Accretion-Induced Collapse of White Dwarfs

E. Abdikamalov
SISSA

In collaboration with

Christian Ott (Celtech/NBIA)
Luc Dessart (Marseille)
Hans-Thomas Janka (MPA)
Luciano Rezzolla (AEI)
Harald Dimmelmeier (Areva)
Andreas Marek (MPA)

Micra2009, Copenhagen, August 2009

Punchline:

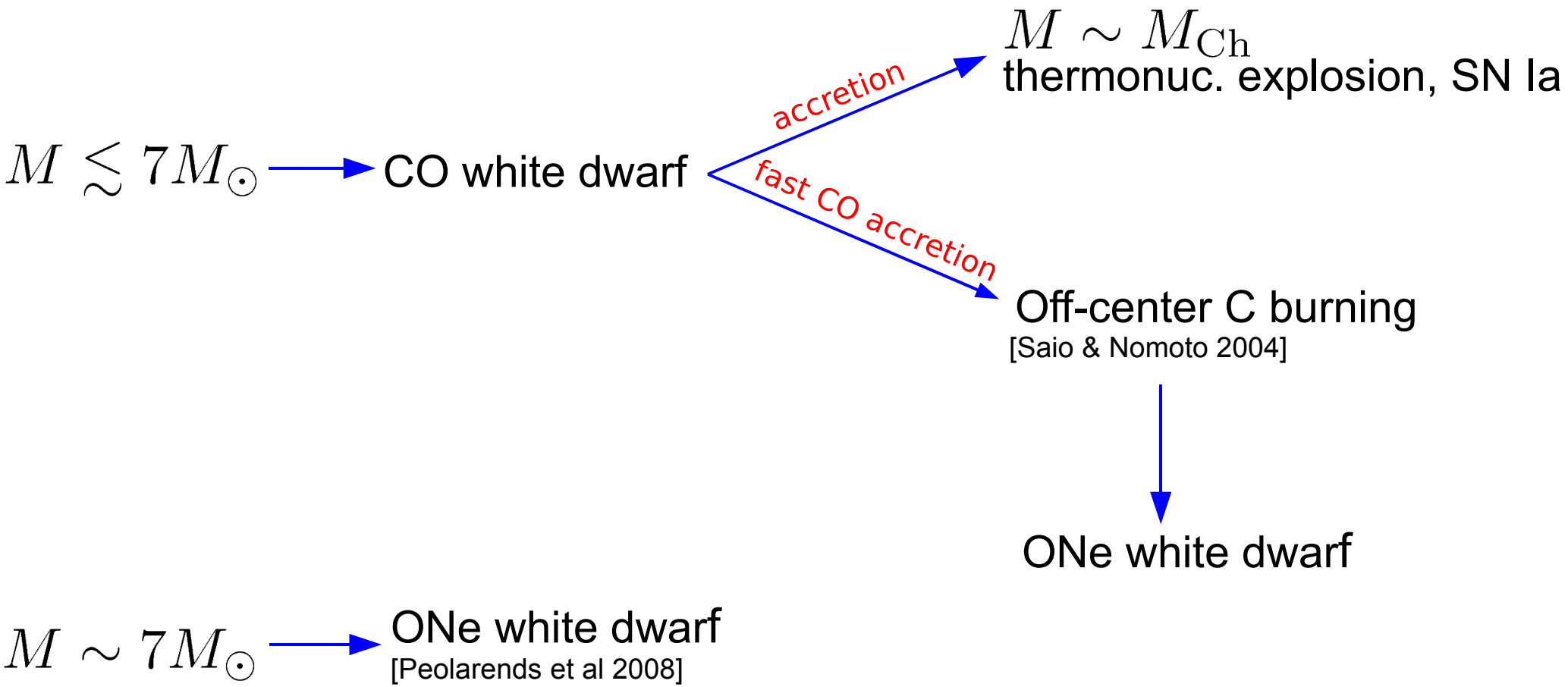
If precollapse white dwarfs are uniformly rotating, it will probably be hard to detect accretion-induced collapse.

