

# **SIMULATIONS FOR HIGHLY ECCENTRIC BLACK HOLES BINARIES**

**TOMAS ANDRADE**



**UNIVERSITAT DE  
BARCELONA**

# COLLABORATORS

## Barcelona



J Trenado

## Valencia

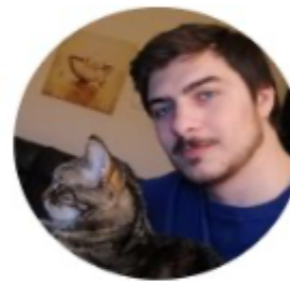


JA Font



A Torres

## Torino



S Albanesi

## Jena



R Gamba

## Santiago



J Calderon-Bustillo



N Sanchis-Gual



A Nagar



S Bernuzzi

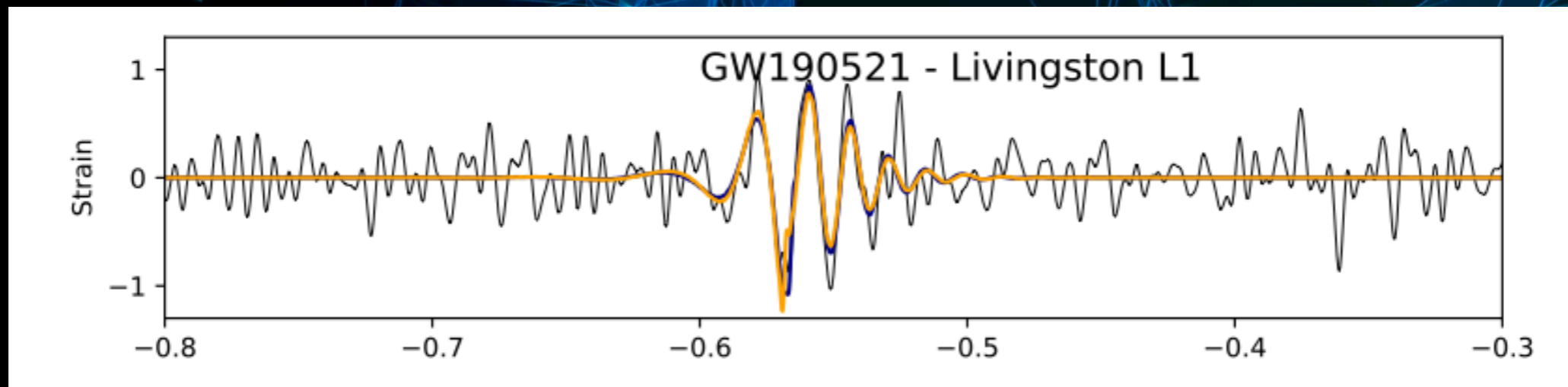
# MOTIVATION

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# CHALLENGING EVENTS

## IMBH GW190521

[Gamba et al 2021]



