eROSITA follow up of candidate continuous gravitational waves from Einstein@Home

Adriana Mancini Pires
Jan Kurpas, Axel Schwope (AIP)

Center for Lunar and Planetary Sciences
Institute of Geochemistry CAS

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And collaborators: Greg Ashton, Paul Lasky, Wynn Ho, Werner Becker

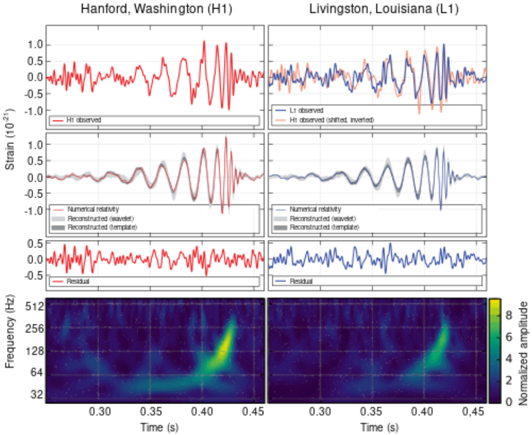
Gravitational wave events

source: GWTC-3

Since GW150914, 90 events have been confirmed (O1, O2, O3)

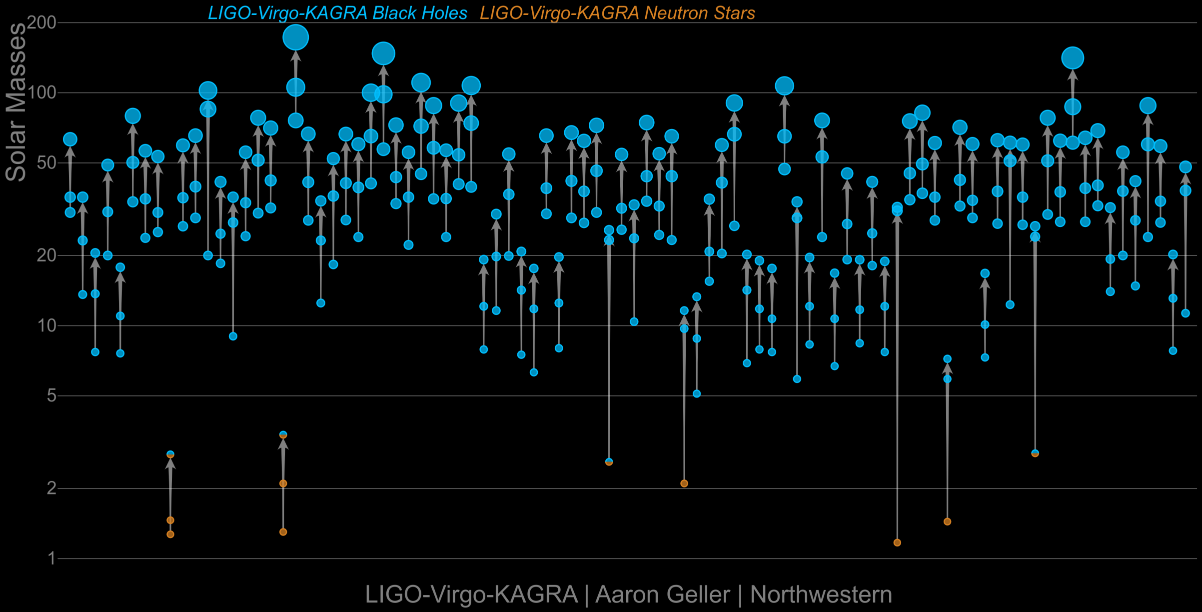
All detections from merging binaries consisting of black holes and neutron stars (BBH, BNS, NSBH)

Sensitivity has improved through detector upgrades and better data quality and analysis techniques

