Characterizing neutron rich matter with Kilonovae and BNS mergers

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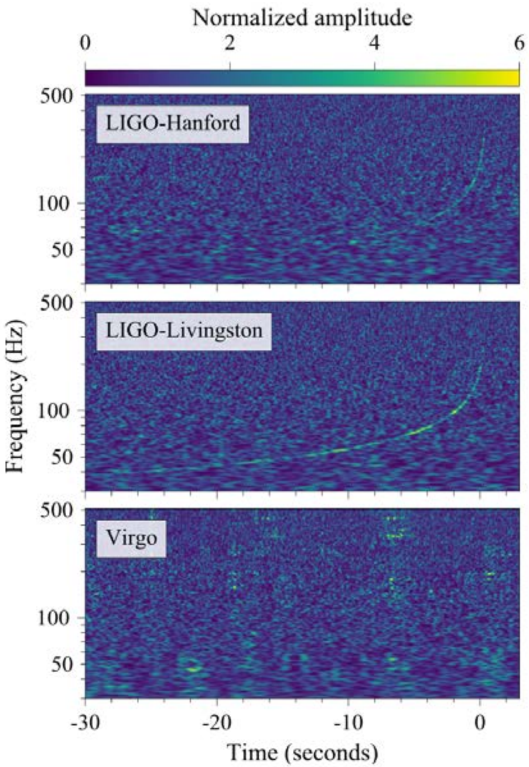
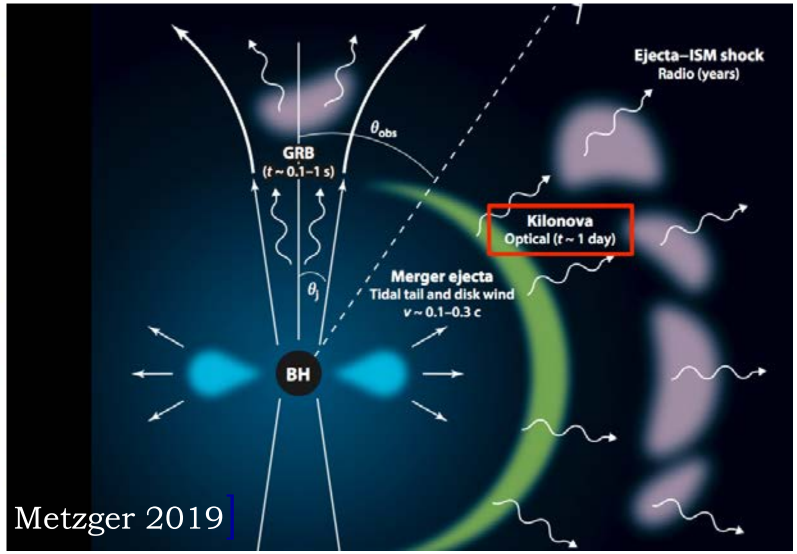
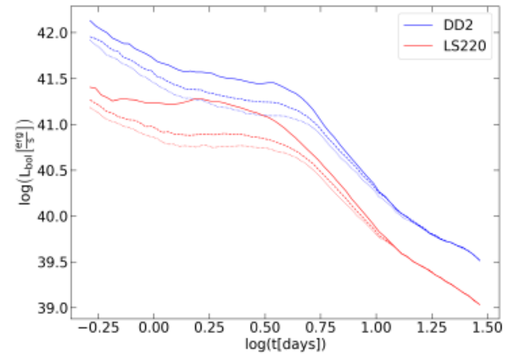
Pérez-García, Izzo, Barba et al, arXiv:2204.00022, accepted A&A

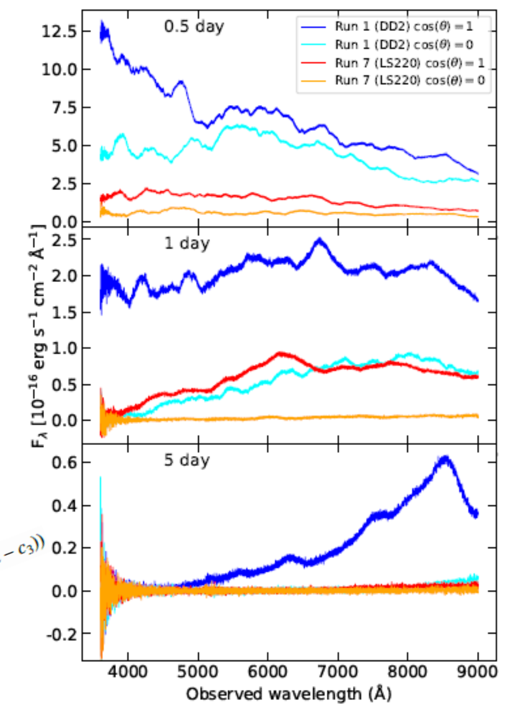
BNS: Kilonovae and EoS

Astro: GW+EM+neutrinos+X
Confirmed BNS: GW170817, GW190425.
Abbot et al 2019,2020

