Iniziativa specifica OG51:

SORGENTI DI ONDE GRAVITAZIONALI

Il gruppo di Roma:

Valeria Ferrari

Omar Benhar

Leonardo Gualtieri

Stefania Marassi (assegnista)

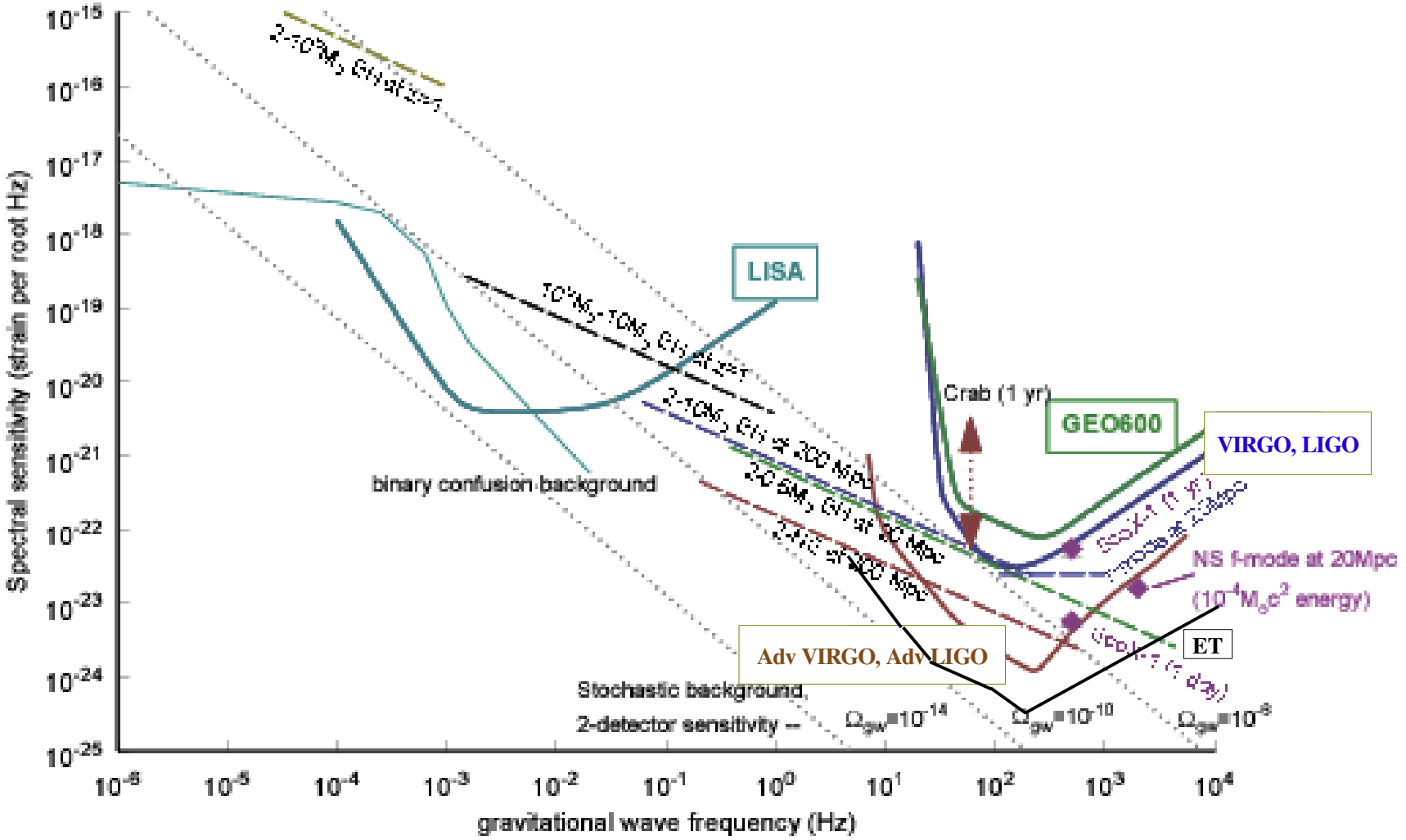
Francesco Pannarale (dottorando)

Riccardo Ciolfi (dottorando)

Lisa Scalone (laureanda)

Vincenzo Obiso (laureando)

Studiamo sorgenti astrofisiche di onde gravitazionali,
per rivelatori interferometrici *terrestri* (VIRGO, LIGO, ET)
e *spaziali* (LISA, DECIGO, BBO).