**ECCENTRICITY AND PRECESSION**

**OTHER FORMATION CHANNELS**

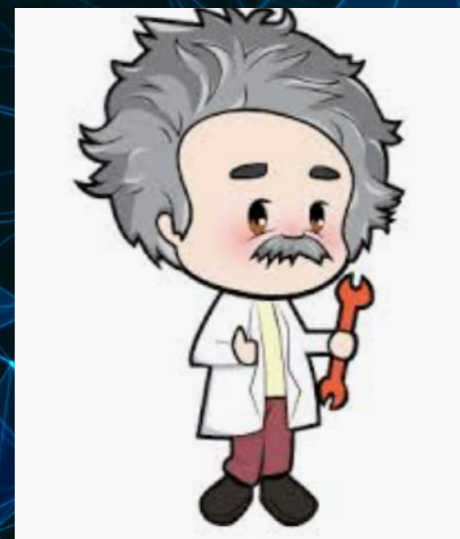
**BUILD MORE DIVERSE TEMPLATE BANKS**

**NUMERICAL RELATIVITY**

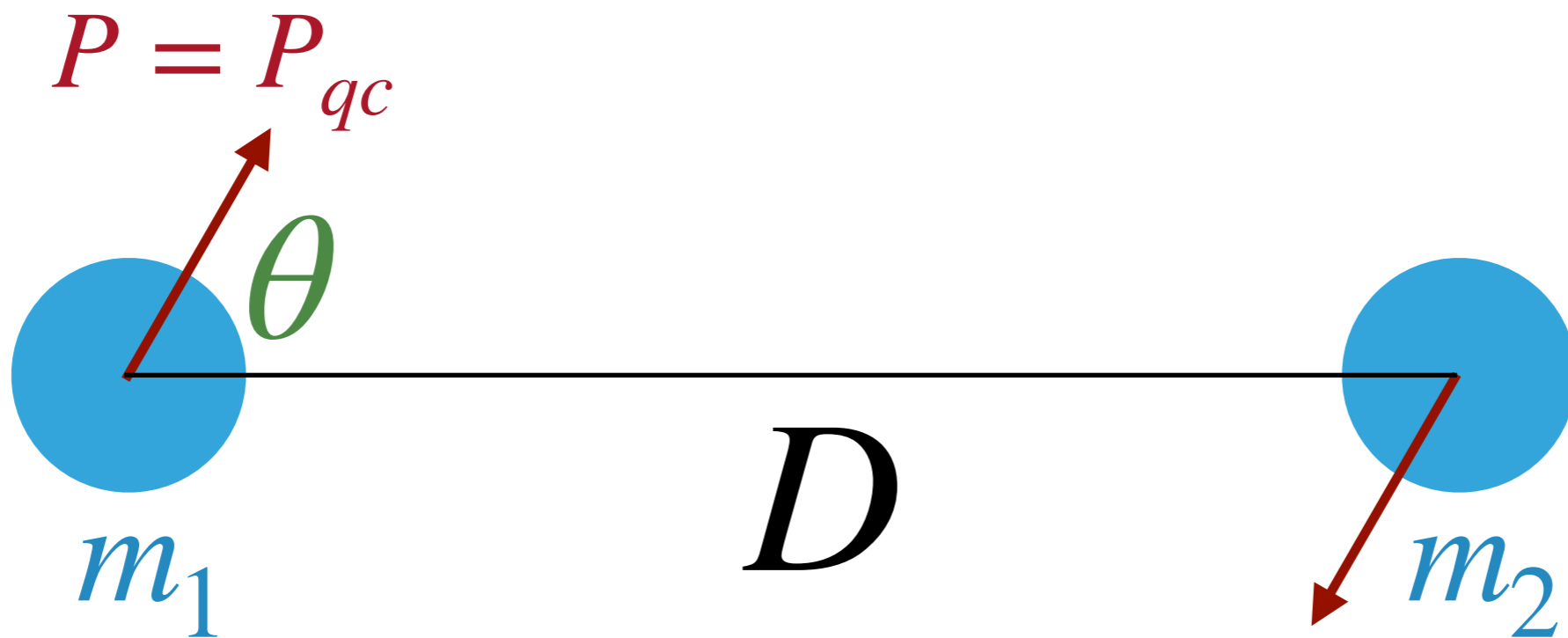
**APPROXIMANTS**

**FOCUS ON  
HIGH ECCENTRICITY**

# NUM REL SIMULATIONS

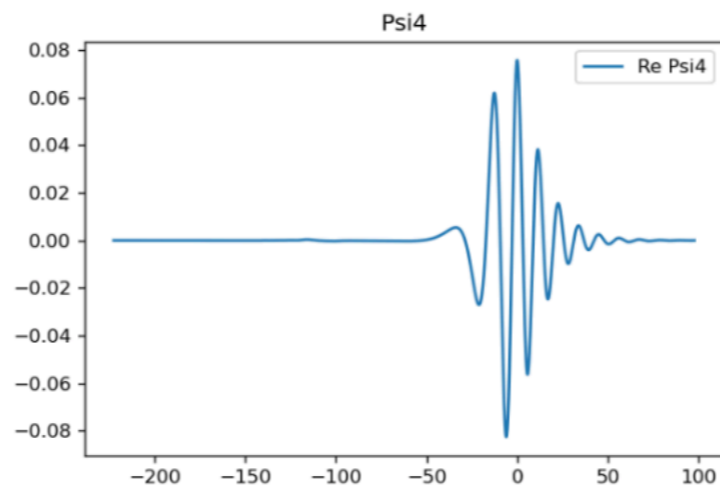
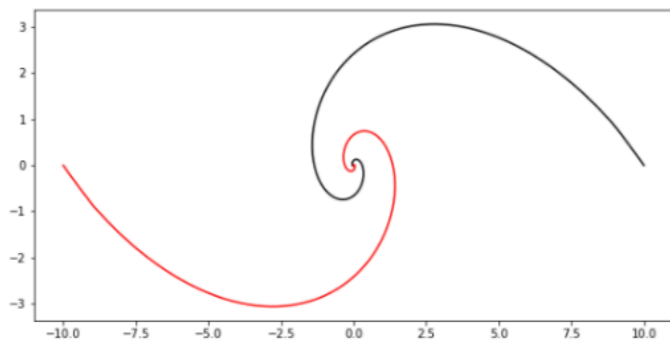


# INITIAL DATA



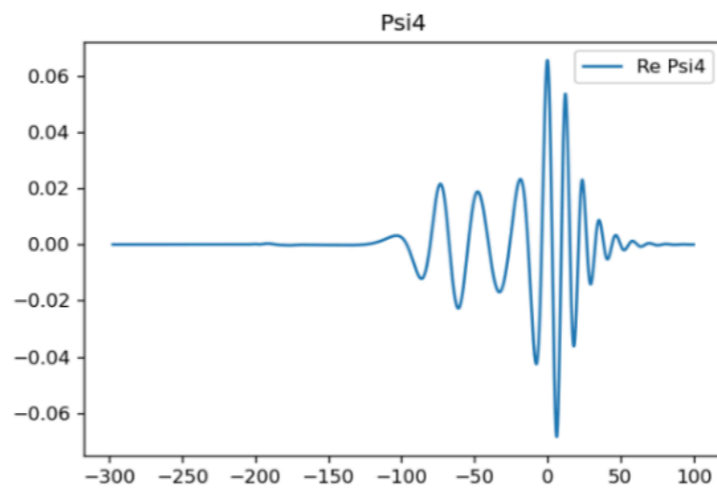
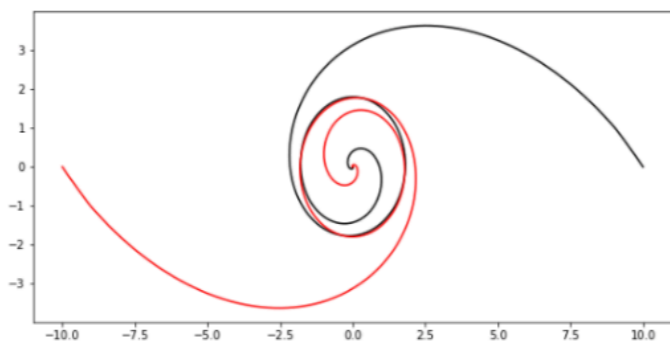
# RICH PHENOMENOLOGY