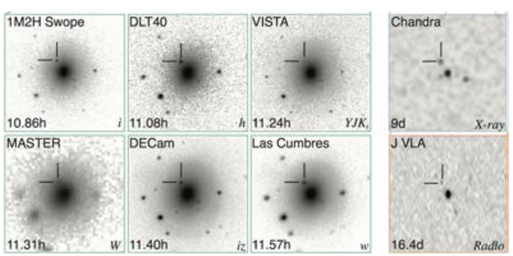






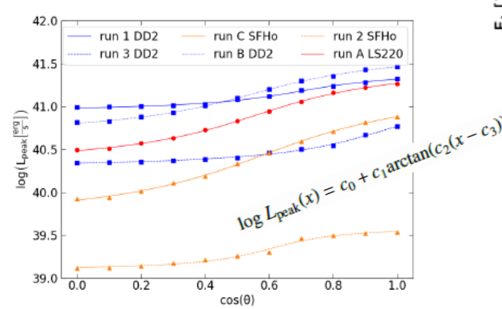


Sky	Telescope	Instrument	Spectral range	Resolution	Field of View	Spatial sampling	IFU
Southern	VLT	MUSE	480–930 nm	1770–3590	59.9″ × 60.0″	0.2″ × 0.2″	mirror slicer
Northern	Keck	KCWI	350–560 nm	3000–4000	8.25″ × 20.0″	0.34″ × 0.147″	mirror slicer
Northern	GTC	MAAT	360–1000 nm	600–4100	12.0″ × 8.5″	0.303″ × 0.127″	mirror slicer



GW170817+
AT2017gfo+
GRB2017A

LC simulated
Radiative transfer
MC (Bulla 2019)



$$\log L_{peak}(x) = c_0 + c_1 \arctan(c_2(x-c_3))$$

Fig. 15. Peak bolometric luminosity as a function of cos θ and fitting functions. LS220, SFHo and DD2 EoS are shown in red, orange and blue colors, respectively. Runs A, B and C have a fixed $M_{chirp} = 1.118M_\odot$. Runs 1, 2 have $M_{chirp} = 1.22M_\odot$ and Run 3 has $M_{chirp} = 1.39M_\odot$. A fixed $q = 1$ value is used.

Fig. 4. Absolute flux obtained at $t = 0.5, 1, 5$ days after the merger as seen by MAAT using R1000B and R1000R gratings. We plot run 1 (EoS DD2) for a polar and equatorial observer (dark and pale blue lines). Same for run 7 (EoS LS220) for a polar and equatorial observer (red and orange lines). A distance of 40 Mpc is assumed.

KN Simulations and EoS

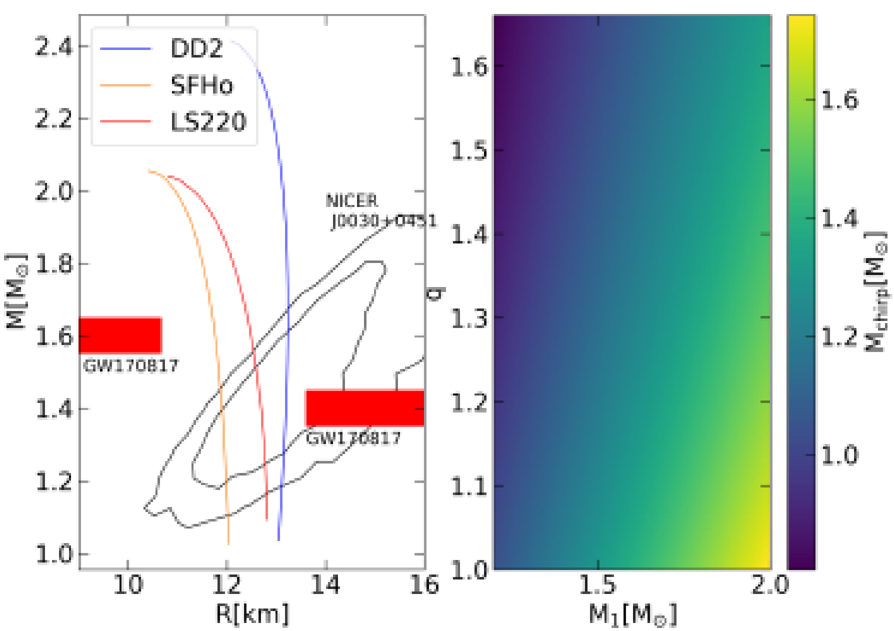
We tested DD2, SFHo, LS220
These EoS are GW informed as allowed for GW170817 from Bayes factors with slight preference towards more compact stars