Progenitors

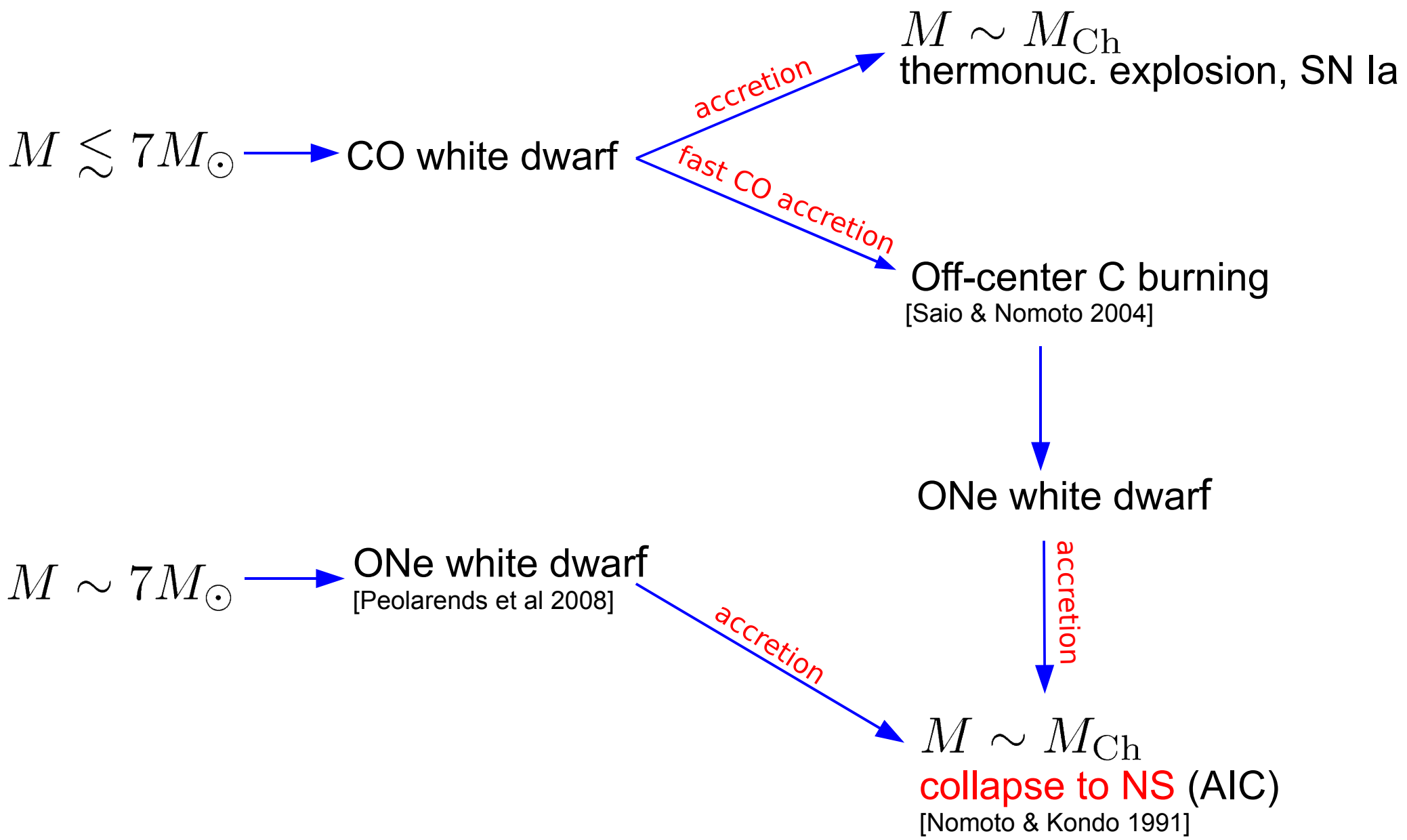
$M \lesssim 7M_\odot$ → CO white dwarf

$M \sim 7M_\odot$ → ONe white dwarf
[Peolarends et al 2008]

