重いアクシオンを考えた場合の超新星爆発の長時間計算

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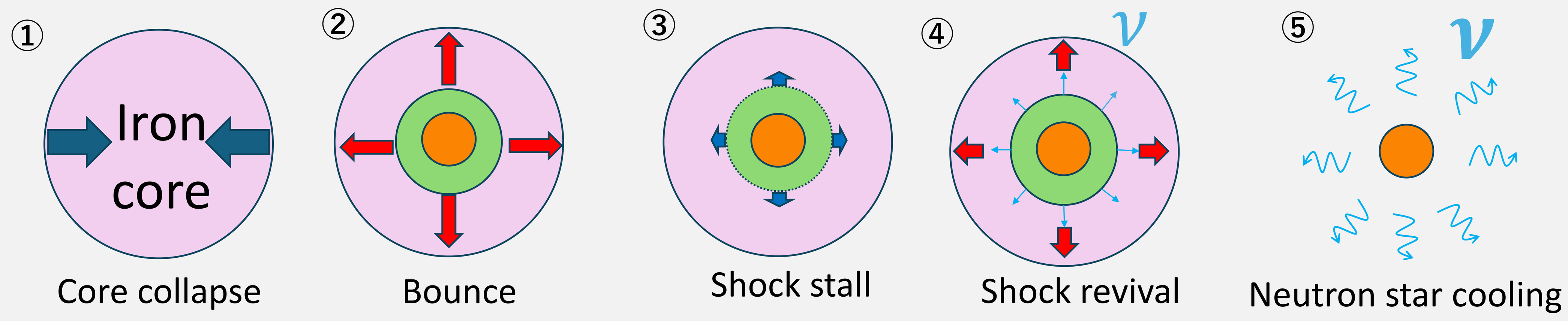
Supernova

- The most energetic explosion in the universe
- Neutrinos play a key role and 99% of the energy emitted as neutrinos
  - ◆ Important to observe supernova neutrinos
- Neutrino emission lasts over 1min.
  - ◆ Important to calculate for a long term

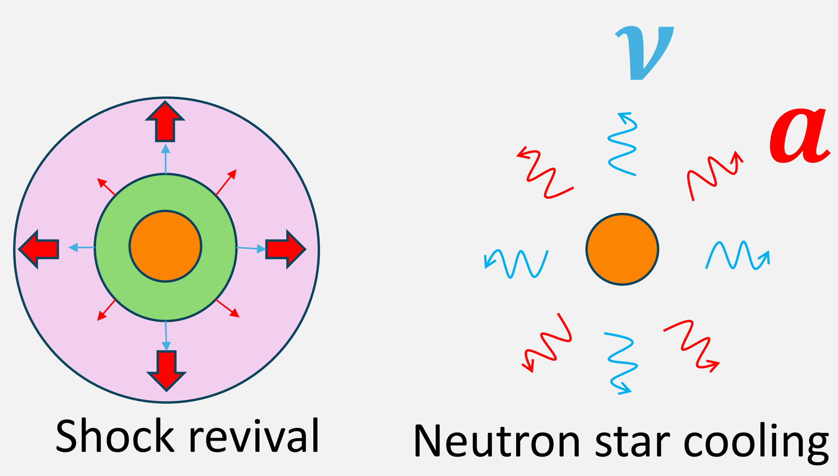


Axion-like particles

- Beyond standard model particle introduced to solve the strong CP problem (**Axion**)
- Pseudo-scalar particles like an axion
  - ◆ Axion-like particles (ALPs)
- Effects of ALPs on supernovae
  - ☐ Enhance heating (Early phase)
  - ☐ Accelerate neutrino cooling (Late phase)