Siamo parte di una comunità internazionale

che collabora e interagisce a questo scopo:

- Collaboriamo con numerosi gruppi in EU e US
- Abbiamo fatto parte del network RTN

  “Sources of gravitational waves”
- Siamo parte del VESF (di cui Valeria è il coordinatore).

  VESF: >40 gruppi di teorici e astrofisici europei che studiano le sorgenti di GW in stretta relazione con VIRGO

We focus on processes involving neutron stars and black holes.

Our main research topics are:

- Structure, oscillations and emission properties of strongly magnetized neutron stars
- Imprint of the equation of state of nuclear matter on the emission frequencies of neutron stars
- Coalescing binary systems
- Stochastic gravitational wave background from stars and black holes

We focus on processes involving neutron stars and black holes.

Our main research topics are:

- Structure, oscillations and emission properties of strongly magnetized neutron stars
- Imprint of the equation of state of nuclear matter on the emission frequencies of neutron stars
- Coalescing binary systems
- Stochastic gravitational wave background from stars and black holes

This is a typically multidisciplinary field, relating GR, astrophysics, nuclear and particle physics, cosmology, and requires both analytical and numerical work.

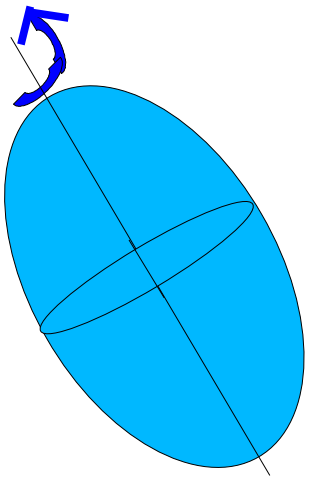
Structure, oscillations and emission properties of strongly magnetized neutron stars

Neutron stars are among the most extreme objects in the universe ($\rho_c \sim 10^{15}$-10^{16} g/cm^3).

Strong sources gravitational waves!

Magnetars: NS with B~10^{15} G on the surface, larger in the interior

It may deform the star in a *prolate shape*.



Structure, oscillations and emission properties of strongly magnetized neutron stars

Neutron stars are among the most extreme objects in the universe ($\rho_c \sim 10^{15}$-10^{16} g/cm^3).