Progenitors

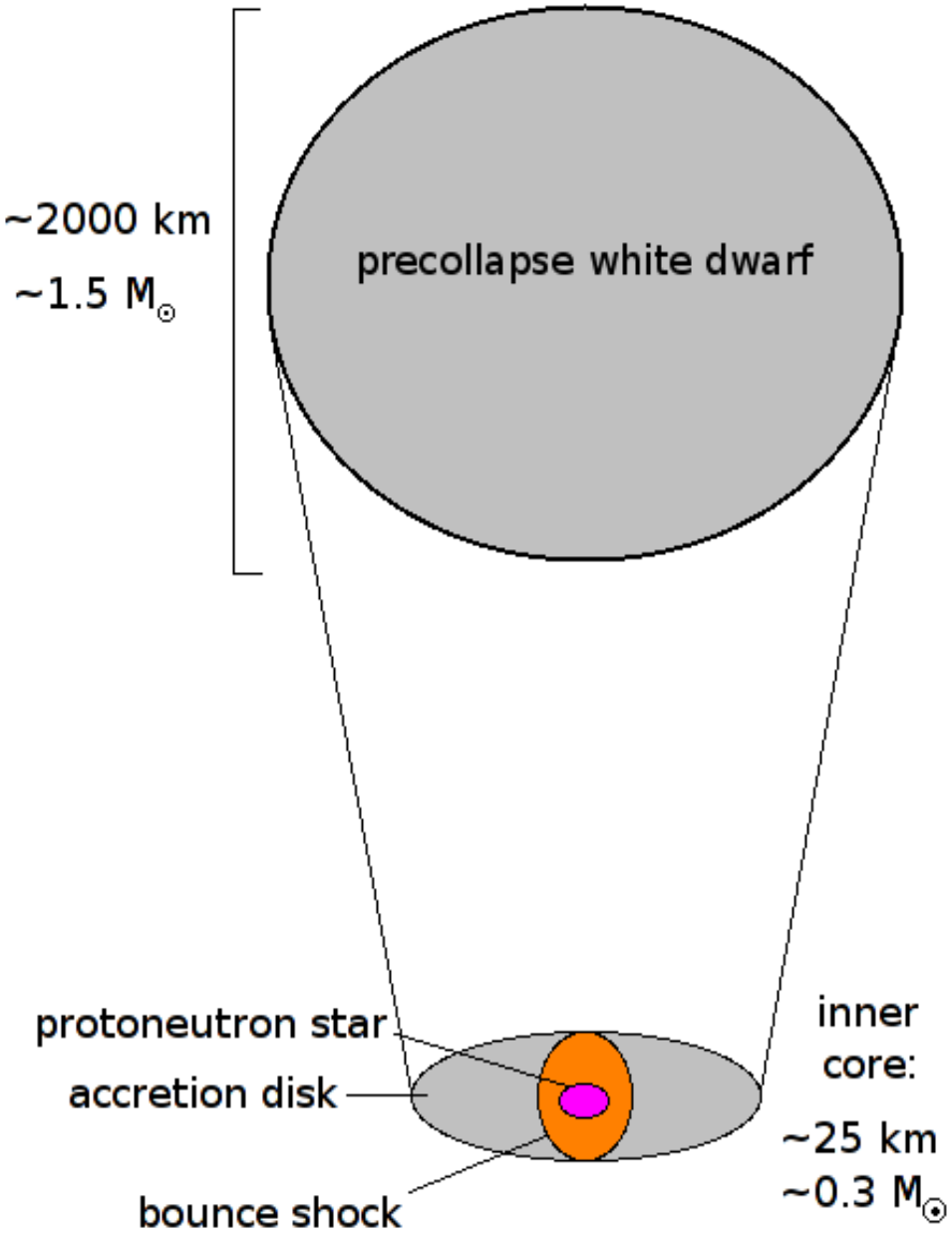


Progenitors



AIC scenario

- Accreting WD: $M \sim M_{\rm Ch},\ \rho \gtrsim 10^{9.6}\ {\rm g/cm}^3$
- e^--capture, infall
- Core bounce, ring-down
- Weak explosion $E \lesssim 10^{50}$ ergs
  [Dessart et al. 2006, 2007]
- Accretion disk, ^{56}Ni, SN-like transient?
  [Dessart et al 2006, Metzger et al. 2009]