$\theta = 42$

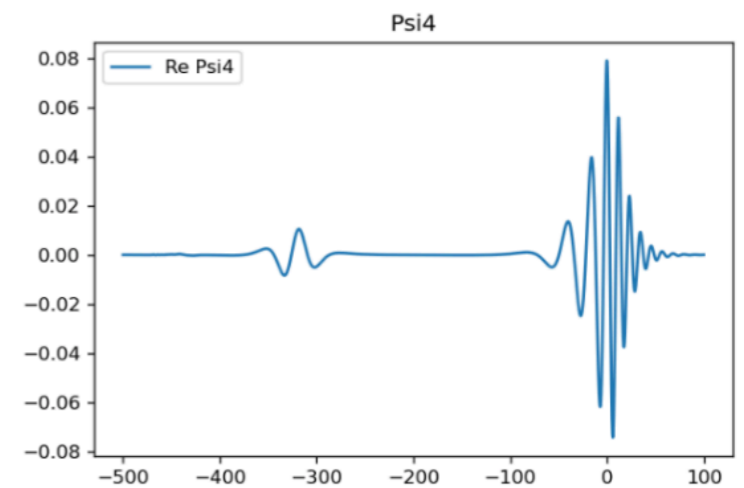
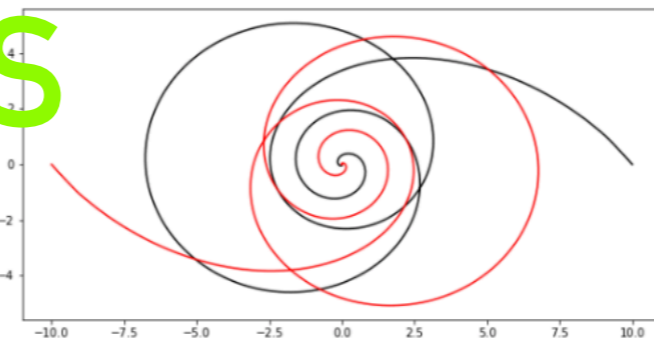


[Gold & Brugmann 2012]

