Workshop Highlights and Actions

PAX IX, King's College London, UK, July 23-25

Community Effort to Develop Science Traceability Matrix for the Cosmic Explorer Project

Science Traceability Matrix

National Aeronautics and Space Administration

NASA

Science Goal:

High-level goal that is identified by an external source, such as NASA or the National Academy of Science decadal survey.

Understand the variables that impact plant growth.

Science Objective:

The specific science questions the mission intends to answer.

Determine the impact of amount of water on plant growth.

Measurement Objective:

The specific measurements or observations needed to collect the data that will address the science objective. (There can be multiple Measurement Objectives for a single Science Objective.)

Measure the amount of plant growth (both the plant and its fruit)) weekly over four weeks when given 50, 125, or 250 milliliters of water per day.

Measurement Requirement:

What the measurement must include in terms of content, precision, quality.

- Measure the height of the plant to the nearest millimeter.
- Measure the circumference of the fruit on the plant to the nearest millimeter.
- Weigh the fruit to the nearest gram without removing it from the plant.

Instrument:

What instrument would be needed to carry out the measurement.

- Ruler
- Caliper
- Hanging Scale

Instrument Requirement:

How and how well the instrument would need to perform.

- Ruler marked in millimeters
- Caliper able to measure in millimeters.
- Hanging scale able to provide weight in grams.

Data Product:

What will be the output (the product) of this measurement (for example, a map or a spectrum)

- Graph of **plant height** by amount of water applied over time.
- Graph of **fruit size** by amount of water applied over time.
- Graph of **fruit weight** by amount of water applied over time.

Mission Requirement:

What would need to happen during the mission to accomplish the measurement objective (and therefore the science objective)

Provide an undisturbed area where plants receive the same amount of light and are kept at the same temperature, humidity, and other environmental conditions for four weeks.

CE-Science-Traceability-Matrix

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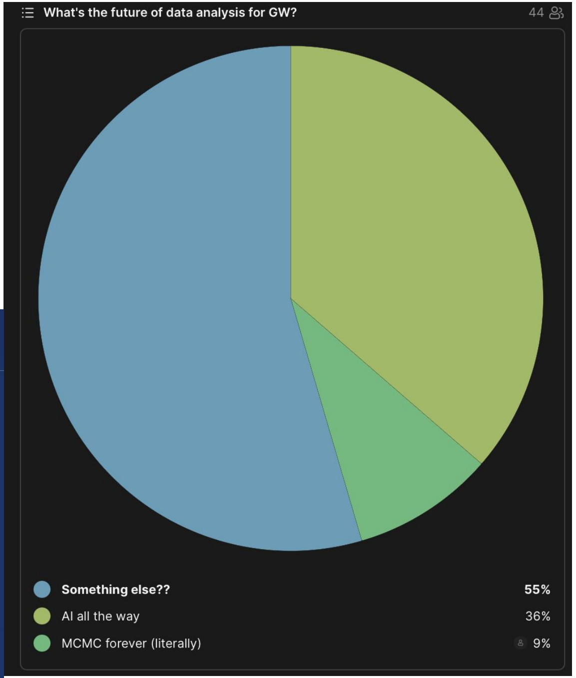
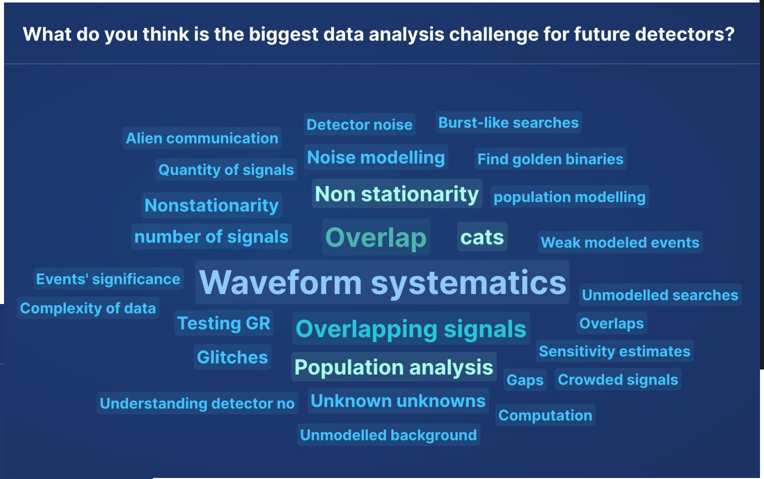
	A	B	C	D	E	F	G	H
1	**Science Goal**	**Science Objectives**	**Measurement Objective**	**Measurement Requirement**	**Instrument**	**Instrument Requirement**	**Data Product**	**Detector Requireme**
2	High-level goal that is identified by an external source, such as NASA or the National Academy of Science decadal survey.	The specific science questions the mission intends to answer.	The specific measurements or observations needed to collect the data that will address the science objective. (There can be multiple Measurement Objectives for a single Science Objective.)	What the measurement must include in terms of content, precision, quality	What instrument would be needed to carry out the measurement.	How and how well the instrument would need to perform	What will be the output (the product) of this measurement (for example, a map or a spectrum)	What would need to happen during the mission to accomplis the measurement objective (and therefo the science objective
3	P5: 2023, p6: Illuminate the Hidden Universe–Determine the Nature of Dark Matter [A class of heavy WIMP dark matter candidates would produce astrophysical signals that reflect their nature. Searches for these signals are part of a broader multi-messenger astrophysics program that maps our universe with light, neutrinos, and gravitational waves.] Pathways to Discovery in Astronomy and Astrophysics for the 2020s: New Messengers and New							

