Nuclear Physics
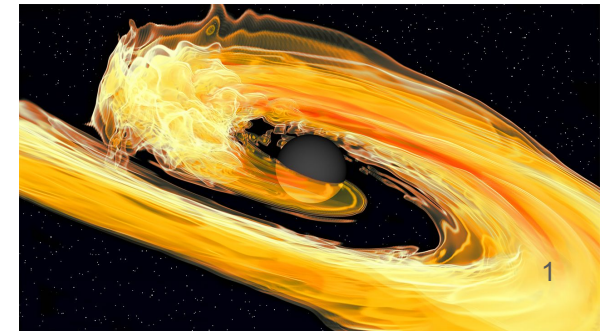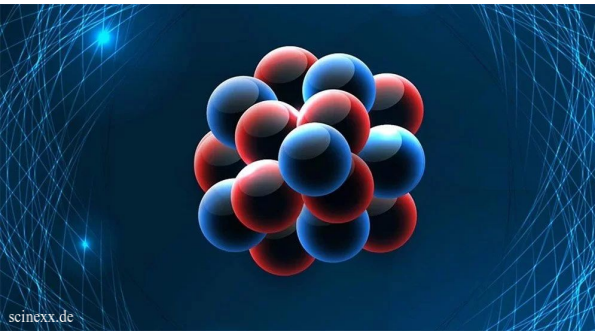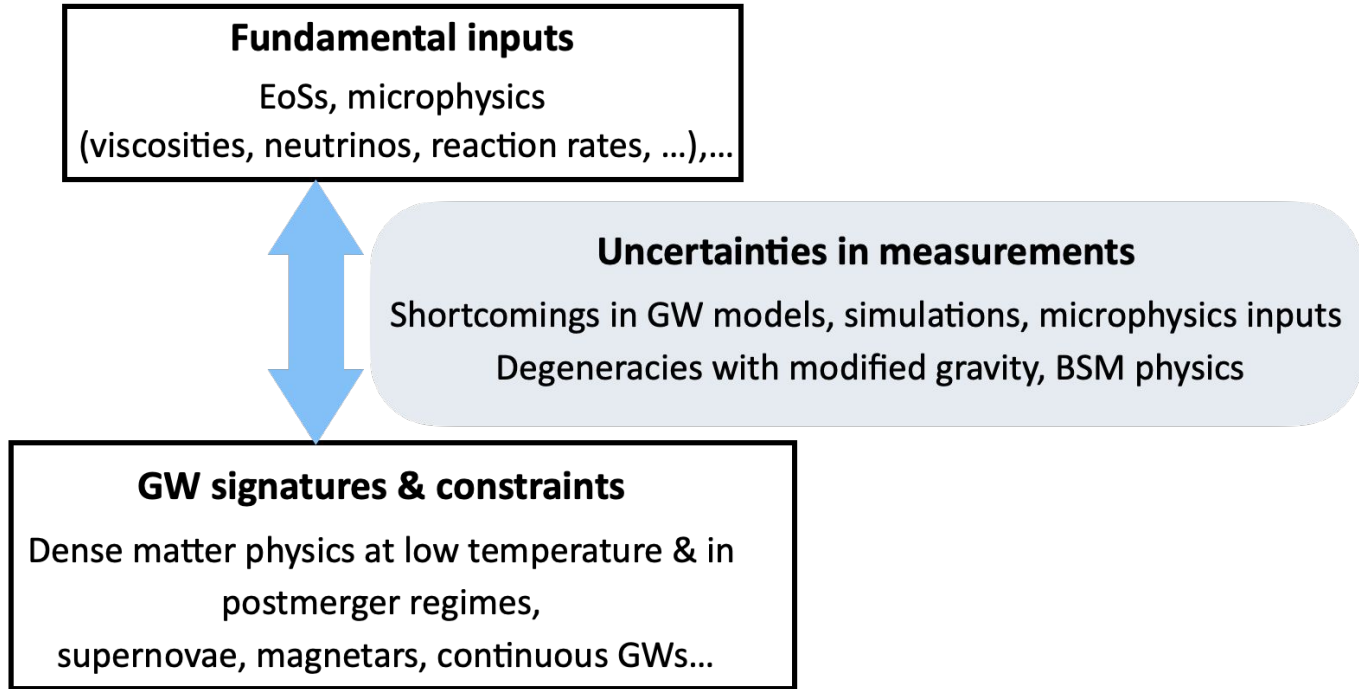## -- Division 6 --
Status of the Blue Book
chairs: Tim Dietrich, Tanja Hinderer, Micaela Oertel

Main subjects and questions

Fundamental inputs

EoSs, microphysics
(viscosities, neutrinos, reaction rates, …),…

Uncertainties in measurements

Shortcomings in GW models, simulations, microphysics inputs
Degeneracies with modified gravity, BSM physics

GW signatures & constraints

Dense matter physics at low temperature & in
postmerger regimes,
supernovae, magnetars, continuous GWs…

- Main question for the BlueBook: to which extent ET will be able to improve our understanding of dense (and hot) matter?

Progress on the chapter for the bluebook

Organization, structure, and section leads established, writing underway

1. **Microphysics inputs (what is the current state of the art?)**

    1. EoS modeling [text]

    2. Reaction rates, neutrinos, viscosities, nucleosynthesis, nuclear masses [text]

2. **Constraints on microphysics with ET (what can we learn with ET?)**

    1. *Low-temperature*: NS-NS inspirals, NS-BH binaries, continuous GWs [text]

    2. *Finite-temperature:* NS-NS postmergers, supernovae [text]

    3. *Nucleosynthesis* (with multimessenger) [outline]

3. **Uncertainties and degeneracies in measurements and interpretations (how precise can we be?)**

    1. Impact of waveform systematics [text]

    2. Uncertainties in simulations and the microphysics included [text]

    3. Modified gravity and BSM physics impacts on EoS inferences and quasi-universal relations [text]

Progress on the chapter for the bluebook

Organization, structure, and section leads established, writing underway

1. **Microphysics inputs**

   1. ~~EoS modeling~~

   2.

