SAHA-S7 Equation of state tables, Version 7

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1 Introduction

Tables are provided for four sets of relative abundances of heavy elements. Two of them correspond to widely used Z mixtures AGSS09 ([1]) and GN93 ([2]). The third set includes only C, N, O and Ne, and abundances of these elements are taken exactly as in OPAL EOS tables ([5], [4]). Fourth set (MB22) is for the composition from [3]. The mass fractions of heavy elements in SAHA-S7 are listed below:

	AGSS09	GN93	OPAL	MB22
C	0.181632	0.177215	0.190661	0.196841424
N	0.053204	0.054357	0.055848	0.060377226
O	0.440270	0.493204	0.542978	0.425246773
Ne	0.096497	0.098587	0.210511	0.128658052
Mg	0.054363	0.038425	0.0	0.038925389
Si	0.051061	0.041438	0.0	0.049319594
S	0.023745	0.021621	0.0	0.020917070
Fe	0.099223	0.075148	0.0	0.079714472

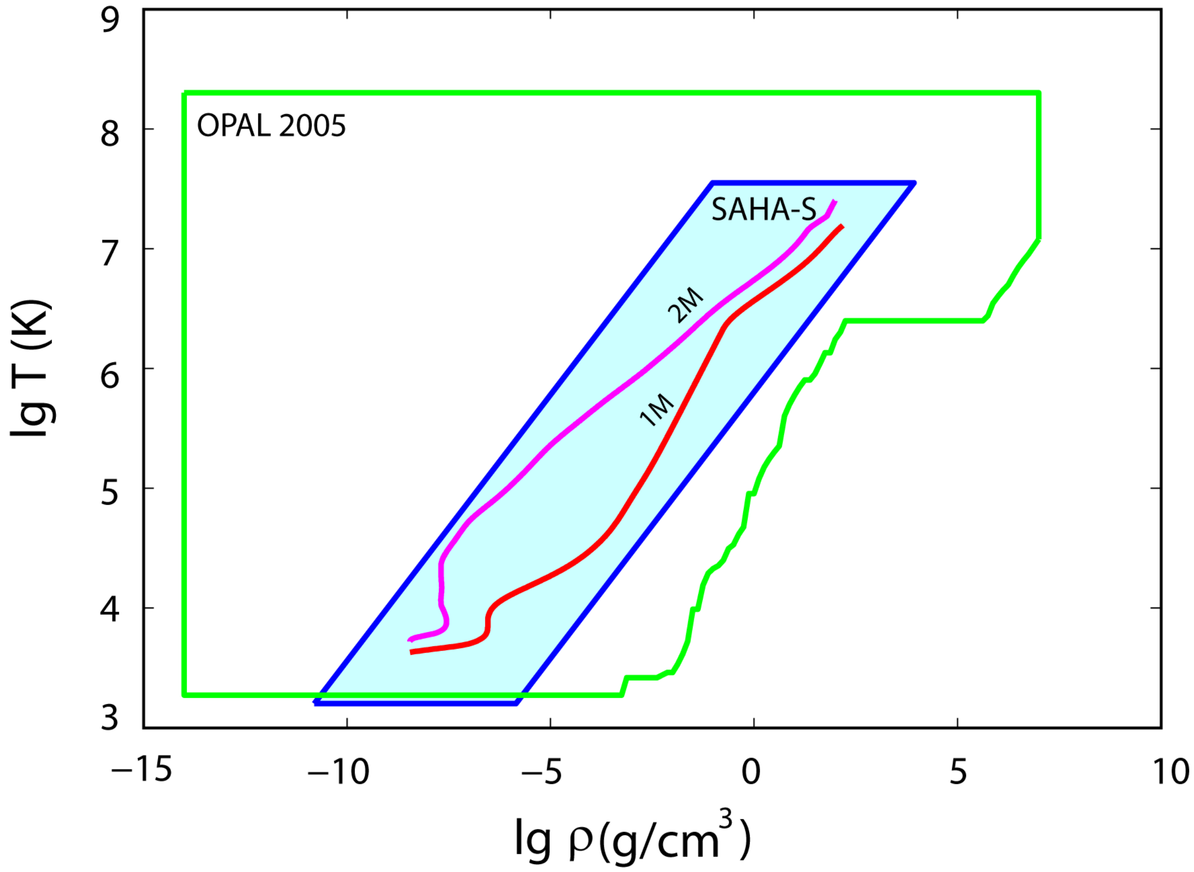
2 Mesh of SAHA-S

The SAHA-S tables are rectangular and have mesh evenly spaced in $\lg T$ and $\lg Q_s$. Here $Q_s = \rho/T_6^{2.25}$, $T_6 = T/10^6$. The Q_s coordinate was chosen to ensure that tables are rectangular.

