RG-SLy4 EoS with neutrino opacity data, extended version

EoS Submission Details

EoS name	RG-SLy4 EoS with neutrino opacity data, extended version
category	nuclear
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Abstract

This EoS table corresponds to the extended NSE model proposed in Refs. [1,2] where excluded volume effects between nuclear clusters and unbound nucleons are implemented via energy shifts of clusters binding energies. For nuclei for which experimental masses are known, the mass tables of Audi el al. [4] are used. Then, up to the drip lines, evaluated masses of the 10-parameter model by Duflo and Zuker (DZ10) [5] are employed. Beyond drip lines, nuclear binding energies are described according to the Liquid Drop Model like parametrization of Ref. [6], corresponding to SLy4 [7]. This expression is modified in two respects. First, a phenomenological pairing term, $\Delta(A) = \pm 12/A$, where $+(-)$ corresponds to even-even (odd-odd) nuclei, is added. Then, two correction terms are included such as to smoothly match, for each isotopic chain, the liquid-drop predictions with the limiting values of DZ10. The allowed mass range of clusters is $2 \leq A \leq 300$. Unbound nucleons are modelled within the standard density functional theory [8] model. The Skyrme SLy4 [7] effective interaction is used.

The grid in temperature, baryon number density and electron fraction has been modified with respect to the original table (RG-SLy4) to have regular spacing and temperature has been extended to a maximal value of 109.8 MeV. Information on effective masses and interaction potentials have been added in eos.micro. The file `nu_opacities_rpa.h5` contains tabulated charged-current opacities from RPA for ν_e and $\bar{\nu}_e$ [3].

References to the original work

1. *Unified treatment of sub-saturation stellar matter at zero and finite temperature*, F. Gulminelli, Ad. R. Raduta, Phys. Rev. C 92 (2015) 055803.

2. *Nuclear Statistical Equilibrium Equation of State for Core Collapse*, Ad. R. Raduta and F. Gulminelli, Nucl.Phys. A983, 252 (2019)

3. *Improved neutrino-nucleon interactions in dense and hot matter for numerical simulations*, M. Oertel, A. Pascal, M. Mancini, J. Novak, submitted.

Further References

4. *The Ame2012 atomic mass evaluation*, G. Audi, M. Wang, A. H. Wapstra, F. G. Kondev, M. MacCormick, X. Xu, and B. Pfeiffer, Chin. Phys. C 36 (2012) 1287; *The Ame2012 atomic mass evaluation*, M. Wang, G. Audi, A. H. Wapstra, F. G. Kondev, M. MacCormick, X. Xu, and B. Pfeiffer, Chin. Phys. C 36 (2012) 1603; http : //amdc . impcas . ac.Cn/evaluation/data2012/data/nubase. mas12.

5. *Microscopic mass formulas*, J. Duflo and A. P. Zuker, Phys. Rev. C 52 (1995) R23.

6. *Symmetry energy I: Semi-infinite matter*, P. Danielewicz and J. Lee, Nucl. Phys. A 818 (2009) 36.

7. *A Skyrme parametrization from subnuclear to neutron star densities Part II. Nuclei far from stabilities*, E. Chabanat, P. Bonche, P. Haensel, J. Meyer, and R. Schaeffer, Nucl. Phys. A 635 (1998) 231.

8. *Many-body methods at finite temperature*, D. Vautherin, Adv. Nucl. Phys. 22 (1996) 123.

Nuclear Matter Properties[1]

	Quantity	Unit	
n_S	saturation density in symmetric matter	fm^{-3}	0.159
E_0	binding energy per baryon at saturation	MeV	15.97
K	incompressibility	MeV	230.0
K'	skewness	MeV	-363.11
J	symmetry energy	MeV	32.04
L	symmetry energy slope parameter	MeV	46.00
K_{sym}	symmetry incompressibility	MeV	-119.73

Neutron Star Properties[1]

	Quantity	Unit	
M_{max}	maximum mass	M_{sun}	2.075
$M_{DU,e}$	mass at DUrca threshold (1/9) w/o μ^-	M_{sun}	0
$R_{M_{max}}$	radius at maximum NS mass	km	10.09
$R_{1.4}$	radius at 1.4 M_{sun} NS mass	km	11.86
$\tilde{\Lambda}$	tidal deformability GW170817 at $q = M_1/M_2 = 0.8$		396

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	756000

Range and density (#) of the grid parameters:

	Quantity	Unit	min	max	#
T	Temperature	MeV	0.1	109.80	90
n_b	Baryon Nr Density	fm^{-3}	1.0E-12	1.50	140
Y_q	Charge Fraction		0.01	0.60	60

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

[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	α-particle
	- end of table -

further particle sets are defined as quadruples representing an average heavy nucleus ($A \geq 20$) and average light nuclei ($2 \leq A < 20$).

index	description
1	Average mass number, proton number and fraction for light nuclei ($2 \leq A < 20$)
2	Average mass number, proton number and fraction for heavy nuclei ($A \geq 20$)
	- end of table -

eos.micro : available

index	quantity	particle
10040	Landau effective mass divided by particle mass m_i^L/m_i	n
11040	Landau effective mass divided by particle mass m_i^L/m_i	p
10050	non-relativistic single-particle potential U_i [MeV]	n
11050	non-relativistic single-particle potential U_i [MeV]	p
	- end of table -	