Waveform Challenges and Numerical Relativity

Rossella Gamba

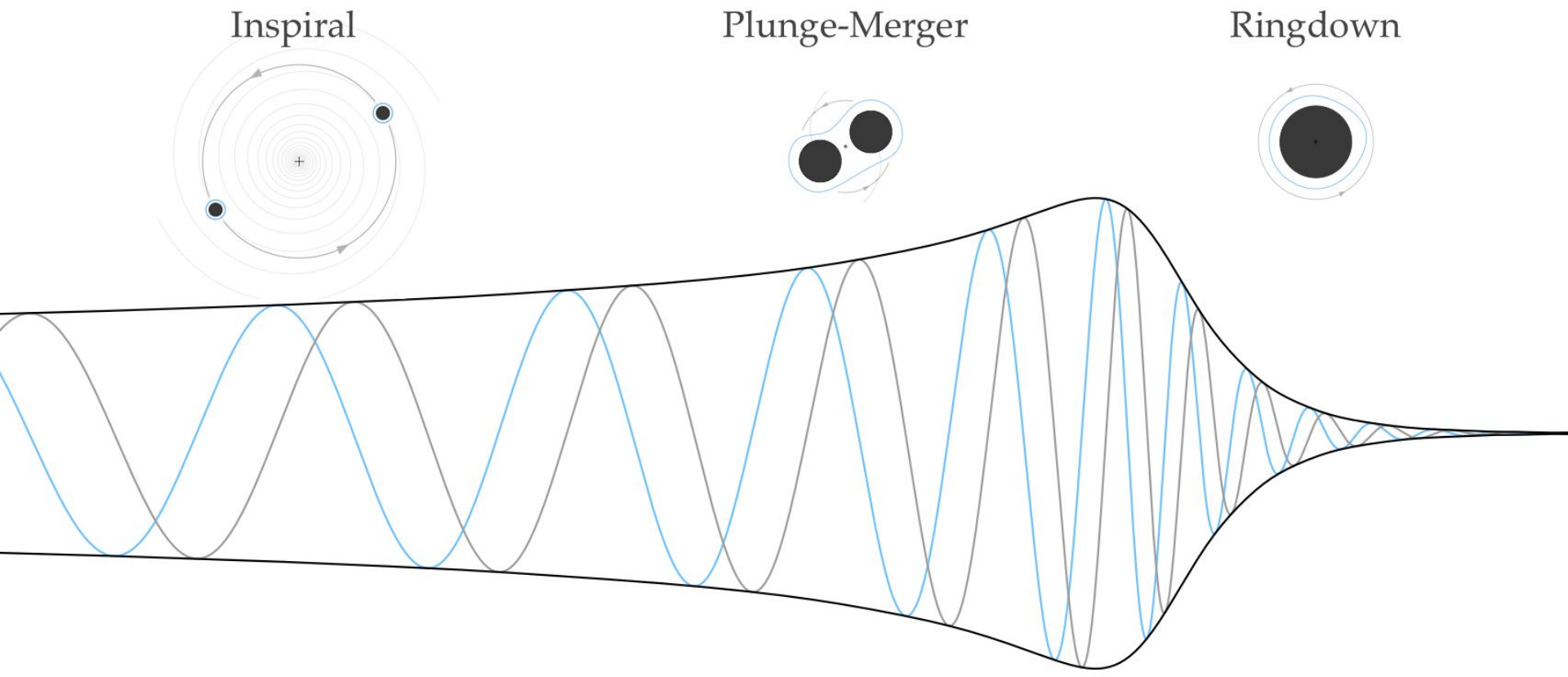
Lionel London

Kenta Kiuchi

Vijay Varma

Mark Hannam

Waveform modeling (source and radiation)

