# SRO version of LNS, SNA

## EoS Submission Details

## Abstract

This table contains the EoS by Schneider, Roberts, and Ott (SRO) [1] computed using the LNS Skyrme parametrization [2]. The nuclear interaction is an effective non-relativistic Skyrme type model without momentum dependence generalized from the seminal work of Lattimer and Swesty [3]. The model includes nucleons, which are treated as non-relativistic particles; $\alpha$-particles, modeled as hard spheres of volume $v_\alpha = 24\text{fm}^{-3}$ forming an ideal Boltzmann gas; and photos, electrons, and positrons, all treated as thermally equilibrated non-interacting relativistic gases. At low densities and temperatures nucleons may cluster into heavy nuclei computed within the single nuclues approximation (SNA). In the SNA, one representative nucleus or, more generally, a high-density structure such as a pasta phase, is determined from equilibrium conditions within a spherical Wigner-Seitz cell, including surface, Coulomb, and translational energy corrections using a liquid-drop model for the surface corrections. The Wigner-Seitz cell is charge neutral, and heavy nuclei are surrounded by a gas of free nucleons, $\alpha$-particles, photons, electrons and positrons. Interactions between the outside gas and the nuclei are taken into account through an excluded volume. At high densities and temperatures heavy nuclei or the pasta phases dissolve in favor of homogeneous nuclear matter. The configuration of matter and the balance between the different phases is given by the thermodynamically most favorable state, that is, the one that minimizes the Helmholtz free energy of the system and, thus, guarantees thermodynamic consistency of the EoS. Unlike Ref. [3], transitions from inhomogeneous to bulk nuclear matter are first order and simply chosen from the phase which minimizes the Helmholtz free energy. Further details can be found in Refs. [1,3]. A link to additional information which includes our open-source SROEOS code and many pre-computed tables for different Skyrme parametrizations found in the literature are found in the webpage `https://stellarcollapse.org/SROEOS`. Tables where a transition from the SNA treatment to one considering 3 335 nuclei in nuclear statistical equilibrium (NSE) are also available.

**References to the original work**

1. A.S. Schneider, L. Roberts, C.D. Ott, Phys.Rev. C96, 065802 (2017)

2. L.G. Cao, U. Lombardo, C.W. Shen, Nguyen Van Giai, Phys. Rev. C 73, 014313 (2006)

**Further References**

3. J. M. Lattimer and F. D. Swesty, Nucl. Phys. A 535, 331 (1991).

### Nuclear Matter Properties[1]

| | Quantity | Unit | |
|---|---|---|---|
| $n_S$ | saturation density in symmetric matter | fm$^{-3}$ | 0.175 |
| $E_0$ | binding energy per baryon at saturation | MeV | 15.96 |
| $K$ | incompressibility | MeV | 211 |
| $K'$ | skewness | MeV | 383 |
| $J$ | symmetry energy | MeV | 33.43 |
| $L$ | symmetry energy slope parameter | MeV | 61.45 |
| $K_{sym}$ | symmetry incompressibility | MeV | -127 |

### Neutron Star Properties[1]

| | Quantity | Unit | |
|---|---|---|---|
| $M_{max}$ | maximum mass | M$_{sun}$ | 1.72 |
| $M_{DU,e}$ | mass at DUrca threshold (1/9) w/o $\mu^-$ | M$_{sun}$ | 0 |
| $R_{M_{max}}$ | radius at maximum NS mass | km | 9.29 |
| $R_{1.4}$ | radius at 1.4 M$_{sun}$ NS mass | km | 11.0 |
| $\tilde{\Lambda}$ | tidal deformability GW170817 at $q = M_1/M_2 = 0.8$ | | 0 |

### eos.thermo

eos.thermo and the three grid defining files are CompOSE standard data files and by definition available.

| | |
|---|---|
| table dimension | 3 |
| table type | 1 |
| total number of grid points | 4206378 |

Range and density (#) of the grid parameters:

| | Quantity | Unit | min | max | # |
|---|---|---|---|---|---|
| T | Temperature | MeV | 0.001 | 250 | 133 |
| $n_b$ | Baryon Nr Density | fm$^{-3}$ | 5.4e-13 | 2. | 378 |
| $Y_q$ | Charge Fraction | | 0.005 | 0.655 | 66 |

T, $n_b$, and $Y_q$ are stored in eos.t, eos.nb, and eos.yq, respectively. The sound speed is stored in eos.thermo as additional quantity.

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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 |
|------:|----------|
| 0 | e |
| 10 | n |
| 11 | p |
| 4002 | $^4$He |
| | - end of table - |

Two sets of quadruples are present, one for an average light nucleus (index 998), considering light nuclei with $Z < 6$ (excluding nucleons and $\alpha$ particles) and one for heavy nuclei ($Z > 6$), index 999.

**eos.micro** : available

| index | particle |
|------:|----------|
| 11040 | effective mass of protons divided by proton mass $m_p^*/m_p$ |
| 10040 | effective mass of neutrons divided by neutron mass $m_n^*/m_n$ |
| 11050 | $U_p$ proton mean field interaction potential |
| 10050 | $U_n$ neutron mean field interaction potential |
| | - end of table - |