

The Boltzmann equation is: $\log(N_i/N) = -\theta \chi_i + \log[g_i/u(T)]$;

and the Saha equation is:

$$\log(N^{n+1}/N^n) = 2.5 \log T - \theta I_n + \log P_e - 0.4772 + \log [2 u_{n+1}(T)/u_n(T)],$$

where $\theta = 5040.3/T$.

Here we consider:

$$\log [Mg II(^2D)/Mg II] = \frac{-5040.3}{T} \times 8.859 + \log(4/2)$$

$$= \frac{-44652.018}{T} + 0.30103$$

$$\log [Mg II/Mg I] = 2.5 \log T - \frac{5040.3}{T} \times 7.645 + 10.165 - 2.77 \log T$$

$$- 0.4772 + \log(2 \times 2/1)$$

$$= \frac{-38533.094}{T} - 0.27 \log T + 10.28986$$

$$\log [Mg III/Mg II] = 2.5 \log T - \frac{5040.3}{T} \times 15.032 + 10.165 - 2.77 \log T$$

$$- 0.4772 + \log(2 \times 1/2)$$

$$= \frac{-75765.79}{T} - 0.27 \log T + 9.6878$$

$$\log [Mg IV/Mg III] = 2.5 \log T - \frac{5040.3}{T} \times 80.119 + 10.165 - 2.77 \log T$$

$$- 0.4772 + \log(2 \times 2/1)$$

$$= \frac{-403823.8}{T} - 0.27 \log T + 10.28986$$

And we wish to examine the ratio:

$$\frac{Mg II(^2D)}{\text{All Mg}} = \frac{Mg II(^2D)}{Mg I + Mg II + Mg III + Mg IV}$$

$$= \frac{Mg II(^2D)/Mg II}{1 + (Mg II/Mg I) + (Mg III/Mg II) + (Mg IV/Mg III)}$$

ignore higher ions

Results were examined in an EXCEL file and plotted graphically. Maximum occurs for $T = 9000$ K

From Appendix E, $T_{eff}(B7-B8 \text{ Iab}) = 11,200 - 12,200$ K.

$T_{eff}(A2 \text{ Iab}) = 9080$ K.

Either tables in Appendix E are wrong or results are skewed by an erroneous assumption about $\log P_e$ dependence.