$\theta = 48$



$\theta = 50$



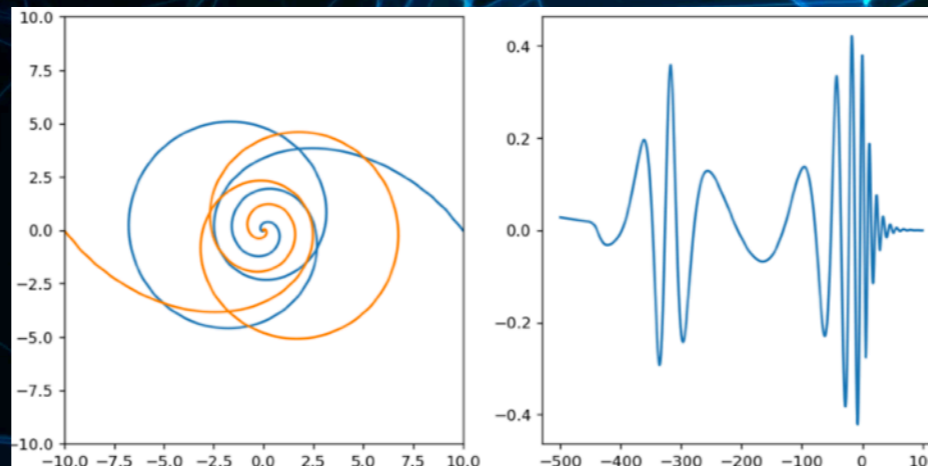
ZOOM-WHIRLS



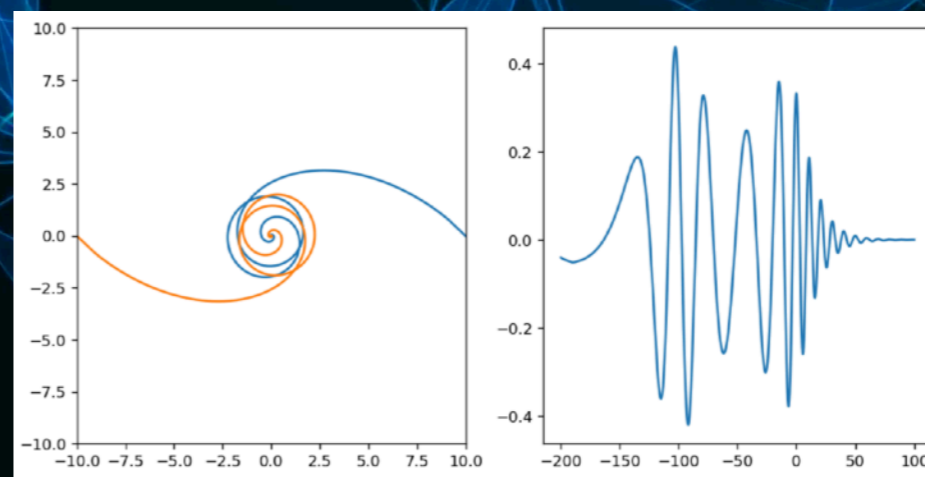
# BESTIARY 12 CASE STUDIES



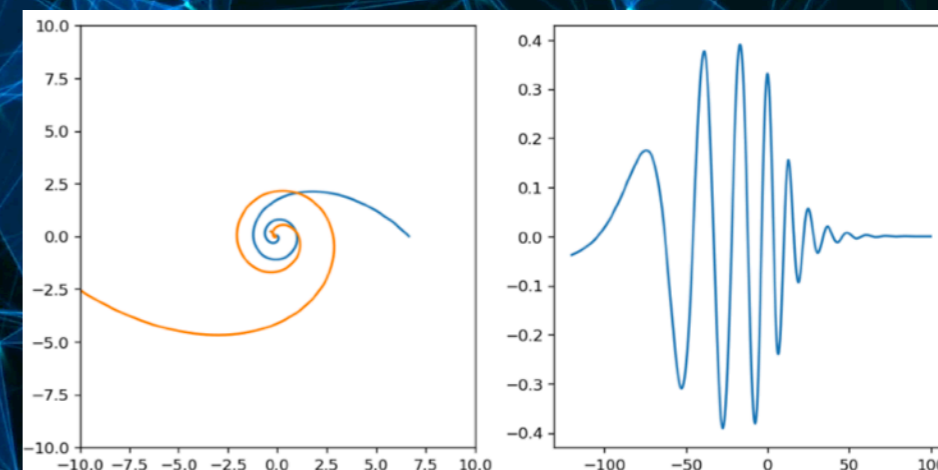
$$6 : q = 1, \chi = 0$$



$$3 : q = 1, \chi = \pm 0.5$$



$$3 : q > 1, \chi = 0$$



**MOST EXPENSIVE**

**72 HRS 300 CPUS**

# QUALITY ASSESSMENT

4TH ORDER  
CONVERGENCE

COMPARISON

GR-Athena++

AGREEMENT TO 2%

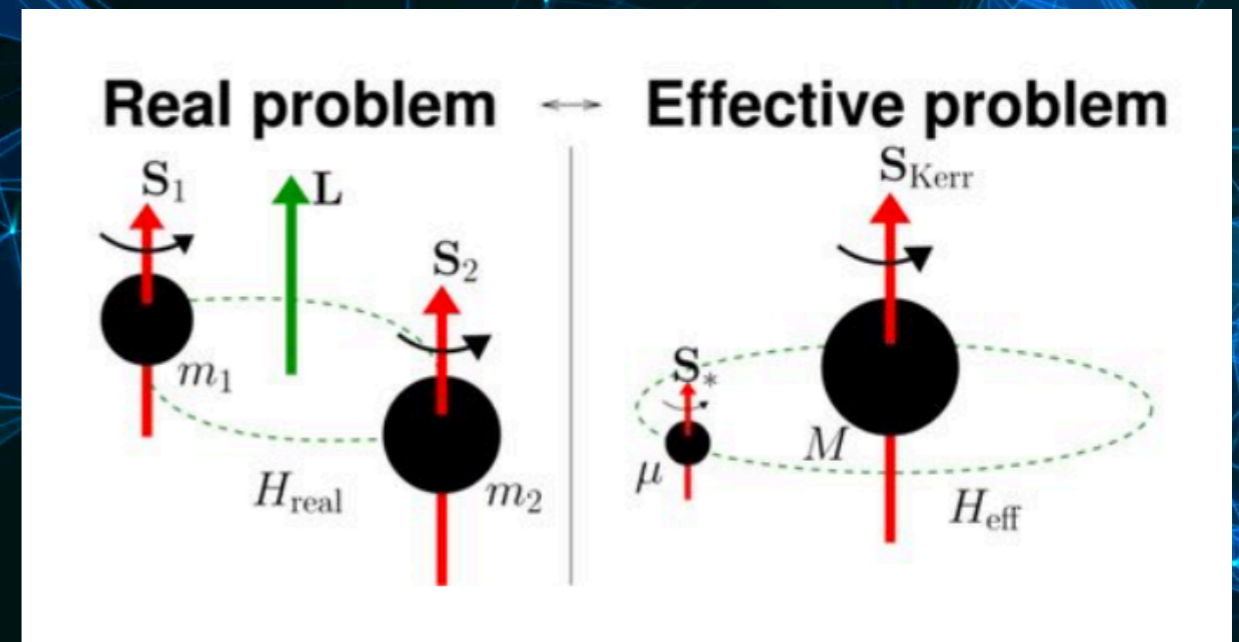
[Daszuta et al 2021]