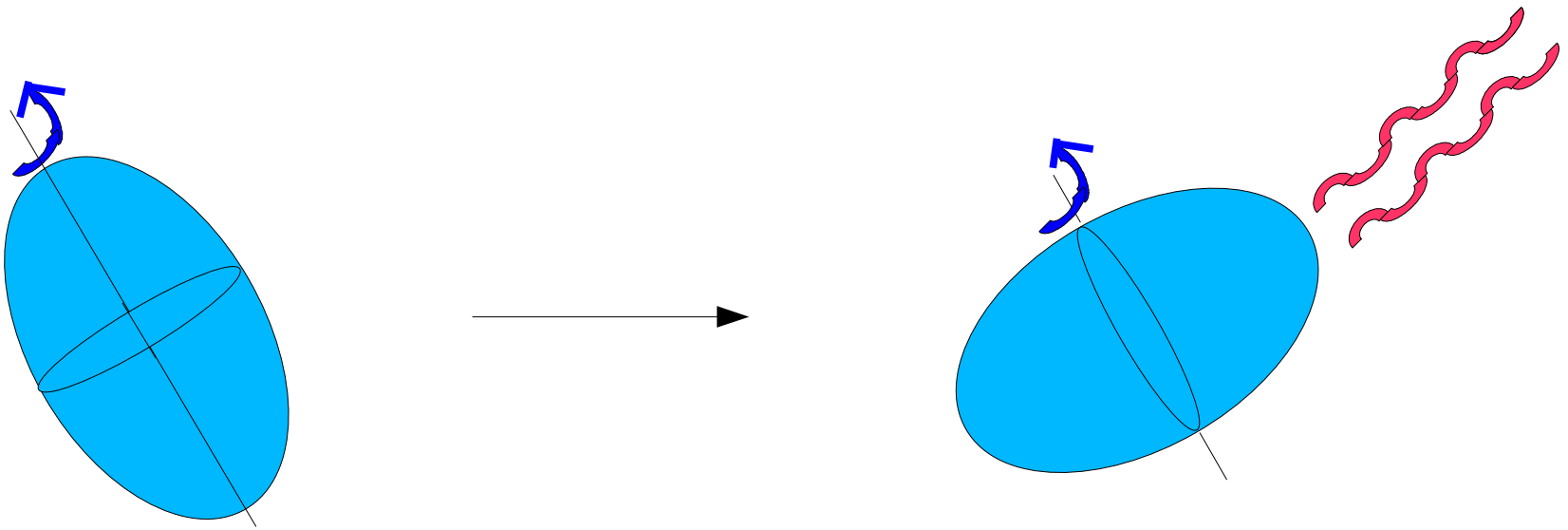
Strong sources gravitational waves!

Magnetars: NS with B~10^{15} G on the surface, larger in the interior

It may deform the star in a *prolate shape*.

IF prolate shape, then “spin flip” => strong GW signal!

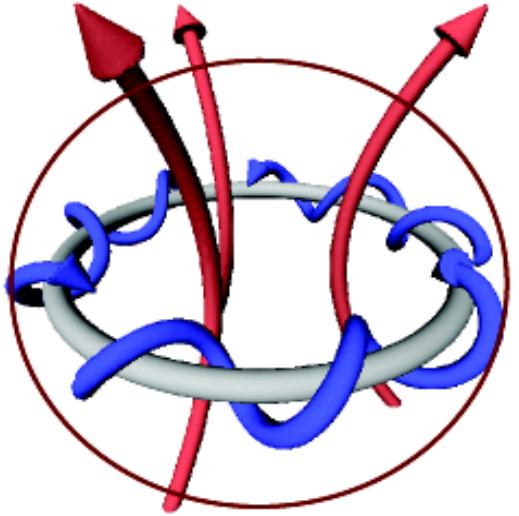
(VIRGO, LIGO)



Is this scenario possible?

We model NS deformed by magnetic field

General Relativity is important: $GM/c^2R \sim 0.1\text{-}0.2$!

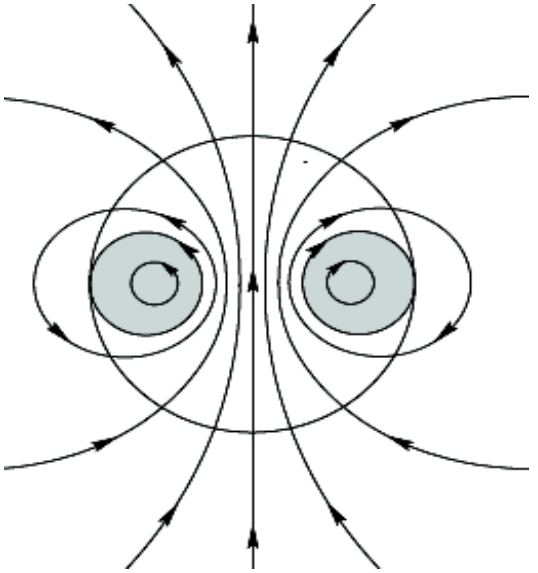


Our model: poloidal field (everywhere) +

toroidal field (confined in a region)

