

# DD2F-SF quark-hadron model RDF 1.4 with electrons

## EoS Submission Details

|                     |   |
|---------------------|---|
| EoS name            | DD2F-SF quark-hadron model RDF 1.4 with electrons |
| category            | hybrid  |
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## Abstract

RDF 1.4 is from a set of equation of state models with a first-order phase transition from hadron to quark matter presented in Ref. [1]. This publication focuses on the super-saturated regime and for the treatment of nuclear clusters below saturation on the nuclear statistical equilibrium with excluded volume approach of Hempel and Schaffner-Bielich [2]. The relativistic density function approach, which is used for the high density regime and in particular the string-flip model for quarks was introduced in Ref. [3] with applications to neutron star configurations. The current extension of this model to finite temperature and arbitrary chargefractions was successfully applied to core-collapse supernova simulations [4] and binary neutron star merger simulations [5-7].

On the website of the author<sup>1</sup> you will find further information about the provided data, and the data in different formats. Please feel free to contact the author, if you run into problems with these tabulations.

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<sup>1</sup><https://eos.bastian.science>

### References to the original work

1. N.-U. F. Bastian, Phys. Rev. D 103.2, p. 023001 (2021).  
doi: 10.1103/PhysRevD.103.023001.
2. M. Hempel and J. Schaffner-Bielich, Nucl. Phys. A 837 (2010) 210.  
doi: 10.1016/j.nuclphysa.2010.02.010

### Further References

3. M. A. R. Kaltenborn, N.-U. F. Bastian, and D. B. Blaschke, Phys. Rev. D 96, 056024.  
doi: 10.1103/PhysRevD.96.056024.
4. T. Fischer, N.-U. F. Bastian, M.-R. Wu, P. Baklanov, E. Sorokina, S. Blinnikov, S. Typel, T. Klähn, D. B. Blaschke, Nature Astronomy 2, 980–986 (2018),  
doi: 10.1038/s41550-018-0583-0
5. Andreas Bauswein, Niels-Uwe F. Bastian, David B. Blaschke, Katerina Chatziioannou, James A. Clark, Tobias Fischer, and Micaela Oertel, Phys. Rev. Lett. 122, 061102 (2019),  
doi: 10.1103/PhysRevLett.122.061102
6. Andreas Bauswein, Sebastian Blacker, Vimal Vijayan, Nikolaos Stergioulas, Katerina Chatziioannou, James A. Clark, Niels-Uwe F. Bastian, David B. Blaschke, Mateusz Cierniak, and Tobias Fischer, Phys. Rev. Lett. 125, 141103 (2020),  
doi: 10.1103/PhysRevLett.125.141103
7. Sebastian Blacker, Niels-Uwe F. Bastian, Andreas Bauswein, David B. Blaschke, Tobias Fischer, Micaela Oertel, Theodoros Soutanis, and Stefan Typel, Phys. Rev. D 102, 123023 (2020),  
doi: 10.1103/PhysRevD.102.123023

## Nuclear Matter Properties<sup>2</sup>

|           | Quantity                                | Unit             |        |
|-----------|---|------------------|--------|
| $n_S$     | saturation density in symmetric matter  | $\text{fm}^{-3}$ | 0.149  |
| $E_0$     | binding energy per baryon at saturation | MeV              | 16.02  |
| $K$       | incompressibility                       | MeV              | 242.7  |
| $K'$      | skewness                                | MeV              | 168.8  |
| $J$       | symmetry energy                         | MeV              | 31.67  |
| $L$       | symmetry energy slope parameter         | MeV              | 55.04  |
| $K_{sym}$ | symmetry incompressibility              | MeV              | -93.23 |

## Neutron Star Properties<sup>2</sup>

|               | Quantity                                  | Unit      |      |
|---------------|---|-----------|------|
| $M_{max}$     | maximum mass                              | $M_{sun}$ | 2.02 |
| $M_{DU,e}$    | mass at DUrca threshold (1/9) w/o $\mu^-$ | $M_{sun}$ | N/A  |
| $R_{M_{max}}$ | radius at maximum NS mass                 | km        | N/A  |
| $R_{1.4}$     | radius at 1.4 $M_{sun}$ NS mass           | km        | N/A  |

## eos.thermo

eos.thermo and the three grid defining files are ComPOSE standard data files and by definition available. eos.thermo does not necessarily provide all possible data.

```
table dimension          3
table type              1
total number of grid points 1142100
```

Range and density (#) of the grid parameters:

|       | Quantity          | Unit             | min            | max            | #   |
|-------|-------------------|------------------|----------------|----------------|-----|
| T     | Temperature       | MeV              | 0.1E+00        | 0.15848932E+03 | 81  |
| $n_b$ | Baryon Nr Density | $\text{fm}^{-3}$ | 0.1E-11        | 0.1E+02        | 235 |
| $Y_q$ | Charge Fraction   |                  | 0.10000000E-01 | 0.60000000E+00 | 60  |

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

<sup>2</sup>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  | ${}^2_4\text{He}$ |
| 3002  | ${}^2_3\text{He}$ |
| 3001  | ${}^1_3\text{H}$  |
| 2001  | ${}^1_2\text{H}$  |
| 500   | u                 |
| 501   | d                 |
|       | - end of table -  |

The listed particle number fractions are net fractions, i.e., they are given by the difference between the corresponding particle and anti-particle fractions. Further particle sets are defined.

| index | description  |
|-------|--|
| 999   | Average fraction, mass and proton number for all nuclei not listed above |
|       | - end of table -   |

**eos.micro** : available

| index  | quantity  | particle |
|--------|---|----------|
| 10041  | Dirac effective mass divided by particle mass $m_i^D/m_i$ | n        |
| 11041  | Dirac effective mass divided by particle mass $m_i^D/m_i$ | p        |
| 500041 | Dirac effective mass divided by particle mass $m_i^D/m_i$ | u        |
| 501041 | Dirac effective mass divided by particle mass $m_i^D/m_i$ | d        |
| 10051  | relativistic vector self-energy $V_i$                     | n        |
| 11051  | relativistic vector self-energy $V_i$                     | p        |
| 500051 | relativistic vector self-energy $V_i$                     | u        |
| 501051 | relativistic vector self-energy $V_i$                     | d        |
|        | - end of table -  |          |