# EOB APPROXIMANT



# TEOBResumS

[Nagar et al 2018] **GIOTTO**



## DYNAMICS

$$H_{EOB}(r, \phi, p_r, p_\phi) \sim \text{particle in BH}$$

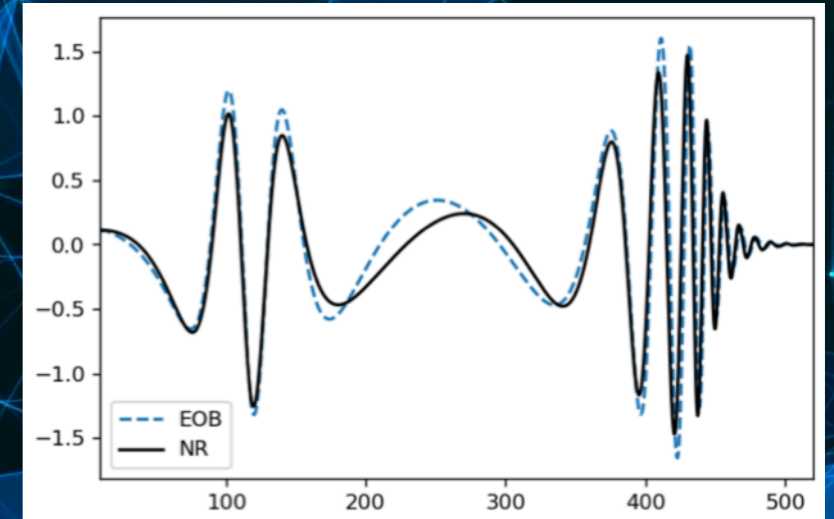
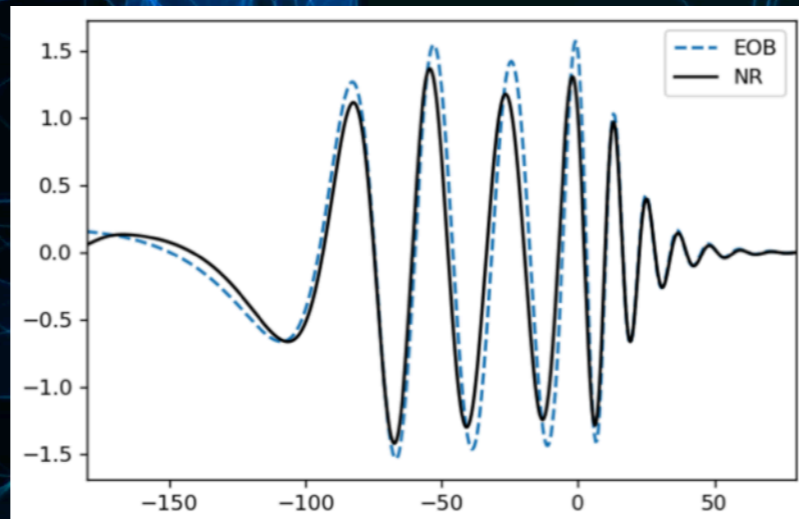
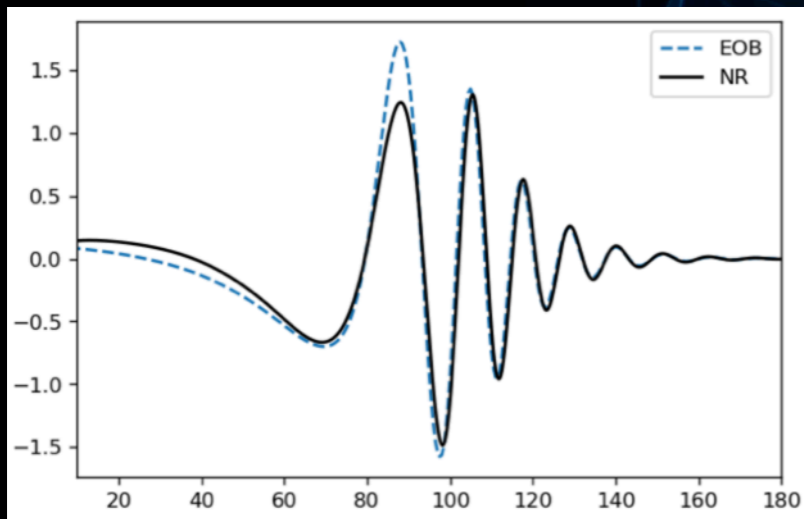
## STRAIN