(*Colaiuda, Ferrari, Gualtieri, Pons, MNRAS 385, 2080, '08;*

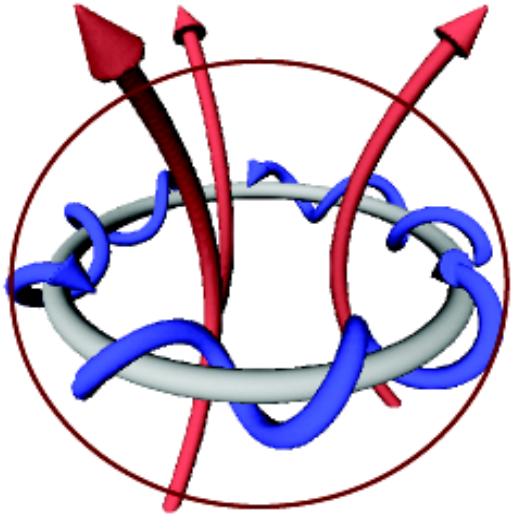
Ciolfi, Ferrari, Gualtieri, Pons, MNRAS in press., '08)



Is this scenario possible?

We model NS deformed by magnetic field

General Relativity is important: $GM/c^2R \sim 0.1\text{-}0.2$!



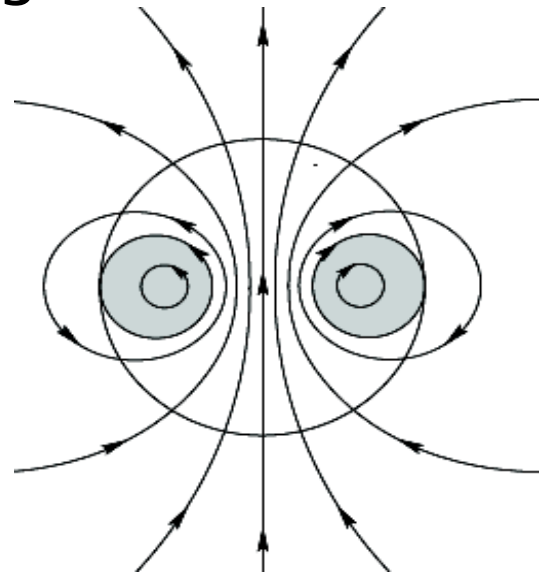
Our model: poloidal field (everywhere) +

toroidal field (confined in a region)

(*Colaiuda, Ferrari, Gualtieri, Pons, MNRAS 385, 2080, '08;*

Ciolfi, Ferrari, Gualtieri, Pons, MNRAS in press., '08)

Recent observations: *stellar oscillations* in magnetars.



We are modelling oscillating magnetars,

to compare with observations.