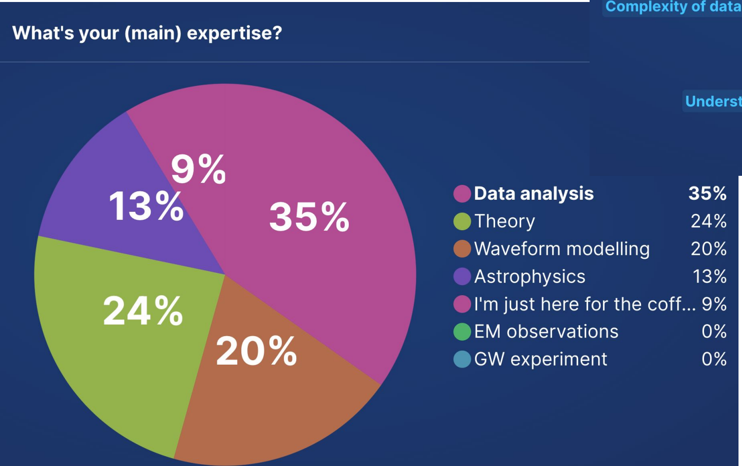
CE-STM-A | CE-STM-B | CE-STM-C | CE-STM-D | CE-STM-E | CE-STM-F | CE-STM-G | CE-STM-Template

Data Analysis Challenges

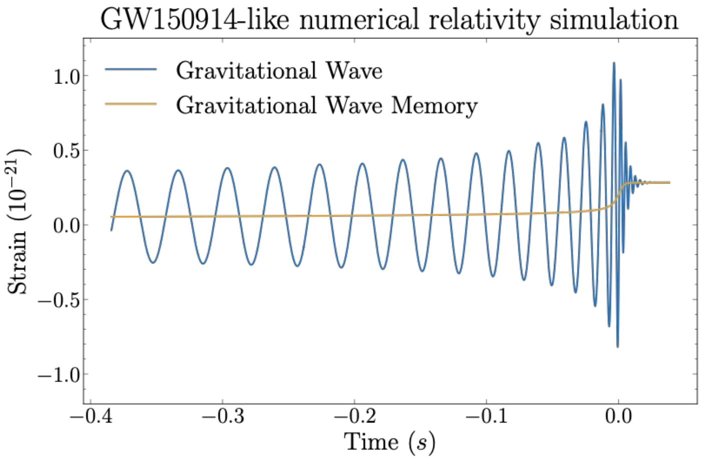
- Chris Van Den Broeck (chair), Laura Sberna, Aditya Vijaykumar
- SBI is the way to go but it does not work for all kind of systems

