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A new set of core-collapse supernovae models to study the γ-process nucleosynthesis

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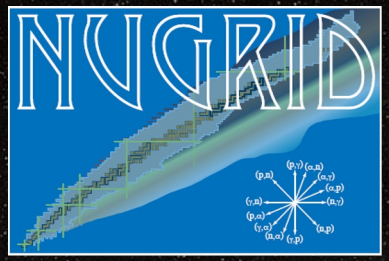
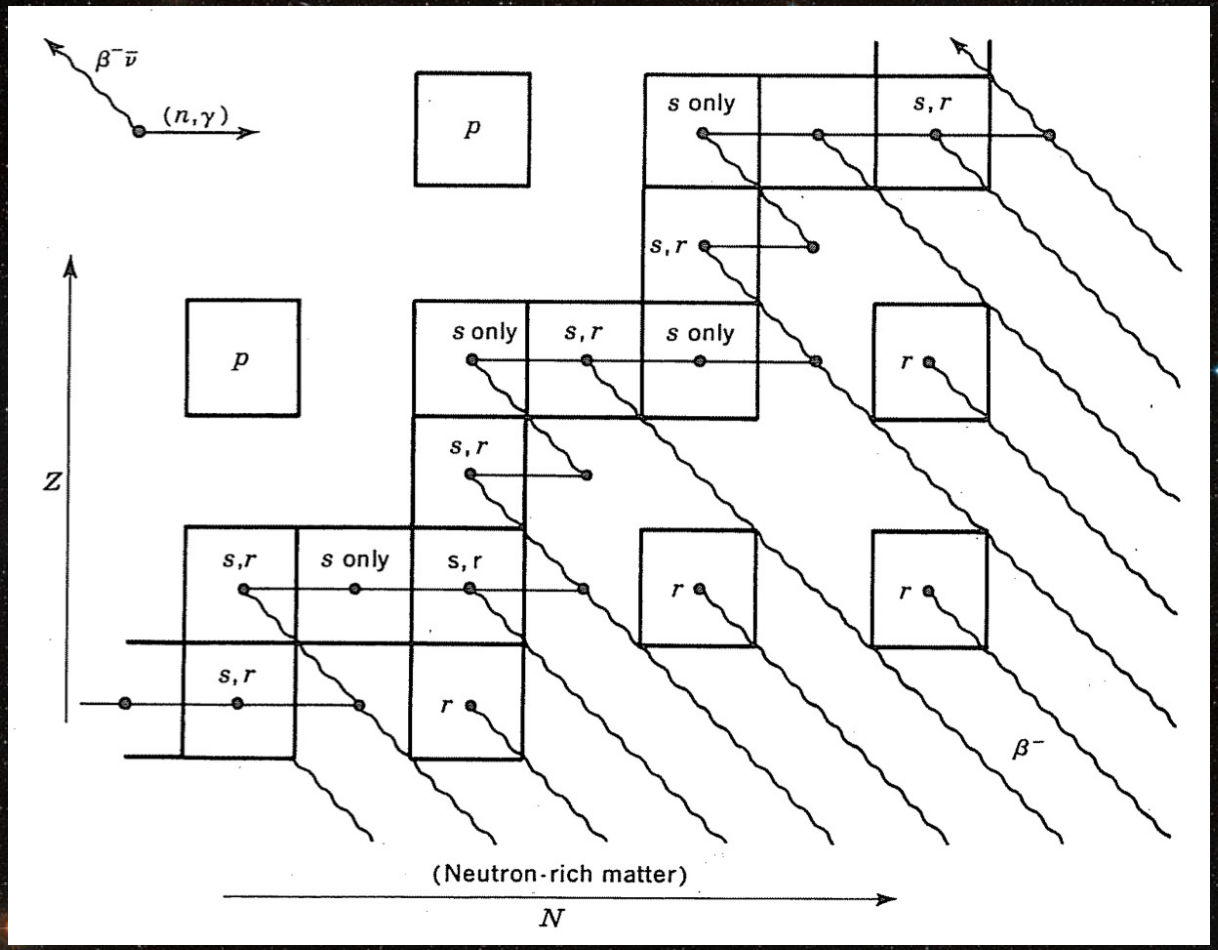


Transnational Access projects

- Project 22102724-ST: “A new set of core-collapse supernovae models to study the γ-process nucleosynthesis”
- Project 23103142-ST: “NuGIPi: a new stellar model pipeline for nuclear astrophysics impact studies”

The p-nuclei



Clayton, D.D. (1968) Principles of Stellar Evolution and Nucleosynthesis. University of Chicago Press, Chicago.

