Brussels-Montreal BSk24

EoS Submission Details

EoS name	Brussels-Montreal BSk24
category	nuclear
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Abstract

This table corresponds to the zero temperature unified equation of state (EoS) for cold non-accreting neutron stars in beta equilibrium based on the Brussels-Montreal energy-density functional BSk24 [1]. Details on the EoS model can be found in Ref. [2] and the routines to construct an analytical fit of the EoS are also available on the Ioffe website [3]. The tidal deformability associated to this EoS model was calculated in Ref. [4].

The outer crust was calculated using the Hartree-Fock-Bogoliubov atomic mass table HFB-24 available on the BRUSLIB data base [5], except when experimental values were available, for which we used the 2016 Atomic Mass Evaluation [6], supplemented by the measurements of copper isotopes from Ref. [7]. The inner crust was computed using the 4th-order Extended Thomas-Fermi (ETF) method with proton shell and pairing corrections added perturbatively via the Strutinsky integral (SI); the nucleon distributions were parametrized using damped Fermi profiles and the Coulomb energy was calculated within the Wigner-Seitz (WS) approximation. Although the EoS was originally calculated ignoring nuclear pastas, their presence in neutron-star crust was later discussed in Refs. [8,9] and was shown to be marginal in the Extended Thomas-Fermi plus Strutinski Integral framework [9]. The core was assumed to be made up by an admixture of neutrons and protons neutralised by electrons and possibly by muons. $^1S_0$ neutron and proton pairing gaps in neutron-star cores were calculated in Ref. [10].

References to the original work

1. S. Goriely, N. Chamel, and J. M. Pearson, Phys. Rev. C 88 (2013) 024308.
2. J. M. Pearson, N. Chamel, A. Y. Potekhin, A. F. Fantina, C. Ducoin, A. K. Dutta, and S. Goriely, MNRAS 481 (2018) 2994; MNRAS 486 (2019) 768.
3. `http://www.ioffe.ru/astro/NSG/BSk/`
4. L. Perot, N. Chamel, and A. Sourie, Phys. Rev. C 100 (2019) 035801.

5. Y. Xu, S. Goriely, A. Jorissen, G. L. Chen, and M. Arnould, Astronomy & Astrophysics 549 (2013) A106.

6. M. Wang, G. Audi, F. G. Kondev, W. J. Huang, S. Naimi, and X. Xu, Chinese Phys. C 41 (2017) 030003.

7. A. Welker, et al., Phys. Rev. Lett. 119 (2017) 192502.

8. J. M. Pearson, N. Chamel, and A. Y. Potekhin, Phys. Rev. C 101 (2020) 015802.

9. J. M. Pearson and N. Chamel, Phys. Rev. C 105 (2022) 015803.

10. V. Allard and N. Chamel, Universe 7 (2021) 470.

Nuclear Matter Properties[1]

	Quantity	Unit	
n_S	saturation density in symmetric matter	fm^{-3}	0.1578
E_0	binding energy per baryon at saturation	MeV	16.048
K	incompressibility	MeV	245.5
K'	skewness	MeV	274.5
J	symmetry energy	MeV	30.0
L	symmetry energy slope parameter	MeV	46.4
K_{sym}	symmetry incompressibility	MeV	-37.6
$M_s^\star/M$	isoscalar effective mass over nucleon mass	dimensionless	0.8
$M_v^\star/M$	isovector effective mass over nucleon mass	dimensionless	0.71

Neutron Star Properties[1]

	Quantity	Unit	
M_{max}	maximum mass	M_{sun}	2.28
$M_{DU,e}$	mass at DUrca threshold (1/9) w/o μ^-	M_{sun}	1.595
$R_{M_{max}}$	radius at maximum NS mass	km	11.08
$R_{1.4}$	radius at 1.4 M_{sun} NS mass	km	12.57
$\tilde{\Lambda}$	tidal deformability for GW170817 at a mass ratio of $q = 0.8$		594.2
n_{caus}	causality limit	fm^{-3}	1.088

The value of the $\tilde{\Lambda}$ parameter has been determined for the following neutron-star masses: $M_1 = 1.53\ M_\odot$ and $M_2 = 1.22\ M_\odot$, yielding a chirp mass $\mathcal{M} = 1.189\ M_\odot$ and a mass ratio $q = 0.8$.

eos.thermo

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

table dimension	1
table type	1
total number of grid points	454

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

Range and density (#) of the grid parameters:

	Quantity	Unit	min	max	#
T	Temperature	MeV	0	0	1
n_b	Baryon Nr Density	fm^{-3}	4.6796E-010	1.4958	454
Y_q	Charge Fraction		0	0	1

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

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^-
1	μ^-
10	n
11	p
	- end of table -

Description of phases

Phase index # 1 : inhomogeneous matter in the outer crust (ions and electrons)

Phase index # 2 : inhomogeneous matter in the inner crust (ions, electrons, and free nucleons)

Phase index # 0 : homogeneous matter in the core (neutrons, protons, electrons, muons)

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	single-particle potential U_i	n
11051	single-particle potential U_i	p
700060	pairing gap in the $nn(^1S_0)$ channel	n
702060	pairing gap in the $pp(^1S_0)$ channel	p
	- end of table -	

The quantities in eos.micro are only available for the core.

eos.mr : available