Value	Range	Step	No. of knots
lgT	3.20...7.55	0.025	175
lgQs	-4.50...0.45	0.05	100
X	0.1...0.9	0.1	9
Z	0.0...0.020	0.005	5 [*]

[*] GN93 mixture is computed only for Z=0, 0.01 and 0.02.

The following figure presents domains of definition for SAHA-S and OPAL equations of state. Red and magenta curves show points from models of stars with 1 and 2 solar masses.



3 Description of data in SAHA-S7 tables

All values do not include contribution from radiation where applicable.

1	X	mass fraction of hydrogen
2	Z	mass fraction of elements heavier than helium
3	$\lg T$	decimal logarithm of temperature, K
4	ρ	density, g/cm^3
5	$\lg Q_s$	decimal logarithm of Q_s, see above
6	P	pressure, dyn/cm^2
7	χ_T	$(\partial \log P/\partial \log T)_{\rho,X,Z}$
8	χ_ρ	$(\partial \log P/\partial \log \rho)_{T,X,Z}$
9	C_V	specific heat at constant volume, erg/(g*K)
10	Γ_1	adiabatic exponent $(\partial \log P/\partial \log \rho)_{ad}$
11	$\lg N_e$	decimal logarithm of electron concentration, 1/cm^3
12	E	internal energy per unit mass, erg/g
13	$(\partial E/\partial X)_{T,\rho,Z}$	derivative of internal energy per unit mass by hydrogen mass fraction
14	$(\partial P/\partial X)_{T,\rho,Z}$	derivative of pressure by hydrogen mass fraction

All values do not include contribution from radiation where applicable.
You can follow `http://crydee.sai.msu.ru/SAHA-S1/radiation_on.php` to include radiative contribution.

4 SAHA-S7 data files

These tables have been prepared from original SAHA-S version 7 tables.

```
Filename                              Description
saha_s7_z000_br.tab                   Z=0.0 (same for all mixtures)

saha_s7_agss09_z005_br.tab            AGSS09 Z=0.005
saha_s7_agss09_z010_br.tab            AGSS09 Z=0.010
saha_s7_agss09_z015_br.tab            AGSS09 Z=0.015
saha_s7_agss09_z020_br.tab            AGSS09 Z=0.020
```

```
saha_s7_gn93_z010_br.tab               GN93 Z=0.010
saha_s7_gn93_z020_br.tab               GN93 Z=0.020

saha_s7_opal_z005_br.tab               OPAL mixture Z=0.005
saha_s7_opal_z010_br.tab               OPAL mixture Z=0.010
saha_s7_opal_z015_br.tab               OPAL mixture Z=0.015
saha_s7_opal_z020_br.tab               OPAL mixture Z=0.020

saha_s7_mb22_0050_br.tab               MB22 mixture Z=0.005
saha_s7_mb22_0100_br.tab               MB22 mixture Z=0.010
saha_s7_mb22_0150_br.tab               MB22 mixture Z=0.015
saha_s7_mb22_0200_br.tab               MB22 mixture Z=0.020
```

5 References

More information about SAHA-S equation of state is available at the web site
`http://crydee.sai.msu.ru/SAHA-S/`

References

[1] M Asplund, N Grevesse, J Sauval, and P Scott. *Annu. Rev. Astron. Astrophys.*, 47:481, 2009.

[2] N Grevesse and A Noels. Cosmic abundances of the elements. In N. Prantzos, E. Vangioni-Flam, and M. Casse, editors, *Origin and Evolution of the Elements*, pages 15–25, January 1993.

[3] Ekaterina Magg, Maria Bergemann, Aldo Serenelli, Manuel Bautista, Bertrand Plez, Ulrike Heiter, Jeffrey M Gerber, Hans-Günter Ludwig, Sarbani Basu, Jason W Ferguson, Helena Carvajal Gallego, Sébastien Gamrath, Patrick Palmeri, and Pascal Quinet. Observational constraints on the origin of the elements. IV. Standard composition of the Sun. *Astronomy and Astrophysics*, 661:A140, May 2022.

[4] F J Rogers and A Nayfonov. *Astrophys. J.*, 576:1064, 2002.

[5] F J Rogers, F J Swenson, and C A Iglesias. *Astrophys J.*, 456:902, 1996.