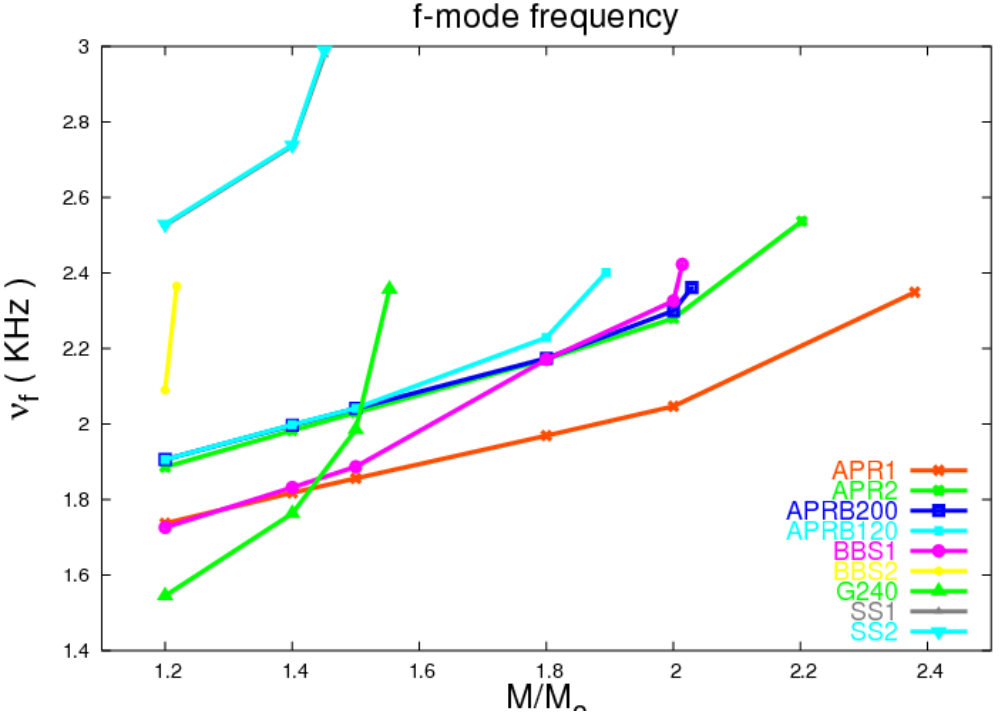
Imprint of the equation of state of nuclear matter on the emission frequencies of neutron stars

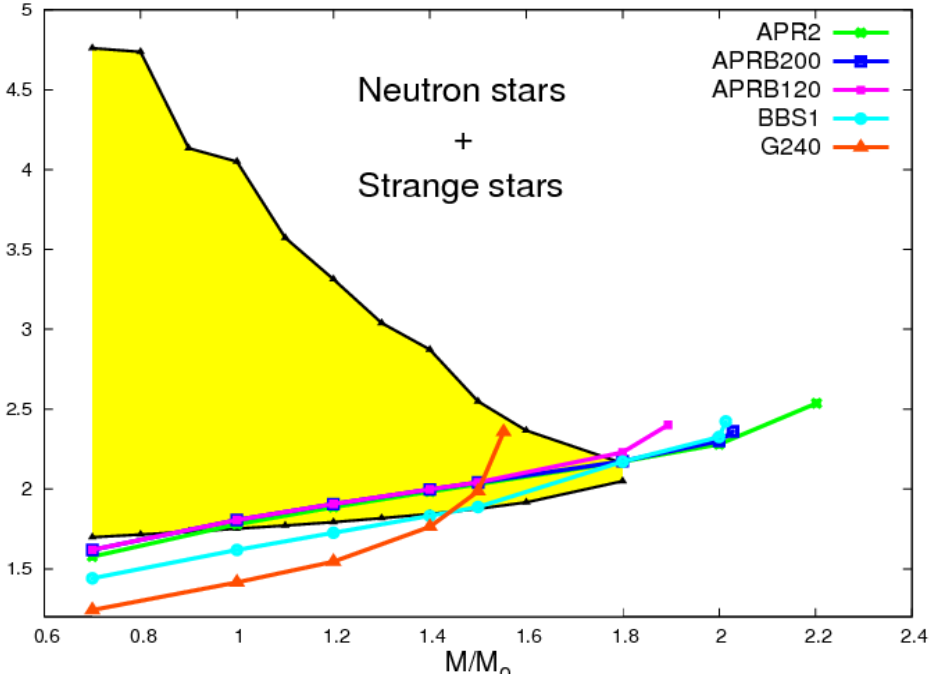
NS pulsate in damped oscillations (QNM) and emit GW. Detection of these signals (VIRGO, LIGO) will give information on the structure of the star (and on hadronic interactions):

gravitational wave asteroseismology

(*Benhar, Ferrari, Gualtieri, PRD 70, 124015, '04;*

Benhar, Ferrari, Gualtieri, Marassi, GRG 39, 1323, '07)





We are extending this study
to hot, newly born proto-neutrons stars
(*Ferrari, Pons, Miniutti, MNRAS 342, 629, '03;*
Ferrari, Gualtieri, Pons, Stavridis, MNRAS 350, 763, '04;
Ferrari, Gualtieri, Pons, Stavridis, CQG 21, S515, '04)
studying the effect of temperature and entropy profiles.

