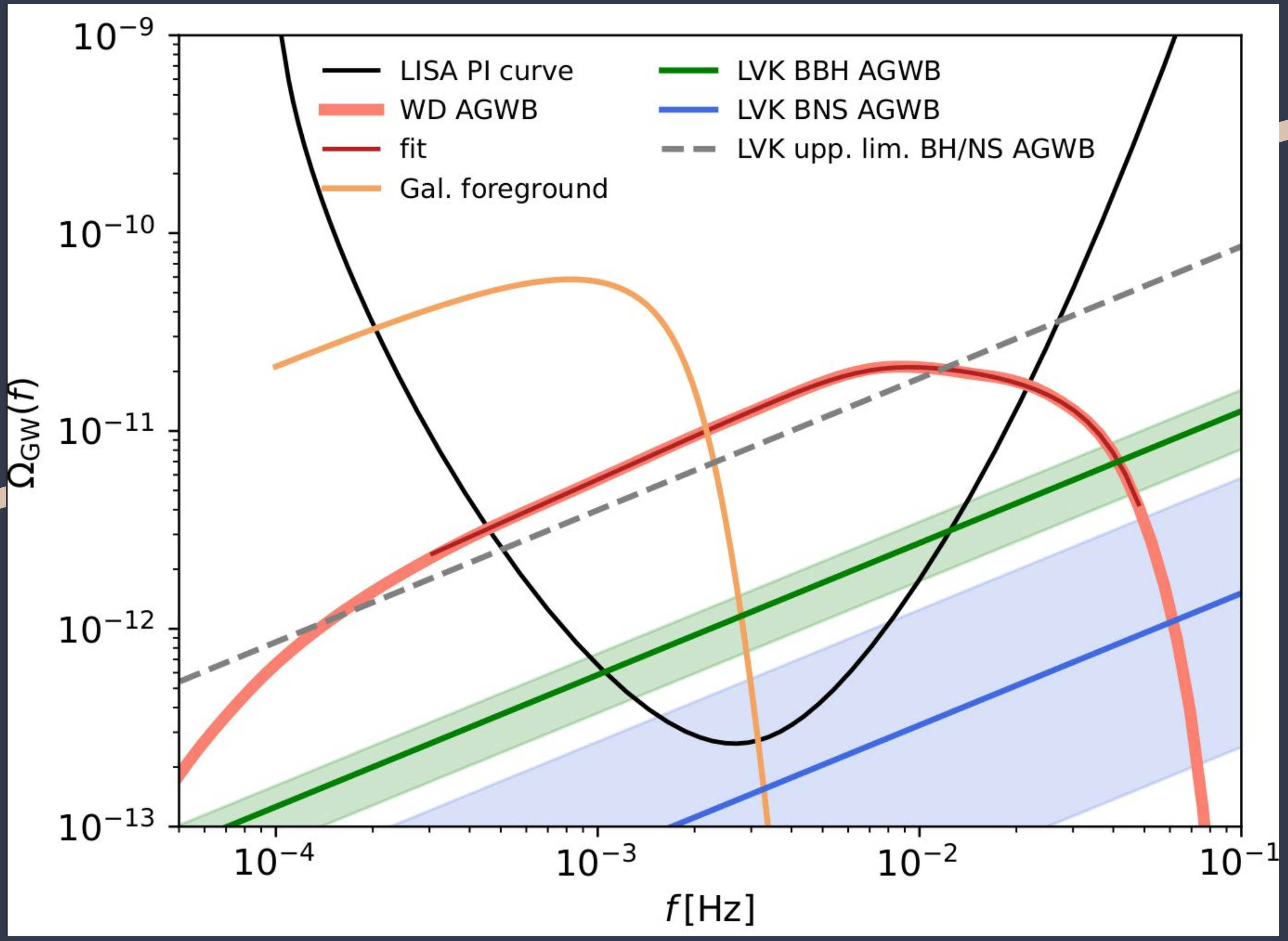


Seppe Staelens

Department of Applied Mathematics and Theoretical Physics (DAMTP)

