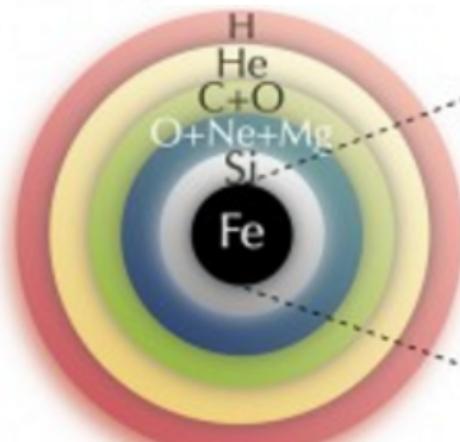


Circular polarization of gravitational wave from core collapse supernova

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T. Kuroda(UT Darmstadt), K. Nakamura(U Fukuoka), S. Yamada(U Waseda), K. Kotake(U Fukuoka), T. Takiwaki(NAOJ)

Supernova explosion

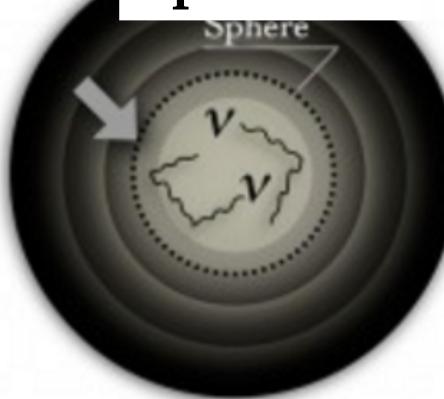
(a) Red giant



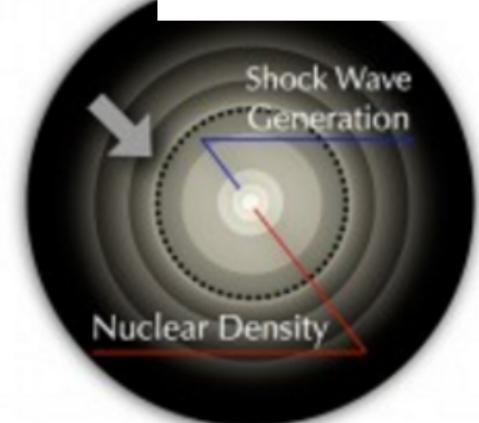
(b) collapse



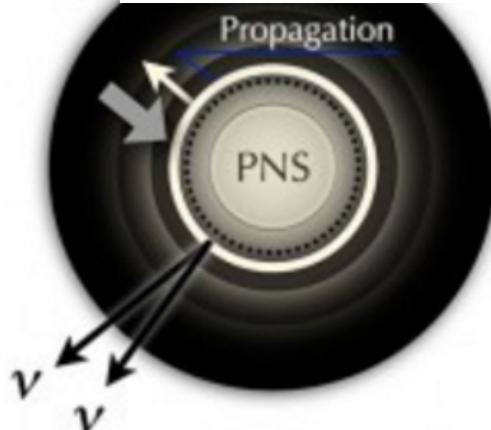
(c) Neutrino Sphere



(d) Core Bounce



(e) Shock Wave Propagation



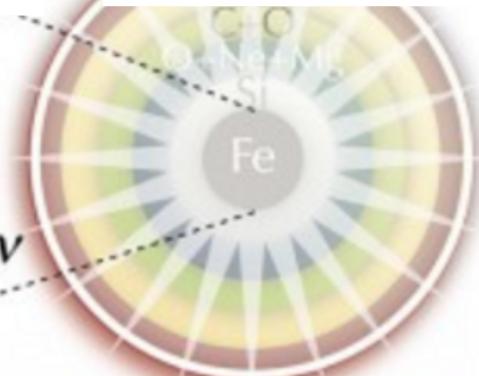
(f) Shock Wave Stagnation



(g) Shock Wave Revival



(h) Neutrino Heating ?



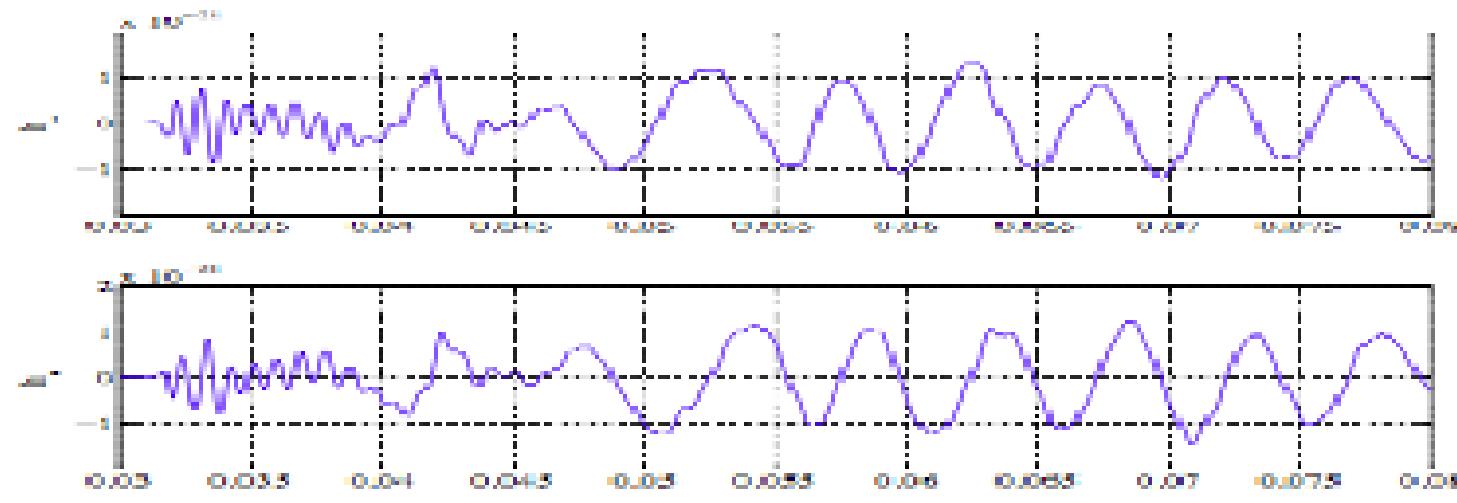
Understanding mechanisms of core-collapse supernovae

- Recent simulation of CCSNe suggested the key to the explosion is to understand how to revive stagnated shock waves.
- The proposed mechanisms of the revival of shock wave are non-(axi-)symmetric feature s.t. rotation, non-stationarity of fluid, Neutrino heating. Important how to observe such signature.
- GW is not main source of SNe. Energy of radiated from SN is $\sim 10^{47}$ erg, which is far smaller than 10^{52} erg. But its observation will play important roles for understanding since GW is generated by the non-symmetric feature.

Rotation, non-axisymmetric instabilities

Recent 3D GR simulation of rapidly rotating core-collapse supernova performed by Kuroda, T. + + (2014) shows that

