LISA Astrophysics
Working Group Meeting 2024

E-poster slide deck

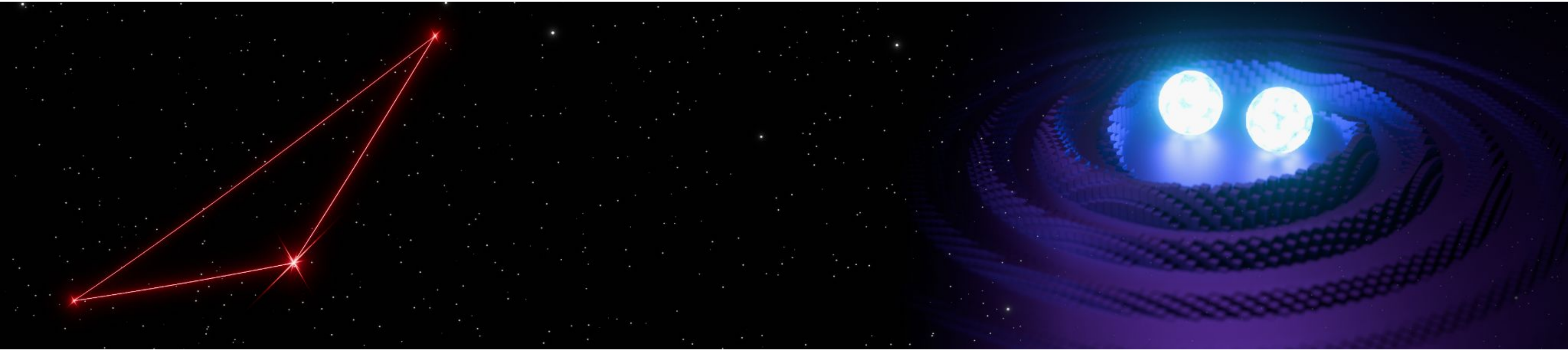
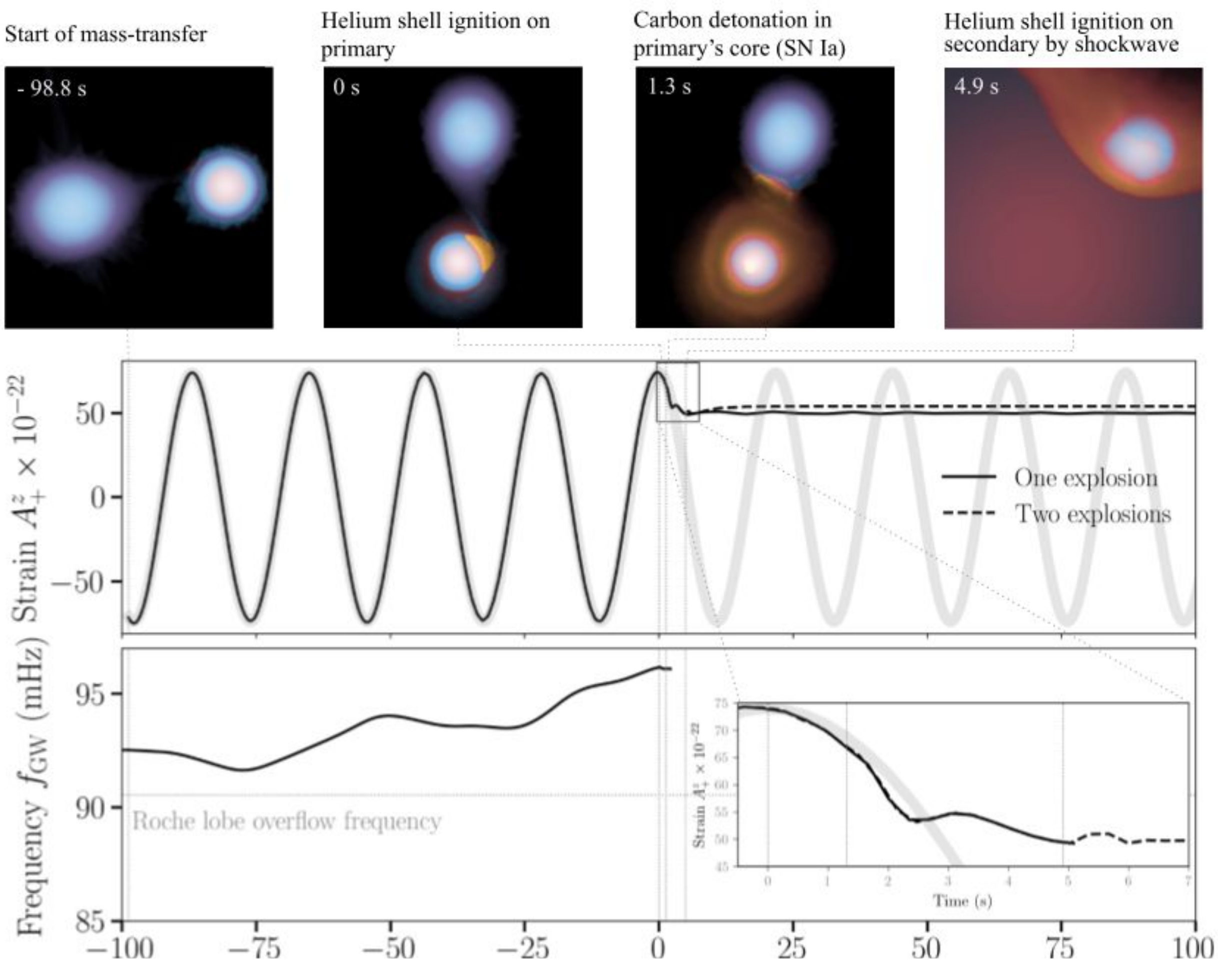


