WG1-WG2: Report and discussion

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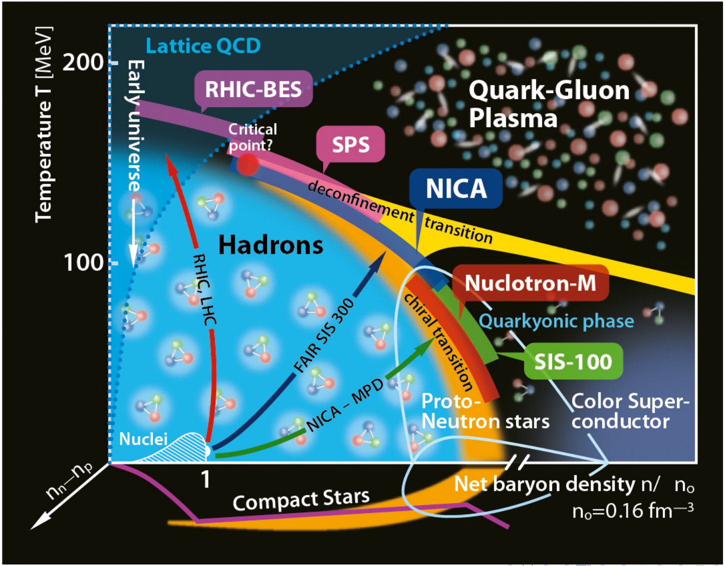
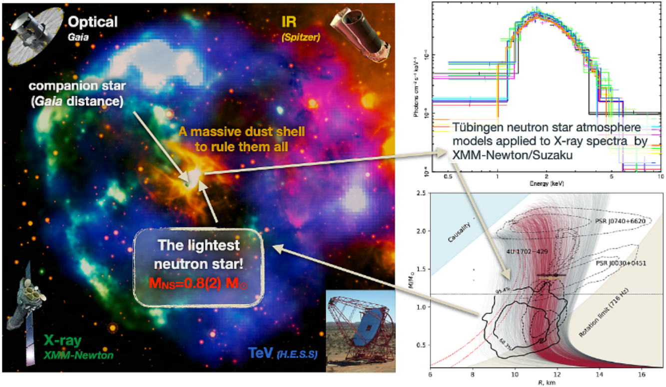
WG1 questions

- Phase transition(s) at high net-baryon density.
- Are the masses and radii of NS well determined?
- Can we test nucleon dynamics with GW?
- Neutron star Equation of State in the 3G era: do we control systematics and modelling well enough?
- Is deconfined quark matter present in quiescent neutron stars, and/or does it get produced in NS mergers? What will be the role of GW observations in answering this question?
- Strong magnetic fields in magnetars and mergers.
- How to systematically study the high-density QCD EoS in neutron stars and BNSM as well as heavy ion collisions and how to relate these results to one another quantitatively.
- How to relate heavy-ion collisions and neutron star mergers.
- Combined analysis of heavy-ion collisions and neutron star mergers.

Strongly interacting matter phase diagram

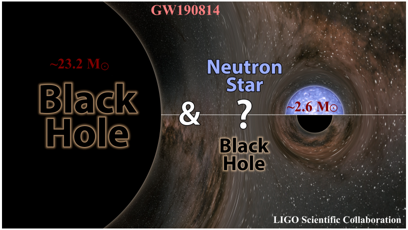


HESS J1731-347



A false-color image of the supernova remnant HESS J1731-347 hosting the X-ray emitting neutron star observed by XMM-Newton and the optical star observed by Gaia missions (in the center of the shell in the left panel). The image is a result of synergies between various facilities observing all kinds of invisible light from infra-red (orange, Spitzer) to X-rays (green, XMM-Newton) and ultra-high energy TeV band (blue, HESS). The deep observations by XMM-Newton and Suzaku telescopes allowed us to measure the high-fidelity X-ray spectra of the neutron star (top right) which helped to deduce neutron star's mass using the neutron star atmosphere models developed in Tübingen.

What is the nature of the GW190814 secondary component?