$$h_{EOB}(t) \sim h^{(Newt)}(t) h^{merger}(t) \dots$$

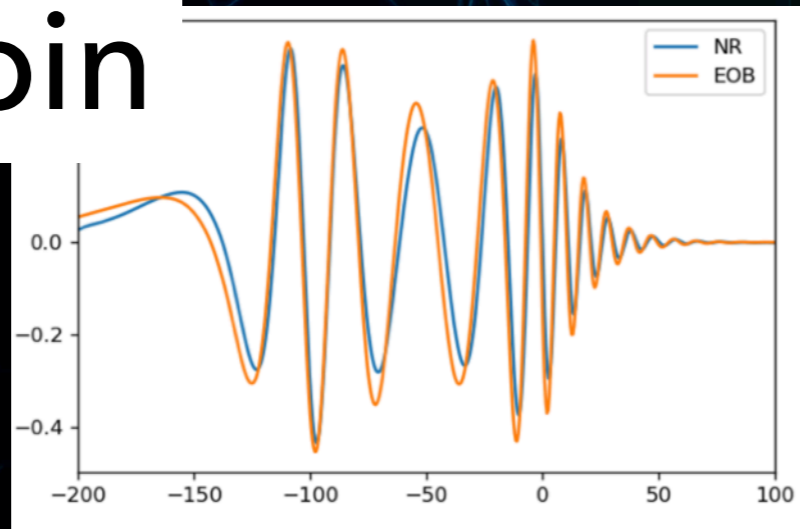
**HYPER-PARAMS  
FIXED BY NR**

# COMPARE USING QC SETTINGS

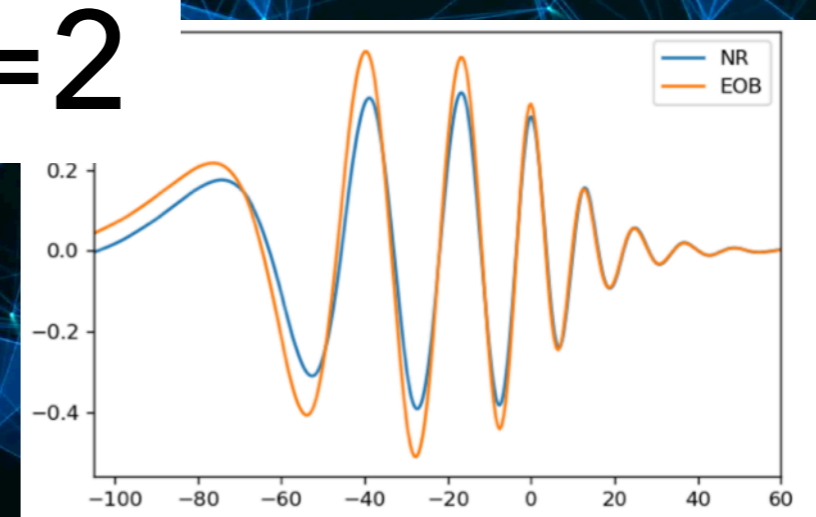
$$E_{eob} = E_{ADM} \quad J_{eob} = J_{ADM} \quad r_{eob} = D$$



Spin



q=2