NR simulations Radice et al 2018 and Nedora et al 2021+ spectra generated with MC radiative transfer (Bulla 2019)
Neutrino processes incorporated to varios degrees of accuracy

Some underlying Model dependencies

$$\mathcal{M}_{\rm chirp} = \mathcal{M} = \left[\frac{q}{(1+q)^2}\right]^{3/5} M$$

$$\tilde{\Lambda} \equiv \frac{16}{13}\left[\frac{\Lambda_1 M_1^4 (M_1 + 12M_2) + \Lambda_2 M_2^4 (M_2 + 12M_1)}{(M_1 + M_2)^5}\right].$$



Run	EoS	q	M_{chirp} ($M_\odot$)	M_1 ($M_\odot$)	M_{wind} ($M_\odot$)	M_{dyn} ($M_\odot$)	$\langle v_{ej}\rangle/c$	$\langle Y_e\rangle$
1	DD2	1	1.22	1.4	3.708×10^{-2}	4×10^{-4}	0.22	0.17
2	SFHo	1	1.22	1.4	3×10^{-3}	4×10^{-4}	0.35	0.19
3	DD2	1	1.39	1.6	5.88×10^{-3}	1.2×10^{-3}	0.24	0.14
4	DD2	1	1.31	1.5	5.31×10^{-2}	7.0×10^{-4}	0.17	0.2
5	DD2	1.036	1.23	1.44	4.32×10^{-2}	5.0×10^{-4}	0.2	0.17
6	SFHo	1.036	1.23	1.44	2.7×10^{-4}	4.0×10^{-4}	0.33	0.18
7	LS220	1	1.22	1.4	1.37×10^{-2}	1.4×10^{-3}	0.17	0.14
8	LS220	1.036	1.23	1.44	1.17×10^{-2}	1.9×10^{-3}	0.16	0.14
9	LS220	1	1.31	1.5	4.80×10^{-4}	3.0×10^{-4}	0.19	0.08
10	LS220	1	1.39	1.6	2.10×10^{-4}	3.0×10^{-4}	0.21	0.07
11	LS220	1	1.49	1.71	1.80×10^{-4}	3.0×10^{-4}	0.22	0.08
12	SFHo	1.092	1.137	1.365	2.64×10^{-2}	1.5×10^{-3}	0.23	0.14
13	SFHo	1.17	1.128	1.4	3.52×10^{-2}	1.2×10^{-3}	0.2	0.14
14	SFHo	1	[illegible]	1.35	1.87×10^{-2}	3.50×10^{-3}	0.24	0.17
A	LS220	1	1.188	1.365	2.16×10^{-2}	1.6×10^{-3}	0.16	0.22
B	DD2	1	1.188	1.365	4.62×10^{-2}	1.1×10^{-3}	0.18	0.25
C	SFHo	1	1.188	1.365	5.67×10^{-3}	2.8×10^{-3}	0.21	0.23
D	DD2	1.43	1.188	1.637	9.12×10^{-2}	7.0×10^{-3}	0.14	0.14
E	LS220	1.43	1.188	1.637	5.34×10^{-2}	7.3×10^{-3}	0.17	0.16
F	LS220	1.66	1.188	1.769	2.04×10^{-2}	1.11×10^{-2}	0.14	0.07
G	DD2	1.22	1.188	1.509	6.27×10^{-2}	2.50×10^{-3}	0.17	0.19
H	SFHo	1.43	1.188	1.637	6.03×10^{-2}	3.80×10^{-3}	0.2	0.14
I	SFHo	1.66	1.188	1.769	5.31×10^{-2}	1.50×10^{-3}	0.12	0.07