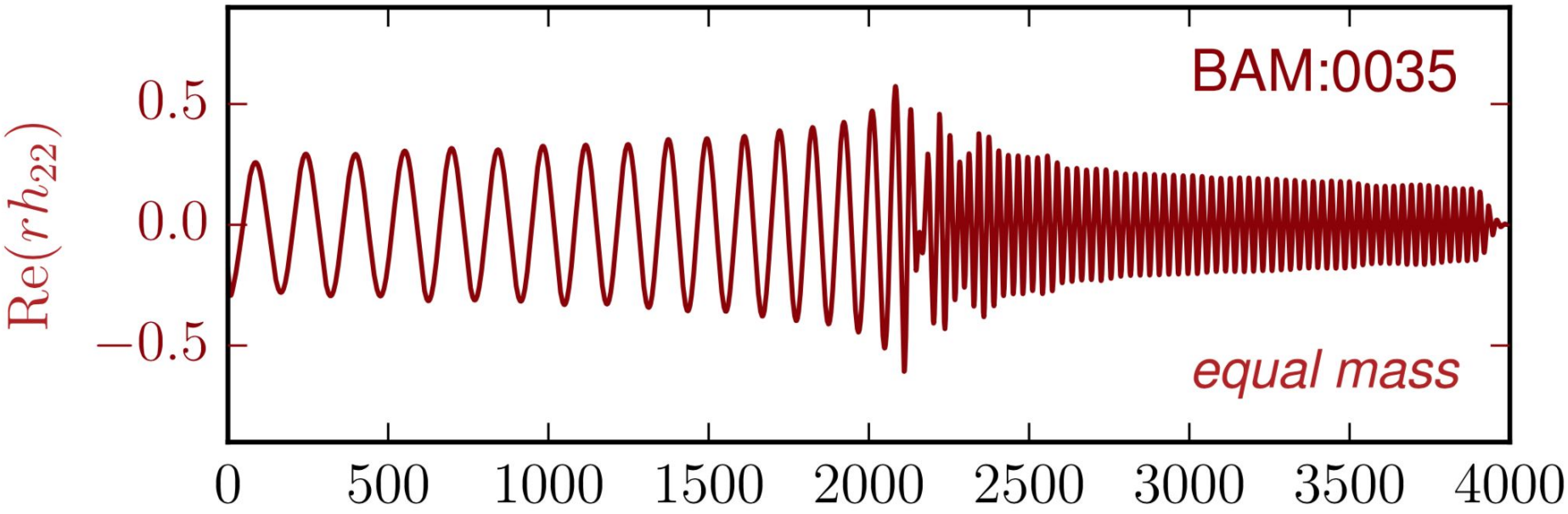


Binary black holes

(Model error limit ~O(1/SNR^2))	Basic astro (SNR 20-100)	Systematics-free Measurements (SNR ~1000)	Testing GR
Accuracy increase req'd	10x - 100x	1000x	10^4 x
Numerical relativity	✅	(maybe)	(unlikely)
High-mass models	✅	(tricky)	(unlikely)
Low mass models (PN/EOB/…)	❓	❓	(unlikely)
High mass ratios (>20)	❓	❓	(unlikely)
Beyond GR & ECOs	(maybe)	(unlikely)	(even worse)

Need to understand scientific trade-offs, and decide where to put resources

Example BNS Numerical Waveform



(Dietrich et al 2018)

Binary neutron stars

	Inspiral			Post-merger		
	Current accuracy	Accuracy increase	Systematics free	Current accuracy	Accuracy increase	Systematics free
Numerical relativity	O(1) to O(0.1) rad	10x	(maybe)	? (do not converge)	? (more physics needed)	?
Waveform models	> O(1) rad, esp for high spins	10-100x	(unlikely)	Fbar~ 10^-1 to 10^-3	? 10-100x	?
Next decade	• Explore wider parameter region (EOS, chirp mass, mass ratio, NS spins, eccentricity?) • …with more accuracy (x10-100)			• Update the input physics and numerics (NR) • Explore biases and systematics due to universal relations, improve accuracy (models)		