EoS name: CMF hadronic (#1 to #8) with crust
Category: Hadronic
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Abstract:

The relativistic SU(3) Chiral Mean Field (CMF) model was the first model developed with the intent of describing several systems, among which are the interior of neutron and proto-neutron stars. More specifically it is a non-linear realization of the sigma model which includes pseudo-scalar mesons as the angular parameters for the chiral transformation. Depending on the choice of degrees of freedom, it can include nucleons, hyperons, spin 3/2 (Delta) baryons, light quarks, free leptons and mesons. The model reproduces standard nuclear physical constraints, as well as astrophysical ones, such as massive neutron stars. The quark sector of the model was fitted to reproduce lattice QCD results at zero and small densities. The model results were found to be in agreement with perturbative QCD for the relevant astrophysical regime.

Within the model, baryons and quarks are mediated by vector-isoscalar, vector-isovector, scalar-isoscalar, and scalar-isovector mesons (including strange quark-antiquark states). At low densities and/or temperatures, the nuclear liquid-gas first-order phase transition is reproduced. At high densities and/or temperatures, chiral symmetry is restored, which can be seen in a reduction of the effective baryon masses, and, if the quarks are included in the model, deconfinement takes place. Here, we present two different kinds of EoS. The first one is for cold chemically-equilibrated neutron stars. The second one is for matter out of equilibrium, such as the one created in particle collisions, supernova explosions and neutron star mergers, in which case we vary not only the density, but also the temperature and electric charge fraction.

The versions of the EoS for cold chemically-equilibrated neutron stars are also available connected to crusts, which were chosen for having similar symmetry energy slopes. They are both zero temperature and beta equilibrium unified EoS's by Gulminelli and Raduta (arXiv:1504.04493) available in CompOSE. They considered the effective interactions Rs proposed by Friedrich and Reinhard (for EoS's #1 and #2) and SkM proposed by L. Bennour et al. (for EoS's #2 to #8), both with cluster energy functionals from Danielewicz and Lee. The masses they use for neutrons and protons are 939.5653 MeV and 938.2720 MeV, respectively.

References to the original work:

V. Dexheimer and S. Schramm, Proto-Neutron and Neutron Stars in a Chiral SU(3) Model, Astrophys. J. **683** (2008) 943.

V. Dexheimer and S. Schramm, A Novel Approach to Model Hybrid Stars, Phys.Rev.C **81** (2010) 045201.

V. Dexheimer, Tabulated Neutron Star Equations of State Modelled within the Chiral Mean Field Model, Publications of the Astronomical Society of Australia **34** (2017).

V. Dexheimer, R.O. Gomes, T. Klähn, S. Han, M. Salinas, GW190814 as a massive rapidly rotating neutron star with exotic degrees of freedom, Phys.Rev.C **103** (2021) 2.

Nuclear Matter and Neutron Star Properties (with Rs/SkM crust):

saturation density n_B= 0.15 fm^{-3}
binding energy per nucleon at saturation E/A-M_B= -16 MeV
incompressibility at saturation K= 300 MeV
symmetry energy at saturation E_{sym}= 30 MeV

hyperon potentials at saturation U_Λ=-28 MeV, U_Σ=5 MeV, U_Ξ=-18 MeV or

U_Λ=-27 MeV, U_Σ=6 MeV, U_Ξ=-17 MeV, U_Δ =-64 MeV (with additional interaction ω^4)

critical point for liquid gas phase transition T_C=16.4 MeV, n_C=0.05 fm-^{3}, μ_C=910 MeV (investigated only for EoS #1)

EoS	degrees of freedom	vector interaction	E_{sym} slope L (MeV)	M_{max} (M_{Sun})	R for M_{max} (km)	R for 1.4 M_{Sun} (km)	Λ for 1.4 M_{Sun}	n_B Urca (fm^{-3})
#1	N+Hyp	standard	88	2.07	11.88	13.57	889	0.31
#2	N	standard	88	2.13	11.96	13.70	904	0.48
#3	N+Hyp	standard + $\omega\rho$	75	2.00	11.56	13.15	702	0.45
#4	N	standard + $\omega\rho$	75	2.05	11.60	13.26	739	0.49
#5	N+Hyp	standard + $\omega\rho$ + ω^4	75	2.07	11.43	13.20	723	0.46
#6	N	standard + $\omega\rho$ + ω^4	75	2.11	11.58	13.30	754	0.49
#7	N+Hyp+Δ	standard + $\omega\rho$ + ω^4	75	2.07	11.43	13.20	723	0.46
#8	N+Δ	standard + $\omega\rho$ + ω^4	75	2.09	11.59	13.30	754	0.46

Tables for Cold Chemically-Equilibrated Neutron Stars with Crust:

The 4 tables described in the following are CompOSE standard data files.

eos.thermo
table dimension: 2
total number of grid points: depends on EoS

total number of lines: total number of grid points + 1 (first line contains extra information - the baryon masses refer to the ones in the CMF model)
grid parameters: baryon number density (from 10^{-7})
the n_B values are stored in file eos.nb
the 3 extra columns contain the scaled enthalpy per baryon $(\varepsilon+P)/(n_B m_B)-1$, the strangeness number density, which is the particle sum over $(S_i n_i)$ in fm^{-3}, and the sum over the number density of baryons and quarks in fm^{-3}

eos.compo
table dimension: 2
total number of grid points: depends on EoS
total number of lines: total number of grid points
grid parameters: baryon number density (from 10^{-7})
the n_B values are stored in file eos.nb
the phase index is defined as 1 (bulk hadronic matter) or 4 (heavy nuclei present)
we provide 17 particle pairs and one quadruple for a unique heavy nucleus

eos.nb
table dimension: 1
total number of grid points: depends on EoS
total number of lines: total number of grid points + 2 (first two lines contain extra information)
grid values: baryon number density (from 10^{-7})

eos.mr
table dimension: 2
total number of lines: depends on EoS
the 2 columns contain stellar radii (in km) and stellar masses (in units of solar mass) of a family of stars