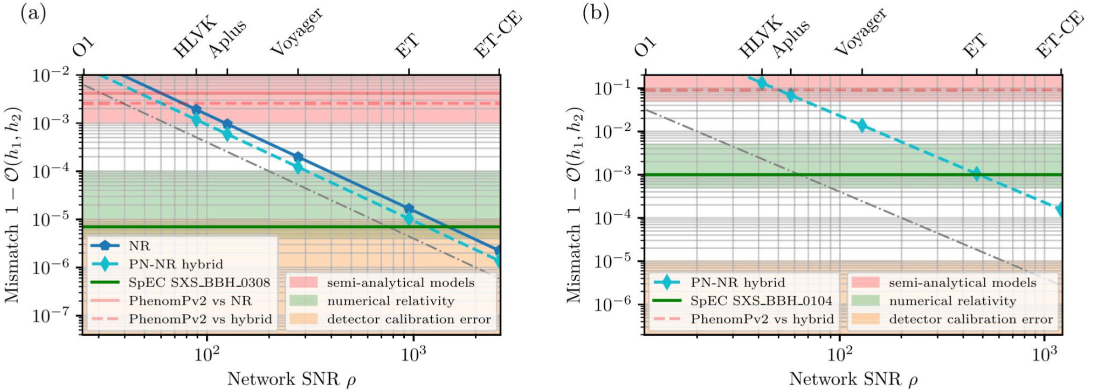


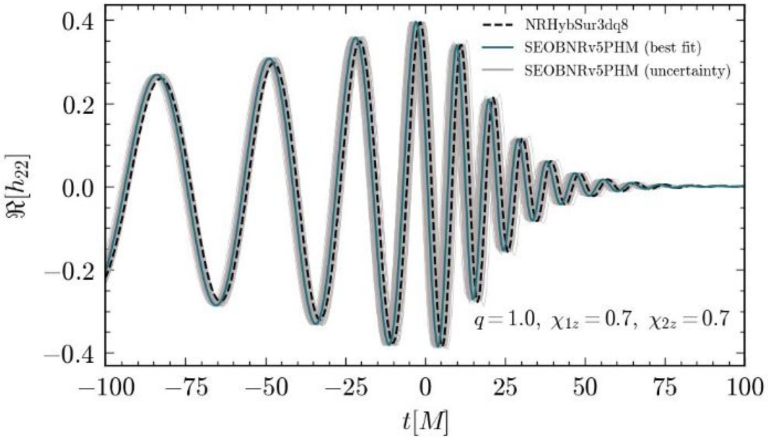


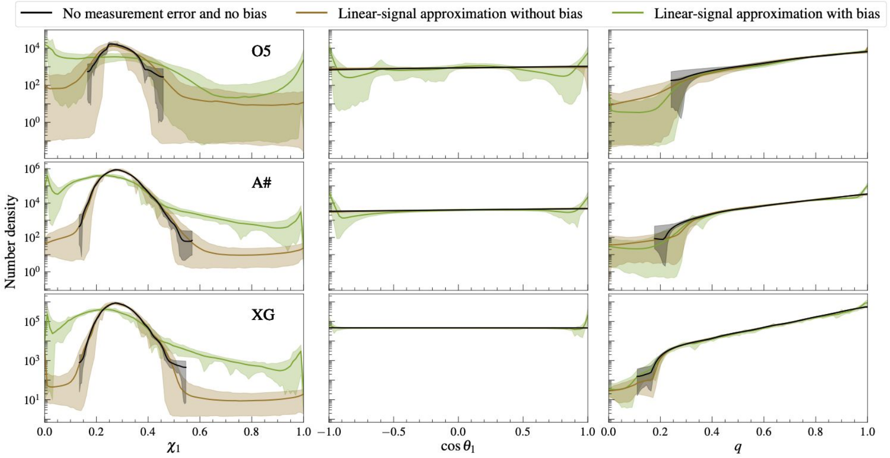


Waveform Challenges and Numerical Relativity









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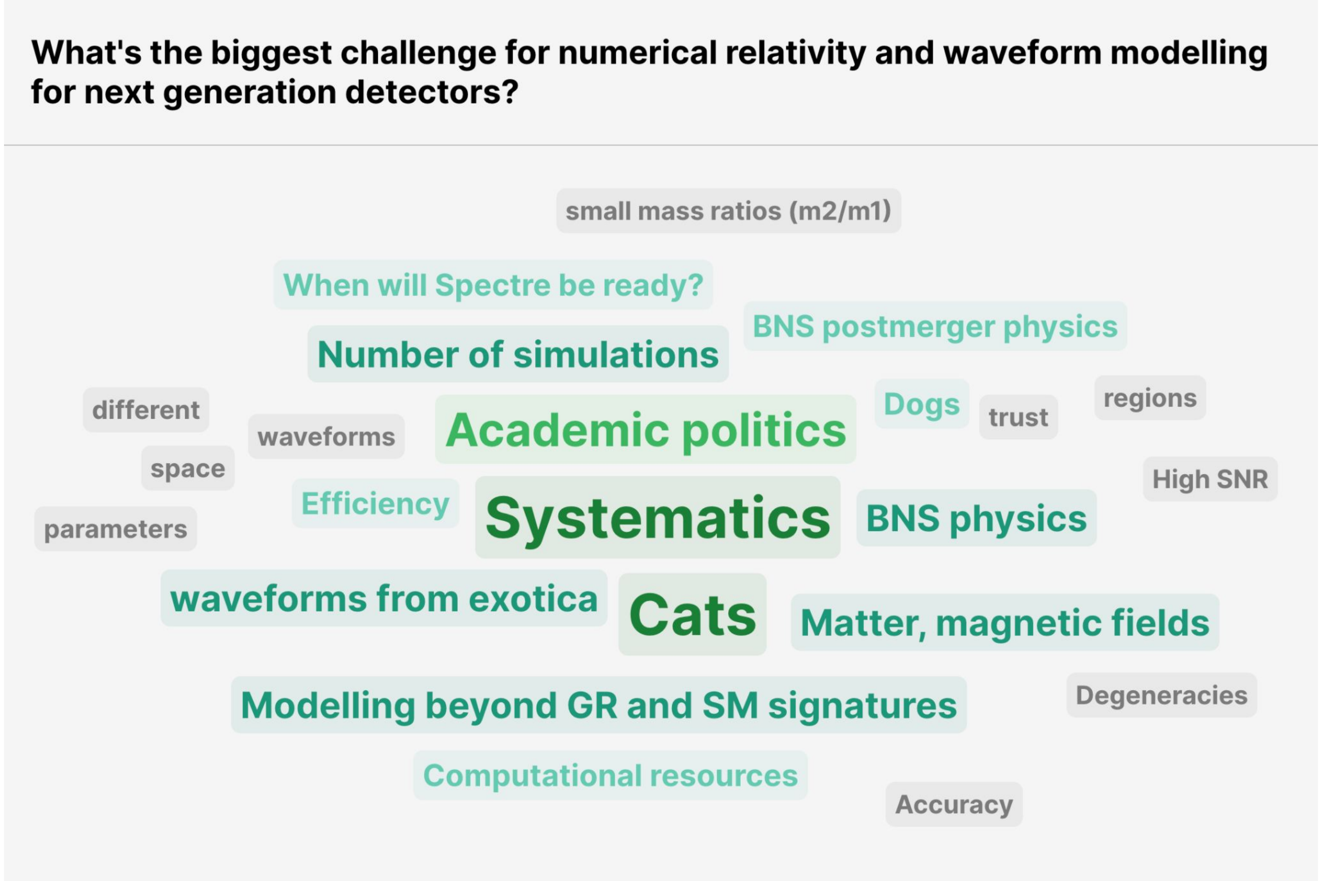