Image credit: Ruggero Valli/MPA

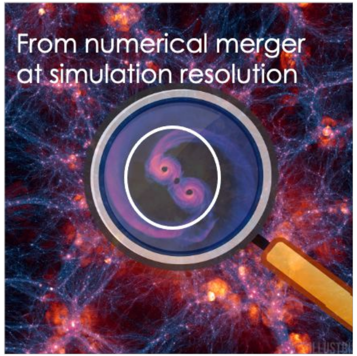
Gravitational wave insights into Type Ia supernova

By Valeriya Korol, Riccardo Buscicchio, Ruediger Pakmor, Javier Moran-Fraile, Christopher Moore, and Selma de Mink

A&A, 691 (2024) A44
arXiv:240703935



Massive black hole dynamics below the resolution limit: RAMCOAL



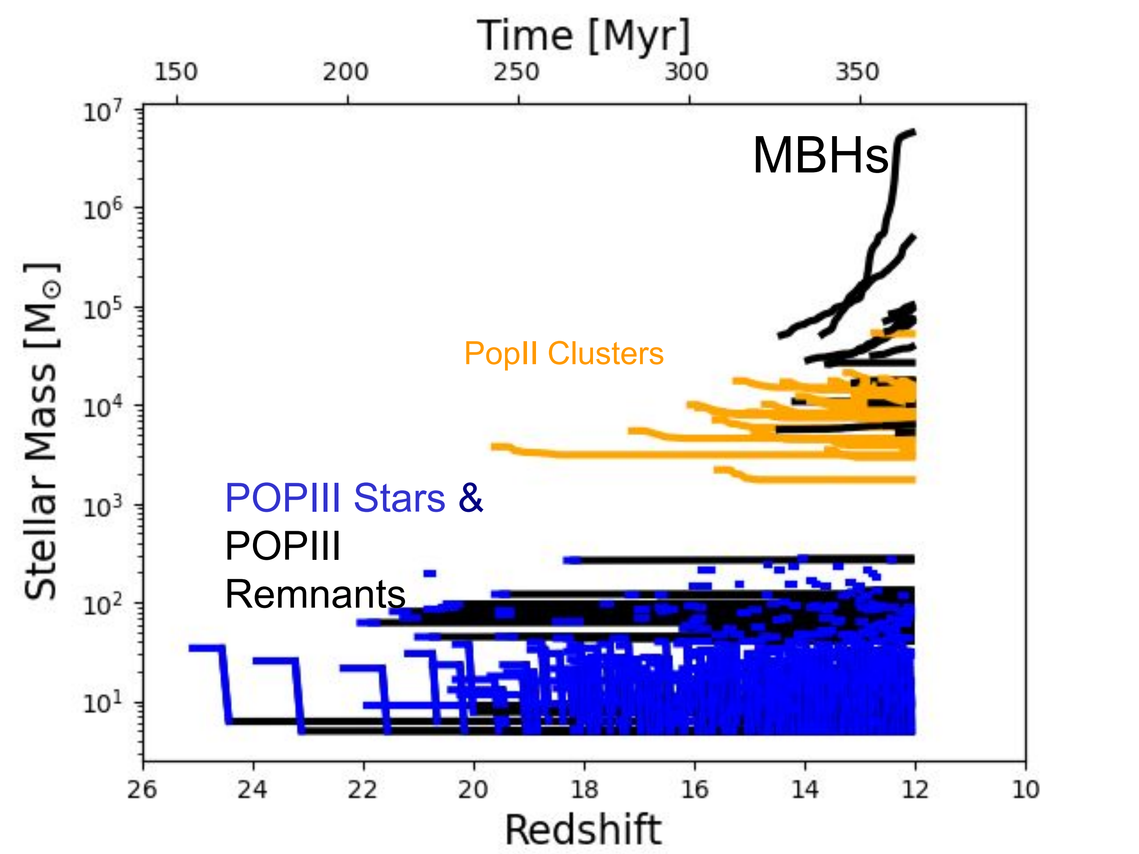
- Dynamical friction: Gas, star, DM
- Radiation feedback effect on gas dynamical friction
- Loss-cone scattering
- Viscous drag in circumbinary disk
- Gravitational wave emission
- Accretion & AGN feedback
- Spin evolution and recoils (coming soon!)

RAMCOAL, a module in the RAMSES code, tracks the real-time evolution of Massive Black Hole Binaries within hydrodynamical simulations down to coalescence to avoid uncertainties in post-processing. Sub-grid model of stellar density makes it almost resolution-independent out to 100 pc resolution – Massive Black Holes merge at 0.001 pc! Gain of 5 orders of magnitude!

Kunyang Li; arXiv:2410.07856

John Regan

SEEDZ



John Regan (Maynooth)
Lewis Prole (Maynooth)
Daxal Mehta (Maynooth)
Pelle van de Bor (Maynooth)
John Brennan (Maynooth)
Joe McCaffrey (Maynooth)
Michael Tremmel (Cork)
John Wise (Georgia Tech)
Ricarda Beckmann (Edinburgh)
Sophie Koudmani (Cambridge/Hertfordshire)
Martin Bourne (Hertfordshire)
Debora Sijacki (Cambridge)
Ruediger Pakmor (MPA)
Paul Clark (Cardiff)
Ralf Klessen (Heidelberg/CfA)
Simon Glover (Heidelberg)
Martin Haehnelt (Cambridge)
Robin Tress (Geneva)