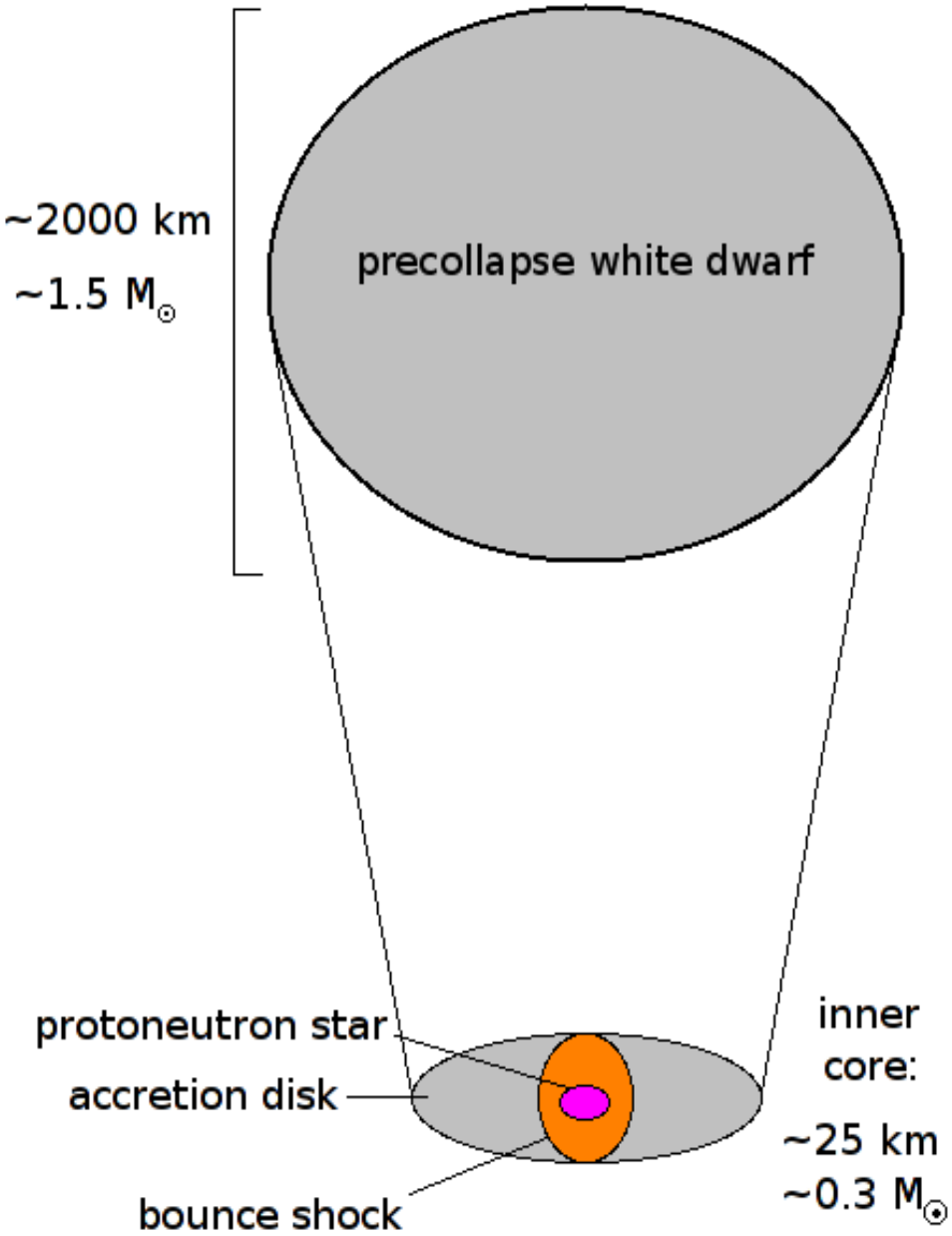


AIC scenario

- Accreting WD: $M \sim M_{\rm Ch},\ \rho \gtrsim 10^{9.6}\ {\rm g/cm}^3$
- e^--capture, infall
- Core bounce, ring-down
- Weak explosion $E \lesssim 10^{50}$ ergs
  [Dessart et al. 2006, 2007]
- Accretion disk, ^{56}Ni, SN-like transient?
  [Dessart et al 2006, Metzger et al. 2009]

In this work:

GW emission?
Accretion disk?
Rotational instabilities?



Our work

“Realistic” progenitors

- Rotation
- Rotation law [Yoon & Langer 2005, Saio & Nomoto 2004]
- Central density
- Temperature

Deleptonization:

- $Y_e(\rho)$ parametrization during collapse [Liebendörfer 2005]
- $Y_e(\rho)$ from VULCAN/2D (Newtonian MGFLD) [Livne et al 1993, Burrows et al. 2007, Dessart et al 2006]

Shen et al. EOS [Shen et al. 1998, Marek et al. 2005]

Parameter study with CoCoNuT [Dimmelmeier 2002, 2005, 2007]

- CFC approximation to GR [Isenberg 1978, Wilson & Mathews 1996]
- Hydro: HRSC
- Axisymmetry