2. **C**

   1.

   2.

   > Work in close coordination with other divisions
   >
   > ➢ focus of Div. 6 material: implications for subatomic-/microphysics
   >
   > interpretations

   3. Nucleosynthesis (with multimessenger) [outline]

3. **Uncertainties and degeneracies in measurements and interpretations**

   1. Impact of waveform systematics [text]

   2. Uncertainties in simulations and the microphysics included [text]

   3. Modified gravity and BSM physics impacts on EoS inferences and quasi-universal relations [text]
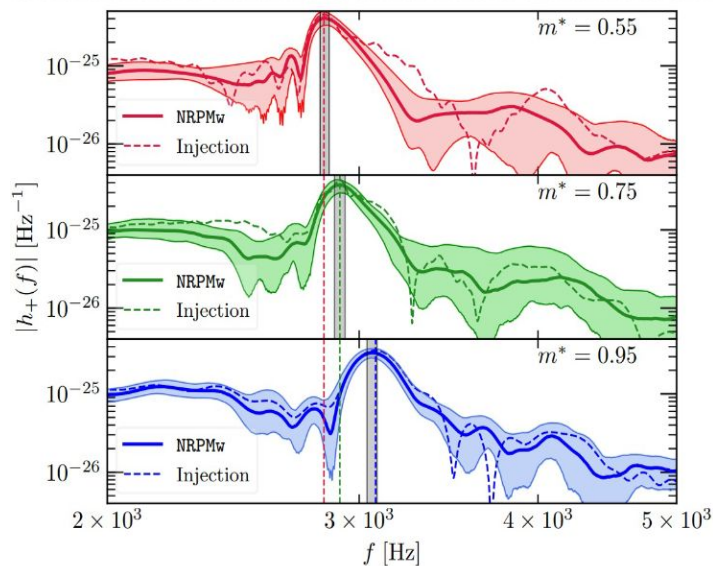
Some selected topics

- To what extent can we constrain the dense matter EoS from tidal deformability measurements during BNS inspiral?
  Coba study + https://arxiv.org/pdf/2303.11201.pdf + https://arxiv.org/pdf/2206.11286 + …
  -> NS EoS and NS properties very well constrained

- Thermal effects in the postmerger -> shift in peak frequency depending on importance of thermal effects detectable for SNR >~15 https://doi.org/10.48550/arXiv.2302.11359
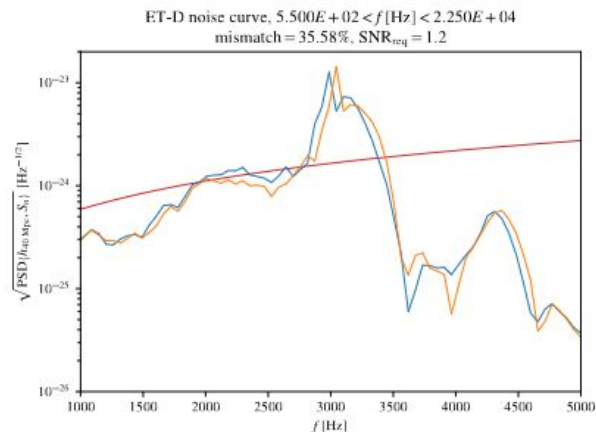- And many others (detectability of a phase transition, ….)

4

Some selected topics

Microphysics inputs

- Relevance of pQCD constraints for NS EoS (discussion) -> constraints only active at relatively high densities, above central NS density within GR but interesting for Div. 1
- To constrain nuclear EoS/interaction from inspiral additional nuclear physics input desirable

Uncertainties in measurements

- Improvement of measurement accuracy with additional effects
  (e.g. resonant r-modes https://arxiv.org/pdf/2205.01182)
- Effect of weak reactions on postmerger oscillation frequencies -> careful treatment needed to extract correct frequency https://arxiv.org/pdf/2205.11377

ET-D noise curve, $5.500E+02 < f\,[Hz] < 2.250E+04$
mismatch $= 35.58\%$, $SNR_{req} = 1.2$

Bluebook further planning

- First draft for most individual sections is ready

- Material shared with all division members for comments since September

- Harmonizing and smoothening work to be done

- Some sections need still need some input

  (illustrations, focus on ET science)
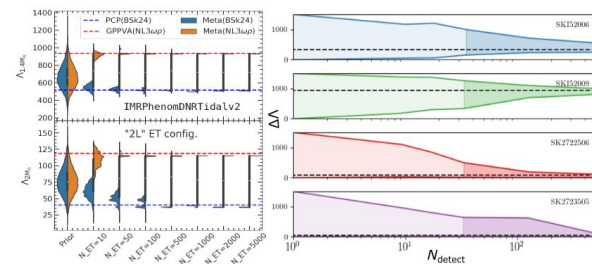
- Share with other OSB divisions by end of the year

Figure 1: Left panel: Enhancement in the precision of the tidal deformability for a $1.4 M_\odot$ and $2.0 M_\odot$ NS using nucleonic meta-modelling technique. Right panel: Reduction in the uncertainty on the tidal deformability with increasing number of detection. Figures adapted from Ref. [189] (left) and Ref. [216] (right panel).

3.1.2 Continuous GWs (including young magnetars)

4 pages, coordinators: Cristiano Palomba, Nils Andersson
contributors: Fabien Gittins, Ian Jones, Michał Bejger, Bryn Haskell,
Simone Dall'Osso