Tests of General Relativity

- Krishnendu (Chair), Swetha Bhagwat, Elisa Maggio, Félix-Louis Julié, Tamara Evstafyeva, Thomas Sotiriou
- Post-merger tests of GR: With ringdown signal-to-noise ratios (SNRs) reaching up to 200 in 3G detectors, it is essential to improve the calibration of ringdown models. This includes incorporating precession, eccentricity effect on ringdown models amplitudes, nonlinear modes, and tail effects. To achieve this, we need more extensive coverage from NR simulations and better parameterization.
- False deviations of general relativity could show in GW observations with large signal-to-noise ratio. Which effects should be accounted for in the waveform models or analysis methods? If we find a deviation from general relativity, which checklist should we follow?

Tests of General Relativity

- Some progress in constructing beyond GR and/or exotic compact objects full IMR waveforms (NR simulations and PN efforts).
- We now have the tools to model inspiral-merger-ringdown waveforms for some modified gravities. In the future, it is important to adapt and extend these results to wider classes of modified gravities, and develop semi-analytic waveform libraries, e.g., by comparing EOB and NR templates.
- Semi-agnostic tests of GR
- Poll Qn: “Do you expect a confirmed deviation from GR to show up in the current or future GW data?” Majority answered NO!

Multimessenger Observations

- Andrea Maselli (chair), Zsuzsa Marka, Nikhil Sarin
- The value of multi-messenger observations is obvious.
  - What can we robustly extract given systematics in EM/GW modelling?
- How are we going to deal with coincidences?
  - Statistical frameworks exist but not always immediately usable.
- Need to improve our modelling of counterparts
  - Has to be a joint effort from nuclear, numerical, and analytical theory community.
- Broaden definition of multi-messenger astronomy - It is not just joint detections.
  - Populations in EM independent of GW
    - Gaia, Galactic pulsars, Transients like SNe, GRBs, Kilonovae, Luminous Red Novae, etc
  - Different probes in time/evolutionary stage of stellar/neutron star evolution.
    - Different time in the Universe/SFR/Metallicity.
- What EM facilities do we need to keep up with 3G instruments?

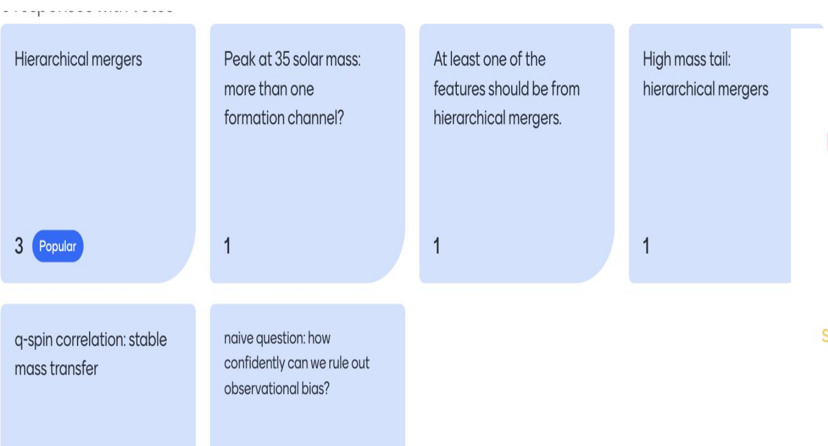
Astrophysical Populations

- Anuradha (chair), Debarti C., Amanda F., Martyna C., Matthew M.

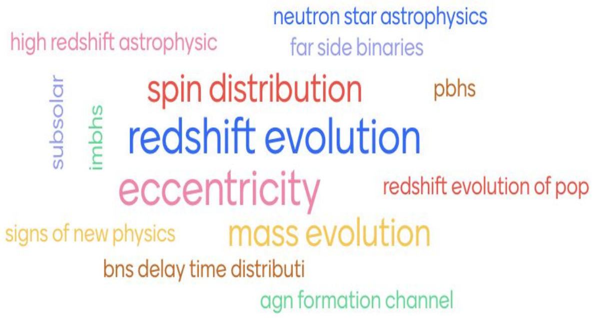
What was predicted in the population but not (yet) seen

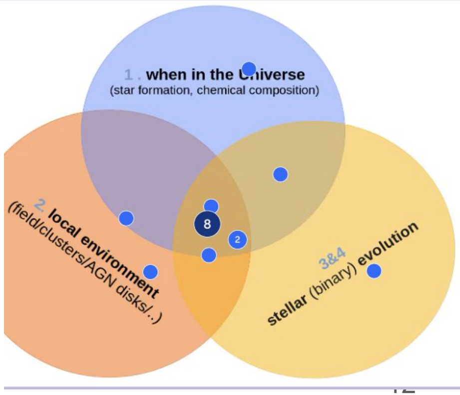
What determines the observed population properties of BBH mergers?