Pérez-García et al, arXiv:2204.00022

KN Simulations and EoS

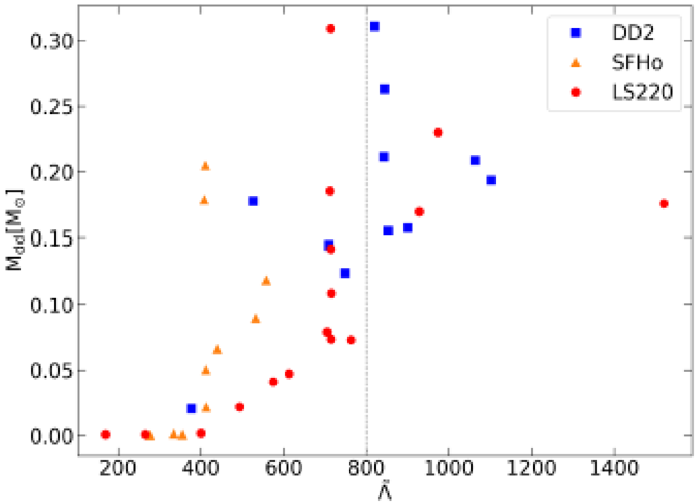
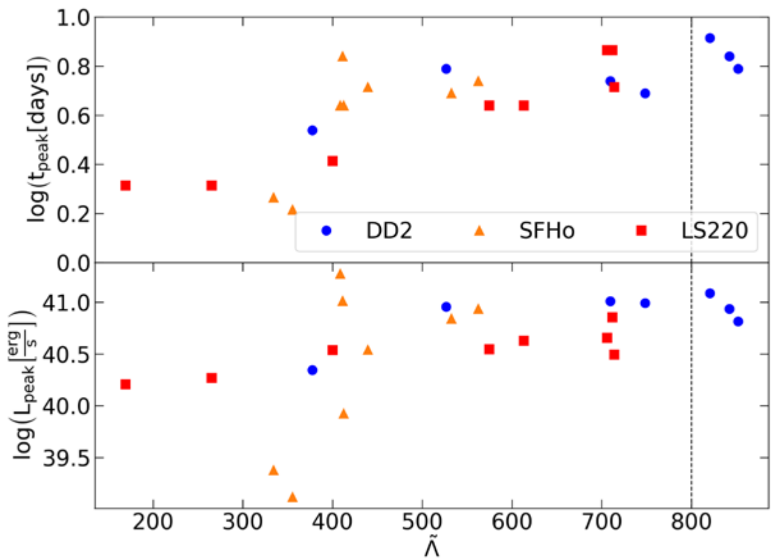


Fig. 8. Dynamical plus disk mass, M_{dd}, as a function of $\tilde{\Lambda}$ for runs from (Radice et al. 2018) and (Nedora et al. 2021), along with the $\tilde{\Lambda}$ = 800 limit (Abbott et al. 2017) depicted as a vertical dashed line.



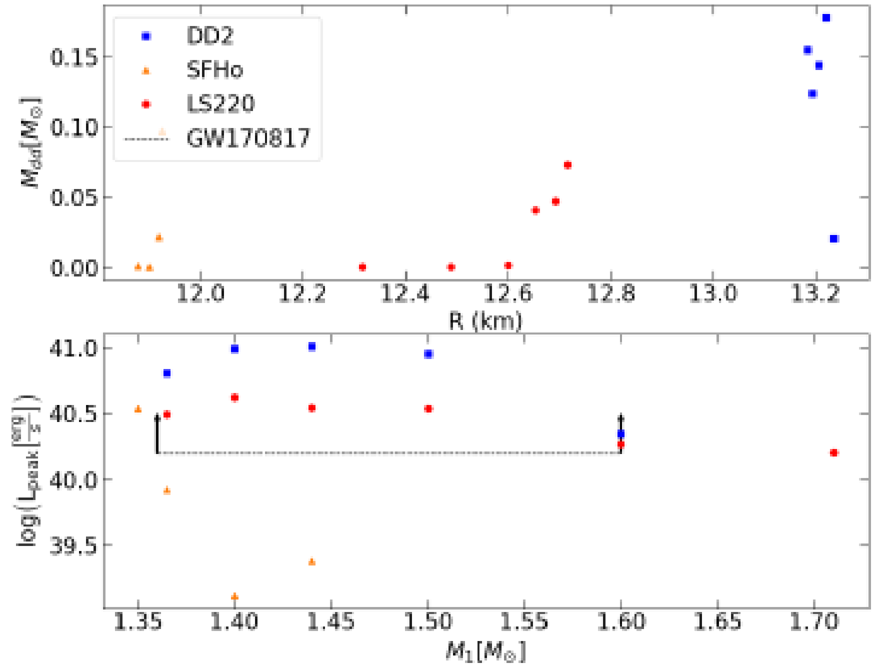


Fig. 10. (Top panel) M_{dd} as a function of NS radius from NR runs due to Radice et al. 2018 and Nedora et al. 2021 having $q \simeq 1$. (Bottom panel) $\log\left(L_{peak}[erg/s]\right)$ for an equatorial orientation as a function of primary mass M_1, for runs in Table 1 also having $q \simeq 1$.We also indicate a conservative lower limit estimate of equatorial peak luminosity for a GW170817-like transient.

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Thanks @ MAAT, Univ. of Salamanca