UNIVERSITY OF CAMBRIDGE

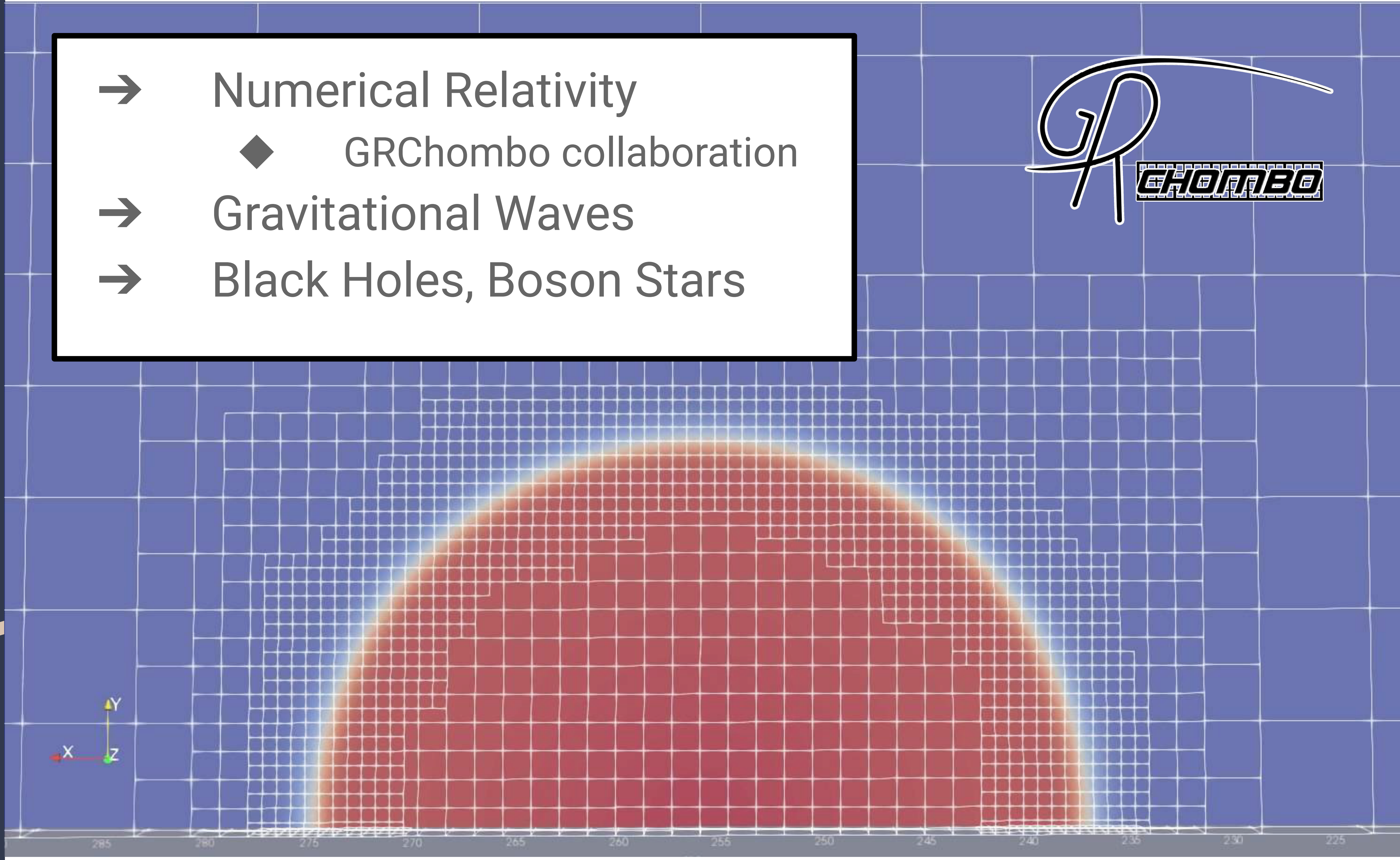
St. Edmund's College



- ➔ MSc Theoretical Physics, Astrophysics
- ➔ 2nd year PhD

KU LEUVEN

- ➔ Numerical Relativity
  - ◆ GRChombo collaboration
- ➔ Gravitational Waves
- ➔ Black Holes, Boson Stars



- ➔ Poster
  - ◆ A&A, 683 (2024) A139
  - ◆ *"Likelihood of white dwarf binaries to dominate the astrophysical GW background in the mHz band."*