What astrophysical processes could explain these features?



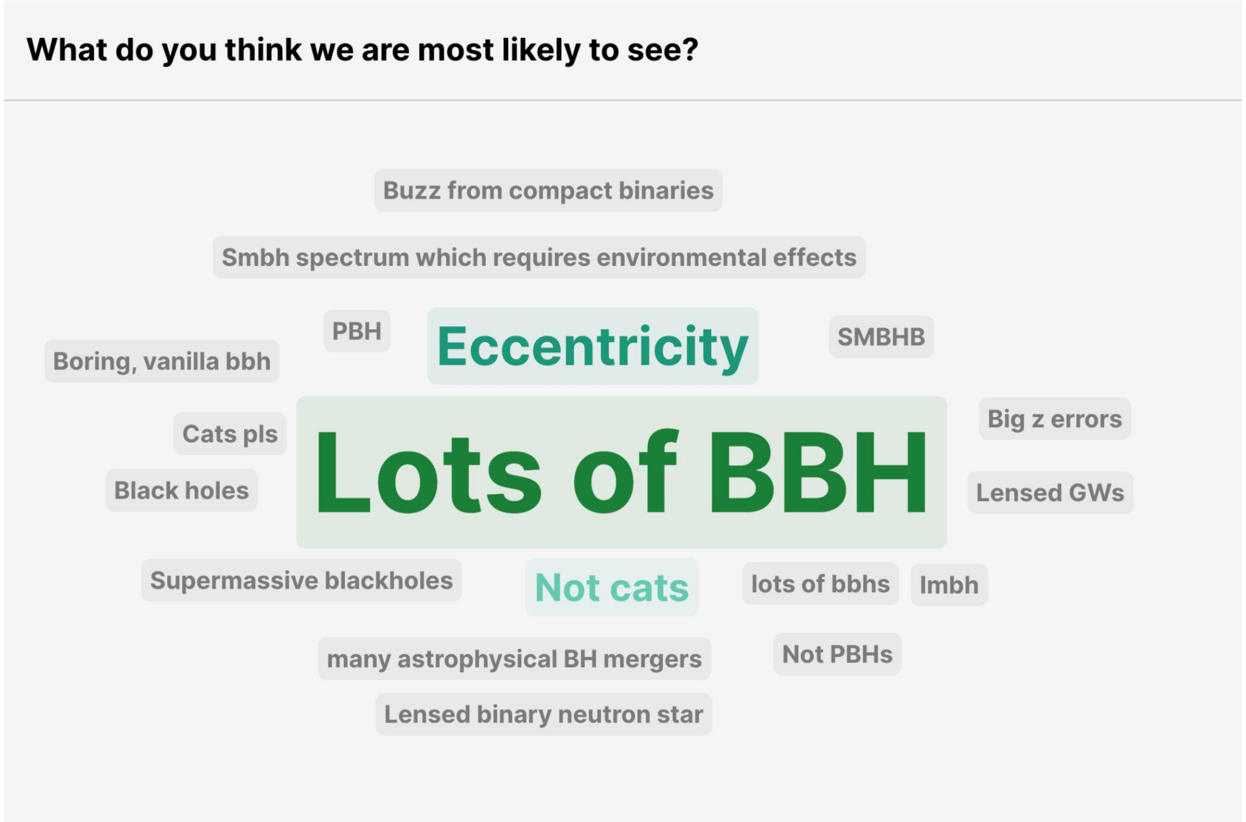
What are you most excited to learn in XG?





