Explanation of FSU2.1 Equation of State Tables

This is the version of the FSU equation of state with a maximum neutron star mass of $2.1M_{\odot}$. Here we describe the physical quantities provided in the tables for the equation of state, FSU2.1eos1.01.dat and FSU2.1eosb1.01.dat. One should download the gzip compressed files FSU2.1eos1.01.dat.gz and FSU2.1eosb1.01.dat.gz and use gunzip to decompress them. [For example gunzip FSU2.1eos1.01.dat.gz will create FSU2.1eos1.01.dat which is 500 MB.] References include:[1, 2, 3, 4].

There are 16 items in each row. In FSU2.1eosb1.01.dat, only the contribution from baryons is taken into account for items 4,5,6. In FSU2.1eos1.01.dat, the contributions from electrons, positrons, and photons are also included.

Table 1: Range of temperatures, densities and proton fractions in the EOS table.

Parameter	minimum	maximum	number of grid points
T [MeV]	0, $10^{-0.8}$	$10^{1.875}$	109
$\log_{10}(\mathrm{n}_B)$ [fm^{-3}]	-8.0	0.175	328
Y_p	0, 0.05	0.56	1(Y_p=0)+52

1. Temperature T [MeV]. The range of temperature is first $T = 0$ and then from $T = 10^{-0.8}$ to $10^{1.9}$ MeV. The log10 step for grid point in temperature is 0.025 for nonzero temperatures.

2. Proton fraction Y_p. The range of proton fraction is first 0 and then from $0.05 \sim 0.56$. The step in proton fraction is 0.01.

3. Baryon number density n [fm^{-3}]. The range of density is from 10^{-8} to $10^{0.2}$ fm^{-3}. The log10 step for grid points in density is 0.025.

4. Free energy per baryon F [MeV], which has subtracted the free nucleon mass 939 MeV.

5. Pressure P [MeV/fm^3].

6. Entropy per baryon S [k_B].

7. Chemical potential for neutrons μ_n [MeV]. The value is relative to the nucleon mass 939 MeV.

8. Chemical potential for protons μ_p [MeV]. The value is relative to the nucleon mass.

9. Chemical potential for electrons μ_e [MeV]. The value is the physical value including the electron mass.

10. Average mass number $\bar{A}$ of heavy nuclei, which exclude alpha particles.

11. Average proton number $\bar{Z}$ of heavy nuclei, which exclude alpha particles.

12. Mass fraction of free neutrons.

13. Mass fraction of free protons.

14. Mass fraction of alpha particles.

15. Mass fraction of heavy nuclei, which exclude alpha particles.

16. Effective nucleon mass M^* [MeV]. In uniform matter it is obtained from RMF theory. For virial gas and non-uniform matter, it is chosen to be the free nucleon mass.

Sample Fortran Program readeos_FSU2.1.f

The Fortran program readeos_FSU2.1.f includes a very short main program that calls the subroutine load_table, to read FSU2.1eos1.01.dat or FSU2.1eosb1.01.dat, and then calls the subroutine readeos with inputs T (in MeV), proton fraction Y_p, and density n (in fm^{-3}). The subroutine readeos uses triliner interpolation (in T, Y_p, and n) to return the above 16 values plus the internal energy per baryon (in MeV) and the chemical potential for electron neutrinos in chemical equilibrium (in MeV). Note that one needs to call load_table only once and then one can call readeos many times. For further details please see the comments in readeos_FSU2.1.f.

References

[1] A New Relativistic Mean Field and Virial Equation of State for Astrophysical Simulations, G. Shen, C. J. Horowitz, and E. O'Connor, to be published.

[2] A New Equation of State for Astrophysical Simulations, G. Shen, C. J. Horowitz, S. Teige Phys. Rev. C **83**, 035802 (2011).

[3] G. Shen, C. J. Horowitz, and S. Teige, Phys. Rev. C **82**, 015806 (2010).

[4] G. Shen, C. J. Horowitz, and S. Teige, Phys. Rev. C **82**, 045802 (2010).