The γ-process nucleosynthesis

- Neutron-deficient nuclei (p-nuclei) are (mostly) produced through a sequence of photodisintegrations (γ,n), (γ,p), and (γ,α) in O/Ne rich layers in CCSN explosions from massive star progenitors (e.g., Woosley & Howard, 1978; Rayet et al., 1995);
- The typical γ-process yields from massive stars are underproduced by a factor of ~2-4 compared to the solar system abundances;
- ^{92,94}Mo and ^{96,98}Ru are underproduced by more than an order of magnitude compared to the other γ-process nuclei.

The γ-process nucleosynthesis in CCSNe

Main goals of the project:

- Analysis of γ-process yields in 5 different existing sets of core-collapse supernova models (Rauscher+02, Pignatari+16, Sieverding+18, Ritter+18, Lawson+22);
- Update of the nuclear reaction rates for the γ-process nucleosynthesis (in collaboration with ATOMKI);
- Production of new γ-process stellar yields through the NuGrid post-processing codes.

The γ-process nucleosynthesis in CCSNe

The γ–process nucleosynthesis in core-collapse supernovae

I. A novel analysis of γ–process yields in massive stars

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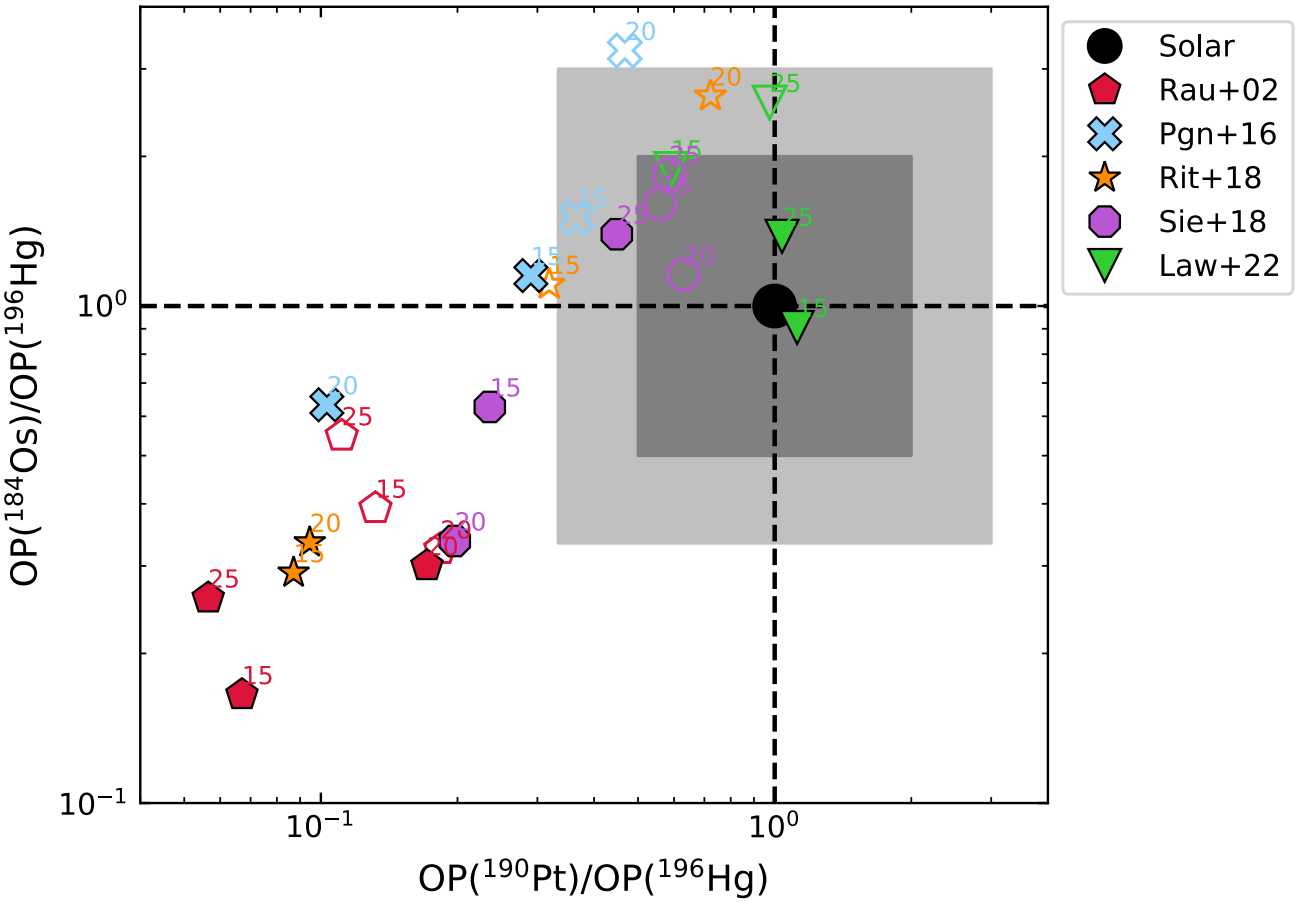
The γ-process nucleosynthesis in CCSNe