Super-Resolution in Astrophysics Simulations

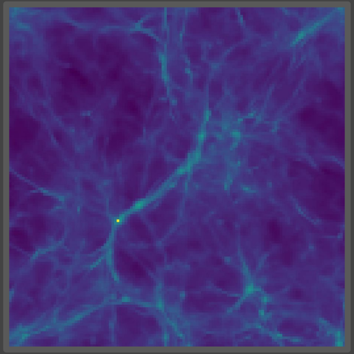
John Brennan, John Regan

Maynooth University
National University of Ireland Maynooth

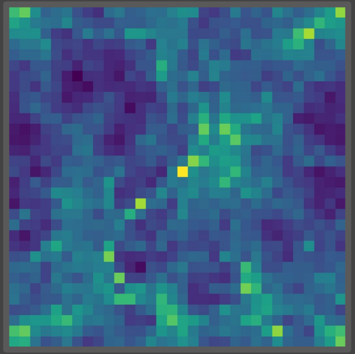
THE ROYAL SOCIETY

- Neural Networks can be used to enhance data resolution
- We are exploring the feasibility of using neural networks to enhance the resolution of astrophysics simulations

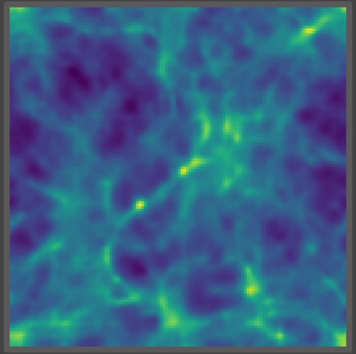
High Resolution



Low Resolution

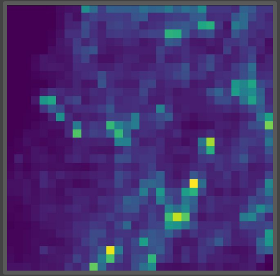


Reconstruction

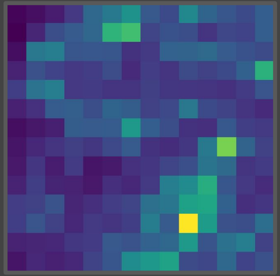


Preliminary results on dark matter mass resolution enhancement

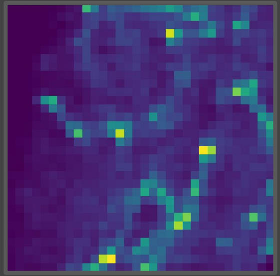
HR



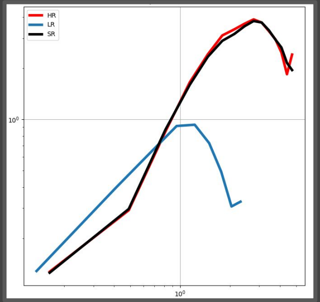
LR



SR



Power Spectrum



