Constants

$c = 2.99792458 \times 10^{10}\ \mathrm{cm\,s^{-1}}$

$G = 6.6726 \times 10^{-8}\ \mathrm{cm^3\,g^{-1}\,s^{-2}}$

$M_\odot = 1.989 \times 10^{33}\ \mathrm{g}$

Units

Rest mass density ρ, energy density ϵ and pressure p are all measured in $\mathrm{g\,cm^{-3}}$. (One can convert any of them to $\mathrm{erg\,cm^{-3}} = \mathrm{dyn\,cm^{-2}}$ by multiplying with c^2). The specific enthalpy h is dimensionless and is defined by $h = 1 + \eta = (\epsilon + p) / \rho$.

Parametrized EOS

In the $i-$th interval $(\eta_{i-1} \le \eta < \eta_i)$ the equation of state is parameterized by (astro-ph/0812.2163):

$$\rho(\eta) = \left[\frac{\eta - a_i}{K_i(n_i + 1)}\right]^{n_i}; \quad p(\eta) = K_i \rho(\eta)^{\Gamma_i}; \quad \epsilon(\eta) = \left(1 + \frac{a_i + n_i \eta}{n_i + 1}\right)\rho(\eta) \tag{1.1}$$

where $\Gamma_i = 1 + 1 / n_i$. Parameters for each EOS candidate are given below. Initial candidates (1-9) have only two pieces, but later candidates can have three or four. Please see an example (EOS SLy), appended at the end, for implementing a piecewise polytropic EOS with an arbitrary number of pieces.

EOS Candidate 1 (Candidate **HB** in gr-qc/0901.3258)

$P = 13.45$

$p_1 = 10^P\ \mathrm{g\,cm^{-3}}$ (pressure at the fiducial density $\rho_1 = 10^{14.7}\ \mathrm{g\,cm^{-3}}$)

Interval	Adiabatic index Γ_i	Dividing density $(\mathrm{g\,cm^{-3}})$	K_i	a_i	Dividing η
$0 \le \rho < \rho_0$	$\Gamma_0 = 1.35692395$		$K_0 = 3.99873692 \times 10^{-08}$	$a_0 = 0$	
$\rho_0 \le \rho$	$\Gamma_1 = 3.0$	$\rho_0 = 10^{\frac{P - \Gamma_1 \times 14.7 - \log_{10} K_0}{\Gamma_0 - \Gamma_1}}$ $= 1.4172898657009434 \times 10^{14}$	$K_1 = K_0 \rho_0^{\Gamma_0 - \Gamma_1}$ $= 2.238721138568332 \times 10^{-31}$	$a_1 = a_0 + \frac{K_0}{\Gamma_0 - 1}\rho_0^{\Gamma_0 - 1} - \frac{K_1}{\Gamma_1 - 1}\rho_0^{\Gamma_1 - 1}$ $= 0.01035069096964138$	$\eta_0 = a_1 + K_1 \frac{\Gamma_1}{\Gamma_1 - 1}\rho_0^{\Gamma_1 - 1}$ $= 0.017096105169027462$

With $P, K_0, \Gamma_0, \Gamma_1$ specified, one may algorithmically compute ρ_0, K_1, a_1, η_0 using the formulas above (last row).

EOS Candidate 4 (Candidate **B** in gr-qc/0901.3258)

$P = 13.35$

$p_1 = 10^P\ \mathrm{g\,cm^{-3}}$

Interval	Adiabatic index Γ_i	Dividing density $(\mathrm{g\,cm^{-3}})$	K_i	a_i	Dividing η
$0 \le \rho < \rho_0$	$\Gamma_0 = 1.35692395$		$K_0 = 3.99873692 \times 10^{-08}$	$a_0 = 0$	
$\rho_0 \le \rho$	$\Gamma_1 = 3.0$	$\rho_0 = 1.630497500125504 \times 10^{14}$	$K_1 = 1.778279410038963 \times 10^{-31}$	$a_1 = 0.01088158737430845$	$\eta_0 = 0.017972980036093586$

EOS Candidate 6 (B')

$P = 13.35$

$p_1 = 10^P \ \mathrm{g\,cm^{-3}}$

Interval	Adiabatic index Γ_i	Dividing density $(\mathrm{g\,cm^{-3}})$	K_i	a_i	Dividing η
$0 \le \rho < \rho_0$	$\Gamma_0 = 1.35692395$		$K_0 = 3.99873692 \times 10^{-08}$	$a_0 = 0$	
$\rho_0 \le \rho$	$\Gamma_1 = 2.7$	$\rho_0 = 1.268785300163927 \times 10^{14}$	$K_1 = 4.570881896148805 \times 10^{-27}$	$a_1 = 0.00956832301216044$	$\eta_0 = 0.015798256438541058$

EOS Candidate 7 (B")

