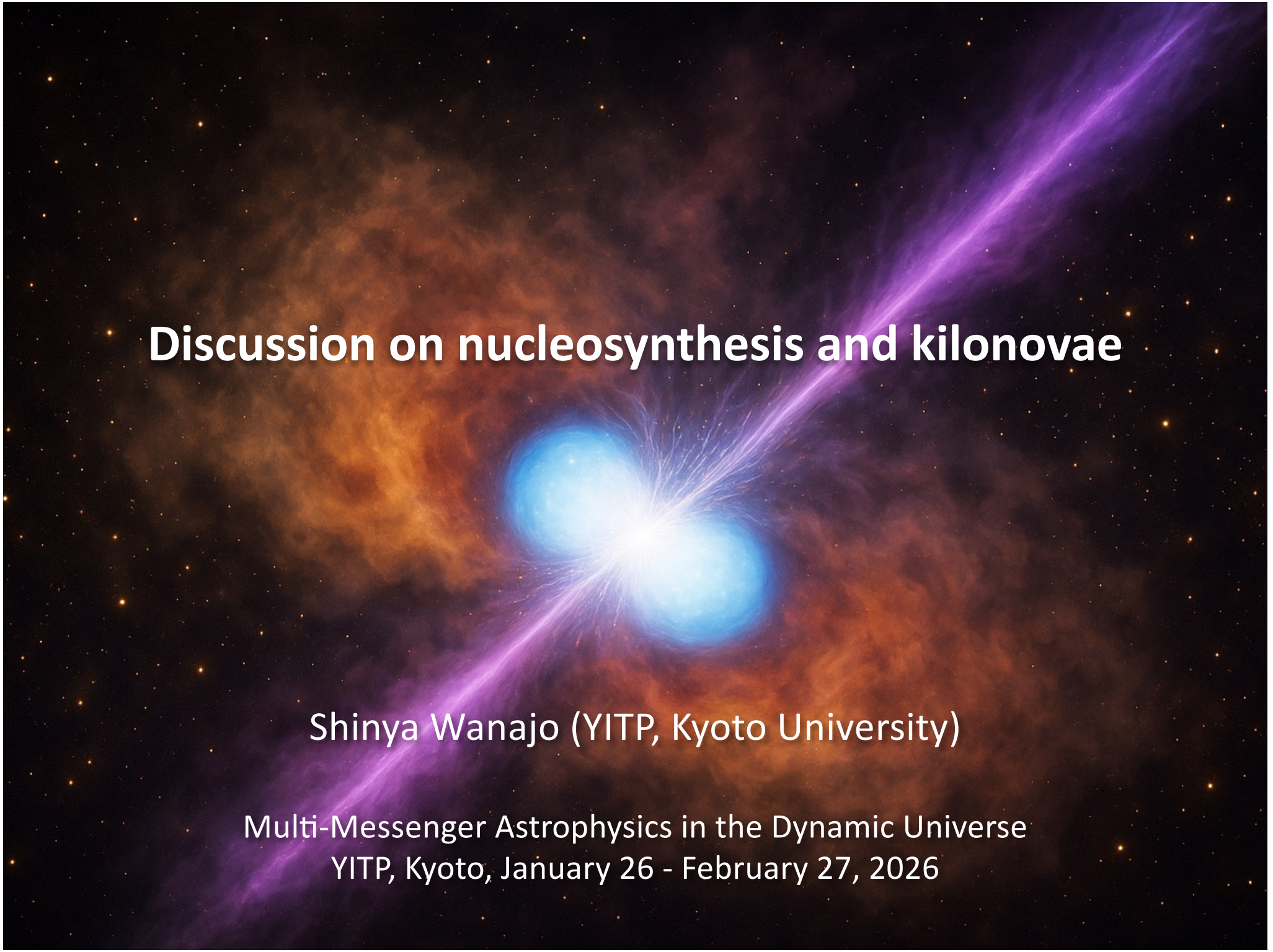

Discussion on nucleosynthesis and kilonovae

Shinya Wanajo (YITP, Kyoto University)

Multi-Messenger Astrophysics in the Dynamic Universe
YITP, Kyoto, January 26 - February 27, 2026

question 1: does GW170817 a typical neutron star merger?

question 2: does the universe need r-process sites other than mergers?