Bounce GWs

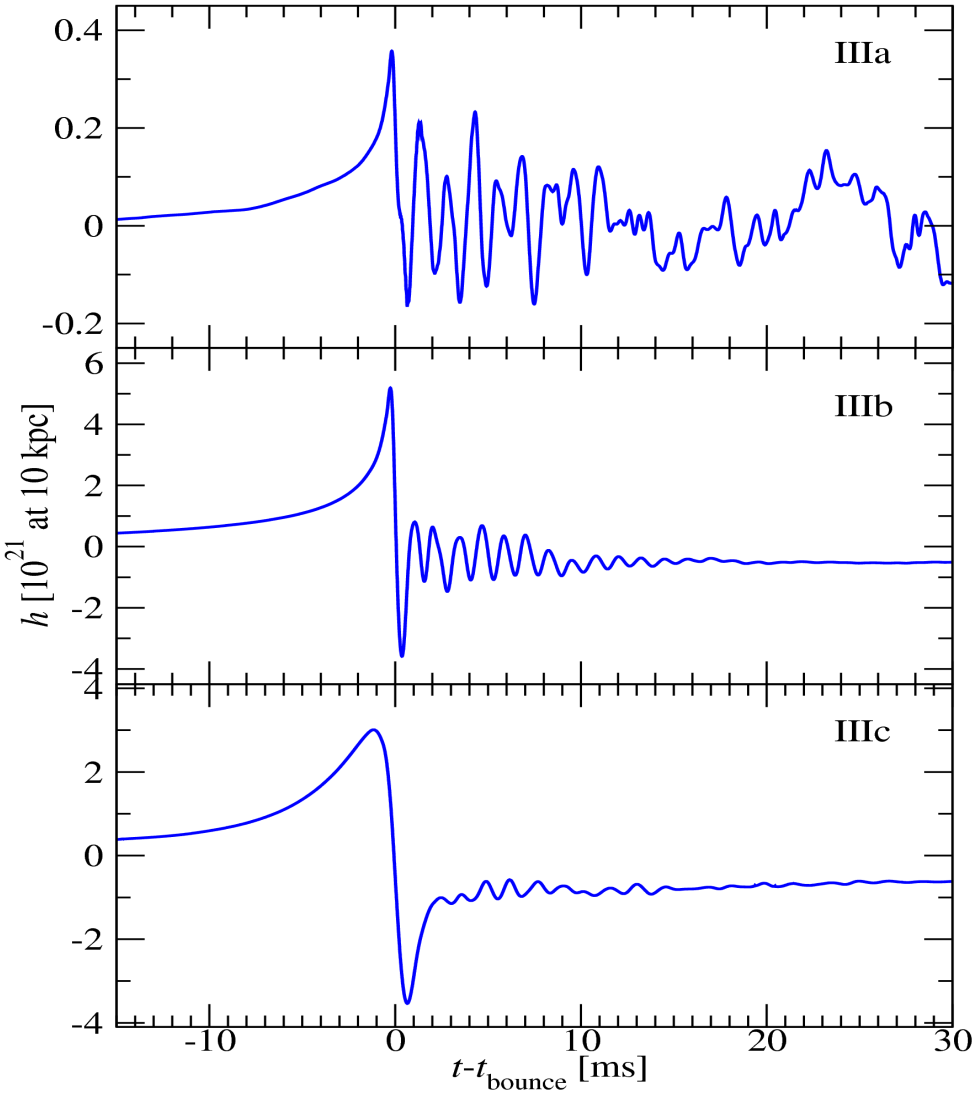
Generic morphology (Type III)
[Zwerger & Muller 1997, Ott 2009]

