QMC-RMF3

EoS Submission Details

EoS name	QMC-RMF3
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 Properties[1]

	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 Properties[1]

	Quantity	Unit	
M_{max}	maximum mass	M_{sun}	2.15
$M_{DU,e}$	mass at DUrca threshold (1/9) w/o μ^-	M_{sun}	0
$R_{M_{max}}$	radius at maximum NS mass	km	10.63
$R_{1.4}$	radius at 1.4 M_{sun} NS mass	km	12.21
$\tilde{\Lambda}$	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

[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	0.1	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	$^1_2$H
3001	$^1_3$H
3002	$^2_3$He
4002	$^2_4$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.