HR
LR
SR

Using neural operators to emulate chemistry in astrophysics simulations

Pelle van de Bor, John Brennan, John Regan

Maynooth University
National University of Ireland Maynooth

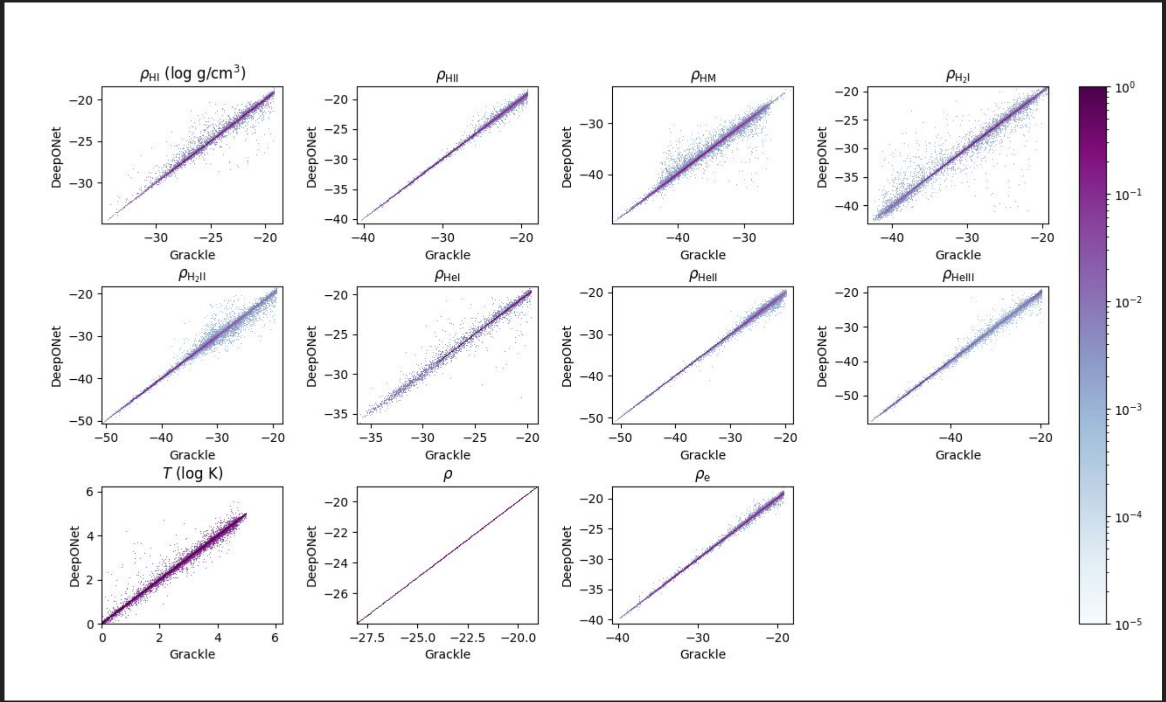
Astrophysics simulations take up large computational resources

Chemistry solver is one bottleneck

Potential of speedup using machine learning methods

Preliminary results show ~10x

Good accuracy agreement

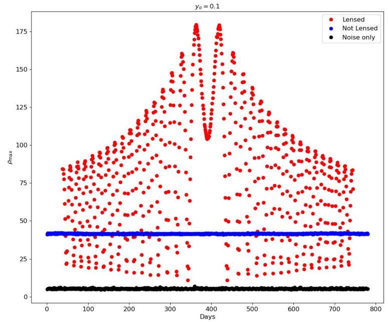


Sudhagar Suyamprakasam

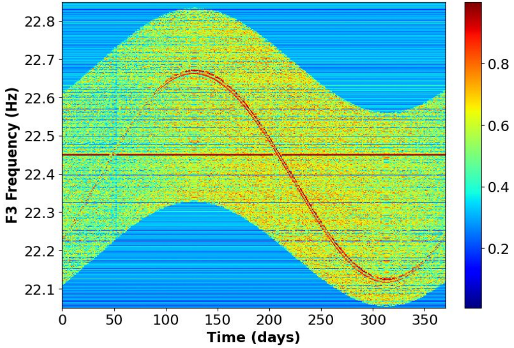
Nicolaus Copernicus Astronomical Center, Warszawa, Poland

Long-duration Gravitational Wave signal detection & estimation

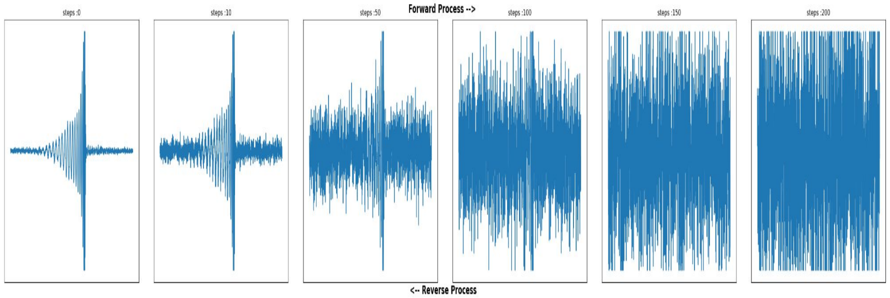
Microlensing effect in continuous GW signal†