**TAKE HOME**

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**NR SIMULATIONS FOR ECCENTRIC BBH**

**GOOD NR-EOB RESULTS**

**TEOBResumS**

**UPGRADE ECCENTRIC VERSION**

**LOOK AT OTHER CATALOGUES**



**THANK YOU!**



# QUALITY ASSESSMENT

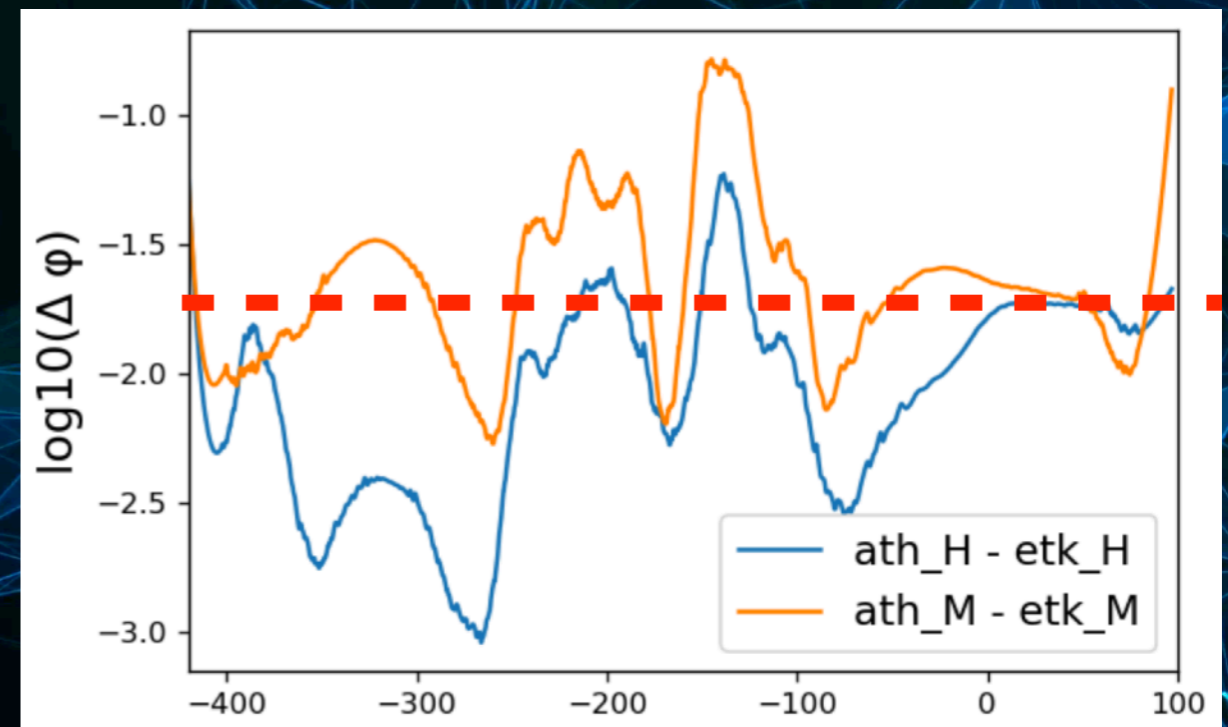
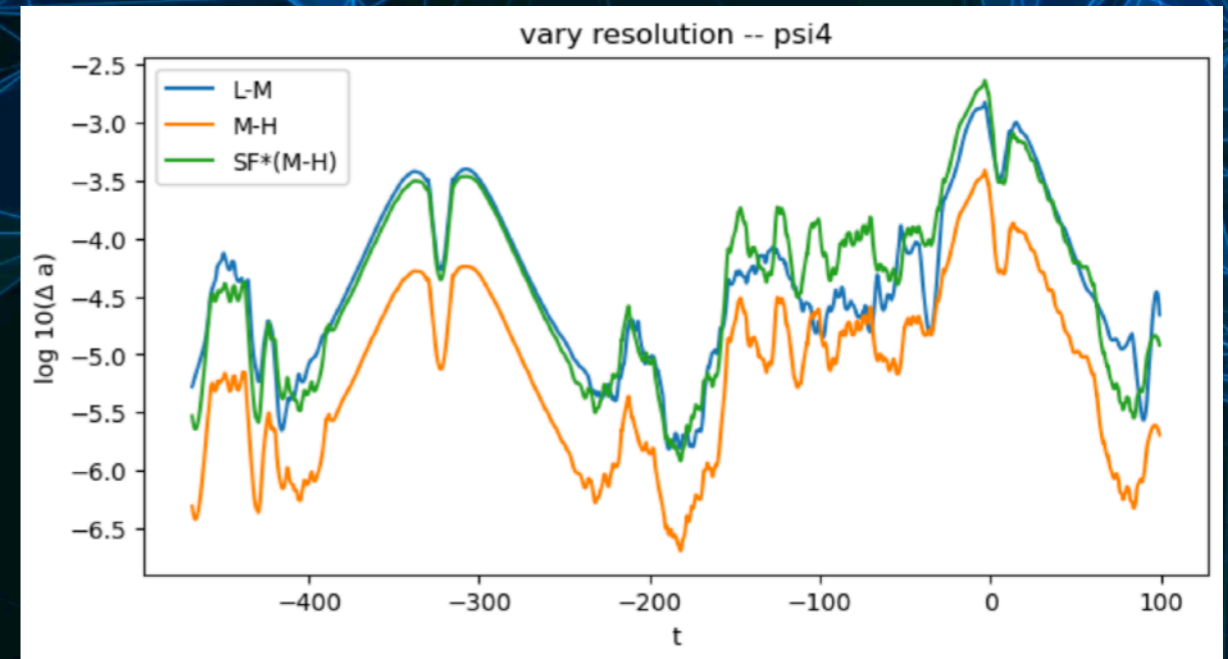
4TH ORDER  
CONVERGENCE