... others to be discussed

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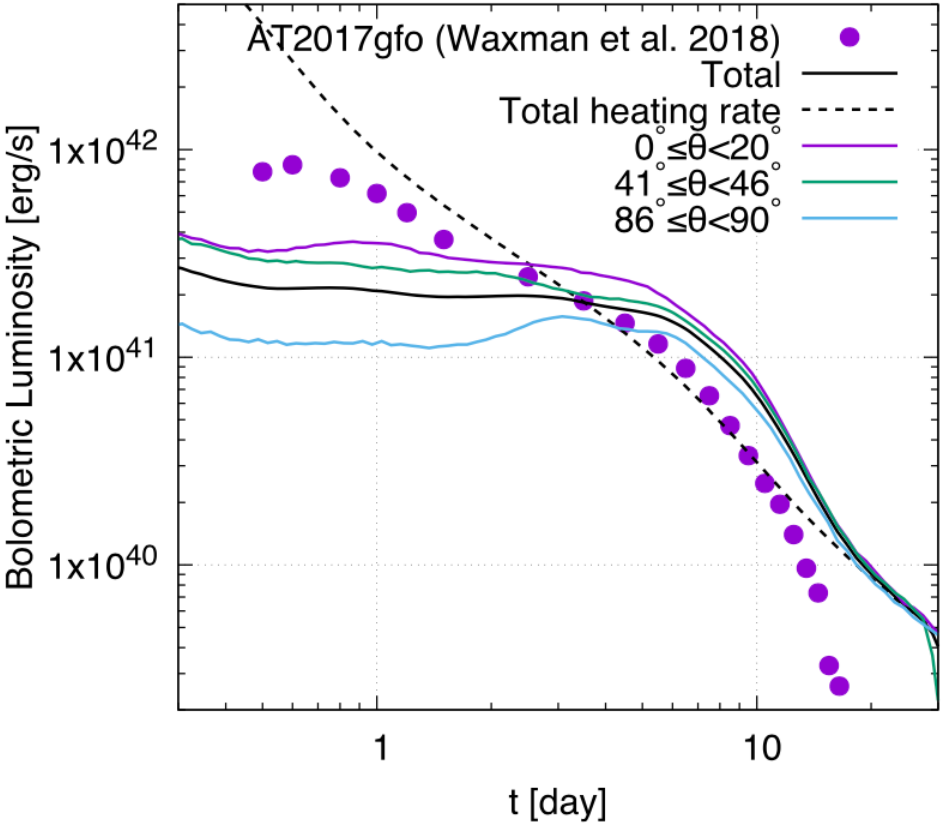
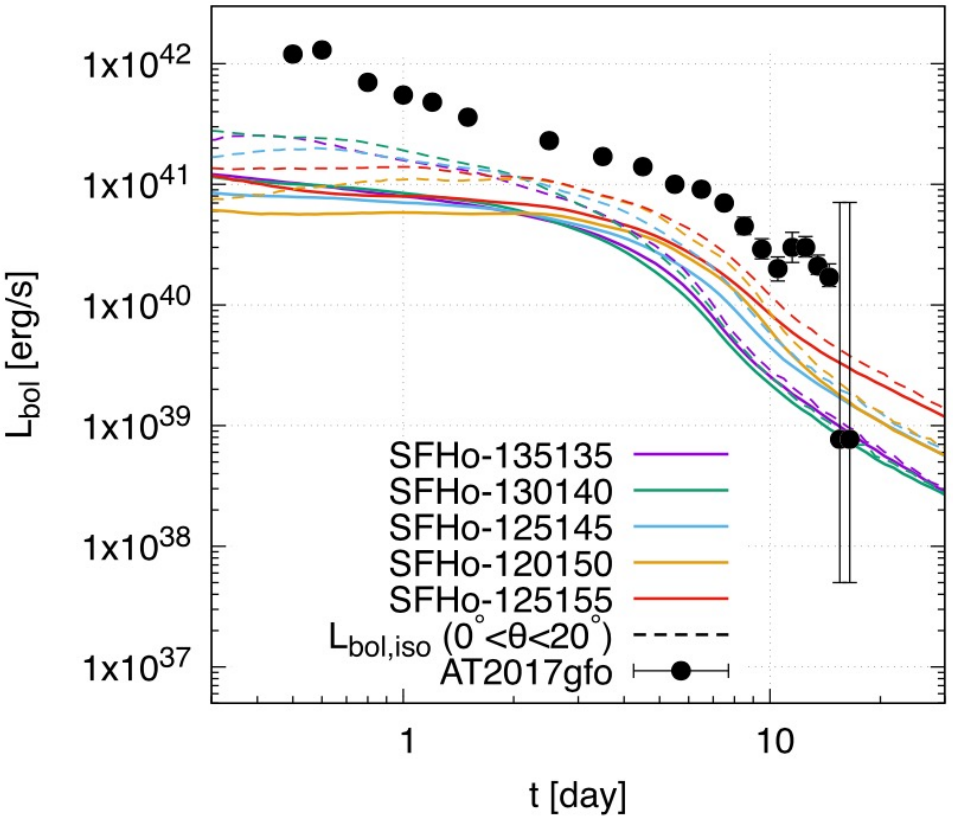
kilonova light curves