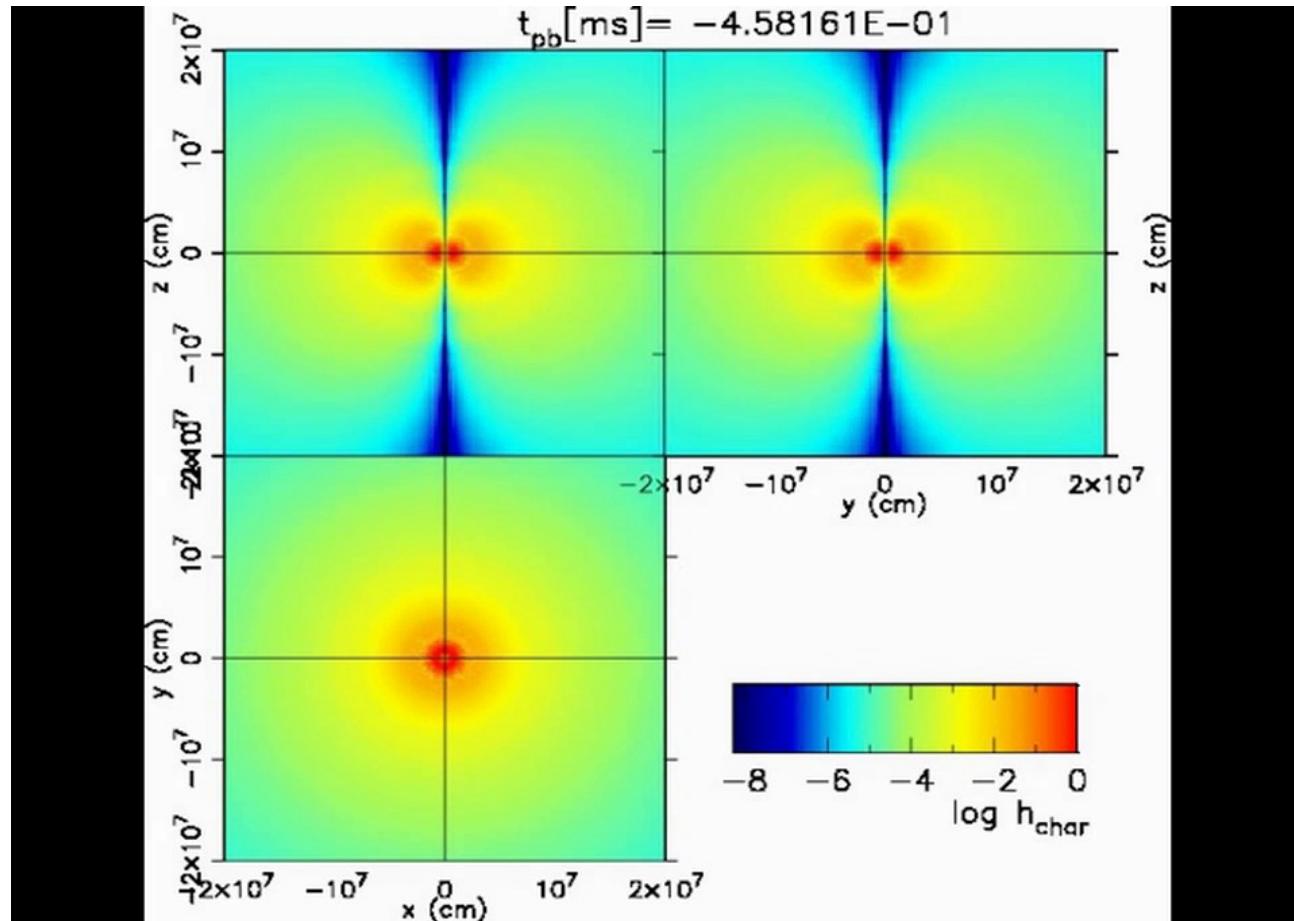
in rapidly differentially rotating core, non-axisymmetric instabilities are growing with $T/|W| > 10\%$



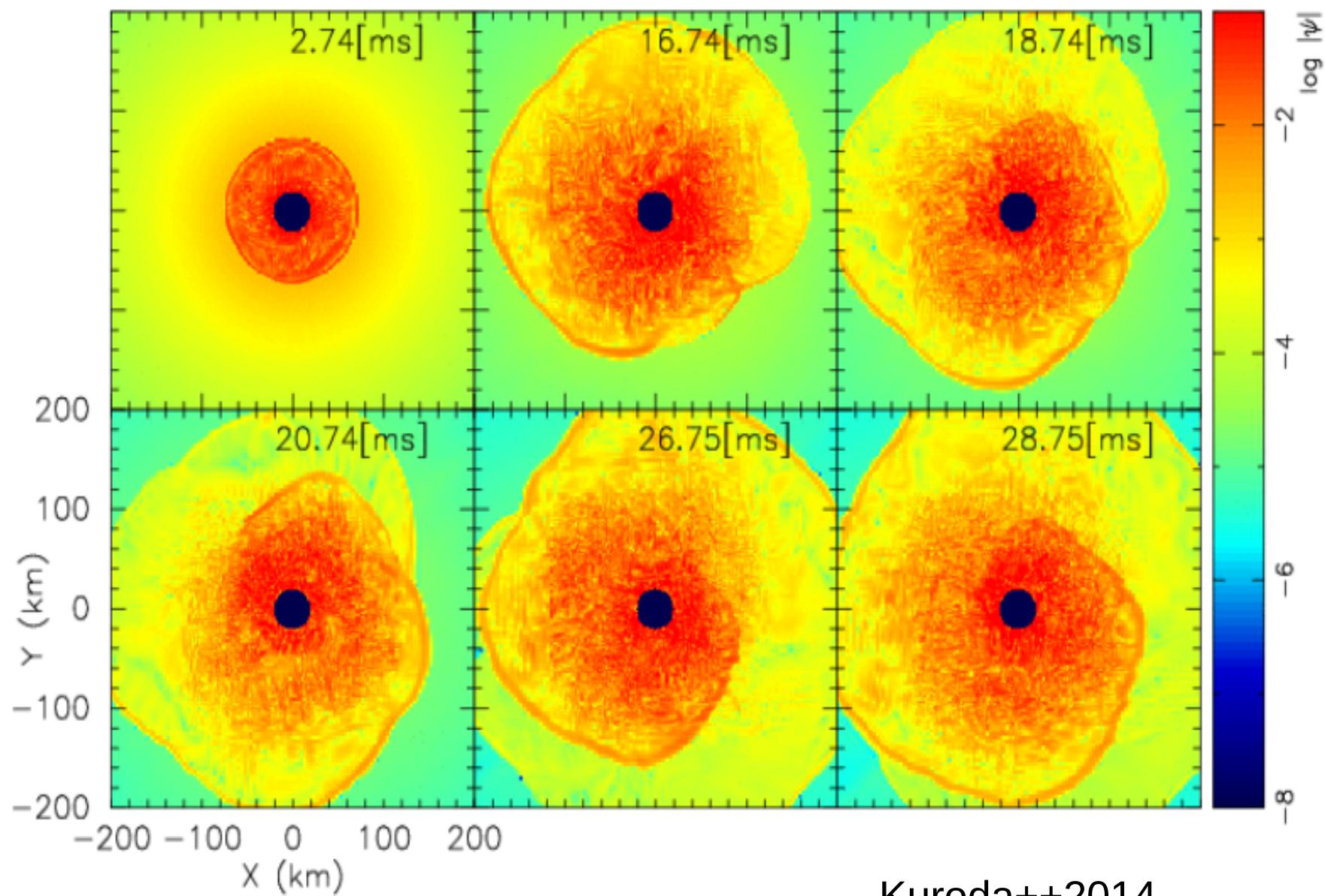
polar direction

Kuroda, Takiwaki, Kotake (PRD89,044011, 2014)