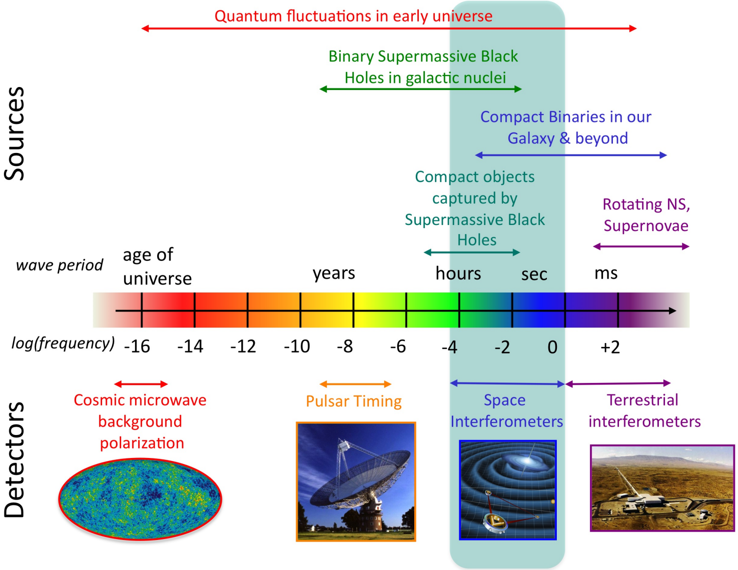


Abbott et al. (LIGO Scientific Collaboration and Virgo Collaboration)

Masses in the Stellar Graveyard



The Gravitational Wave Spectrum



Much more to discover!

PTA (operational)

stochastic GW background (2023)

LIGO+ window

- ✓ inspiralling binaries
- ? core-collapse supernovae
- ? oscillations and instabilities
- ➠ spinning NSs

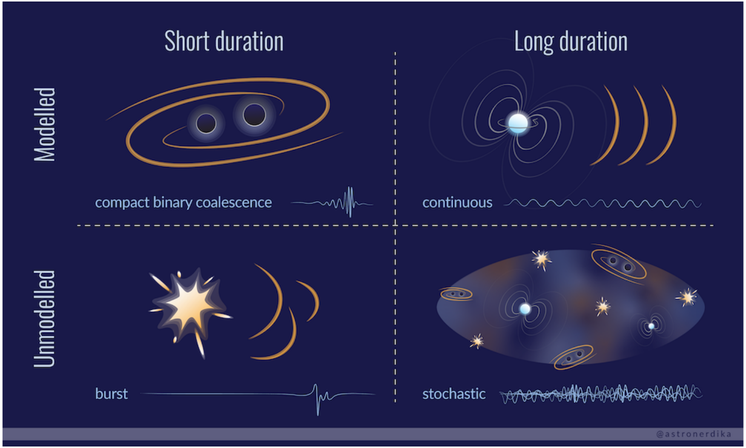
Persistent signals (CW) from spinning neutron stars

Differ *wrt* transient events thus far detected:

- physical mechanism
- signal duration
- signal characteristics
- frequency range

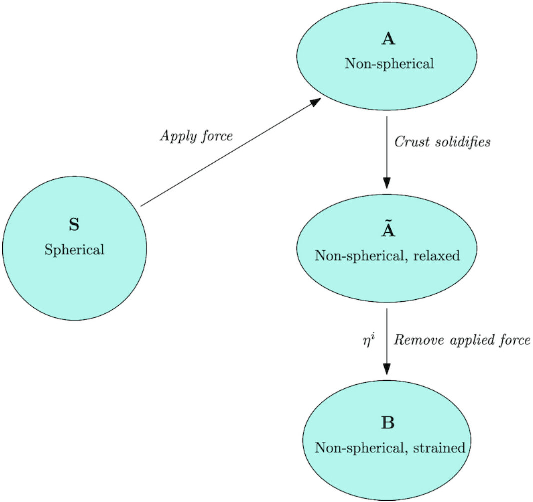
Challenges

Low amplitude and long duration: require sensitive and computationally intensive searches



Credit: Shanika Galaudage, astronerdika

中国科学院
CHINESE ACADEMY OF SCIENCES



Grittins et al. 2021: Configurations of “mountain” calculations

No pulsars spin close to break up

➠ Should emit gravitational waves

How large a bump can be sustained?