Compact Objects at High Redshifts

- Katy (chair), Aurrekoetxea, Mukherjee, Reali, Romero-Shaw



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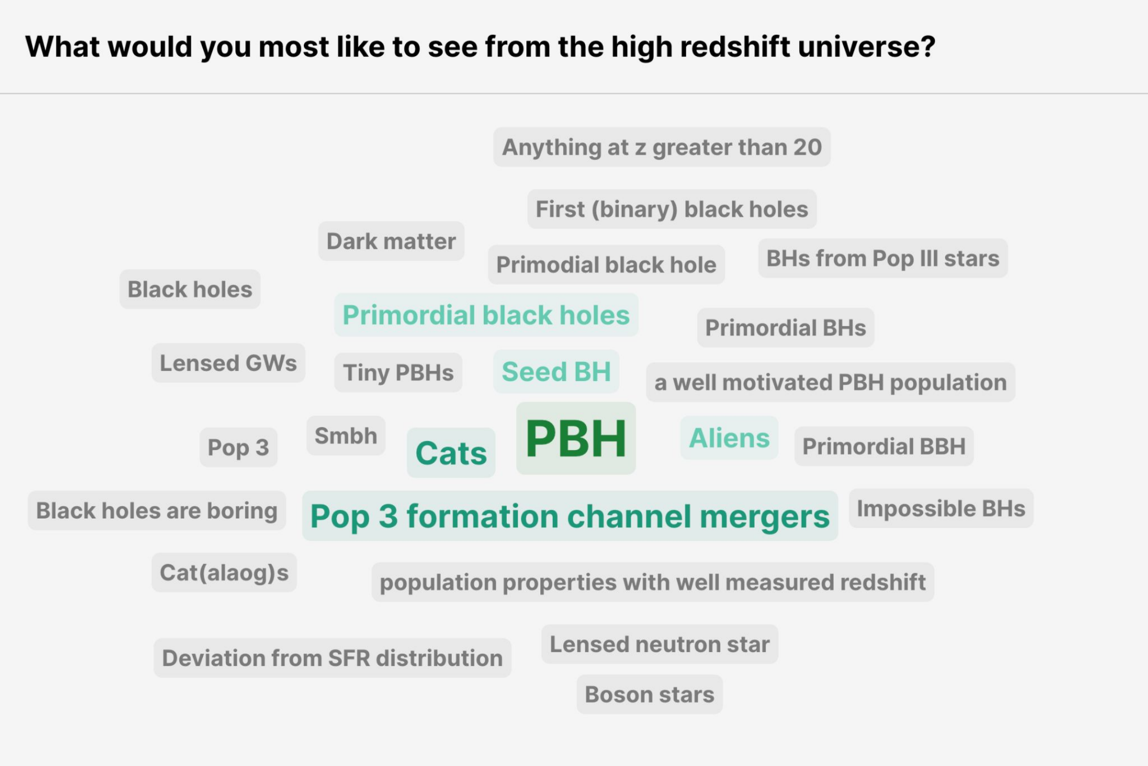
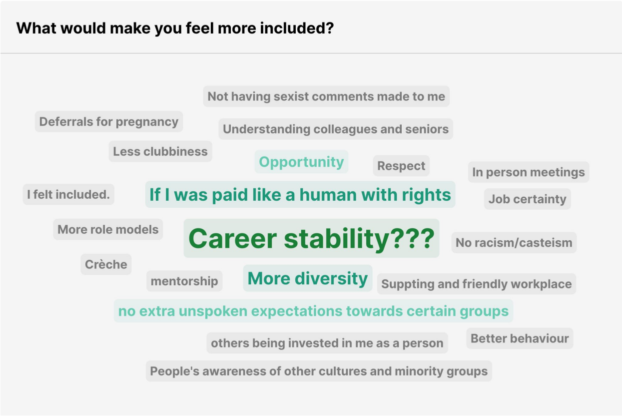


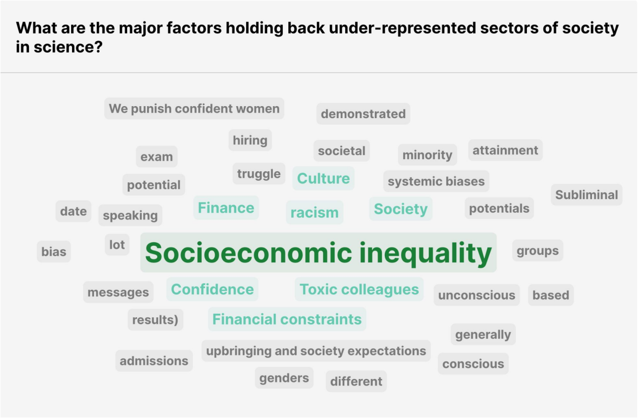
Lunch with Early Career Researchers

- Lionel (chair), Marc Favata, Michalis Agathos, Nils Anderson, Alessandra Buonanno
- Reach out to broader group of people, buy tickets!
- Importance of being at right place, right time
- Funding landscape in USA and Europe–There is never enough funding!
- New group are forming, so more positions but there are also more people applying, so competition is high (as always)
- Apply early for faculty jobs but also negotiate when possible

Equity, Diversity, Inclusion

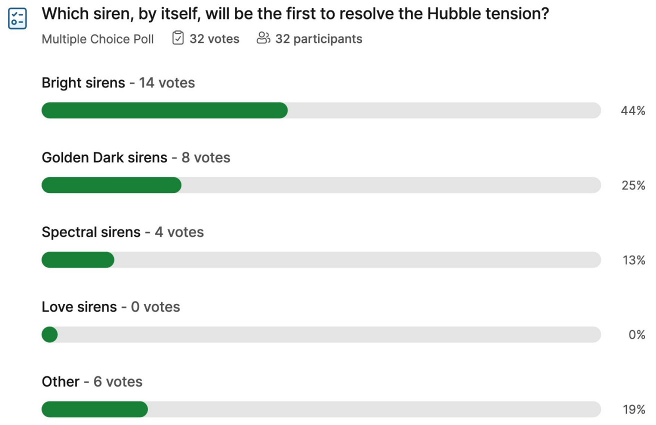
- Katy (chair), Marta Colleoni, Sarah Gossan, Malcolm Fairbairn, Anuradha Gupta
- Code of conduct should also condemn power-based exploitation
- Are there carrots to retain folks from underrepresented groups in academia?
- Are there carrots for folks who to the good job in mentoring and teaching of students from underrepresented groups (often difficult cases)?
- In addition to the letters from senior colleagues, letters from junior colleagues (e.g., mentees) should also be required in the job applications
- Are we doing enough to collaborate with outside expertise?

