

QMC-RMF2

EoS Submission Details

EoS name	QMC-RMF2
category	Hadrons and Leptons
submitted by	Liam Brodie
affiliation	Washington University in St. Louis
e-mail contact	b.liam@wustl.edu
sheet creation date	April 20, 2023

Abstract

An out-of-equilibrium and finite-temperature equation of state (EoS). The core is homogeneous n, p, e matter computed using a relativistic mean-field theory constrained by chiral effective field theory calculations of pure neutron matter at zero temperature (from 0.08 fm^{-3} to 0.32 fm^{-3}), by properties of isospin-symmetric nuclear matter around nuclear saturation density, and by astrophysical observations of neutron stars [1]. To describe nuclear matter over the physically-relevant range of densities for use in, e.g., simulations of neutron star mergers, we attach the HS(IUF) EoS [2,3] in a thermodynamically consistent manner to model inhomogeneous nuclear matter at low densities. See Ref. [4] for more details about this EoS.

References to the original work

1. M. G. Alford, L. Brodie, A. Haber, and I. Tews, Phys. Rev. C 106 (2022) 055804 (2205.10283)
2. M. Hempel and J. Schaffner-Bielich, Nucl. Phys. A 837, 210 (2010) (0911.4073), URL <https://compose.obspm.fr/eos/22>
3. F.J. Fattoyev, C.J. Horowitz, J. Piekarewicz, and G. Shen, Phys. Rev. C 82 (2010) 055803 (1008.3030)
4. M. G. Alford, L. Brodie, A. Haber, and I. Tews, (2023) (2304.07836)

Nuclear Matter Properties¹

	Quantity	Unit	
n_S	saturation density in symmetric matter	fm^{-3}	0.1546
E_0	binding energy per baryon at saturation	MeV	-16.39
K	incompressibility	MeV	231.3
K'	skewness	MeV	-290.3
J	symmetry energy	MeV	31.29
L	symmetry energy slope parameter	MeV	47.2
K_{sym}	symmetry incompressibility	MeV	28.5
U_Λ	Λ -potential at saturation	MeV	0
U_Σ	Σ -potential at saturation	MeV	0
U_Ξ	Ξ -potential at saturation	MeV	0

Neutron Star Properties¹

	Quantity	Unit	
M_{max}	maximum mass	M_{sun}	2.04
$M_{DU,e}$	mass at DUrca threshold (1/9) w/o μ^-	M_{sun}	0
R_{Mmax}	radius at maximum NS mass	km	10.39
$R_{1.4}$	radius at 1.4 M_{sun} NS mass	km	11.94
$\tilde{\Lambda}$	tidal deformability for GW170817 at a mass ratio of $q = 0.8$		373

eos.thermo

eos.thermo and the three grid defining files are CompOSE standard data files and by definition available. The neutron and proton bare masses are both set to 939 MeV.

```
table dimension      3
table type          1
total number of grid points 1487160
```

¹0-values indicate, that the corresponding data is not provided.

Range and density (#) of the grid parameters:

	Quantity	Unit	min	max	#
T	Temperature	MeV	0.1	158.48	81
n_b	Baryon Nr Density	fm^{-3}	1×10^{-12}	1.584	306
Y_q	Charge Fraction		0.01	0.6	60

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

additional quantities in eos.thermo

We provide one additional quantity: the chemical potential (in units of MeV) for a system of charge-neutral nuclear matter at fixed charge fraction and temperature. See Sec. III of Ref. [4] for details.

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
2001	${}^1_2\text{H}$
3001	${}^1_3\text{H}$
3002	${}^2_3\text{He}$
4002	${}^2_4\text{He}$
	- end of table -

This file contains particle fractions, defined as the individual particle number density divided by the total baryon number density. The n, p, e particle number densities are net number densities, i.e., particle minus anti-particle number densities. The phase index '1' within the file indicates the HS(IUF) EoS that we use to model inhomogeneous nuclear matter from Refs. [2,3]. Phase index '2' indicates a volume averaged mixture of phase '1' and phase '3'. Phase index '3' indicates homogeneous n, p, e matter from the chiral effective field theory calibrated relativistic mean-field theory in Ref. [1].

eos.micro : available

index	quantity	particle
10041	Dirac effective mass divided by particle mass m_n^D/m_n	n
11041	Dirac effective mass divided by particle mass m_p^D/m_p	p
10051	vector self-energy V_n	n
	- continued on next page -	

index	quantity	
11051	vector self-energy V_p	p
10040	Landau effective mass divided by particle mass m_n^L/m_n	n
11040	Landau effective mass divided by particle mass m_p^L/m_p	p
- end of table -		

eos.mr : available

This file provides the gravitational mass (in solar masses) and the radius (in kilometers) for a family of neutron stars after solving the Tolman-Oppenheimer-Volkoff (TOV) equations using this EoS in β -equilibrium at different central pressures.