T	log Pe	Mg II/Mg I	Mg III/Mg II	Mg IV/Mg III	Mg ^{en2} /Mg II	Hen2/Hetotal	log Hen2/Hetotal
7000	0.4859	3.747	-2.174	-48.437	-6.078	0.000	-6.081
7100	0.5030	3.823	-2.023	-47.627	-5.988	0.000	-5.992
7200	0.5198	3.897	-1.877	-46.838	-5.901	0.000	-5.906
7300	0.5364	3.968	-1.734	-46.072	-5.816	0.000	-5.824
7400	0.5528	4.038	-1.596	-45.326	-5.733	0.000	-5.744
7500	0.5689	4.106	-1.461	-44.600	-5.653	0.000	-5.667
7600	0.5849	4.172	-1.329	-43.893	-5.574	0.000	-5.594
7700	0.6006	4.236	-1.201	-43.204	-5.498	0.000	-5.524
7800	0.6161	4.299	-1.077	-42.533	-5.424	0.000	-5.459
7900	0.6314	4.360	-0.955	-41.879	-5.351	0.000	-5.397
8000	0.6466	4.419	-0.837	-41.242	-5.280	0.000	-5.340
8100	0.6615	4.477	-0.721	-40.620	-5.212	0.000	-5.287
8200	0.6763	4.534	-0.609	-40.014	-5.144	0.000	-5.240
8300	0.6908	4.589	-0.499	-39.422	-5.079	0.000	-5.198
8400	0.7053	4.643	-0.391	-38.844	-5.015	0.000	-5.163
8500	0.7195	4.696	-0.287	-38.280	-4.952	0.000	-5.133
8600	0.7336	4.747	-0.184	-37.729	-4.891	0.000	-5.110
8700	0.7475	4.797	-0.085	-37.190	-4.831	0.000	-5.092
8800	0.7612	4.846	0.013	-36.664	-4.773	0.000	-5.081
8900	0.7748	4.894	0.108	-36.150	-4.716	0.000	-5.075
9000	0.7883	4.941	0.202	-35.647	-4.660	0.000	-5.074 * MAXIMUM
9100	0.8015	4.987	0.293	-35.155	-4.606	0.000	-5.078
9200	0.8147	5.031	0.382	-34.674	-4.552	0.000	-5.085
9300	0.8277	5.075	0.469	-34.204	-4.500	0.000	-5.097
9400	0.8406	5.118	0.555	-33.743	-4.449	0.000	-5.111
9500	0.8533	5.160	0.638	-33.292	-4.399	0.000	-5.128
9600	0.8659	5.201	0.720	-32.850	-4.350	0.000	-5.146
9700	0.8784	5.241	0.800	-32.418	-4.302	0.000	-5.167
9800	0.8907	5.280	0.879	-31.994	-4.255	0.000	-5.188
9900	0.9029	5.319	0.956	-31.579	-4.209	0.000	-5.211
10000	0.9150	5.357	1.031	-31.173	-4.164	0.000	-5.234
10100	0.9270	5.394	1.105	-30.774	-4.120	0.000	-5.258
10200	0.9388	5.430	1.177	-30.383	-4.077	0.000	-5.282
10300	0.9506	5.465	1.248	-30.000	-4.034	0.000	-5.306
10400	0.9622	5.500	1.318	-29.624	-3.992	0.000	-5.331
10500	0.9737	5.534	1.386	-29.255	-3.952	0.000	-5.355
10600	0.9851	5.568	1.453	-28.894	-3.911	0.000	-5.380
10700	0.9964	5.601	1.519	-28.539	-3.872	0.000	-5.404
10800	1.0076	5.633	1.583	-28.190	-3.833	0.000	-5.428
10900	1.0187	5.665	1.647	-27.848	-3.795	0.000	-5.452
11000	1.0297	5.696	1.709	-27.513	-3.758	0.000	-5.475
11100	1.0405	5.726	1.770	-27.183	-3.722	0.000	-5.499
11200	1.0513	5.756	1.830	-26.859	-3.686	0.000	-5.522
11300	1.0620	5.786	1.889	-26.541	-3.650	0.000	-5.545
11400	1.0726	5.814	1.946	-26.229	-3.616	0.000	-5.567
11500	1.0831	5.843	2.003	-25.922	-3.582	0.000	-5.589
11600	1.0935	5.871	2.059	-25.620	-3.548	0.000	-5.611
11700	1.1039	5.898	2.114	-25.323	-3.515	0.000	-5.632
11800	1.1141	5.925	2.168	-25.032	-3.483	0.000	-5.654
11900	1.1243	5.951	2.221	-24.745	-3.451	0.000	-5.674
12000	1.1343	5.977	2.273	-24.464	-3.420	0.000	-5.695
12100	1.1443	6.003	2.324	-24.186	-3.389	0.000	-5.715
12200	1.1542	6.028	2.374	-23.914	-3.359	0.000	-5.735
12300	1.1640	6.053	2.424	-23.646	-3.329	0.000	-5.755
12400	1.1738	6.077	2.472	-23.382	-3.300	0.000	-5.774
12500	1.1834	6.101	2.520	-23.122	-3.271	0.000	-5.793
12600	1.1930	6.125	2.568	-22.867	-3.243	0.000	-5.811
12700	1.2025	6.148	2.614	-22.615	-3.215	0.000	-5.830
12800	1.2120	6.171	2.660	-22.368	-3.187	0.000	-5.848
12900	1.2213	6.193	2.705	-22.124	-3.160	0.000	-5.866
13000	1.2306	6.215	2.749	-21.884	-3.134	0.000	-5.883
13100	1.2398	6.237	2.792	-21.648	-3.108	0.000	-5.901
13200	1.2490	6.258	2.835	-21.415	-3.082	0.000	-5.918
13300	1.2581	6.279	2.878	-21.186	-3.056	0.000	-5.935
13400	1.2671	6.300	2.919	-20.961	-3.031	0.000	-5.951
13500	1.2760	6.320	2.960	-20.738	-3.007	0.000	-5.967