Banes, Just, Kawaguchi, Kasen, Tanaka, and many others... see talk by Kawaguchi, Perego

Kawaguchi+2021; long-lived



Kawaguchi+2023; short-lived



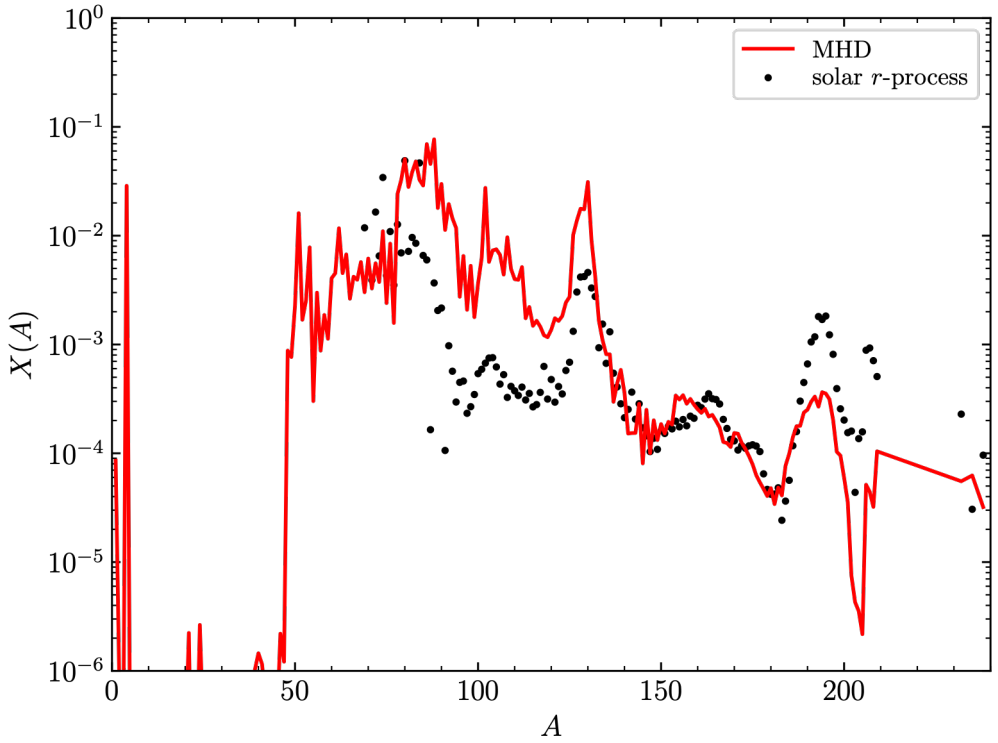
- ❖ long-lived models (r-process mass ~ 0.05 $M_\odot$) match LC
- ❖ short-lived models (r-process mass ~ 0.01 $M_\odot$) under-estimate LC