☆ = undecayed yields

⋆ = undecayed yields + radiogenic contribution

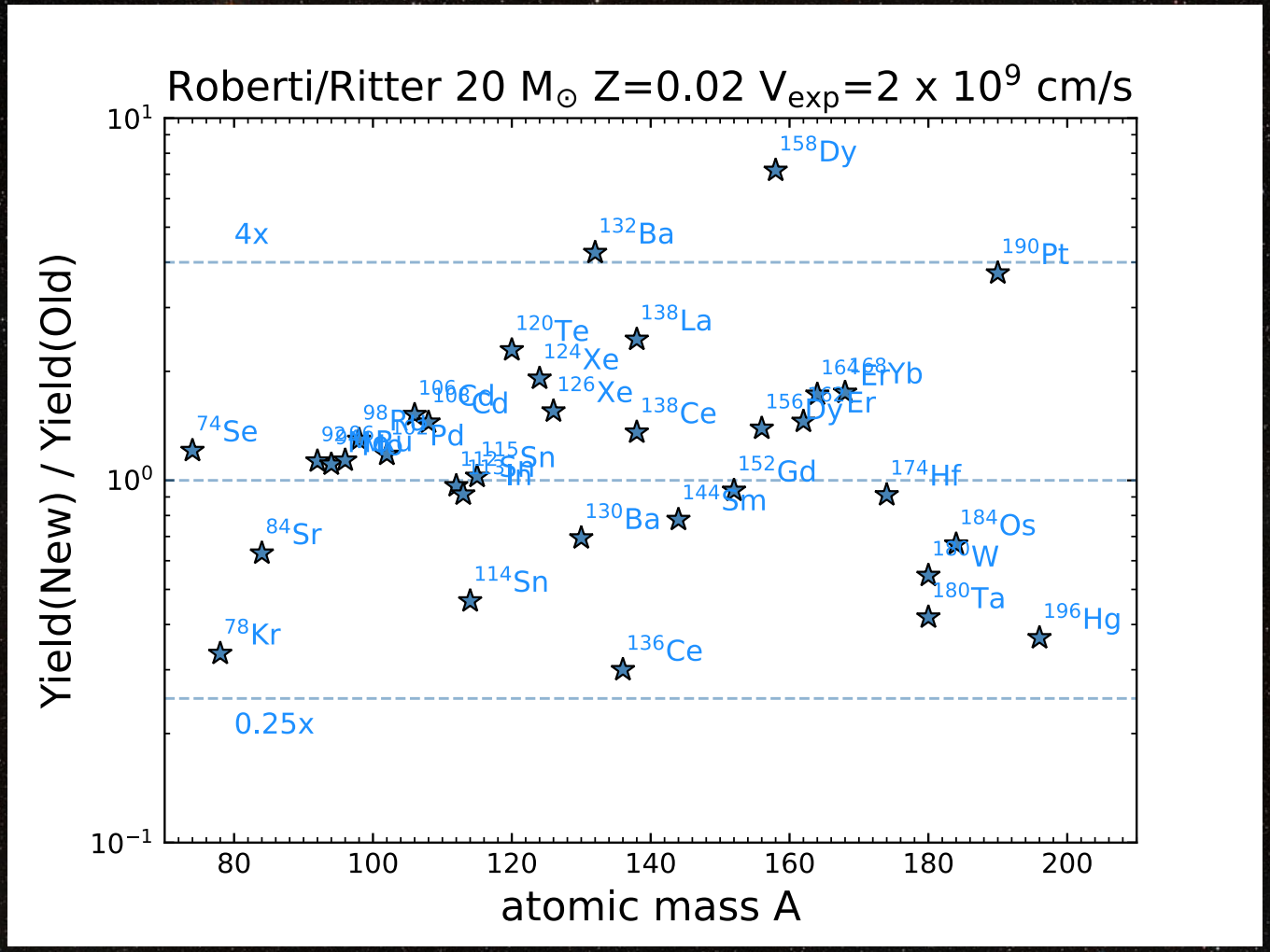
New γ-process calculations in CCSNe

Starting from the same MESA progenitors by Ritter+18 we:

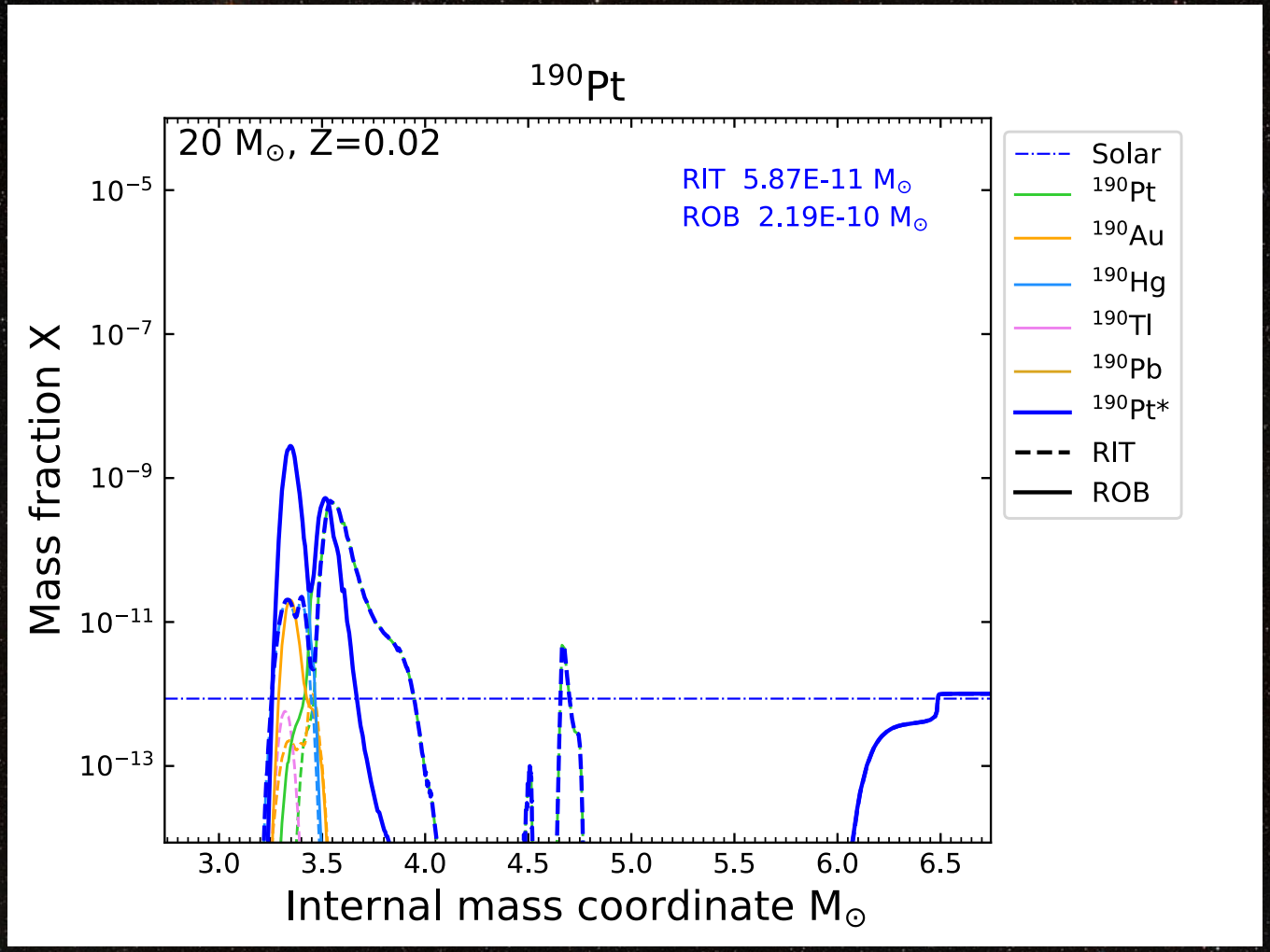
- Calculated the pre-supernova nucleosynthesis with JINA Reclib V2.2;
- Calculated a set of new core-collapse supernova simulations for each model and the associated explosive nucleosynthesis with the RDA + Fryer+12 remnant mass. We varied the initial velocity of the shock wave in the range $v_s = 2\times10^8 - 5\times10^9$ cm/s (Ritter reference: $v_s = 2\times10^9$ cm/s).

PRELIMINARY RESULTS! (Roberti+23, in prep.)

