

## Brussels-Montreal BSk25

### EoS Submission Details

EoS name	Brussels-Montreal BSk25
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 BSk25 [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-25 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 Strutinsky 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<sup>1</sup>

	Quantity	Unit	
$n_S$	saturation density in symmetric matter	$\text{fm}^{-3}$	0.1587
$E_0$	binding energy per baryon at saturation	MeV	16.032
$K$	incompressibility	MeV	236.0
$K'$	skewness	MeV	316.5
$J$	symmetry energy	MeV	29.0
$L$	symmetry energy slope parameter	MeV	36.9
$K_{sym}$	symmetry incompressibility	MeV	-28.5
$M_s^*/M$	isoscalar effective mass over nucleon mass	dimensionless	0.8
$M_v^*/M$	isovector effective mass over nucleon mass	dimensionless	0.74

## Neutron Star Properties<sup>1</sup>

	Quantity	Unit	
$M_{max}$	maximum mass	$M_{\text{sun}}$	2.22
$M_{DU,e}$	mass at DUrca threshold (1/9) w/o $\mu^-$	$M_{\text{sun}}$	1.612
$R_{M_{max}}$	radius at maximum NS mass	km	11.05
$R_{1.4}$	radius at 1.4 $M_{\text{sun}}$ NS mass	km	12.37
$\tilde{\Lambda}$	tidal deformability for GW170817 at a mass ratio of $q = 0.8$		551.8
$n_{caus}$	causality limit	$\text{fm}^{-3}$	1.378

The value of the  $\tilde{\Lambda}$  parameter has been determined for the following neutron-star masses:  $M_1 = 1.54 M_{\odot}$  and  $M_2 = 1.21 M_{\odot}$ , yielding a chirp mass  $\mathcal{M} = 1.188 M_{\odot}$  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	479

<sup>1</sup>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	$\text{fm}^{-3}$	4.6796E-10	1.4999	479
$Y_q$	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	$\mu^-$
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