Gravitational Waves for HEP

Early Universe

↓

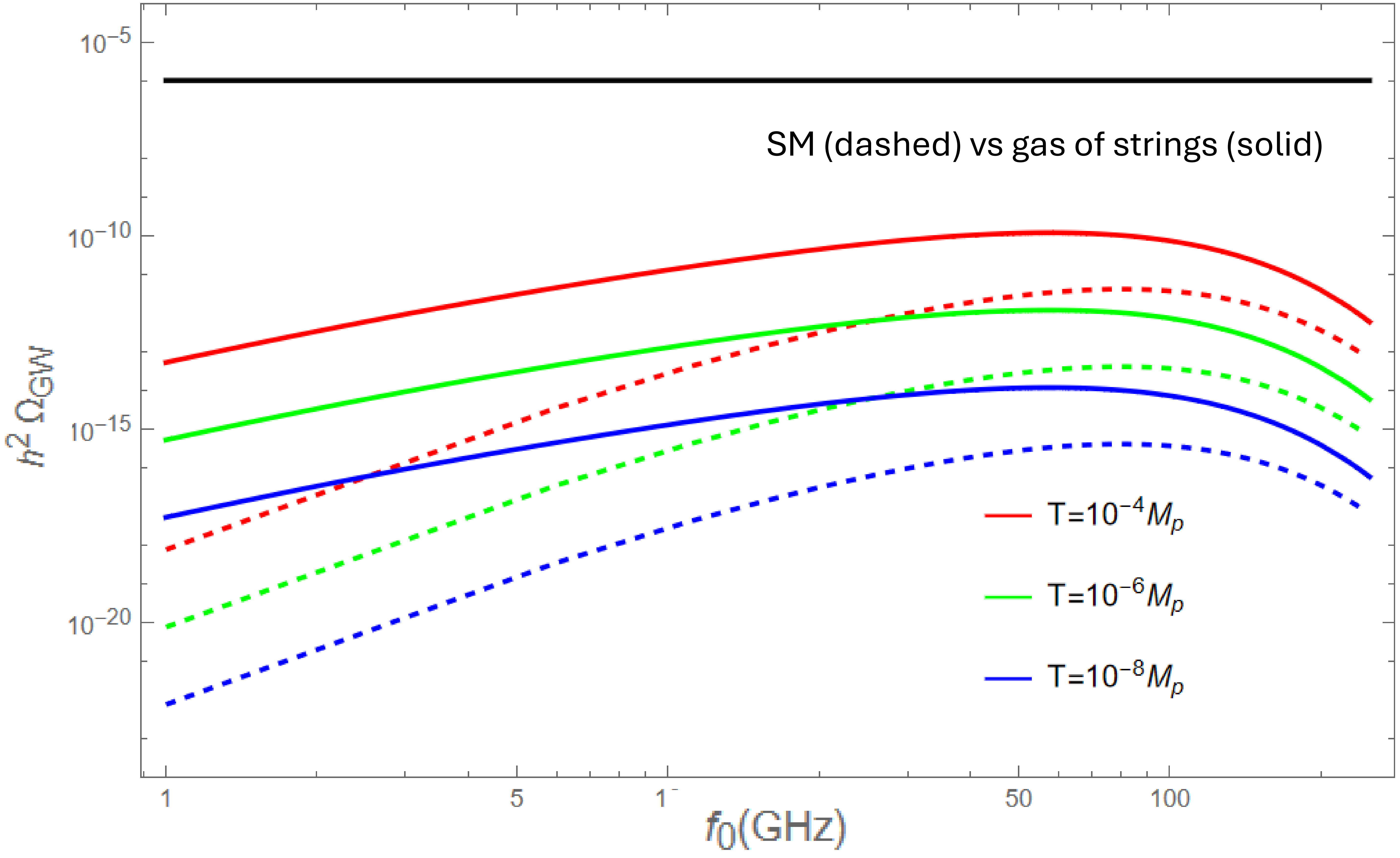
High-frequency GWs

Challenges and opportunities of gravitational-wave searches at MHz to GHz frequencies #2

Nancy Aggarwal (Northwestern U.), Odylio D. Aguiar (Sao Jose, INPE), Andreas Bauswein (Darmstadt, GSI), Giancarlo Cella (INFN, Pisa), Sebastian Clesse (Brussels U.) et al. (Nov 24, 2020)

 e-Print: 2011.12414 [gr-qc]

Recent update: 2501.11723



- UV sensitive! (String theory!?)
- Stochastic backgrounds
- Sensitivities *challenging but rewarding*: no known astrophysics backgrounds.
- GravNET got ERC synergy grant for searches at the GHz

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