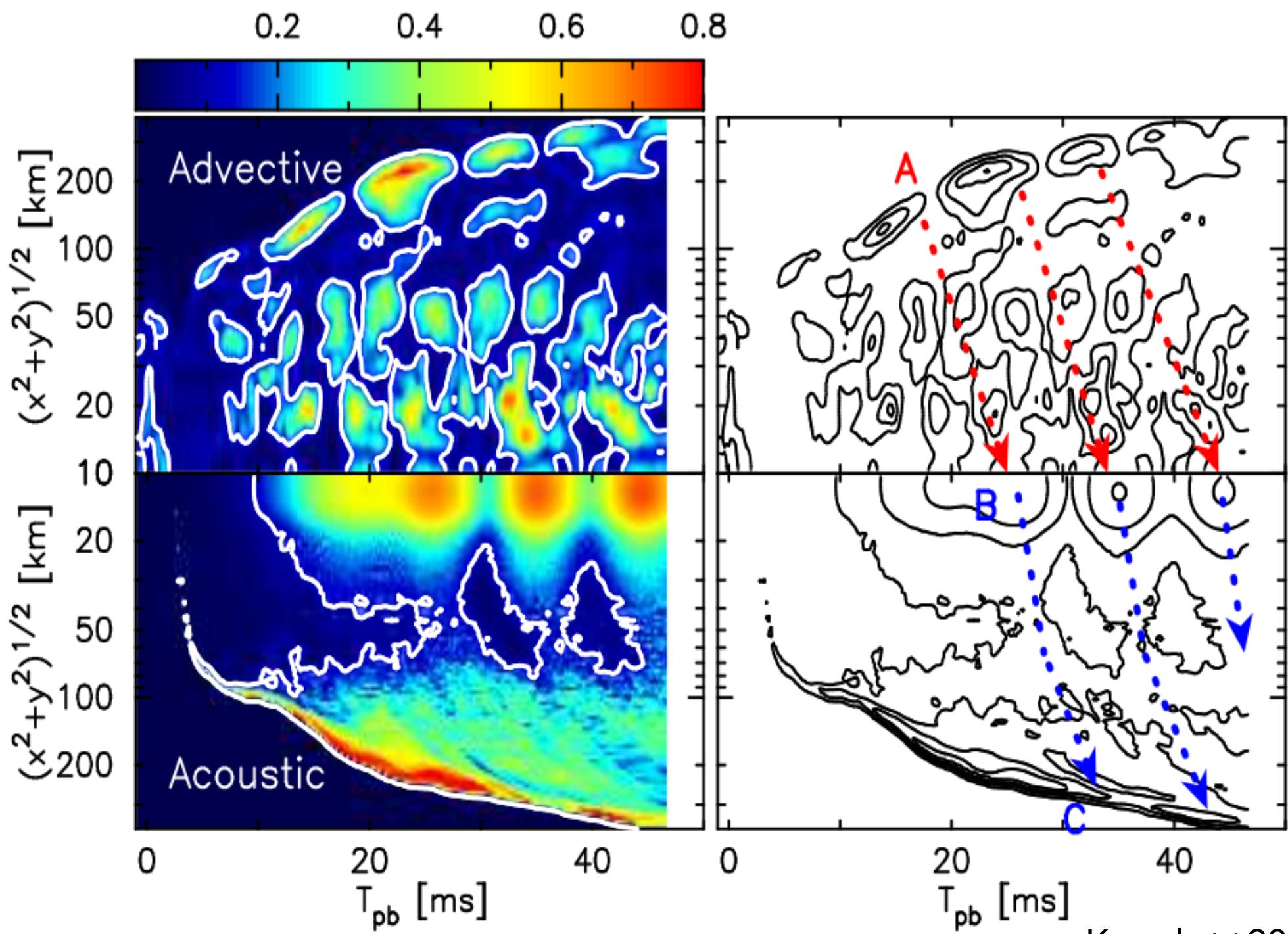
One-Armed Spiral mode of GW from Rapidly Rotating Core-Collapse Supernovae



Kuroda, Takiwaki, Kotake (PRD89,044011, 2014)

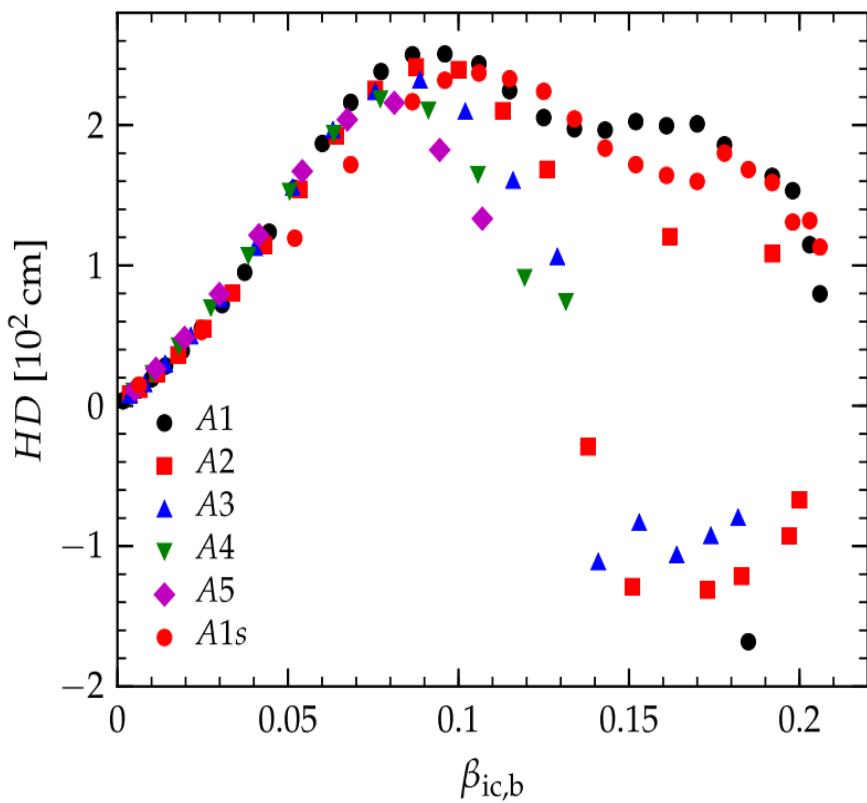


Kuroda++2014

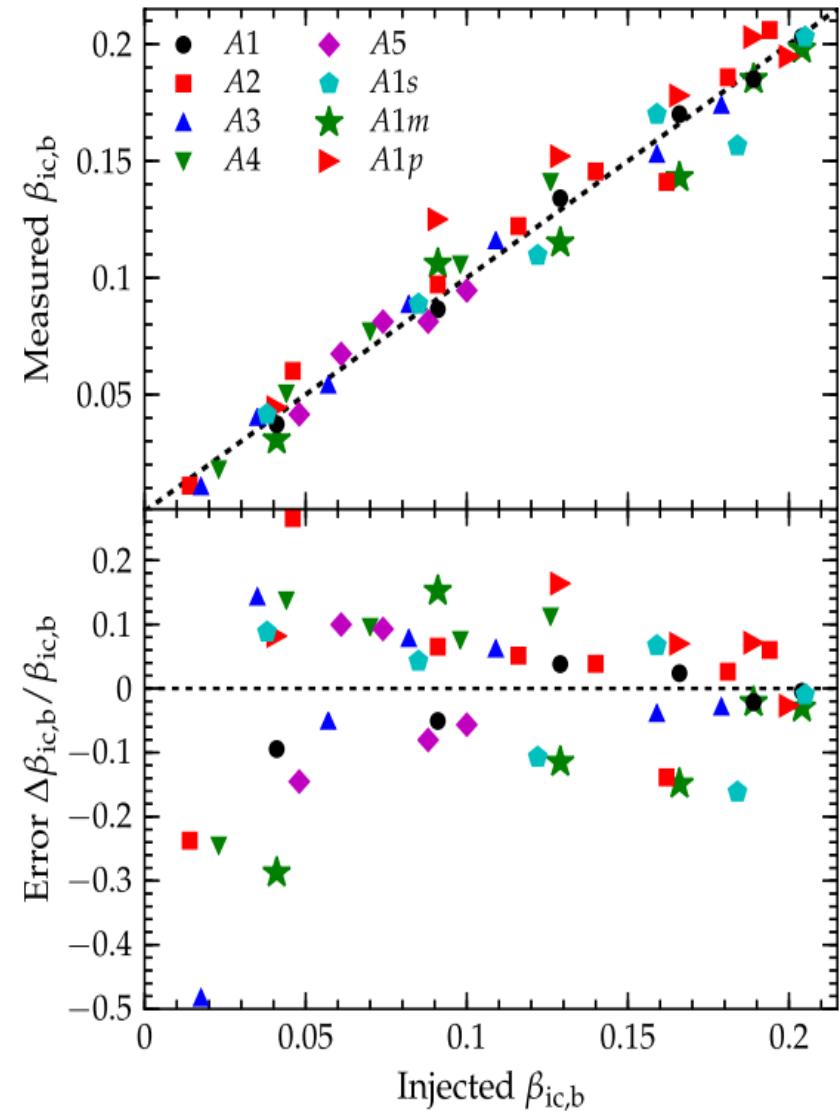


Trying to know rotation

Matched filtering method can



Abdikamalov+PRD2014



Key to know the rotation

- In a system with uniformal rotation, it need astronomically too high $T/|W|$ for non-axisymmetric instabilities evolving.
- But in a system with differential rotation, even $T/|W| < \sim 0.1$ non-axisymmetric instabilities occur, which produce strong GWs.