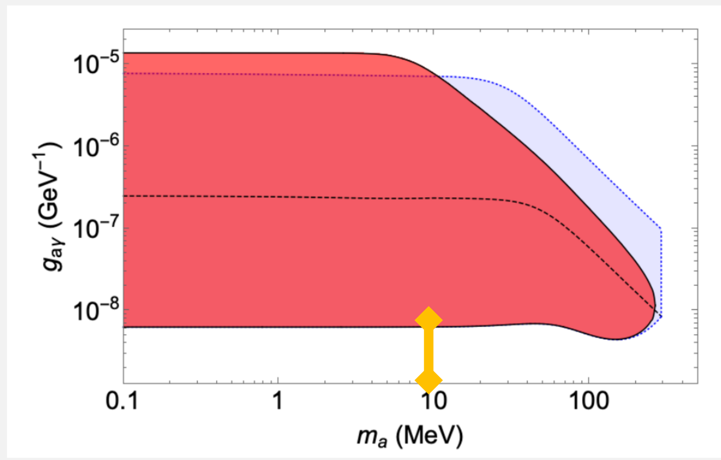
In this study

- To calculate supernovae with ALPs for a long term
- To predict neutrino events in the case that ALPs exist



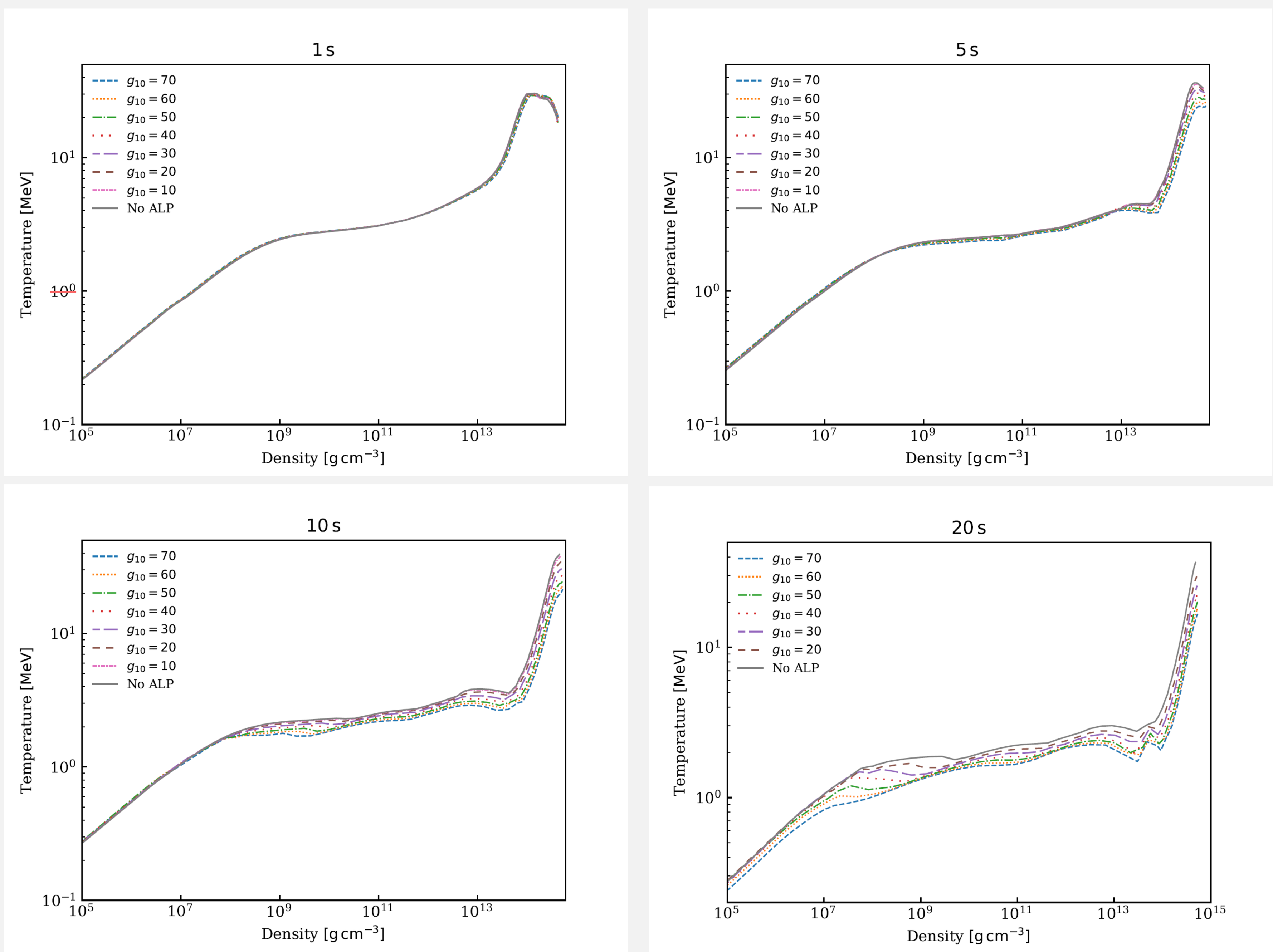
Simulation

- Simulator: GR1D with ALP cooling
  - ◆ 1D
  - ◆ General relativity
  - ◆ Neutrino radiation hydro
  - ◆ Progenitor: 9.6 $M_\odot$
- Axion
  - ◆ Axion mass: 10 MeV
  - ◆ Coupling Constants
  - ☐ $7.0 \times 10^{-9}\mathrm{GeV} \sim 1.0 \times 10^{-9}\mathrm{GeV}$