$P = 13.35$

$p_1 = 10^P \ \mathrm{g\,cm^{-3}}$

Interval	Adiabatic index Γ_i	Dividing density $(\mathrm{g\,cm^{-3}})$	K_i	a_i	Dividing η
$0 \le \rho < \rho_0$	$\Gamma_0 = 1.35692395$		$K_0 = 3.99873692 \times 10^{-08}$	$a_0 = 0$	
$\rho_0 \le \rho$	$\Gamma_1 = 2.4$	$\rho_0 = 8.546653314476217 \times 10^{13}$	$K_1 = 1.17489755493955 \times 10^{-22}$	$a_1 = 0.007836583585155553$	$\eta_0 = 0.014272312295948284$

EOS Candidate 8 (HB')

$P = 13.45$

$p_1 = 10^P \ \mathrm{g\,cm^{-3}}$

Interval	Adiabatic index Γ_i	Dividing density $(\mathrm{g\,cm^{-3}})$	K_i	a_i	Dividing η
$0 \le \rho < \rho_0$	$\Gamma_0 = 1.35692395$		$K_0 = 3.99873692 \times 10^{-08}$	$a_0 = 0$	
$\rho_0 \le \rho$	$\Gamma_1 = 2.7$	$\rho_0 = 1.068887973752668 \times 10^{14}$	$K_1 = 5.754399373371614 \times 10^{-27}$	$a_1 = 0.009000377330119838$	$\eta_0 = 0.015458400028107366$

EOS Candidate 9 (HB")

$P = 13.45$

$p_1 = 10^P \ \mathrm{g\,cm^{-3}}$

Interval	Adiabatic index Γ_i	Dividing density $(\mathrm{g\,cm^{-3}})$	K_i	a_i	Dividing η
$0 \le \rho < \rho_0$	$\Gamma_0 = 1.35692395$		$K_0 = 3.99873692 \times 10^{-08}$	$a_0 = 0$	
$\rho_0 \le \rho$	$\Gamma_1 = 2.4$	$\rho_0 = 6.853711209810516 \times 10^{13}$	$K_1 = 1.479108388168227 \times 10^{-22}$	$a_1 = 0.007242831283078954$	$\eta_0 = 0.013190945882945563$

Example of realistic EOS with four pieces: EOS SLy

$P = 13.430358594144145$

$p_1 = 10^P \text{ g cm}^{-3}$

Interval	Adiabatic index Γ_i	Dividing density (g cm^{-3})	K_i	a_i	Dividing η
$0 \le \rho < \rho_0$	$\Gamma_0 = 1.35692395$		$K_0 = 3.99873692 \times 10^{-08}$	$a_0 = 0$	
$\rho_0 \le \rho < \rho_1$	$\Gamma_1 = 3.005$	$\rho_0 = 10^{\frac{P - \Gamma_1 \times 14.7 - \log_{10} K_0}{\Gamma_0 - \Gamma_1}}$	$K_1 = K_0 \rho_0^{\Gamma_0 - \Gamma_1}$	$a_1 = a_0 + \frac{K_0}{\Gamma_0 - 1} \rho_0^{\Gamma_0 - 1} - \frac{K_1}{\Gamma_1 - 1} \rho_0^{\Gamma_1 - 1}$	$\eta_0 = a_1 + K_1 \frac{\Gamma_1}{\Gamma_1 - 1} \rho_0^{\Gamma_1 - 1}$
$\rho_1 \le \rho < \rho_2$	$\Gamma_2 = 2.988$	$\rho_1 = 10^{14.7} \text{ g cm}^{-3}$	$K_2 = K_1 \rho_1^{\Gamma_1 - \Gamma_2}$	$a_2 = a_1 + \frac{K_1}{\Gamma_1 - 1} \rho_1^{\Gamma_1 - 1} - \frac{K_2}{\Gamma_2 - 1} \rho_1^{\Gamma_2 - 1}$	$\eta_1 = a_2 + K_2 \frac{\Gamma_2}{\Gamma_2 - 1} \rho_1^{\Gamma_2 - 1}$
$\rho_2 \le \rho$	$\Gamma_3 = 2.851$	$\rho_2 = 10^{15.0} \text{ g cm}^{-3}$	$K_3 = K_2 \rho_2^{\Gamma_2 - \Gamma_3}$	$a_3 = a_2 + \frac{K_2}{\Gamma_2 - 1} \rho_2^{\Gamma_2 - 1} - \frac{K_3}{\Gamma_3 - 1} \rho_2^{\Gamma_3 - 1}$	$\eta_2 = a_3 + K_3 \frac{\Gamma_3}{\Gamma_3 - 1} \rho_2^{\Gamma_3 - 1}$

The table above demonstrates how the parameters in a piecewise polytropic EOS subroutine can be obtained:
The parameters K_0, Γ_0, ρ_1 and ρ_2 are *fixed* for all EOS;
the free parameters P (or p_1) and Γ_i $(i > 0)$ are *specified* for each EOS;
then the remaining parameters ρ_0, K_i, a_i and η_i are *computed* using the above tabulated formulas.

With all parameters thus obtained and stored, one can then use eq. (1.1) to compute the EOS.

Candidate 1	HB
Candidate 2	2H
Candidate 3	H
Candidate 4	B
Candidate 5	2B
Candidate 6	B'
Candidate 7	B"
Candidate 8	HB'
Candidate 9	HB"