We study dissipative effects in hot PNS,
(viscosity, heat transport, etc.)
(*Gualtieri, Pons, Miniutti, PRD 70, 084009, '04;*
Pons, Gualtieri, Miralles, Ferrari, MNRAS 363, 121, '05;
Benhar, Valli, PRL 99, 232501, '07;
Benhar, Farina, Fiorilla, Valli, AIP Conf. Proc. 1056, 248, '08)
to determine if their rotational instabilities can grow
and emit strong GW
(potential sources for adv.VIRGO, adv.LIGO!)

Coalescing binary systems

Coalescing binaries: the strongest GW sources!
(VIRGO, LIGO, LISA, etc.)

We study BH-NS and NS-NS coalescences,
strong sources for LIGO, VIRGO (and adv.).

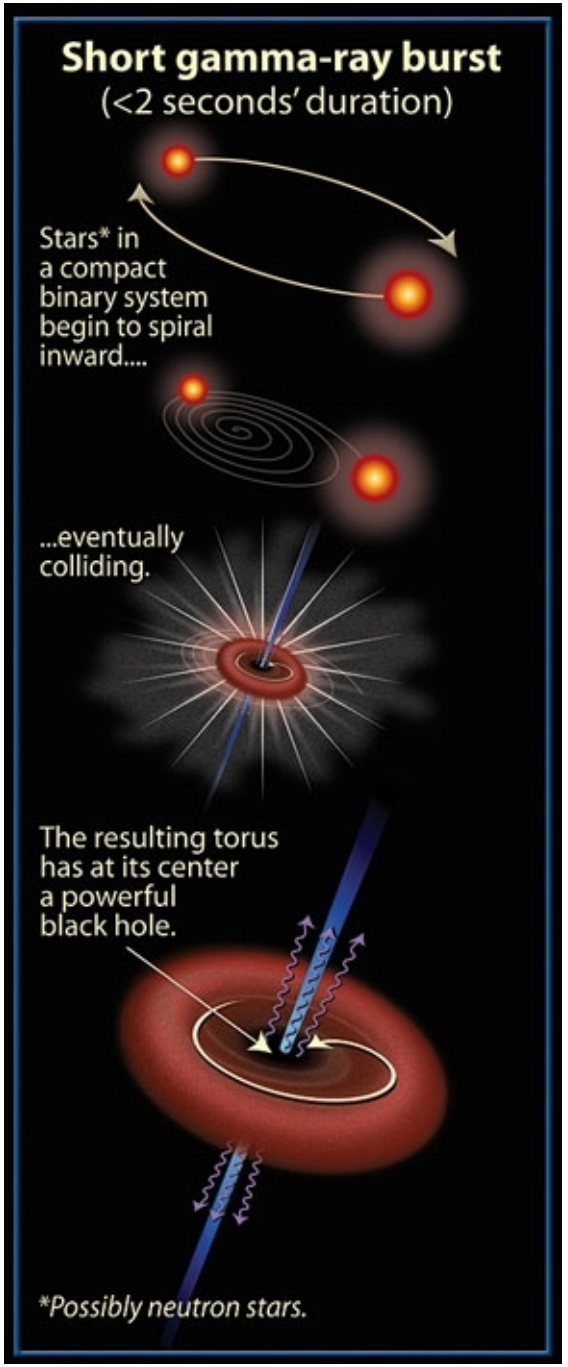
Coalescing binary systems

Coalescing binaries: the strongest GW sources!
(VIRGO, LIGO, LISA, etc.)

