## Brussels-Montreal BSk26

### EoS Submission Details

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|---|---|
| EoS name | Brussels-Montreal BSk26 |
| category | nuclear |
| submitted by | Anthea F. Fantina |
| affiliation | Grand Accélérateur National d'Ions Lourds (GANIL) |
| e-mail contact | anthea.fantina(at)ganil.fr |
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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 BSk26 [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-26 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 | $fm^{-3}$ | 0.1589 |
| $E_0$ | binding energy per baryon at saturation | MeV | 16.064 |
| $K$ | incompressibility | MeV | 240.8 |
| $K'$ | skewness | MeV | 282.9 |
| $J$ | symmetry energy | MeV | 30.0 |
| $L$ | symmetry energy slope parameter | MeV | 37.5 |
| $K_{sym}$ | symmetry incompressibility | MeV | -135.6 |
| $M_s^\star/M$ | isoscalar effective mass over nucleon mass | dimensionless | 0.8 |
| $M_v^\star/M$ | isovector effective mass over nucleon mass | dimensionless | 0.65 |

### Neutron Star Properties[1]

| | Quantity | Unit | |
|---|---|---|---|
| $M_{max}$ | maximum mass | $M_{sun}$ | 2.17 |
| $M_{DU,e}$ | mass at DUrca threshold (1/9) w/o $\mu^-$ | $M_{sun}$ | (2.115) |
| $R_{M_{max}}$ | radius at maximum NS mass | km | 10.20 |
| $R_{1.4}$ | radius at 1.4 $M_{sun}$ NS mass | km | 11.77 |
| $\tilde{\Lambda}$ | tidal deformability for GW170817 at a mass ratio of $q = 0.8$ | | 379.3 |
| $n_{caus}$ | causality limit | $fm^{-3}$ | 0.982 |

The value of $M_{DU,e}$ is enclosed in brackets to indicate that the density at which DUrca occurs corresponds to a spherically symmetric configuration belonging to the unstable branch. Thus, the DUrca processes cannot occur in stable neutron stars described by the BSk26 functional. The value of the $\tilde{\Lambda}$ parameter has been determined for the following neutron-star masses: $M_1 = 1.51\ M_\odot$ and $M_2 = 1.24\ M_\odot$, 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 | 461 |

[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-10 | 1.4921 | 461 |
| $Y_q$ | 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