r-process patterns

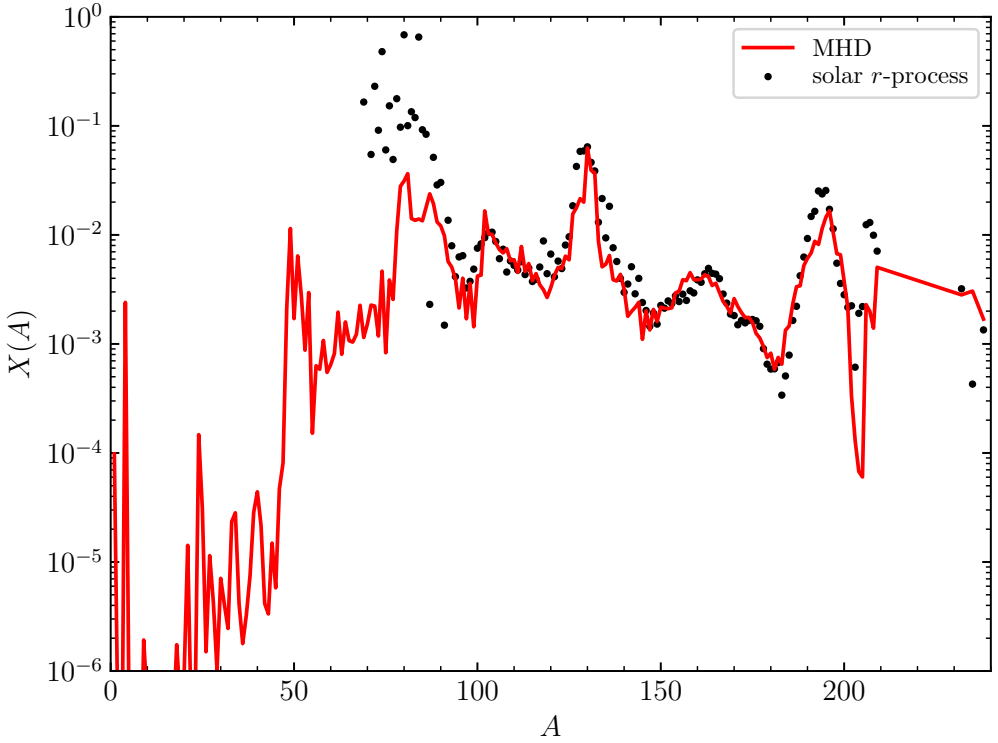
Arcones, Fujibayashi, Goriely, Just,,Korobkin, Perego, Radice, Wanajo, and many others...

see talk by Arcones, Kiuchi

Wanajo+2026, in prep.; long-lived



Wanajo+2026, in prep.; short-lived



- ❖ long-lived models over-produce light r-nuclei with respect to solar
- ❖ short-lived models match solar r-process pattern

question 1: does GW170817 a typical neutron star merger?

universality of r-patterns → GW170817 was a rare event?

use of r-mass ~ 0.05 $M_\odot$ → over estimate heavy r-element?

future direction should be → non-GW170817 type mergers?

note

- poll for the question: yes ~60%, no ~40%
- (yes) all other (non-GW) GRB-kilonovae show similar properties
- (yes) LC highly dependent on NLTE that is important for > a few days
- (yes) disk ejecta amounts still highly uncertain
- (yes) uncertainties in neutrino oscillation

question 1: does GW170817 a typical neutron star merger?

question 2: does the universe need r-process sites other than mergers?