Stokes Parameter

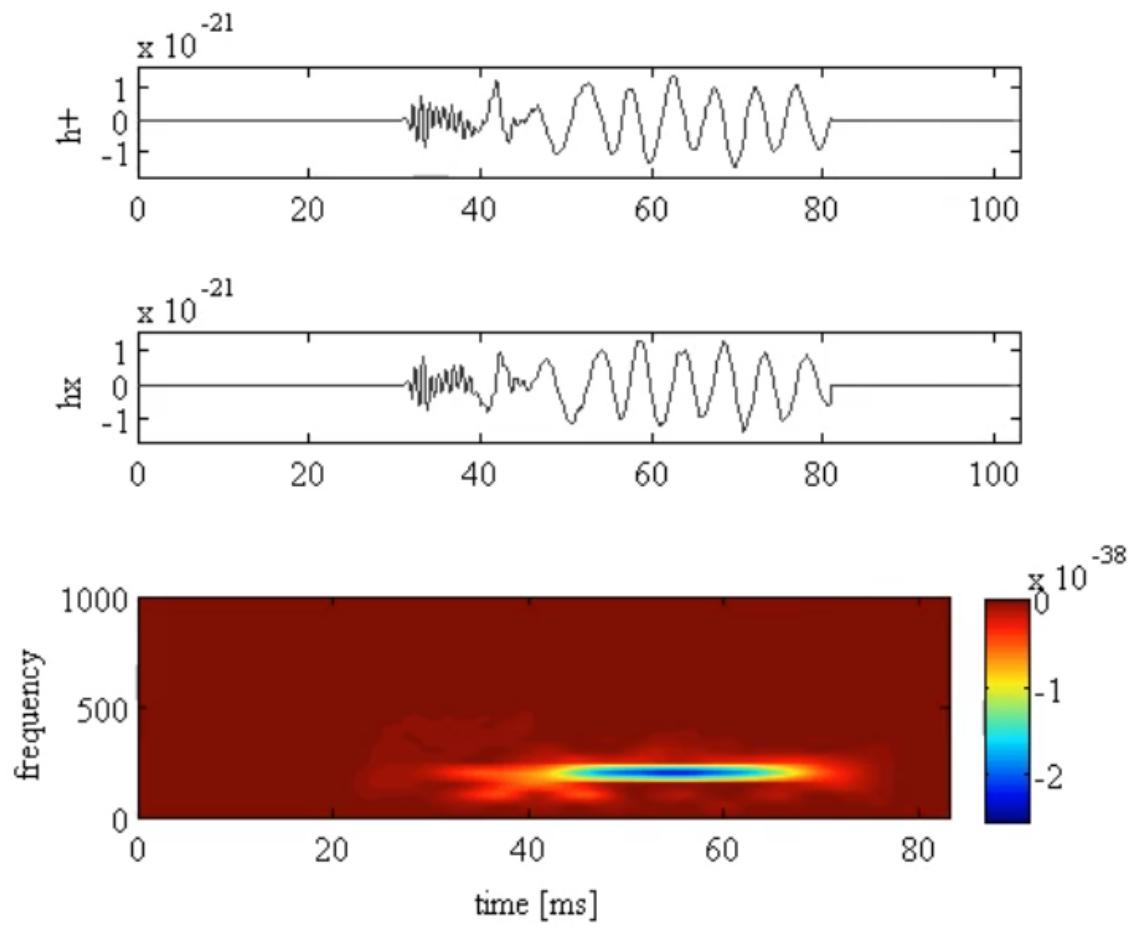
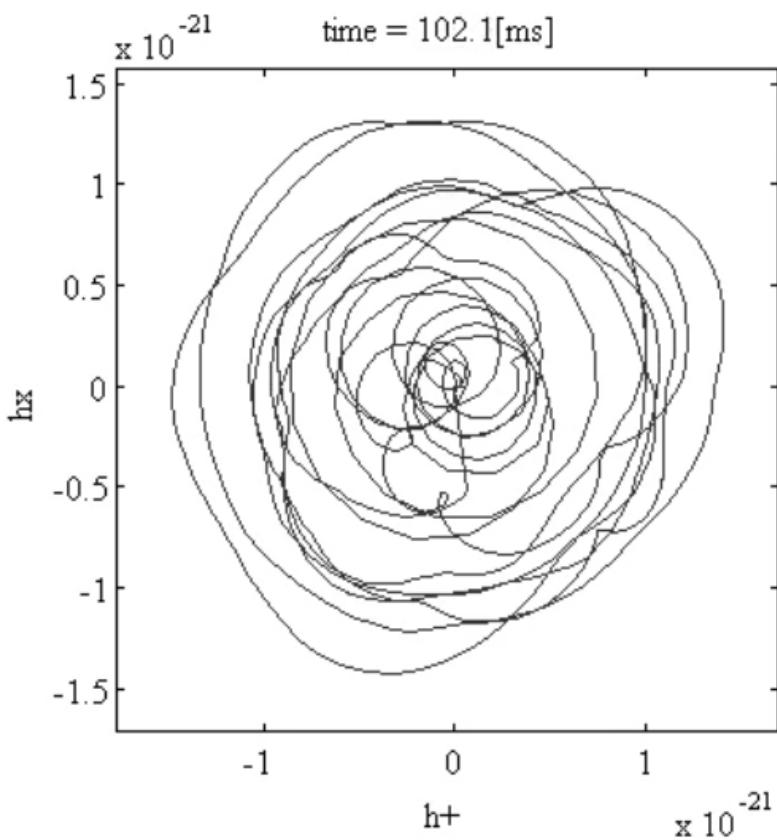
To probe the core rotation, we introduce Stokes parameter.

$$\begin{pmatrix} \langle h_R(f, n)h_R(f', n')^* \rangle \\ \langle h_L(f, n)h_L(f', n')^* \rangle \end{pmatrix} = \frac{1}{4\pi} \delta_D(n - n') \delta_D(n - n')$$
$$\begin{pmatrix} I(f, n) + V(f', n') & Q(f, n) - iU(f', n') \\ Q(f, n) + iU(f', n') & I(f, n) - V(f', n'), \end{pmatrix} \quad (4)$$