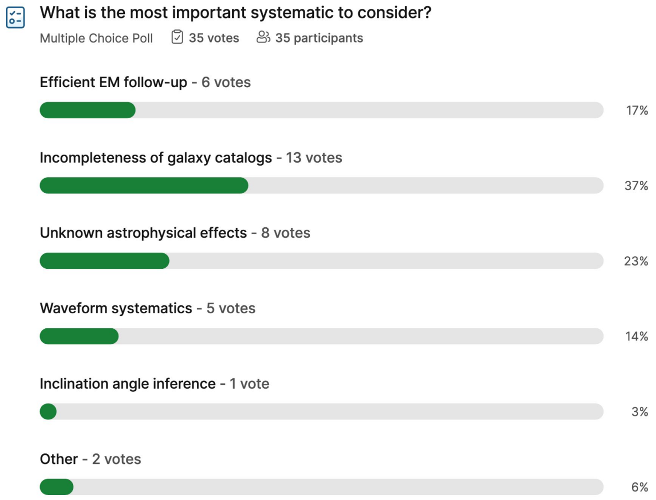




Cosmology

- Sathya (chair), Ish Gupta, Archisman Ghosh, Daniel Holz, Matteo Fasiello
- So many types of sirens to measure H0 from GWs, which one is the most important?
- What if we consider only golden sirens or loud-enough sirens?
- Selection effects from GW can be properly incorporated but EM selection effects can severely affect our estimates
- Other effects that can affect the measurements are non-stationary noise and detector calibration error
- Should we do the galaxy reweighting in statistical method?
- Effect of host-galaxy identification for hierarchical mergers

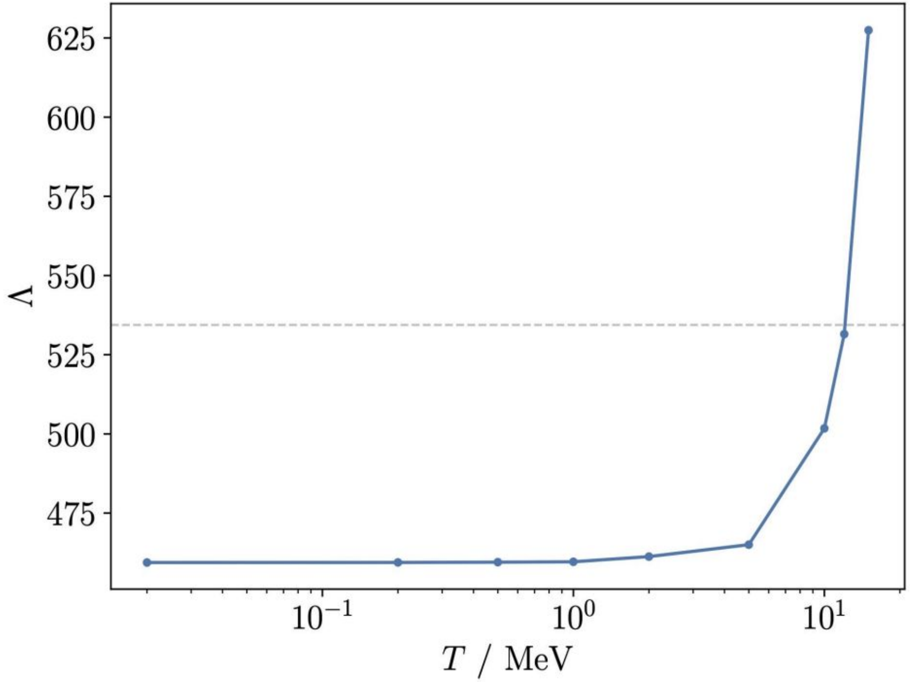




no one loved Love sirens!

Neutron Star Equation of State and Nuclear Physics

- Waveform models need more work
- NR simulation suffer from numerical systematics currently; e.g. artificial surface heating