The compact binary merger event GW190814 had primary mass component, a black hole, with $M = 23.2\ M_{\odot}$ and the second component with $M = 2.5 - 2.67\ M_{\odot}$. The nature of the secondary component raised a lot of questions.

Possible explanations:

- NS with exotic degrees of freedom, e.g. hyperons and/or quarks [Tan+ 2020; Dexheimer+ 2021]
- highly spinning NS [Zhang & Li 2020]
- NS matter with extra stiffening of the EoS at high densities [Fattoyev+ 2020]
- BH from the 'mass gap' [Tews+ 2021; Essick & Landry 2020]
- DM-admixed NS [Das+ 2021; Giovanni+ 2022]

Black widow pulsar

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CrossMark

PSR J0952−0607: The Fastest and Heaviest Known Galactic Neutron Star

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Abstract

We describe Keck-telescope spectrophotometry and imaging of the companion of the "black widow" pulsar PSR J0952−0607, the fastest known spinning neutron star (NS) in the disk of the Milky Way. The companion is very faint at minimum brightness, presenting observational challenges, but we have measured multicolor light curves and obtained radial velocities over the illuminated "day" half of the orbit. The model fits indicate system inclination $i = 59.^{\circ}8 \pm 1.^{\circ}9$ and a pulsar mass $M_{NS} = 2.35 \pm 0.17\, M_{\odot}$, the largest well-measured mass found to date. Modeling uncertainties are small, since the heating is not extreme; the companion lies well within its Roche lobe and a simple direct-heating model provides the best fit. If the NS started at a typical pulsar birth mass, nearly $1\, M_{\odot}$ has been accreted; this may be connected with the especially low intrinsic dipole surface field, estimated at 6×10^{7} G. Joined with reanalysis of other black widow and redback pulsars, we find that the minimum value for the maximum NS mass is $M_{max} > 2.19\, M_{\odot}$ ($2.09\, M_{\odot}$) at 1σ (3σ) confidence. This is $\sim 0.15\, M_{\odot}$ heavier than the lower limit on M_{max} implied by the white dwarf–pulsar binaries measured via radio Shapiro-delay techniques.

Unified Astronomy Thesaurus concepts: Pulsars (1306)

Supporting material: data behind figure

Object in the mass gap

RESEARCH ARTICLE | RADIO ASTRONOMY

A pulsar in a binary with a compact object in the mass gap between neutron stars and black holes

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Abstract

Some compact objects observed in gravitational wave events have masses in the gap between known neutron stars (NSs) and black holes (BHs). The nature of these mass gap objects is unknown, as is the formation of their host binary systems. We report pulsar timing observations made with the Karoo Array Telescope (MeerKAT) of PSR J0514−4002E, an eccentric binary millisecond pulsar in the globular cluster NGC 1851. We found a total binary mass of 3.887 ± 0.004 solar masses ($M_\odot$), and multiwavelength observations show that the pulsar's binary companion is also a compact object. The companion's mass (2.09 to 2.71 $M_\odot$, 95% confidence interval) is in the mass gap, indicating either a very massive NS or a low-mass BH. We propose that the companion formed in a merger between two earlier NSs.

WG1 questions

- Scattering amplitudes and GWs: up to where?
- Gravitational Memory Effects
- Do we have a clear understanding of the continuous gravitational-wave emission?
- Whether GW could reveal the structure of curved spacetime either smooth or at least discretized?
- What is inside astrophysical black holes
- Testing EoS in a theory of gravity independent way - is it possible?
- Dark matter, dark energy, early universe and singularity, inflation, alternative models of gravity and the Universe
- Numerical Relativity beyond GR and SM
- Waveform systematics VS searches for violations of GR with XG detectors?
- What can GWs tell us about reheating after cosmic inflation?
- To what degree can GWs probe the connection between particle physics and cosmology? Example: How sensitive are direct GW signatures and/or CMB B-modes from inflation and reheating to microphysical parameters?

WG2 questions

- How do we cover the spectrum of GWs as best as possible?
- Can GWs solve the Hubble Tension? What is the equation of state of neutron stars?