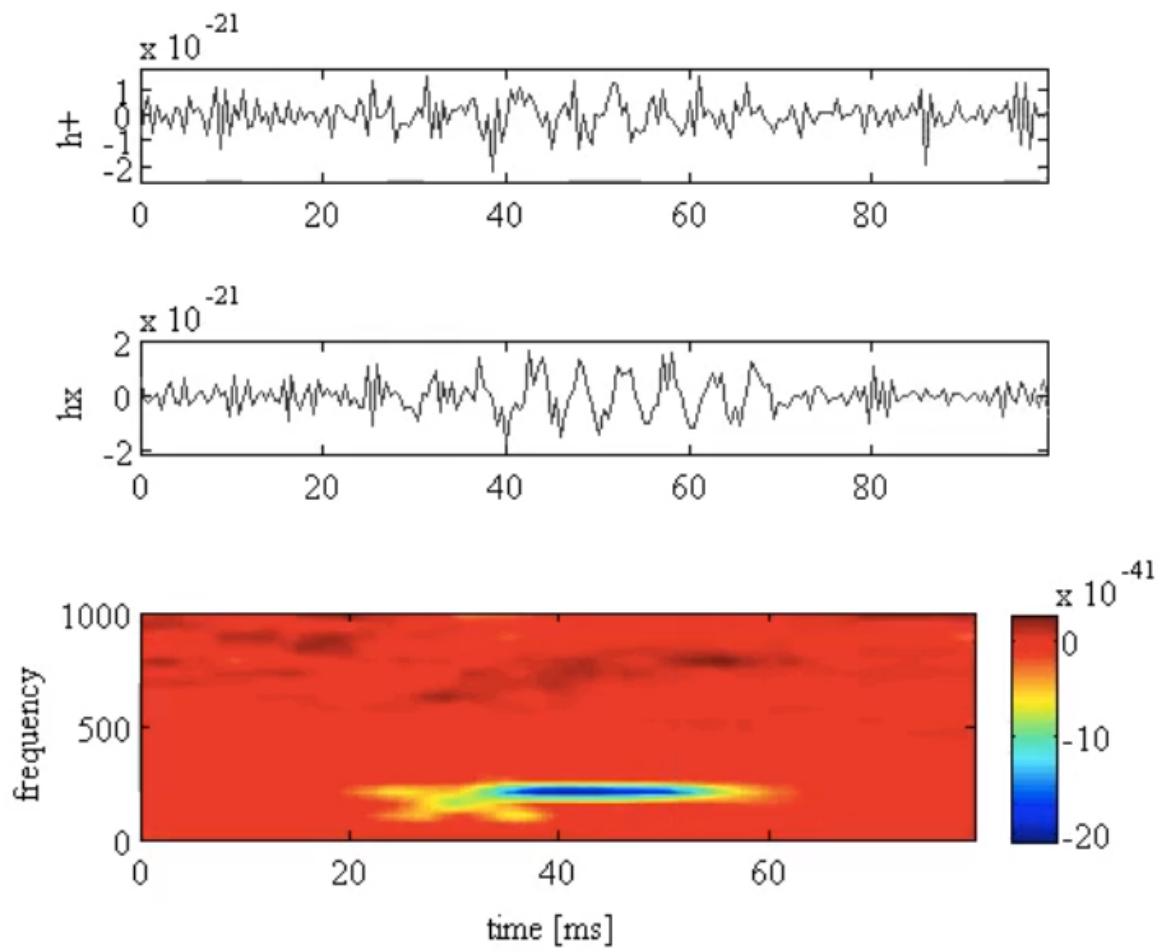
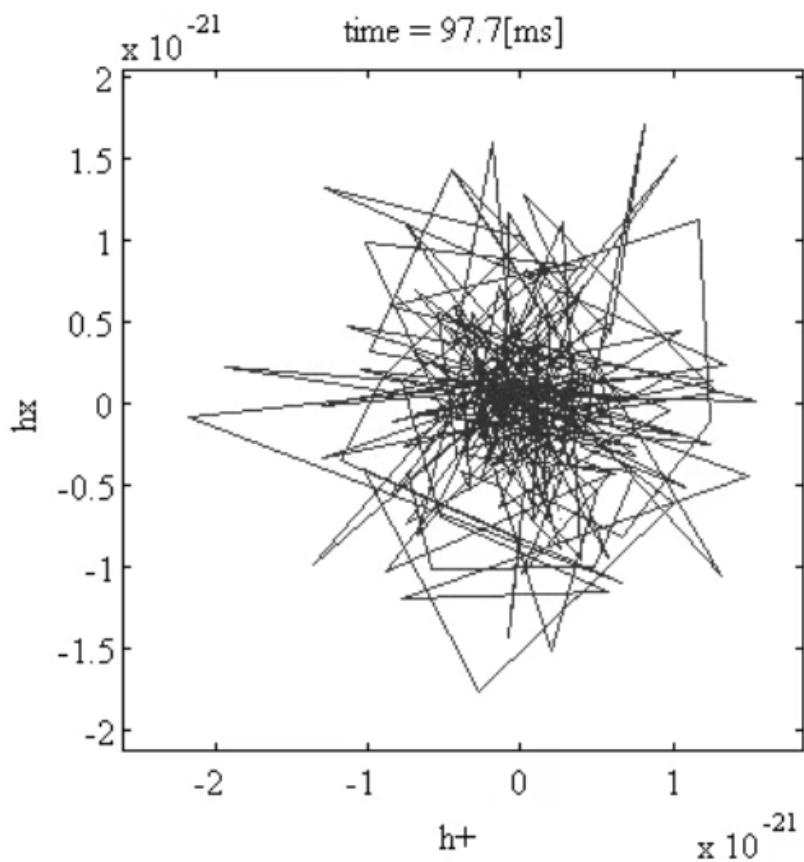
Seto, N. PRL

Hayama, Kuroda, Nakamura, Yamada, PRL 2016

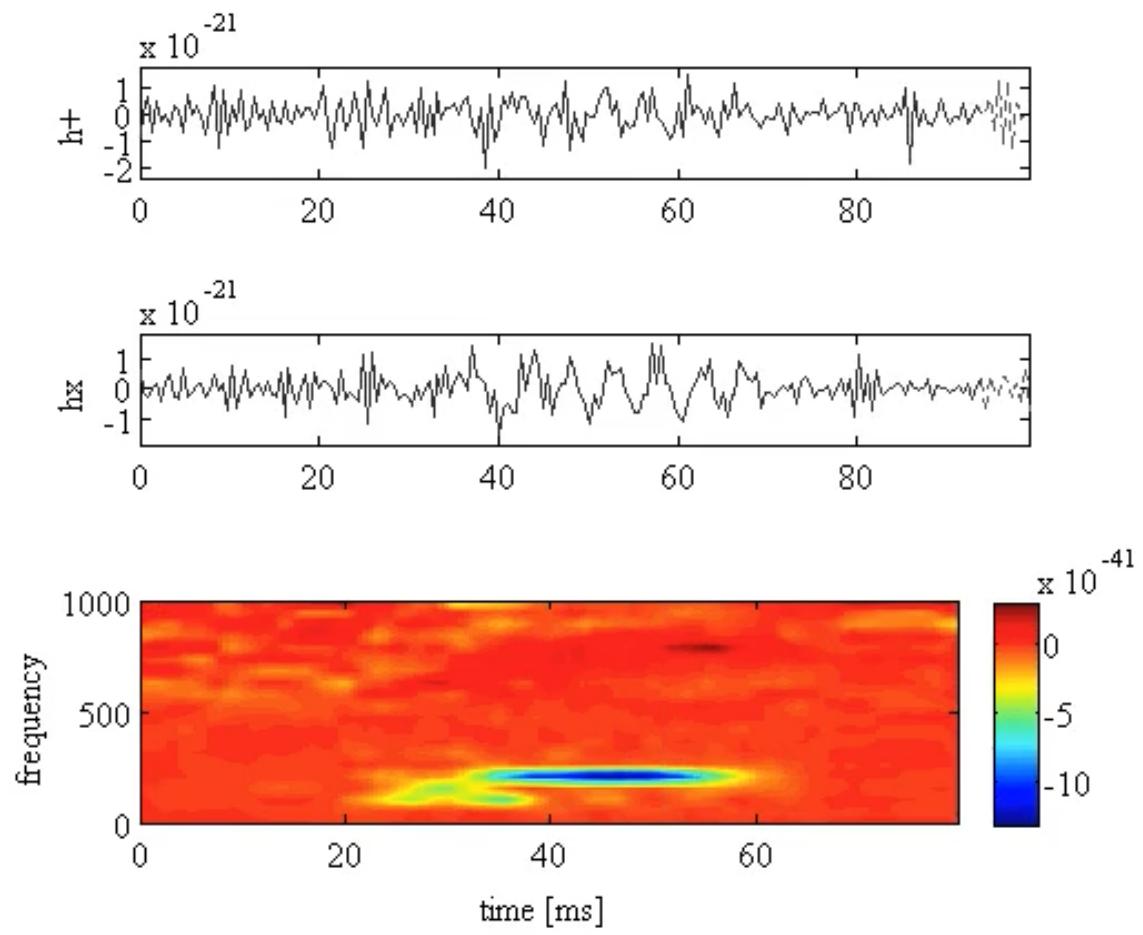
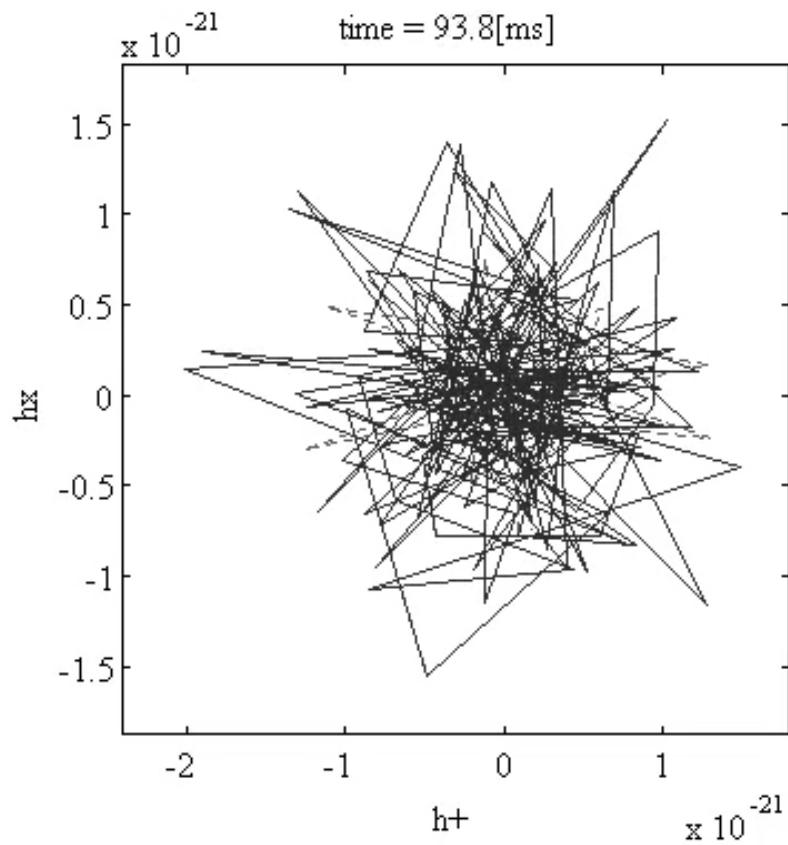
Noise Free case Polar direction