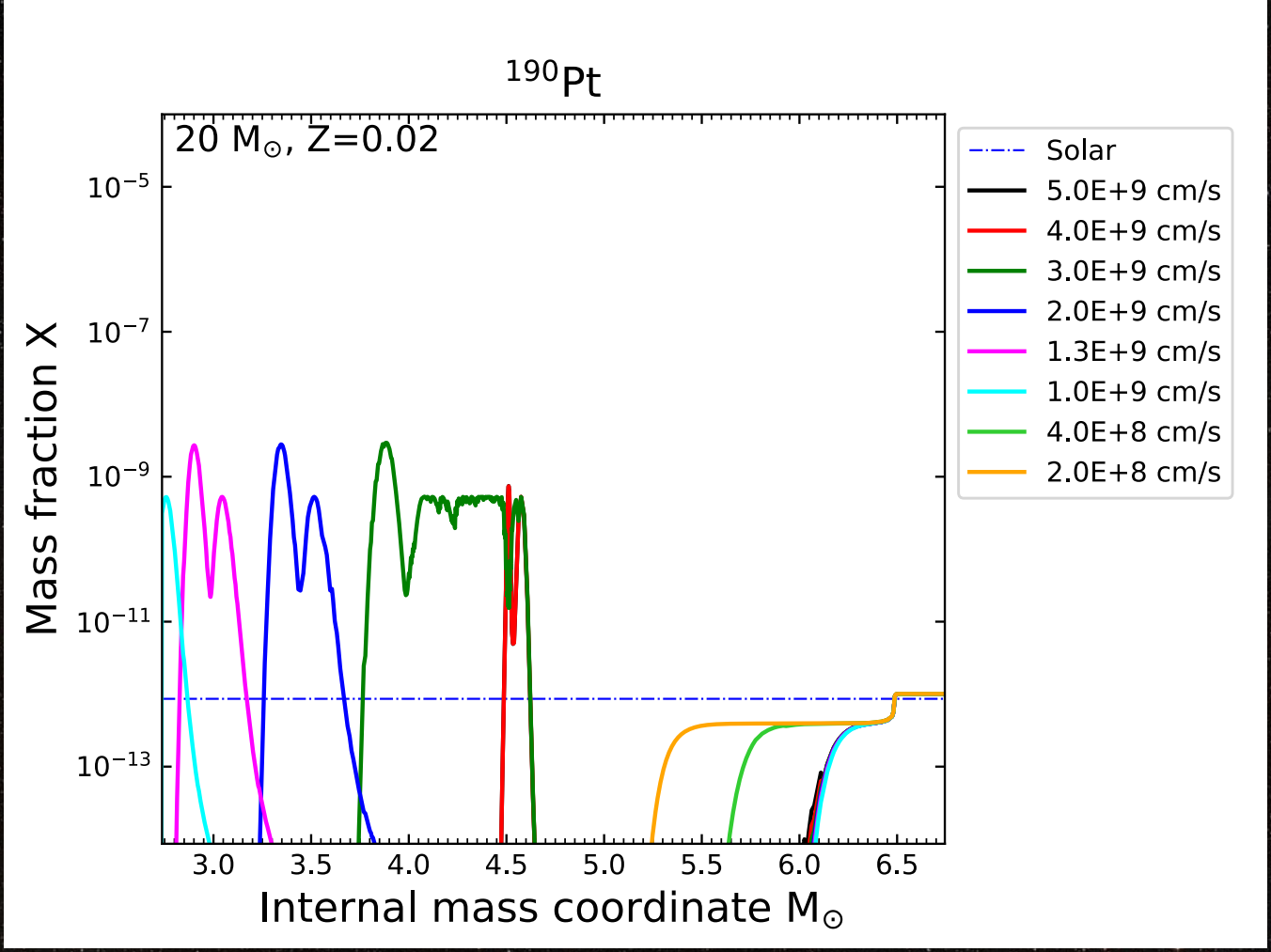
New γ-process calculations in CCSNe: Effect of the network



New γ-process calculations in CCSNe: Effect of the network



New γ-process calculations in CCSNe: Effect of the explosion energy



Summary

- The production of p-nuclei is still unclear, therefore we aim to explore in more detail the CCSN scenario;
- We analysed the γ-process nucleosynthesis in 5 existing different sets of CCSN models. We found large differences, mostly depending on the different sets of reaction rates used;
- We started looking into the effect of different reaction rate database and explosion energies. The different database can largely influence the production of p-nuclei, the variation of the explosion energy mostly results in a translation of the abundance peaks;
- Next steps: radionuclides (^{92}Nb , $^{97-98}Tc$, ^{146}Sm), analysis of the nuclear network for the γ-process nucleosynthesis, production of new γ-process stellar yields.