DEJ(DD2-VQCD), hybrid HS(DD2)-van der Waals-holographic EoS, soft version

EoS Submission Details

EoS name	DEJ(DD2-VQCD), hybrid HS(DD2)-van der Waals-holographic EoS, soft version
category	Hybrid
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Abstract

Three versions (soft, intermediate, and stiff variants) of the temperature and electron fraction dependent holographic V-QCD hybrid EOS model constructed in [1]. The high density part is based on a gauge/gravity duality calculation that describes the deconfinement phase transition from dense nuclear to quark matter within the V-QCD model, while the low density part uses a combination of the HS(DD2) [2,3] and a small contribution of APR [4] around and below nuclear saturation density that is augmented by a gas of light mesons at high temperature. The reduction of the EOSs to beta equilibrium and zero temperature agrees with the three JJ(VQCD(APR)) EOSs (up to very minor adjustments) by construction. The model features a mixed nuclear and quark matter phase at finite temperature that ends on a critical point and is obtained by combining a van der Waals extension of V-QCD nuclear matter with V-QCD quark matter through a Gibbs construction. As additional data, we provide the quark fraction as well as the thermodynamic properties of pure nuclear and quark matter in the region of the mixed phase.

References to the original work

1. T. Demircik, C. Ecker, and M. Järvinen, To appear in Phys. Rev. X [arXiv:2112.12157]

2. M. Hempel and J. Schaffner-Bielich, Nucl. Phys. A 837, 210 (2010) https://doi.org/10.1016/j.nuclphysa.2010.02.010

3. S. Typel, G. Röpke, T. Klähn, D. Blaschke, and H.H. Wolter, Phys. Rev. C 81, 015803 (2010) https://doi.org/10.1103/PhysRevC.81.015803

4. A. Akmal, V. R. Pandharipande and D. G. Ravenhall, Phys. Rev. C 58, 1804 (1998) https://doi.org/10.1103/PhysRevC.58.1804

Nuclear Matter Properties[1]

	Quantity	Unit	
n_S	saturation density in symmetric matter	fm^{-3}	0
E_0	binding energy per baryon at saturation	MeV	0
K	incompressibility	MeV	0
K'	skewness	MeV	0
J	symmetry energy	MeV	0
L	symmetry energy slope parameter	MeV	0
K_{sym}	symmetry incompressibility	MeV	0

Neutron Star Properties[1]

	Quantity	Unit	
M_{max}	maximum mass	M_{sun}	2.02
$M_{DU,e}$	mass at DUrca threshold (1/9) w/o μ^-	M_{sun}	0
$R_{M_{max}}$	radius at maximum NS mass	km	11.90
$R_{1.4}$	radius at 1.4 M_{sun} NS mass	km	12.41
$\tilde{\Lambda}$	tidal deformability for GW170817 at a mass ratio of $q = 0.8$		550

eos.thermo

eos.thermo and the three grid defining files are CompOSE standard data files and by definition available.

In addition to the standard data, the eos.thermo file contains 9 additional quantities which are required for a complete description of the region including the mixed phase between nuclear and quark matter. The additional thermodynamic quantities are given by

1. Quark volume fraction Y_{quark}
2. Entropy per baryon $Q_2 = s/n_b$ for pure nuclear matter
3. Scaled and shifted baryon chemical potential $Q_3 = \mu_b/m_n - 1$ for pure nuclear matter
4. Scaled effective lepton chemical potential $Q_5 = \mu_l/m_n$ for pure nuclear matter
5. Scaled free energy per baryon $Q_6 = f/(n_b m_n) - 1$ for pure nuclear matter
6. Entropy per baryon $Q_2 = s/n_b$ for pure quark matter

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

7. Scaled and shifted baryon chemical potential $Q_3 = \mu_b/m_n - 1$ for pure quark matter
8. Scaled effective lepton chemical potential $Q_5 = \mu_l/m_n$ for pure quark matter
9. Scaled free energy per baryon $Q_6 = f/(n_b m_n) - 1$ for pure quark matter

table dimension	3
table type	1
total number of grid points	3163860

Range and density (#) of the grid parameters:

	Quantity	Unit	min	max	#
T	Temperature	MeV	0.1	158.4893	81
n_b	Baryon Nr Density	fm^{-3}	1e-12	10	651
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.