At 10kpc (polar direction)

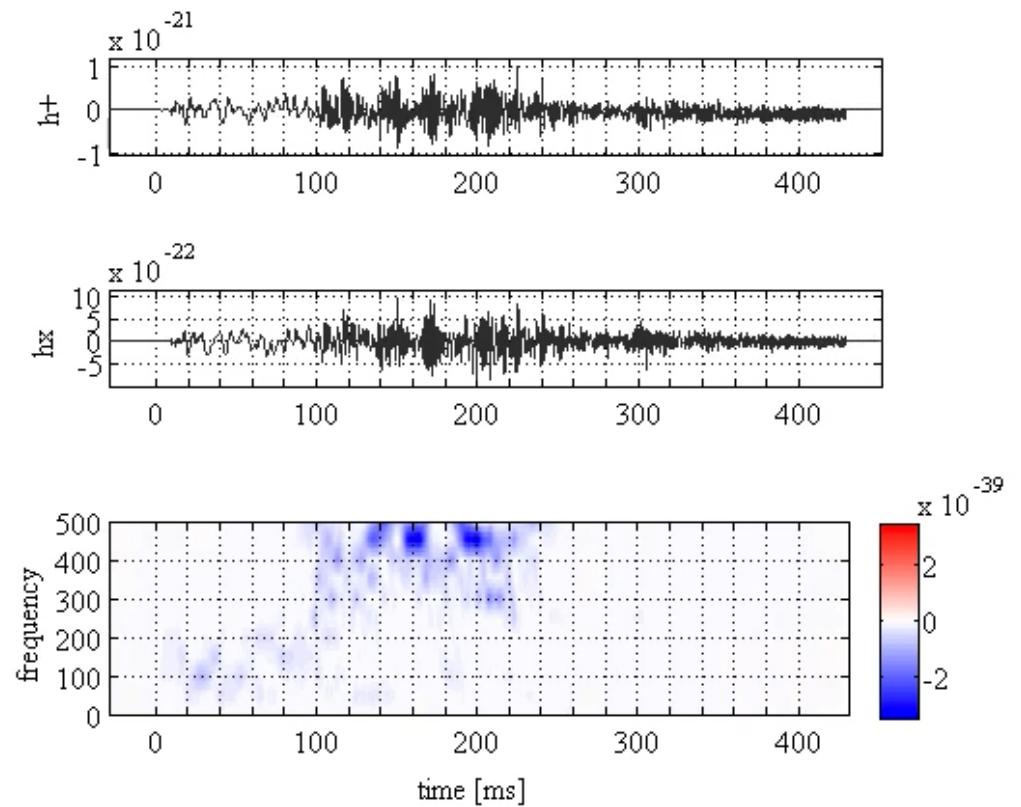
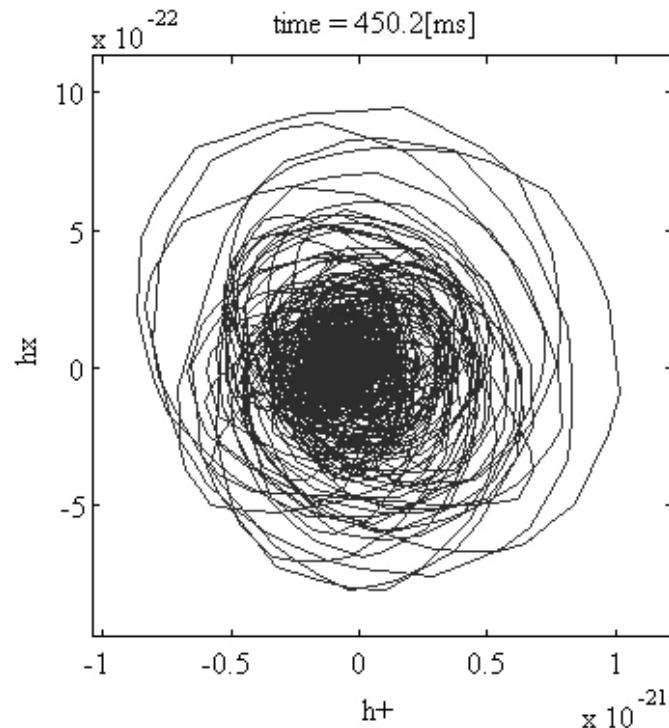