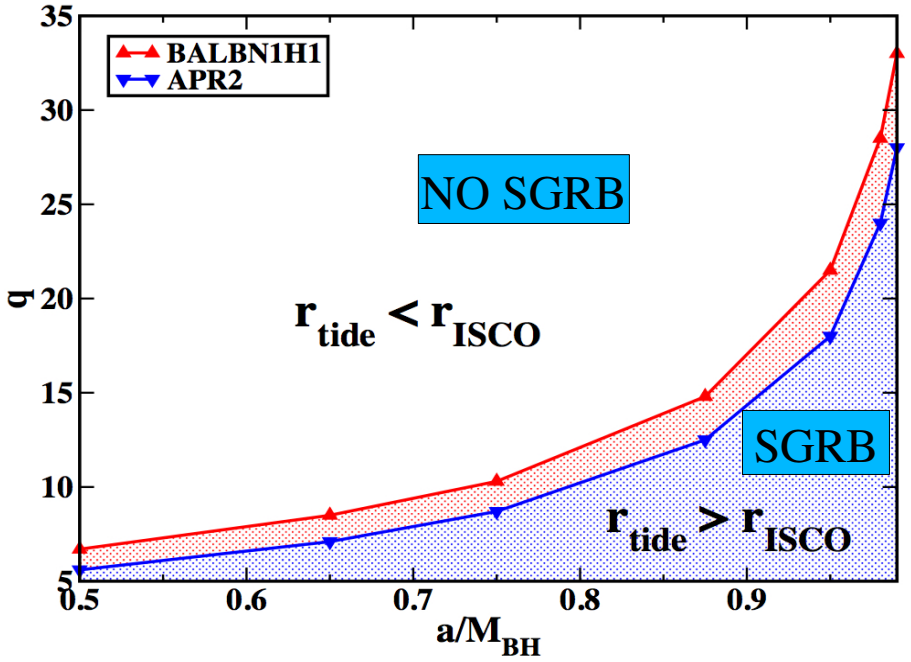
We study BH-NS and NS-NS coalescences,
strong sources for LIGO, VIRGO (and adv.).

Also important for astrophysics:
at the base of short gamma-ray bursts.

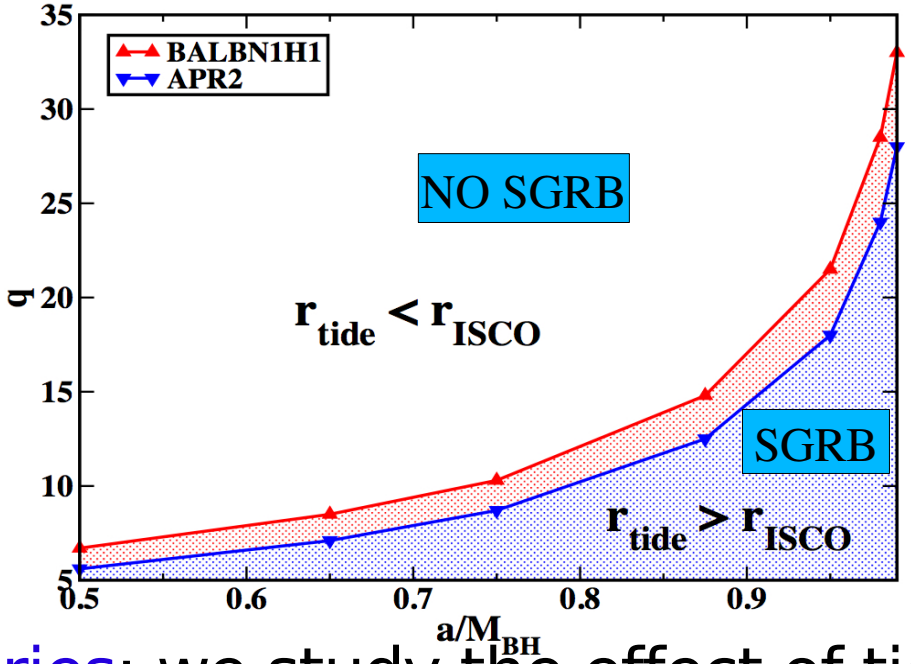
(*Ferrari, Gualtieri, Rezzolla, PRD 73, 124028, '06;*
Ferrari, Gualtieri, Pannarale, CQG in press, '09)