More recent calculations suggest that neutron star mountains are a factor of a few to two orders of magnitude below previous estimates (fractions of a millimeter tall)

Searches

Targeted (most sensitive) *vs.* blind (all-sky)
Best sources: close by, fast spinning, young

CW counterparts: the XINS connection

All-sky searches: unknown sources

- “louder” Crab-like, unless *atypical*
- search for XINS by Jan Kurpas
  see talk on Wednesday!

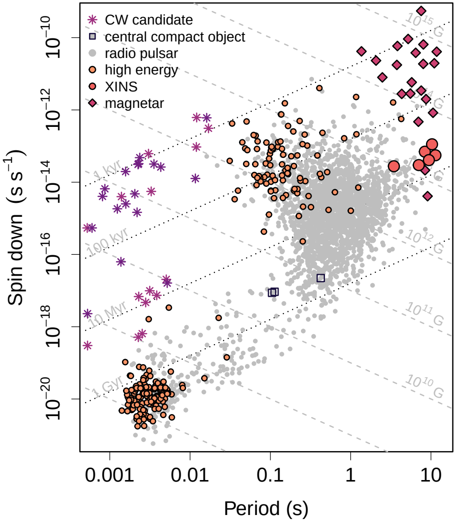
CW candidates from Einstein@Home

ECs: Greg Ashton, Paul Lasky, Wynn Ho

- 56 selected candidates (O2, O3, O4)
- 26 in western hemisphere

Goals

- characterise the X-ray source content
- follow-up plausible counterparts

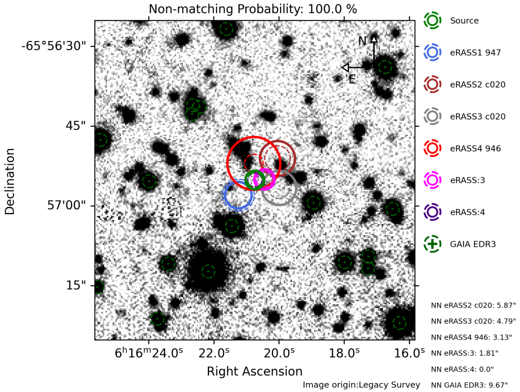


ARCHES cross-matching

http://www.arches-fp7.eu

- 45 arcmin around CW position
- multi-catalogue probabilistic method
  Pineau et al. 2017
- cross-match eRASS sources with:
  - ✓ Gaia DR3
  - ✓ Pan-STARRS DR1
  - ✓ Legacy Survey DR10
  - ✓ VISTA
  - ✓ unWISE
  - ✓ catWISE2020
  - ✓ DeCAPS2

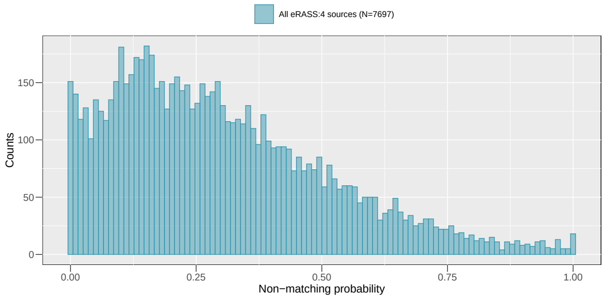
➠ examine flux ratios, hardness ratios, variability, non-matching probability



eRASS:4 content

7697 sources

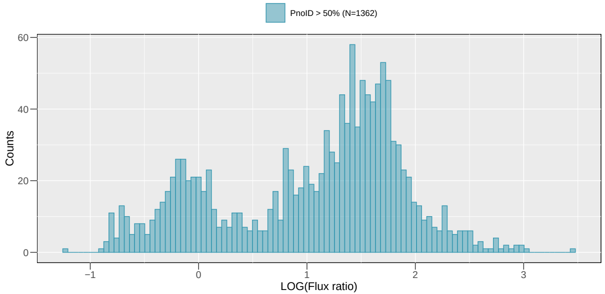
- median ML 10
- $f_X^{\mathrm{median}} = (1.7 \pm 1.0) \times 10^{-14}$ cgs
- RADEC_ERR $4.7'' \pm 1.5''$