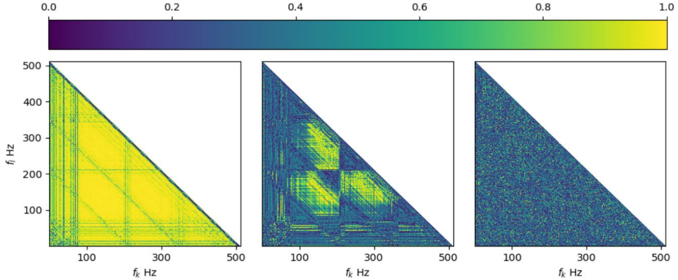
Non-template-based searches from dual harmonics from NS†



Machine learning-based Denoising method in GW signal†



Identifying noise transients in gravitational-wave data arising from nonlinear couplings*

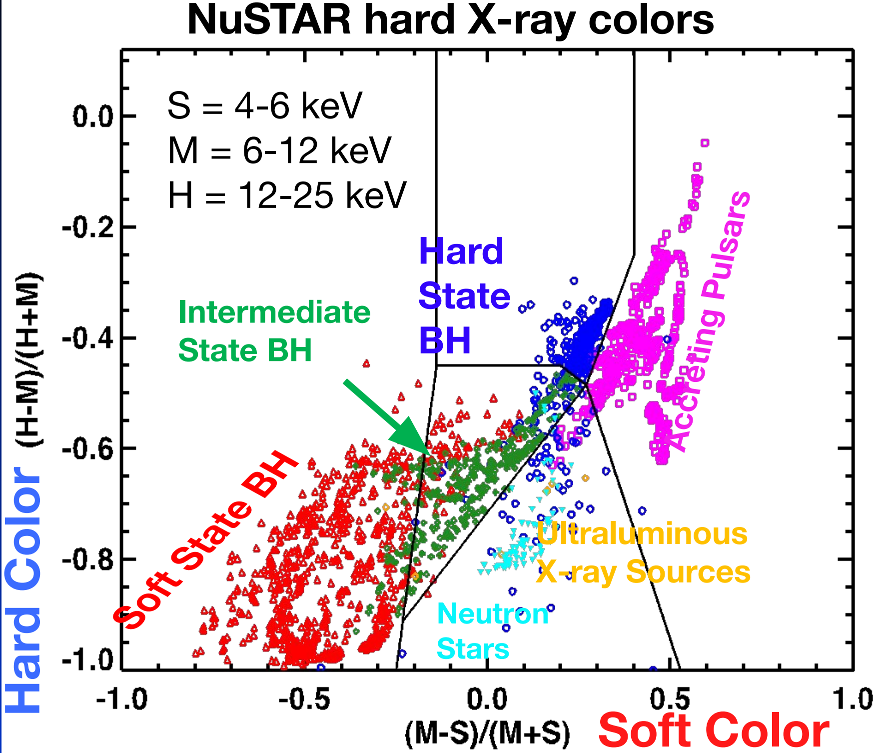


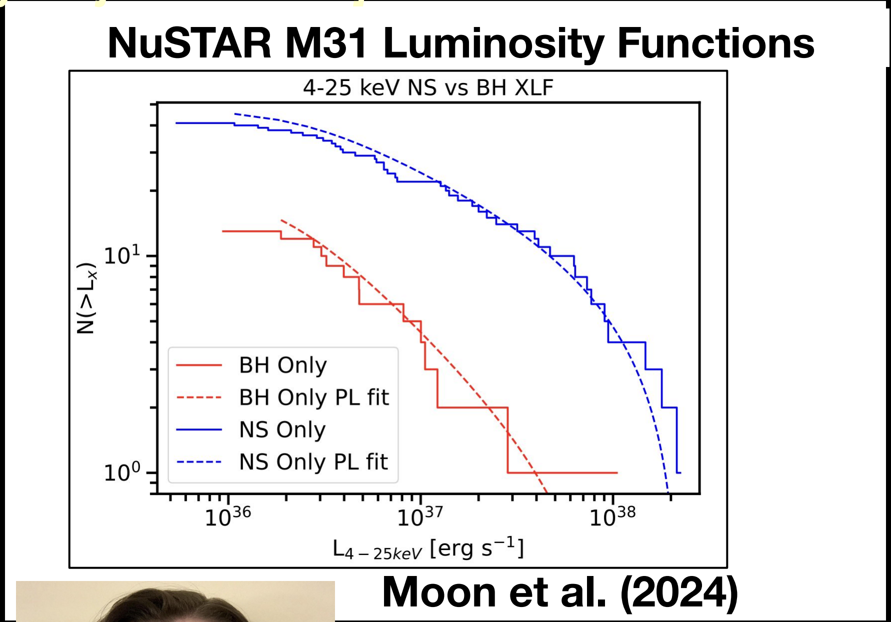
† In Preparation

*** DOI** 10.1088/1361-6382/ad7cb7

Compact Object Identifications using Hard X-rays

Ann Hornschemeier (Cardiff) – NASA GSFC
[NASA LISA Deputy Project Scientist]





Hannah Fritze Moon
(U. of Utah)

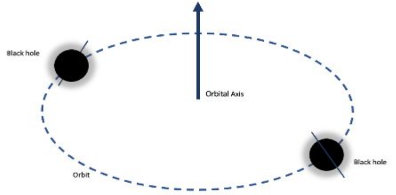
Observational Catalogue of Binary Sources and Database of Associated Gravitational Waves

Florentina Pîslan, Laurențiu Caramete, Ana Caramete

LISA CONSORTIUM

ISS INSTITUTE OF SPACE SCIENCE www.spacescience.ro

Catalog of electromagnetically observed binary systems



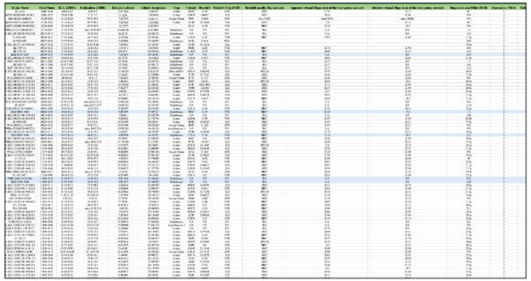


Fig. 1: Catalog of potential GW sources for the future AI experiments the catalog was developed according to the observational data found in literature

Parameter estimation

Source parameters

- Intrinsic parameters
  - MASSES
  - SPINS
- Extrinsic parameters
  - Ecliptic coordinates
  - Redshift
  - Phase at coalescence
  - Polar angles of spins