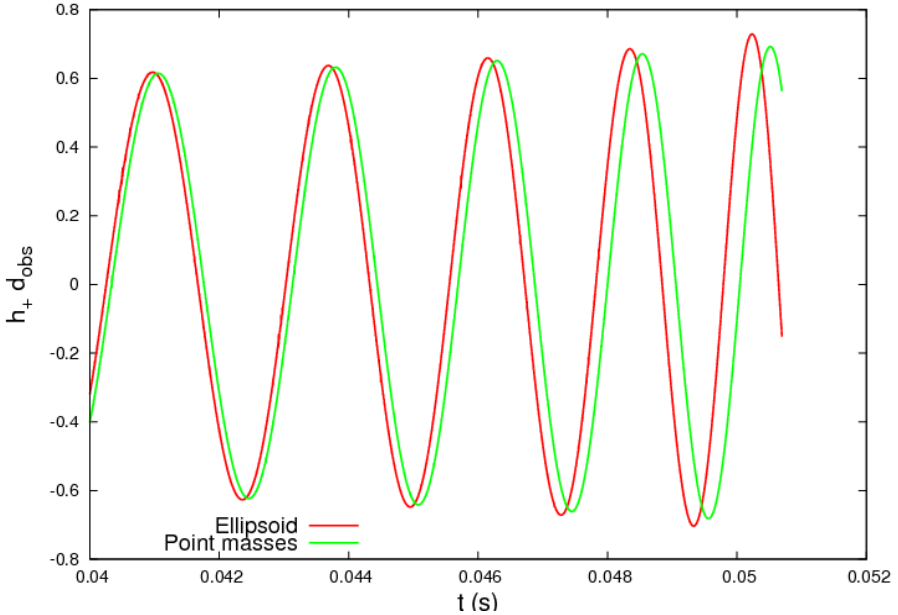
BH-NS binaries: we study under which conditions the star disrupts before falling into the BH (necessary to have SGRB)



BH-NS binaries: we study under which conditions the star disrupts before falling into the BH (necessary to have SGRB)



NS-NS binaries: we study the effect of tidal distorsion on the emitted gravitational waveform



Stochastic gravitational wave background of stars and black holes

Stochastic GW background:

superposition of GW from random directions and times,

overlapping so that individual sources cannot be identified.

Relevant for LISA, DECIGO, BBO, adv.VIRGO, adv.LIGO, ET!

Stochastic gravitational wave background of stars and black holes

Stochastic GW background:
superposition of GW from random directions and times,
overlapping so that individual sources cannot be identified.
Relevant for LISA, DECIGO, BBO, adv.VIRGO, adv.LIGO, ET!

- First computations of astrophysic s.b. from our group

(*Ferrari, Matarrese, Schneider, MNRAS 383, 247, '99; ibid. 303, 258, '99;*
Schneider, Ferrari, Matarrese, Zwart, MNRAS 324, 797, '01)

Stochastic gravitational wave background of stars and black holes

Stochastic GW background:
superposition of GW from random directions and times,
overlapping so that individual sources cannot be identified.
Relevant for LISA, DECIGO, BBO, adv.VIRGO, adv.LIGO, ET!

- First computations of astrophysic s.b. from our group

(*Ferrari, Matarrese, Schneider, MNRAS 383, 247, '99; ibid. 303, 258, '99; Schneider, Ferrari, Matarrese, Zwart, MNRAS 324, 797, '01)*

Recently, including recent stellar formation rates and waveforms:

- We have computed background from collapses of 1^{st} and 2^{nd} generation stars

(*Marassi, Schneider, Ferrari, submitted to MNRAS, '09*)

- We are computing background from coalescences of binary systems (BH, NS, WD)

We also explore the parameter space of cosmological models.