QHC18 (Quark-Hadron-Crossover, ver. 2018)

EoS Submission Details

EoS name	QHC18
category	Unified EoS, from hadronic to quark matter
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Abstract

This table corresponds to the zero temperature and β-equilibrium unified EoS by Baym et al. [1]. The EoS are divided into four distinct domains: the crust, nuclear liquid, hadron-quark crossover, and quark matter domains. For each domain we assign an equation of state as

Crust :	**Togashi EoS** [2]	$[10^{-9}n_0 \leq n_B \leq 0.26n_0]$
Nuclear liquid :	**APR98 EoS** [3]	$[0.26n_0 \leq n_B \leq 2n_0]$
Crossover :	**QHC18** [1]	$[2n_0 \leq n_B \leq 5n_0]$
Quark matter :	**QHC18** [1]	$[5n_0 \leq n_B \leq 10n_0]$

The quark matter EoS (including up-, down-, and strange-quarks) in the QHC18 was calculated using the NJL model within the mean field approximation. As variable parameters, we choose g_V and H which quantify the strength of the repulsive density-density interaction and the attractive paring-interaction between quarks, respectively. We chose $(g_V, H) = (0.80, 1.50)G_s$ which is compatible with the hadron physics. The QHC18 satisfies the empirical constraints from neutron stars as well as the causality and thermodynamic consistency.

References to the original work

1, G. Baym, T. Hatsuda, T. Kojo, P. D. Powell, Y. Song and T. Takatsuka,
"*From hadrons to quarks in neutron stars: a review*,"
Rept. Prog. Phys. **81** (2018) no.5, 056902, doi:10.1088/1361-6633/aaae14

2, H. Togashi, K. Nakazato, Y. Takehara, S. Yamamuro, H. Suzuki and M. Takano,
"Nuclear equation of state for core-collapse supernova simulations with realistic nuclear forces,"
Nucl. Phys. A 961, 78 (2017), doi:10.1016/j.nuclphysa.2017.02.010

3, A. Akmal, V. R. Pandharipande and D. G. Ravenhall,
"The Equation of state of nucleon matter and neutron star structure,"
Phys. Rev. C **58** (1998) 1804, doi:10.1103/PhysRevC.58.1804

Nuclear Matter Properties[1] (same as APR EoS [3])

	quantity	unit	
n_0	saturation density in symmetric matter	fm^{-3}	0.16
E_0	binding energy per baryon at saturation	MeV	16.0
K	incompressibility	MeV	266
K'	skewness	MeV	0
J	symmetry energy	MeV	32.6
L	symmetry energy slope parameter	MeV	57.6
K_{sym}	symmetry incompressibility	MeV	0

Neutron Star Properties

	quantity	unit	
M_{max}	maximum mass	M_{sun}	2.05
$M_{DU,e}$	mass at DUrca threshold (1/9) w/o μ^-	M_{sun}	—
$R_{M_{max}}$	radius at maximum NS mass	km	10.41
$R_{1.4}$	radius at 1.4 M_{sun} NS mass	km	11.49

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	400

Range and density (#) of the grid parameters:

	quantity	unit	min	max	#
T	Temperature	MeV	0.	0.	1
n_B	Baryon Nr density	fm^{-3}	8.686064E-011	1.704272	400
Y_q	Charge fraction		0.	0.	1

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

[1] 0-values indicate, that the corresponding data is not provided.