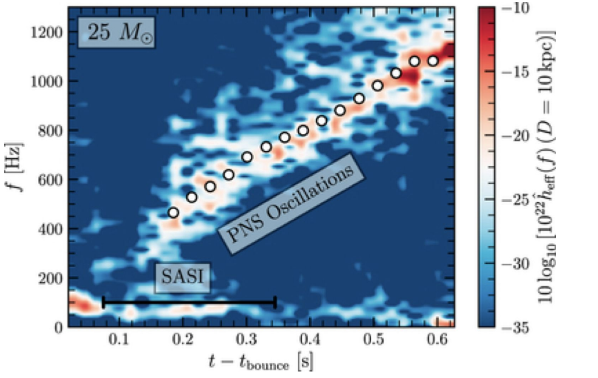


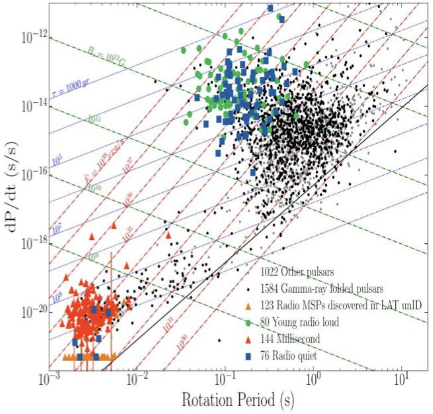
Dark Matter and Astroparticle Physics

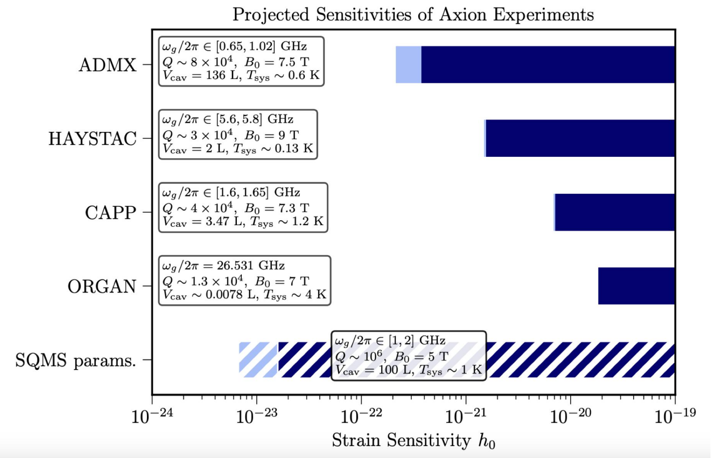
Eugene Lim & Djuna Croon (co-chairs), Pippa Cole, Ema Dimastrogiovanni, Ed Daw

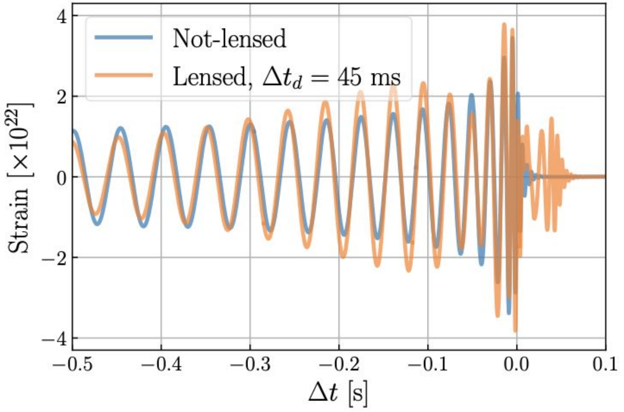
- There are a lot of proposed signals of dark matter and astroparticles in gravitational wave data, both transients and SGWB
- The next important challenge is to understand the background well, as well as possible degeneracies
- Although there is enthusiasm in the community, there is a funding gap in astroparticle physics.

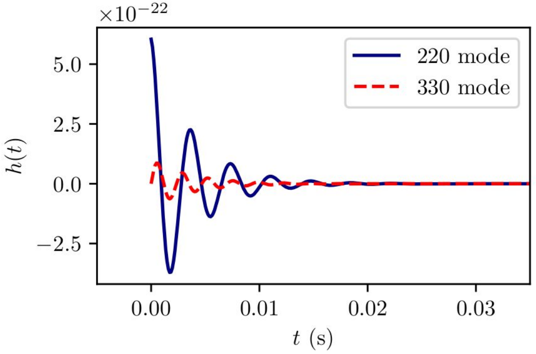
Discovering Exotica

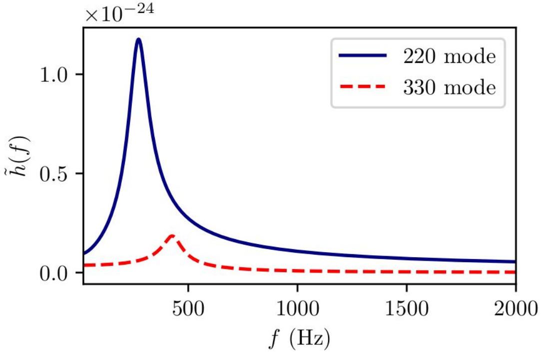












Discovering Exotica

- Sarah Gossan (chair), José M. Ezquiaga, Ani Prabhu, Julian Westerweck + special guest Chandana Hrishikesh
- Require better understanding (modelling+) of GW exotica to search for it
- Development of source-specific searches may be required to improve detection prospects (esp. for long-duration, broad-band emission)
- Looking forward: do we require better coordination to avoid waste of resources (time, computation,+)
- In the ultra-HF regime (10kHz+): require more sources of interest for GW searches
- New physics: how do we prepare to detect the unknown?
- What do *you* think will be our first “non-garden variety CBC”/exotic GW detection?