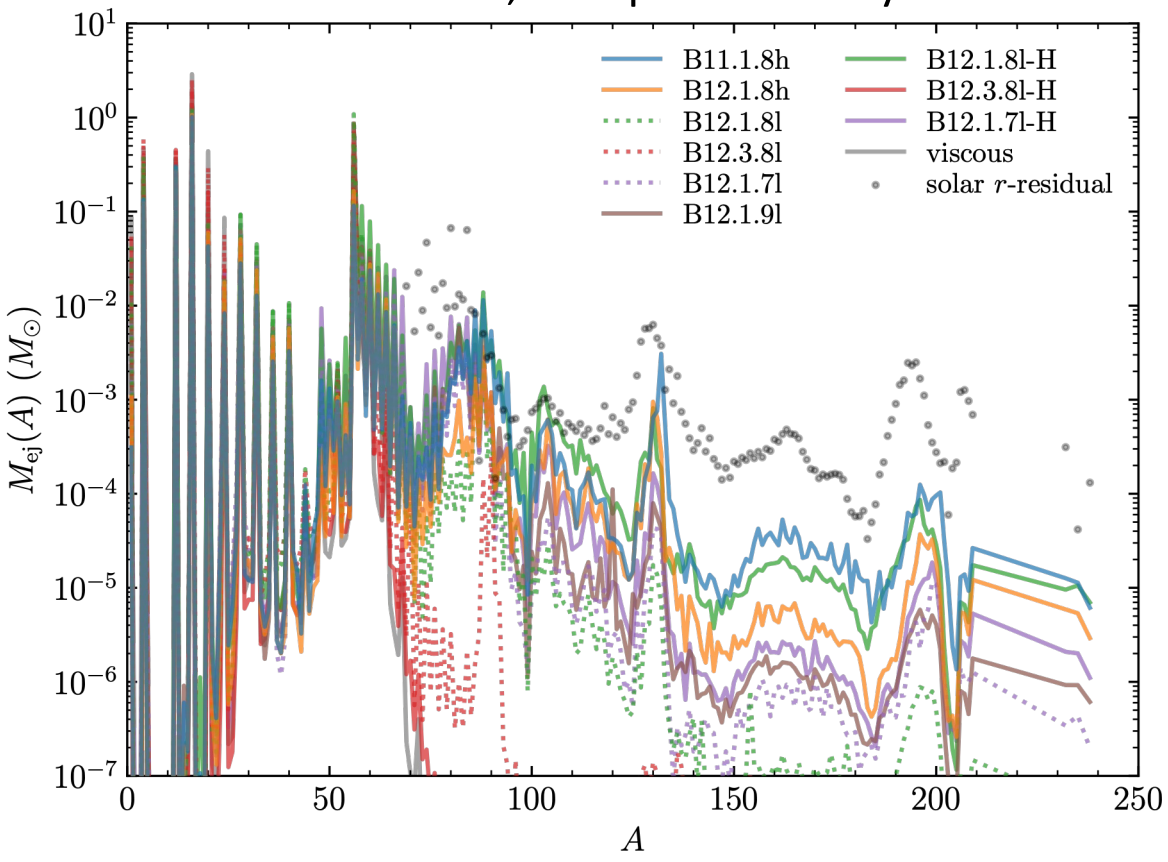
... others to be discussed

r-process sites other than mergers

Arcones, Nishimura, Metzger, Shibata, Siegel, Thompson, and many others...