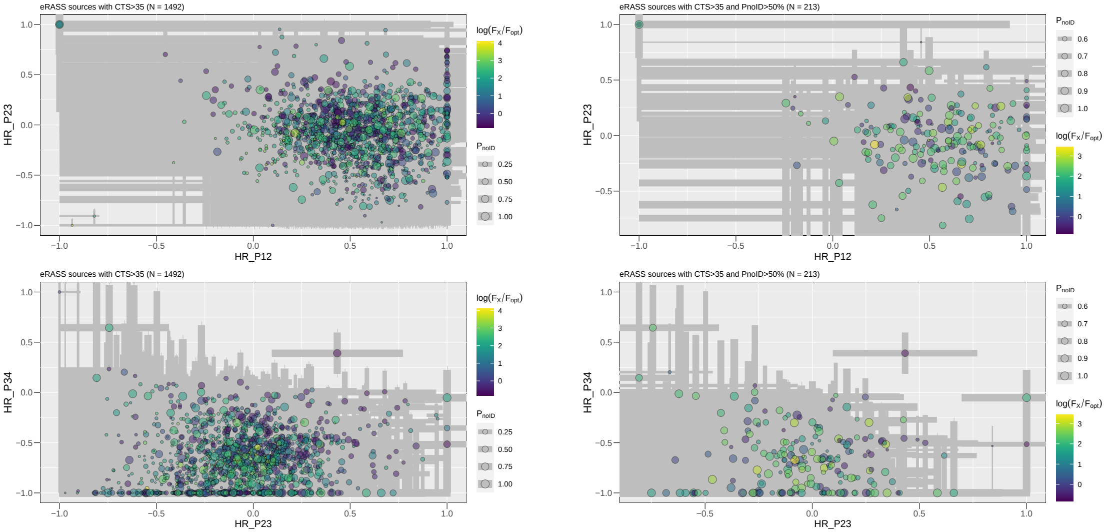
$P_{\mathrm{noID}} > 50\%$

1362 sources

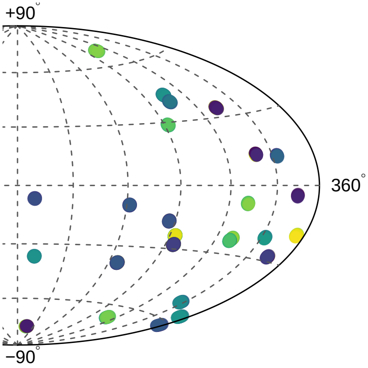
- median ML 7
- $f_X^{\mathrm{median}} = (1.5 \pm 0.8) \times 10^{-14}$ cgs
- RADEC_ERR $5.5'' \pm 1.3''$



Hardness ratio diagrams



Status and outlook



Fields of CW candidates, colour-coded by #eRASS
(N=100–1000, median 270 per field)

All-sky Einstein@Home (O2, O3, O4)

We searched for the X-ray content of 26 candidate CW sources in the eROSITA_DE hemisphere

- ✓ ∼7700 eRASS:4 sources selected
- ✓ ARCHES cross-matching (optical/nIR)
- ✓ 1360 sources have a $P_{\text{noID}} > 50\%$
- ✓ 1500 with more than 35 counts (0.2–2.3 keV)
- ✓ 200 with ML_CTS_1 > 35 and $P_{\text{noID}} > 50\%$
- ➡ spectral characterisation and variability
- ➡ follow-up of promising targets

Thank you!