# FYSS EoS with full nuclear distribution and realistic nuclear forces

## EoS Submission Details

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|---|---|
| EoS name | FYSS EoS with full nuclear distribution and realistic nuclear forces |
| category | nuclear |
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## Abstract

In the present equation of state, nucleons are described within the variational approach of Ref. [1], combined with the quantum approach for $d, t, h$ and $\alpha$, as well as the liquid drop model for the other nuclei under the assumption of nuclear statistical equilibrium, see Refs. [2-5] for details. Temperature dependences of surface and shell energies of heavy nuclei have been taken into account as well as the possibility of pasta phases for heavy nuclei and the Pauli- and self-energy shifts for $d, t, h$ and $\alpha$.

## References to the original work

1. *Nuclear equation of state for core-collapse supernova simulations with realistic nuclear forces*, H. Togashi, K. Nakazato, Y. Takehara, S. Yamamuro, H. Suzuki and M. Takano, Nucl. Phys. A 961 (2017) 78, arXiv:1702.05324 [nucl-th]

2. S. Furusawa, H. Togashi, H. Nagakura, K. Sumiyoshi, S. Yamada, H. Suzuki & M. Takano, *A new equation of state for core-collapse supernovae based on realistic nuclear forces and including a full nuclear ensemble*, J. Phys. G 44, 9 (2017).

3. Shun Furusawa, Kohsuke Sumiyoshi, Shoichi Yamada & Hideyuki Suzuki: *Supernova equations of state including full nuclear ensemble with in-medium effects*, Nuclear Physics A 957, 188 (2017)

4. S. Furusawa, K. Sumiyoshi, S. Yamada, and H. Suzuki, Astrophys. J. 772, 95 (2013).

5. S. Furusawa, S. Yamada, K. Sumiyoshi, and H. Suzuki, Astrophys. J. 738, 178 (2011).

### Nuclear Matter Properties[1]

|        | Quantity                                   | Unit       |        |
|--------|--------------------------------------------|------------|--------|
| $n_S$  | saturation density in symmetric matter     | $fm^{-3}$  | 0.160  |
| $E_0$  | binding energy per baryon at saturation    | MeV        | 16.09  |
| $K$    | incompressibility                          | MeV        | 245    |
| $K'$   | skewness                                   | MeV        | 0      |
| $J$    | symmetry energy                            | MeV        | 30.    |
| $L$    | symmetry energy slope parameter            | MeV        | 35.0   |
| $K_{sym}$ | symmetry incompressibility              | MeV        | 0      |

### Neutron Star Properties[1]

|              | Quantity                            | Unit           |       |
|--------------|-------------------------------------|----------------|-------|
| $M_{max}$    | maximum mass                        | $M_{sun}$      | 2.25  |
| $M_{DU,e}$   | mass at DUrca threshold (1/9) w/o $\mu^-$ | $M_{sun}$ | 0     |
| $R_{M_{max}}$ | radius at maximum NS mass          | km             | 10.3  |
| $R_{1.4}$    | radius at 1.4 $M_{sun}$ NS mass     | km             | 11.5  |

### eos.thermo

eos.thermo and the three grid defining files are CompOSE standard data files and by definition available. eos.thermo does <u>not</u> necessarily provide all possible data.

| table dimension            | 3      |
|----------------------------|--------|
| table type                 | 1      |
| total number of grid points | 650650 |

Range and density (#) of the grid parameters:

|       | Quantity           | Unit      | min       | max       | #    |
|-------|--------------------|-----------|-----------|-----------|------|
| T     | Temperature        | MeV       | 0.1       | 398.1072  | 91   |
| $n_b$ | Baryon Nr Density  | $fm^{-3}$ | 7.58E-11  | 6.02      | 110  |
| $Y_q$ | Charge Fraction    |           | 0.01      | 0.65      | 65   |

T, $n_b$, and $Y_q$ are stored in eos.t, eos.nb, and eos.yq, respectively.

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[1]0-values indicate, that the corresponding data is not provided.

## Further Available Data Files

Files and quantities listed in the following are provided beyond CompOSE's core requirements as outlined in Sec.4.2. of the CompOSE manual.

**eos.compo** : available

| index | particle |
|------:|---|
| 10 | n |
| 11 | p |
| 2001 | $^2$H |
| 3001 | $^3$H |
| 3002 | $^3$He |
| 4002 | $\alpha$-particle |
|  | - end of table - |

further particle sets are defined as quadrupels representing an average heavy nucleus $(Z > 5)$ and average light nuclei $(Z < 6)$.

| index | description |
|------:|---|
| 1 | Average mass number, proton number and fraction for heavy nuclei $(Z > 5)$ |
| 2 | Average mass number, proton number and fraction for light nuclei $(Z < 6)$ |
|  | - end of table - |