see talk by Fijibayashi, Shibata

Shibata+2025; collapsars with dynamo

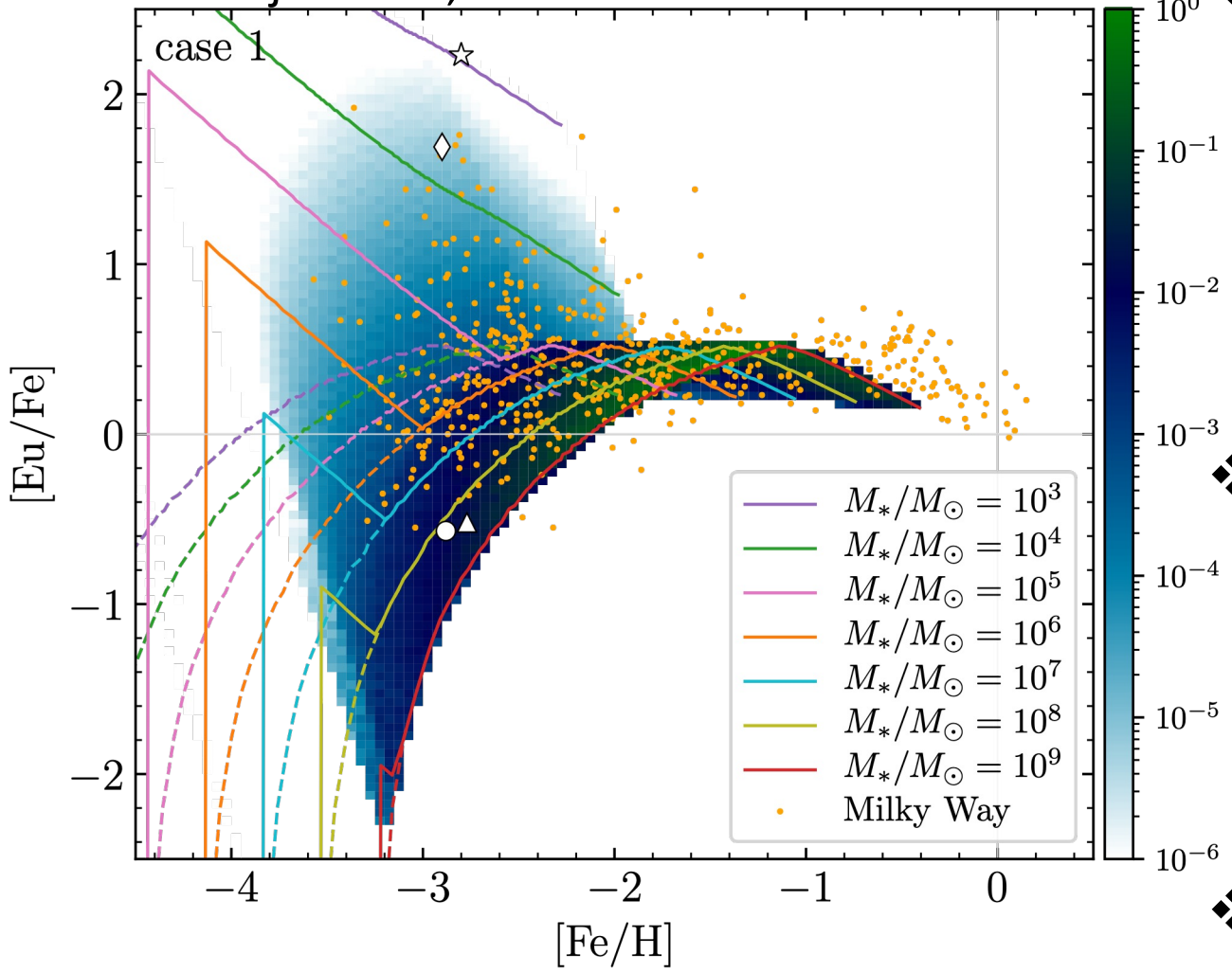


- popular suggested sites include MHD supernovae and collapsars
- generally heavy r-nuclei are under-produced when including neutrinos
- these can be sources of only light r-nuclei?

r-process in MW galaxy

Cescutti, Coté, Hirai, Ishimaru, Kobayashi, Matteucchi, Tsujimoto, and many others...

Wanajo+2021; MW halo as ensemble of dwarfs



[A/B] = log $(A/B)_{star}$ – log $(A/B)_\odot$

- t^{-1} type delay-time distribution cannot explain early r-enrichment and a knee of [r/Fe]?
- early component may solve this problems (Beniamini&Piran 2019; Maoz&Nakar 2025; Pracchia&Sharan Salafia 2026)
- a few 10 / Myr events are needed

question 2: does the universe need r-process sites other than mergers?

MHD supernovae or collapsars → only sites of light r-nuclei?

problems for MW r-process → early component solve these?

future GW observation → how can the event rate be small?

note

- poll: yes ~90%, no~10%
- poll for important sites: NS mergers (38), BH-NS mergers (1), collapsars (4), MHD supernovae (2), giant flare (1), other (2)
- (yes) Sr and Ba in low-metallicity ([Fe/H] < -3) halo stars needs origin with no delay