Three subtypes

Detectable by LIGO if in our Galaxy

Uniform rotation: no centrifugal bounce

Temperature: small effect



Accretion disk

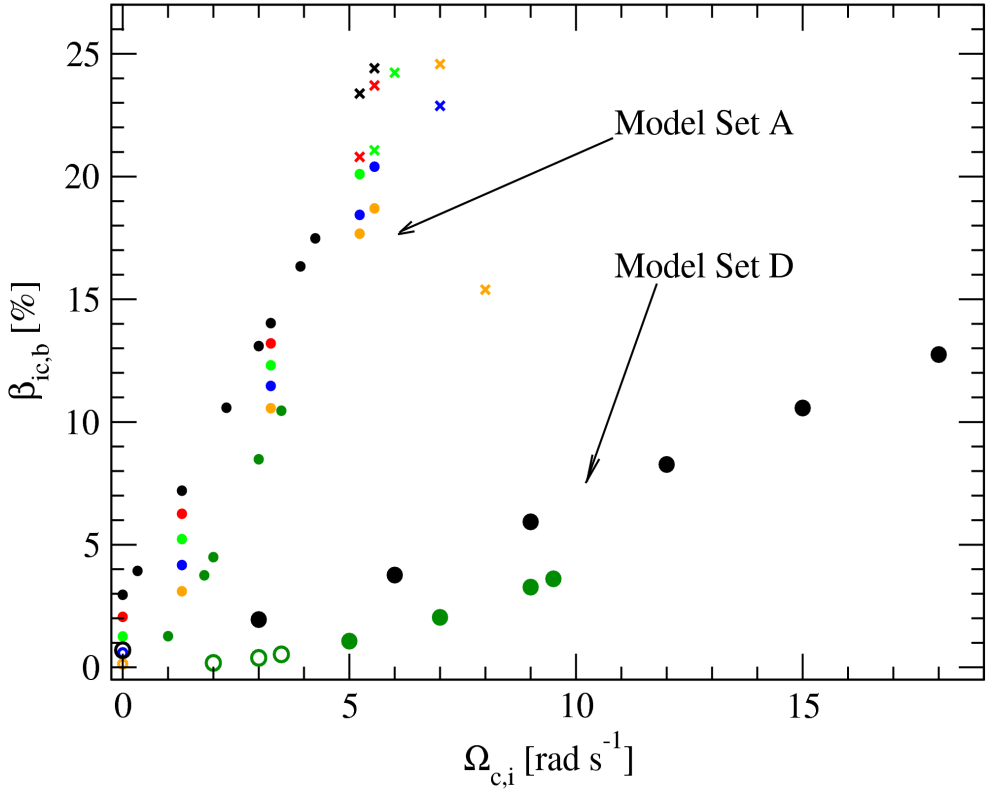
Dessart et al. (2006): $M_{\rm disk} \lesssim 0.6 M_\odot$

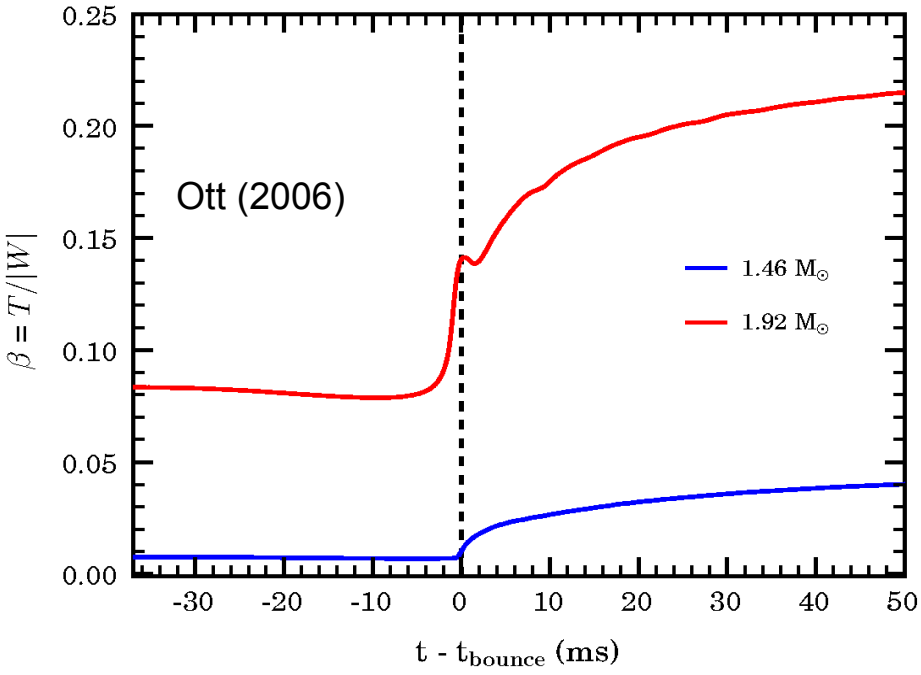
$\sim 0.1 M_{\rm disk}$ → ^{56}Ni [Metzger et al. 2009]

- Differentially rotating WDs: $M_{\rm disk} \lesssim 0.8 M_\odot$
- Uniformly rotating WDs: $M_{\rm disk} \lesssim 0.03 M_\odot$

3D instabilities

- $T/|W|$<~24.5% at bounce. No high-T/|W| instability at bounce.
- Postbounce: $T/|W|$ grows by ~50% in ~50 ms
- $T/|W|$ >~17% at bounce → high-$T/|W|$ instability in DR models
- UR WDs: $T/|W|$<~10% at bounce.
- Low-$T/|W|$ instability is also possible





Summary

Parameter study of AIC in GR

Generic morphology of GWs

Rotational Instabilities

Accretion disk