At 10kpc from 45deg direction



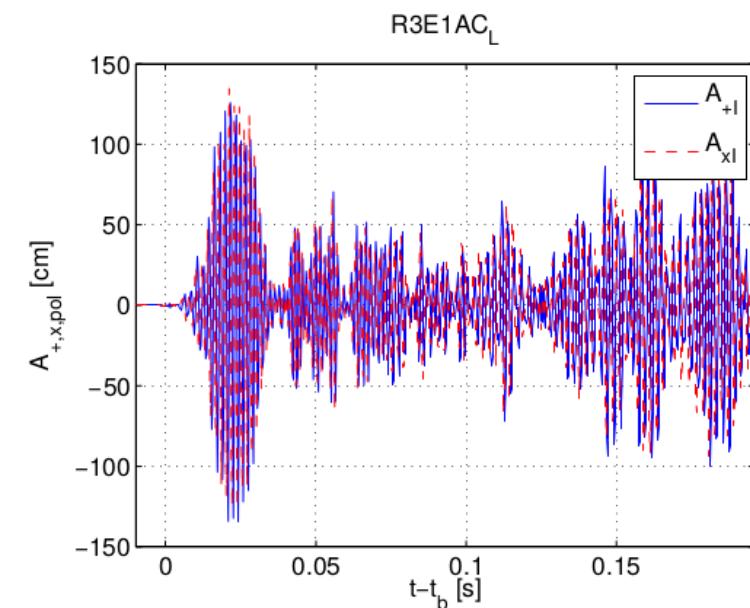
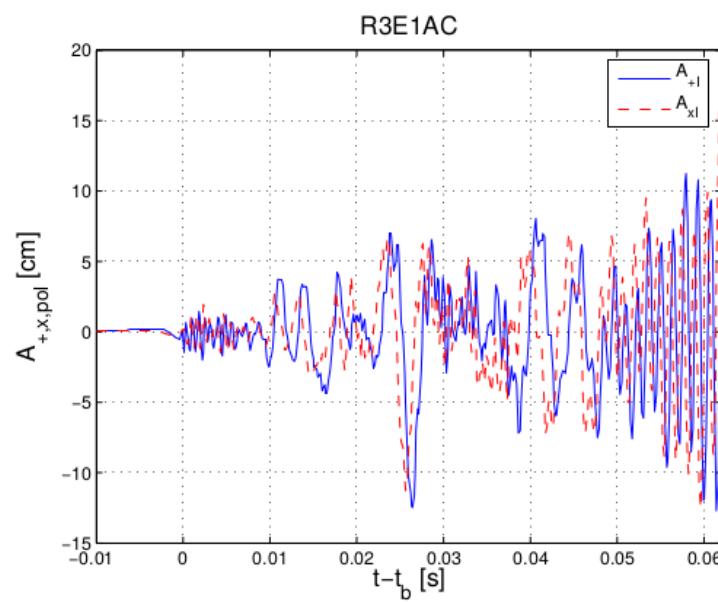
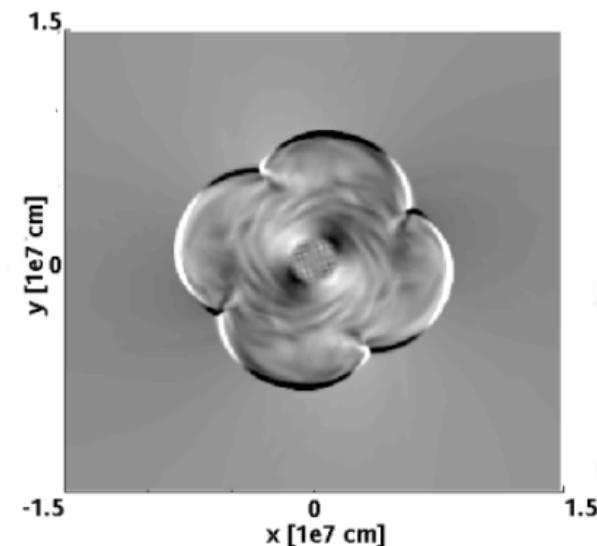
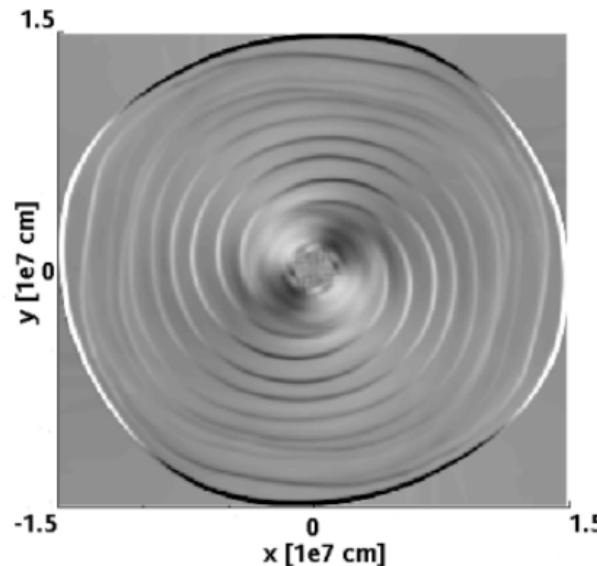
Other models?

- Nakamura(U Fukuoka)'s model also show the polarity feature.



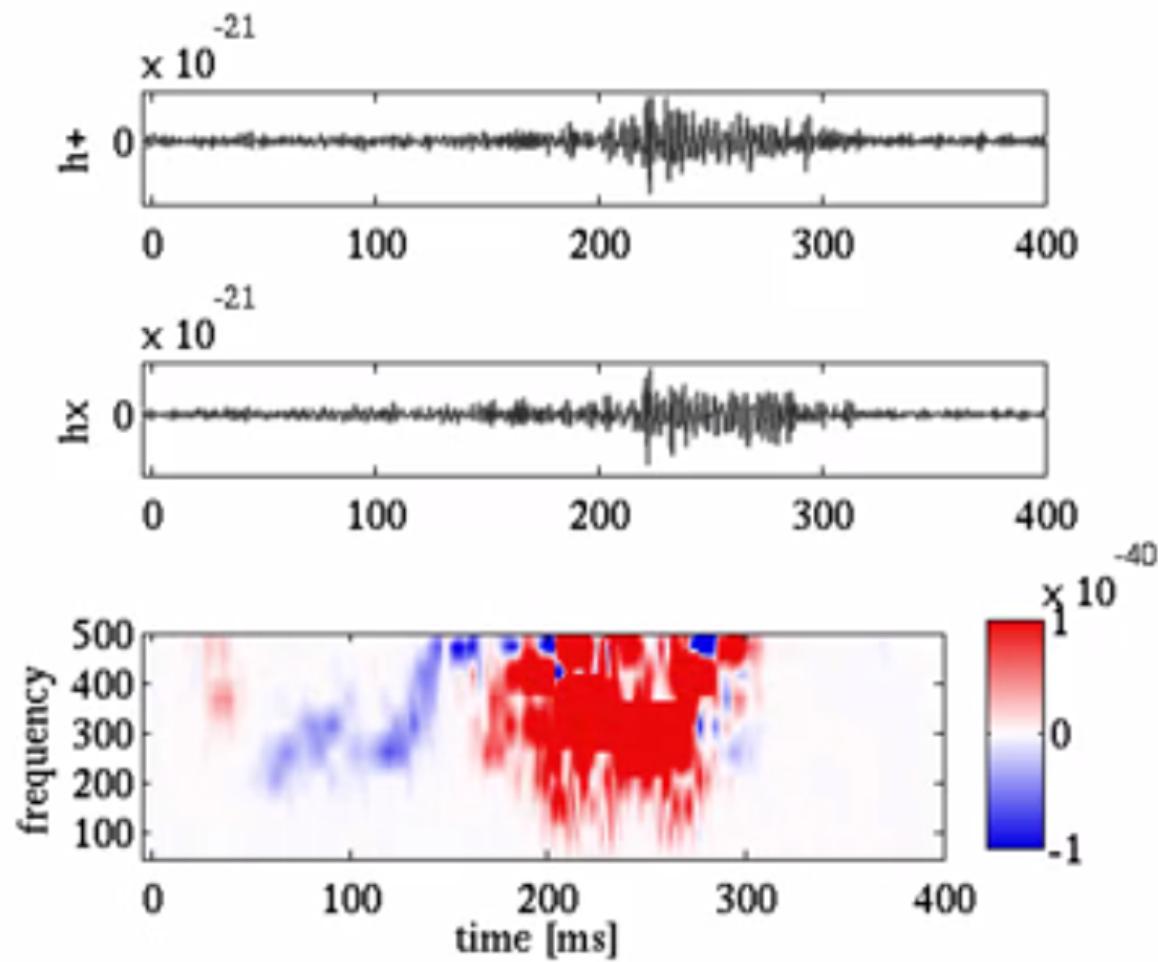
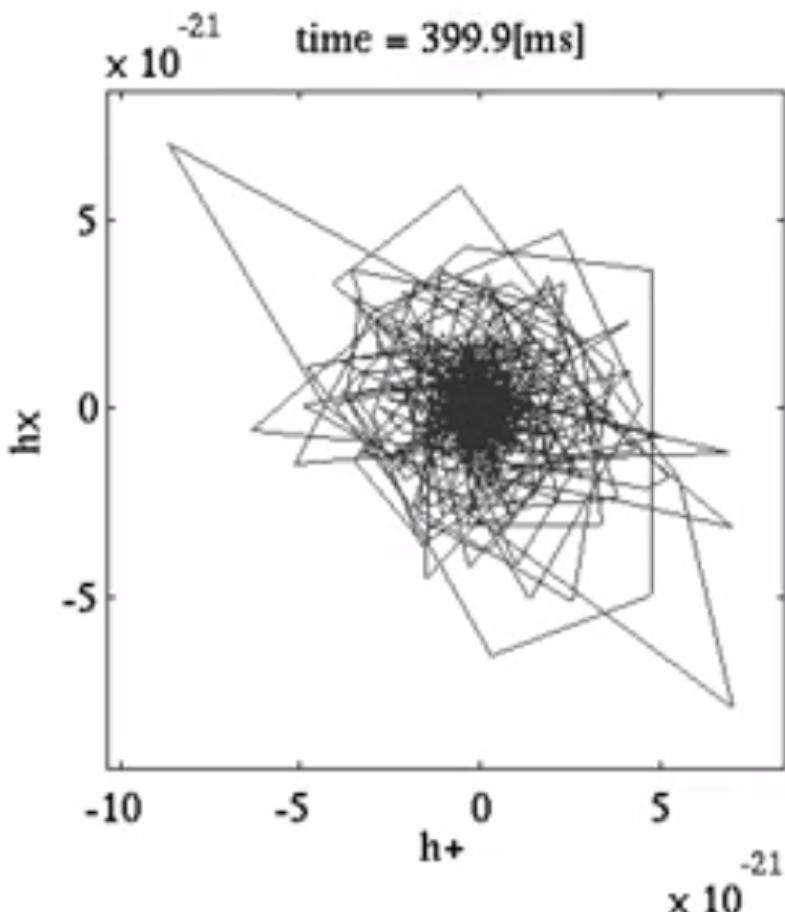
These rotating SN models are coming from 3-dimensional, special-relativistic hydrodynamic simulations in the Cartesian coordinates, employing LS220 EOS. The neutrino-matter interaction is included by a simple light-bulb scheme. Nakamura + ApJ 2014