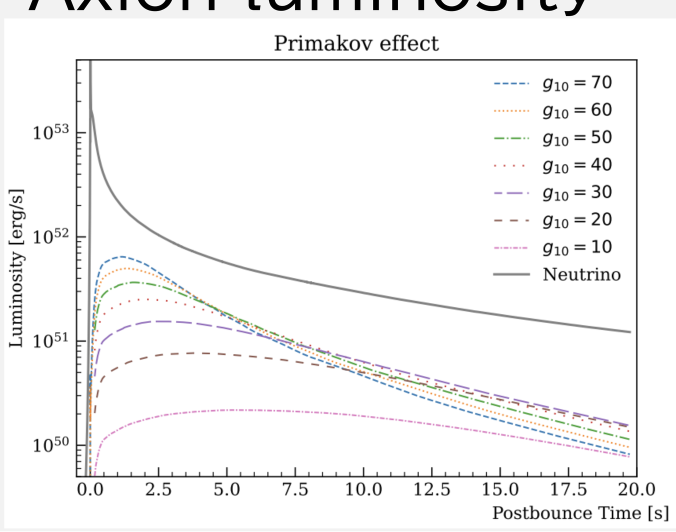


Results

Density vs Temperature



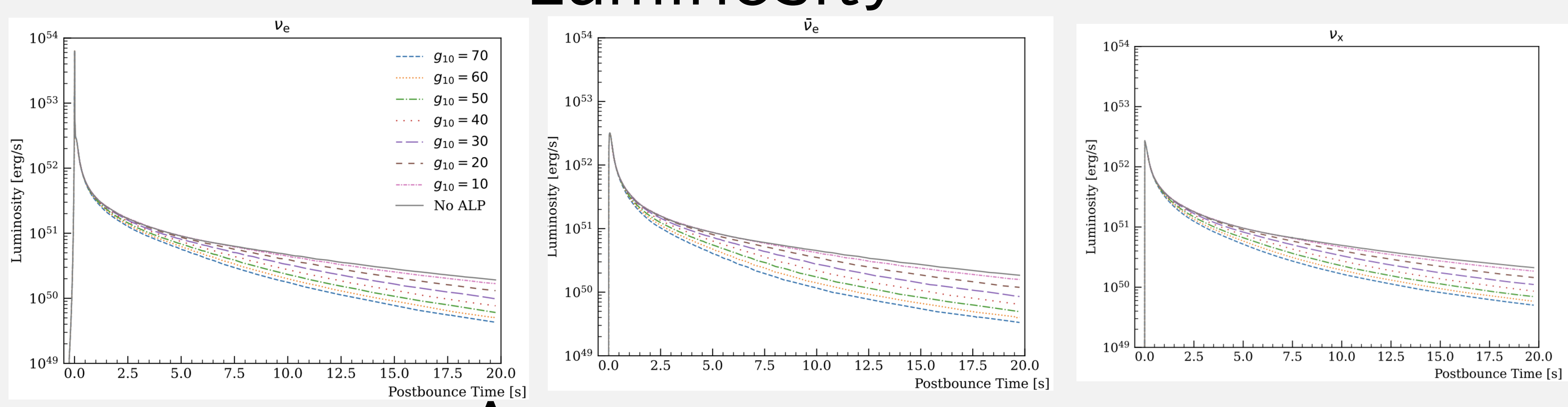
Axion luminosity



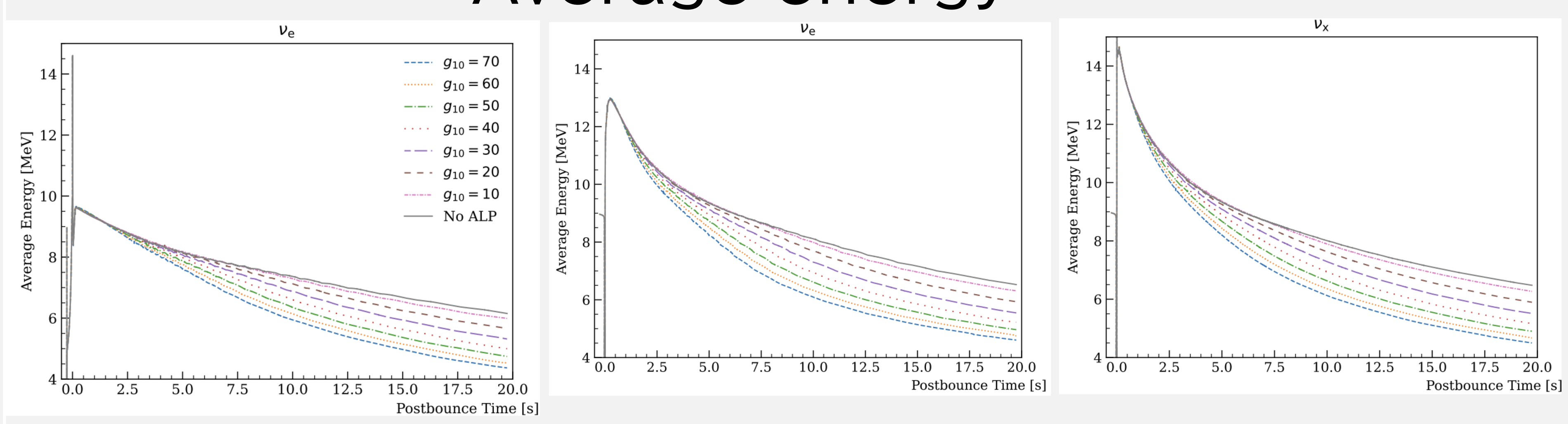
- ALPs faster cool neutron stars
- ALPs with larger coupling constants are made more and cool more in supernovae

Neutrino

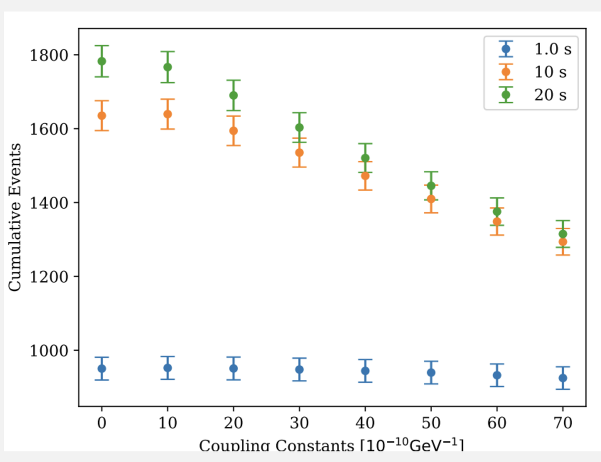
Luminosity



Average energy



Cumulative events 10kpc with Super-Kamiokande



- ALPs decrease the fraction of neutrino energy
- We can detect ALPs from long-term supernova neutrinos

Conclusion

- We simulated long-term supernova with axions.
- ALPs shift neutrino emission and may be detected by neutrino observation.