COMPARISON

GR-Athena++

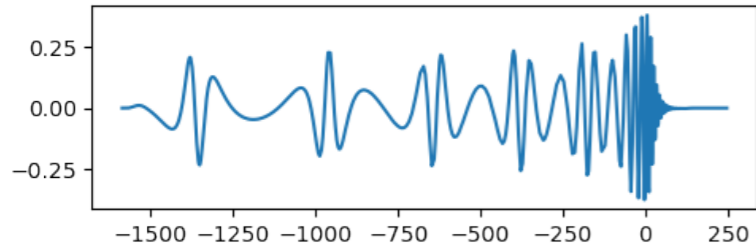
AGREEMENT TO 2%

[Daszuta et al 2021]

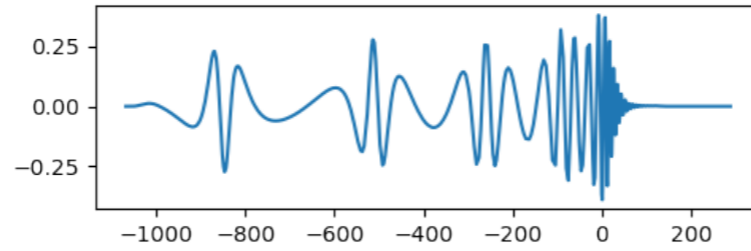


# RIT CATALOGUE

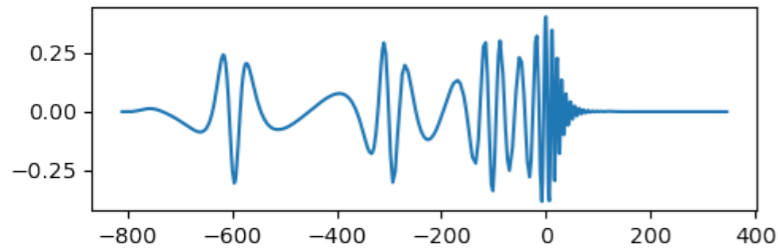
1809



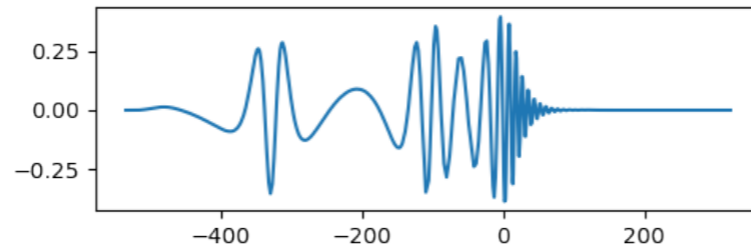
1810



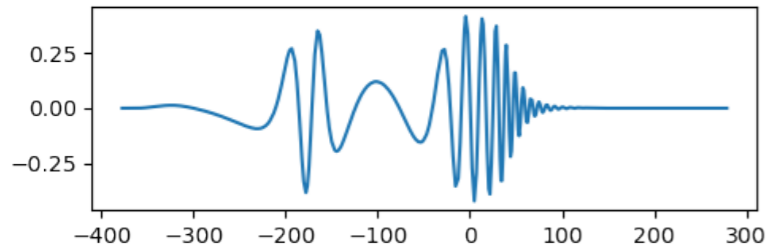
1811



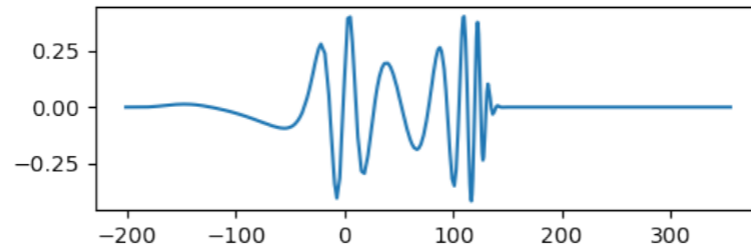
1812



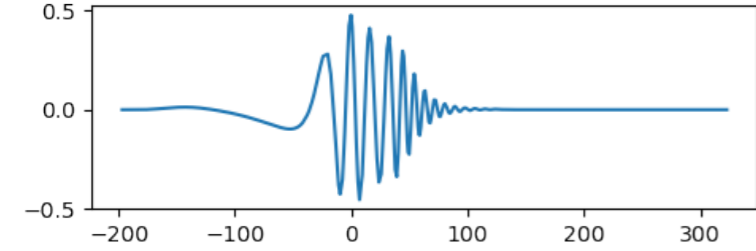
1813



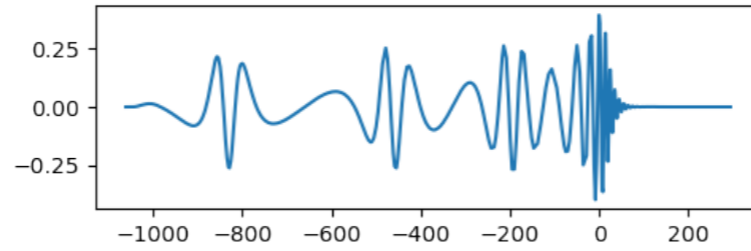
1814



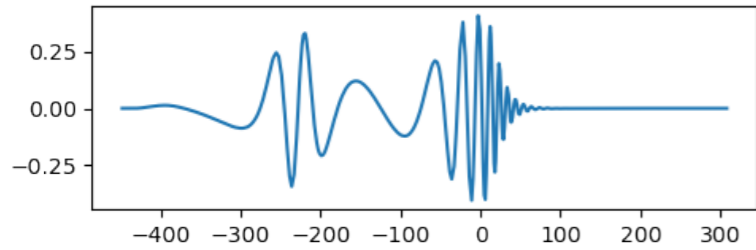
1815



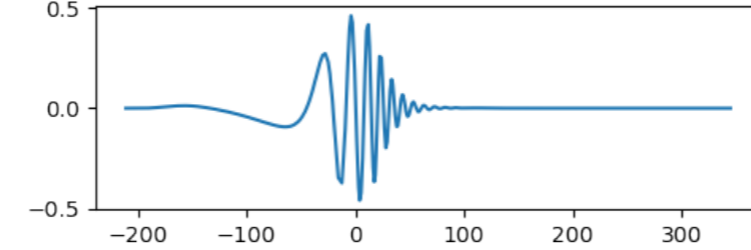
1830



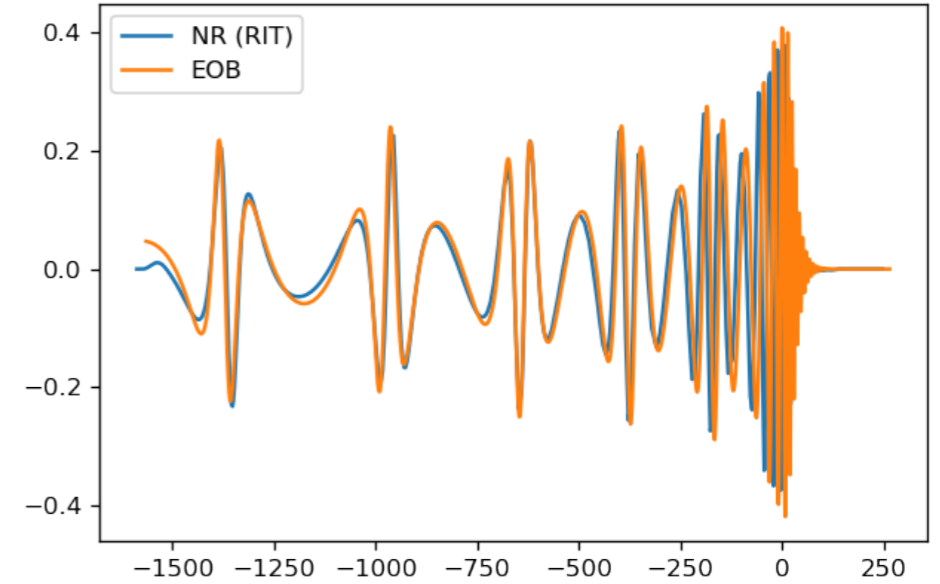
1831



1832



Re  $h_{22}$  1809



abs  $h_{22}$  1809