Fig. 2: Parameters needed for simulating gravitational waveforms

Waveform modelling

Database of gravitational waveforms

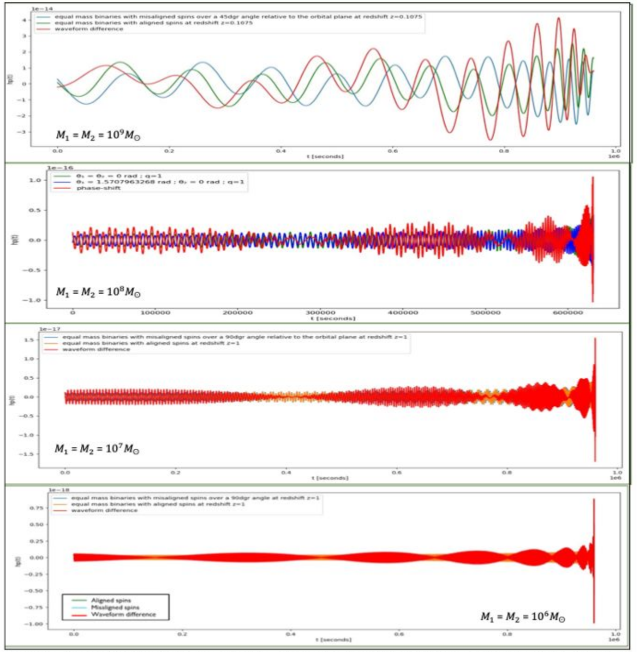


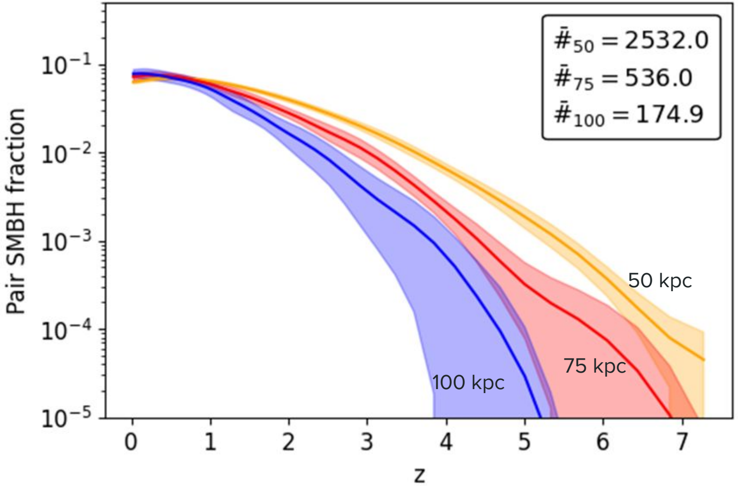
Fig.3: Samples of gravitational waveforms that were generated according to various combinations of the parameters estimated from electromagnetical observations. These graphs present the waveform difference (in red) between GWs produced by binary systems of different masses and positioned at different redshifts in order to emphasize and the difference in waveform between two distinct configurations (GW generated by systems with aligned spins and misaligned spins). All gravitational waveforms were generated with the simulation code developed by the LISA colaboraton

Simulating black hole pairs and their merger rates using PINOCCHIO

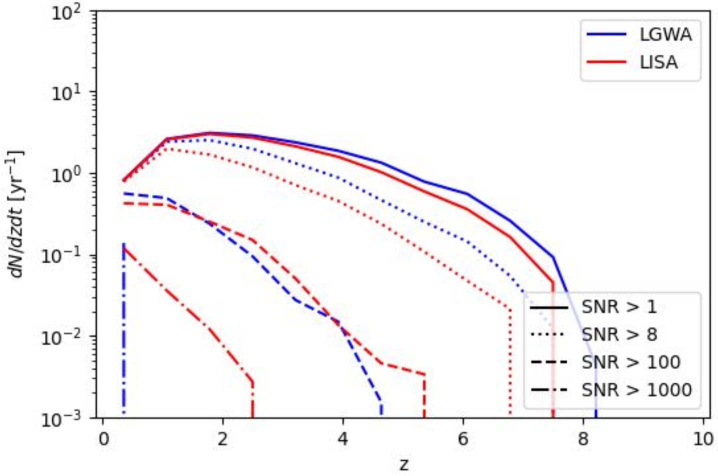
Jasbir Singh, Paola Severgnini, Alessandra De Rosa, Cristian Vignali et al.

Combining dark matter halo merger trees from **PINOCCHIO** simulation (Monaco+02) of (60 Mpc)^3 volume with the semi-analytical model **PinGAEA** (Cammelli+24) and implementing two different black hole seeding schemes:

1. **All Light Seeds (ALS)**: seeding every halo with an intermediate mass black hole (Volonteri+11, Xie+17).
2. **Population III.1 model**: seedings mini-halos of $10^6\ M_\odot$ separated by an isolation distance (50-100 proper kpc) with black holes of $10^5\ M_\odot$ (Banik+19, Singh+23).



Fraction of SMBH pairs with separations ranging from Mpc to kpc scales from **Pop III.1 model** with isolation distances of 50, 75 and 100 kpc.



Merger rate of black holes (with parent halo mergers at z<10) seeded with **ALS seeding scheme** with different SNR cuts as observed by LISA and LGWA detectors.