Other models?



Scheidegger + AA (2010)

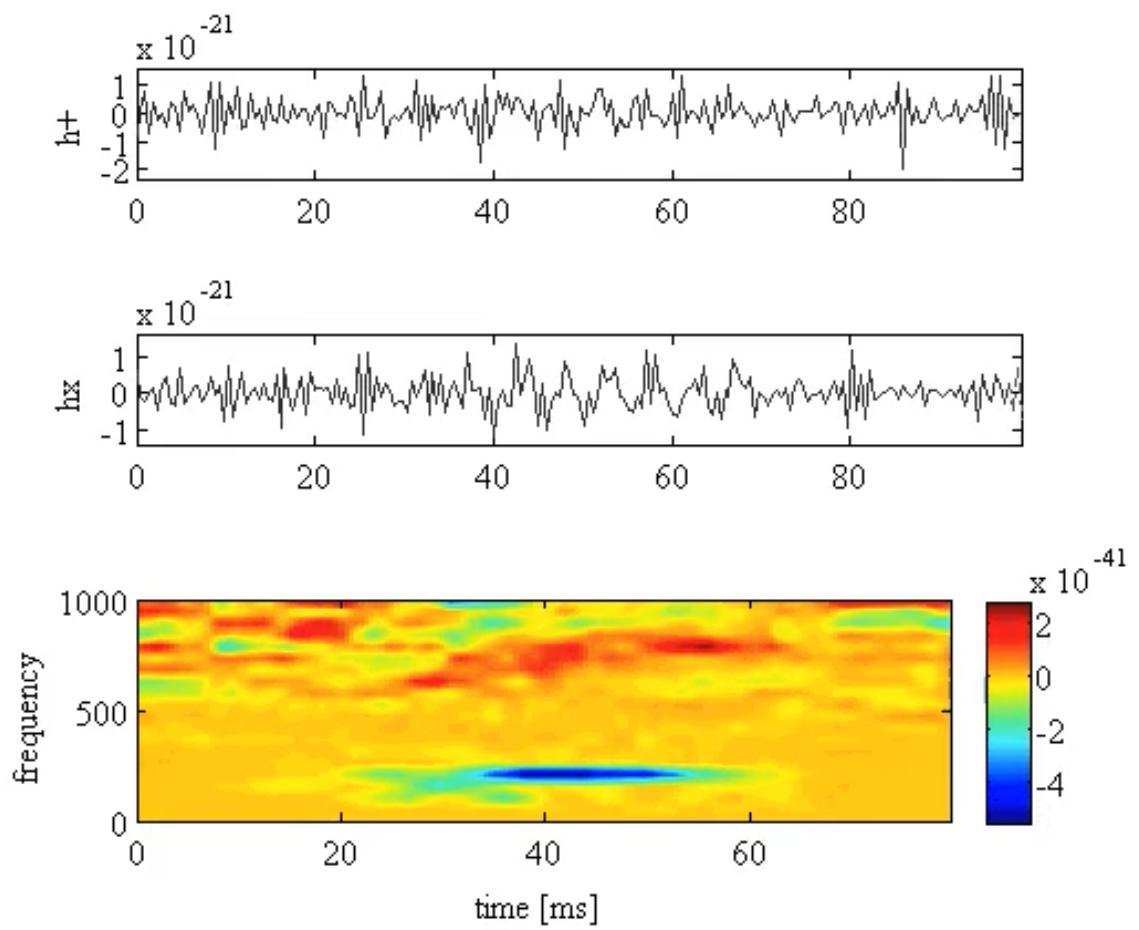
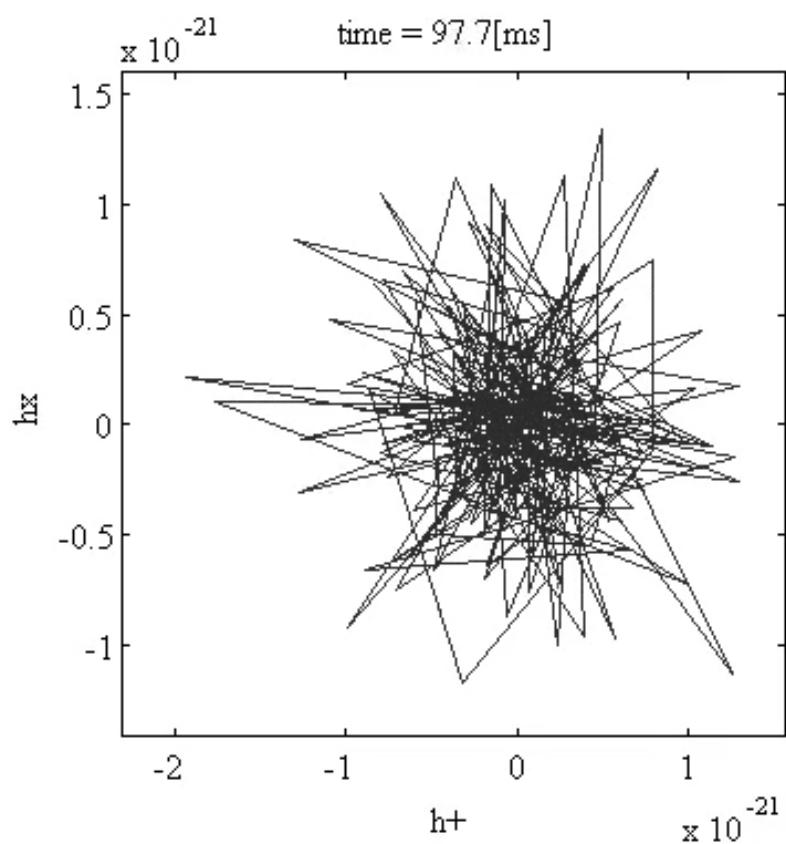
The circular polarization may show some feature of the mechanism of the explosion



Takiwaki, Kuroda, Kotake, +

END

At 20kpc



At 10kpc Equator direction