13600	1.2849	6.340	3.001	-20.519	-2.982	0.000	-5.983
13700	1.2937	6.360	3.041	-20.303	-2.958	0.000	-5.999
13800	1.3025	6.380	3.080	-20.091	-2.935	0.000	-6.015
13900	1.3112	6.399	3.118	-19.881	-2.911	0.000	-6.030
14000	1.3198	6.418	3.157	-19.674	-2.888	0.000	-6.045
14100	1.3283	6.437	3.194	-19.470	-2.866	0.000	-6.060
14200	1.3368	6.455	3.231	-19.270	-2.843	0.000	-6.075
14300	1.3453	6.473	3.268	-19.072	-2.821	0.000	-6.089
14400	1.3537	6.491	3.304	-18.876	-2.800	0.000	-6.104
14500	1.3620	6.509	3.339	-18.684	-2.778	0.000	-6.118
14600	1.3703	6.526	3.374	-18.494	-2.757	0.000	-6.131
14700	1.3785	6.543	3.408	-18.306	-2.737	0.000	-6.145
14800	1.3866	6.560	3.443	-18.122	-2.716	0.000	-6.159
14900	1.3947	6.577	3.476	-17.939	-2.696	0.000	-6.172
15000	1.4028	6.593	3.509	-17.759	-2.676	0.000	-6.185
15100	1.4108	6.610	3.542	-17.582	-2.656	0.000	-6.198
15200	1.4187	6.626	3.574	-17.407	-2.637	0.000	-6.211
15300	1.4266	6.641	3.606	-17.234	-2.617	0.000	-6.223
15400	1.4344	6.657	3.637	-17.063	-2.598	0.000	-6.236
15500	1.4422	6.672	3.668	-16.895	-2.580	0.000	-6.248
15600	1.4500	6.688	3.699	-16.728	-2.561	0.000	-6.260
15700	1.4576	6.703	3.729	-16.564	-2.543	0.000	-6.272
15800	1.4653	6.717	3.759	-16.402	-2.525	0.000	-6.284
15900	1.4729	6.732	3.788	-16.242	-2.507	0.000	-6.296
16000	1.4804	6.746	3.817	-16.084	-2.490	0.000	-6.307
16100	1.4879	6.761	3.846	-15.928	-2.472	0.000	-6.318
16200	1.4954	6.775	3.874	-15.774	-2.455	0.000	-6.330
16300	1.5028	6.789	3.902	-15.622	-2.438	0.000	-6.341
16400	1.5101	6.802	3.930	-15.472	-2.422	0.000	-6.352
16500	1.5174	6.816	3.957	-15.323	-2.405	0.000	-6.362
16600	1.5247	6.829	3.984	-15.176	-2.389	0.000	-6.373
16700	1.5319	6.842	4.011	-15.031	-2.373	0.000	-6.384
16800	1.5391	6.855	4.037	-14.888	-2.357	0.000	-6.394
16900	1.5462	6.868	4.063	-14.747	-2.341	0.000	-6.404
17000	1.5533	6.881	4.089	-14.607	-2.326	0.000	-6.414
17100	1.5604	6.894	4.114	-14.468	-2.310	0.000	-6.424
17200	1.5674	6.906	4.139	-14.332	-2.295	0.000	-6.434
17300	1.5744	6.918	4.164	-14.197	-2.280	0.000	-6.444
17400	1.5813	6.930	4.188	-14.063	-2.265	0.000	-6.454
17500	1.5882	6.942	4.213	-13.931	-2.251	0.000	-6.463
17600	1.5951	6.954	4.237	-13.801	-2.236	0.000	-6.473
17700	1.6019	6.966	4.260	-13.672	-2.222	0.000	-6.482
17800	1.6087	6.977	4.284	-13.544	-2.208	0.000	-6.491
17900	1.6154	6.989	4.307	-13.418	-2.193	0.000	-6.500
18000	1.6221	7.000	4.330	-13.294	-2.180	0.000	-6.509
18100	1.6288	7.011	4.352	-13.170	-2.166	0.000	-6.518
18200	1.6354	7.022	4.375	-13.048	-2.152	0.000	-6.527
18300	1.6420	7.033	4.397	-12.928	-2.139	0.000	-6.536
18400	1.6485	7.044	4.419	-12.809	-2.126	0.000	-6.544
18500	1.6551	7.055	4.440	-12.691	-2.113	0.000	-6.553
18600	1.6616	7.065	4.462	-12.574	-2.100	0.000	-6.561
18700	1.6680	7.076	4.483	-12.458	-2.087	0.000	-6.570
18800	1.6744	7.086	4.504	-12.344	-2.074	0.000	-6.578
18900	1.6808	7.096	4.524	-12.231	-2.062	0.000	-6.586
19000	1.6871	7.107	4.545	-12.119	-2.049	0.000	-6.594
19100	1.6935	7.117	4.565	-12.009	-2.037	0.000	-6.602
19200	1.6997	7.126	4.585	-11.899	-2.025	0.000	-6.610
19300	1.7060	7.136	4.605	-11.791	-2.013	0.000	-6.618
19400	1.7122	7.146	4.625	-11.684	-2.001	0.000	-6.625
19500	1.7184	7.155	4.644	-11.577	-1.989	0.000	-6.633
19600	1.7245	7.165	4.663	-11.472	-1.977	0.000	-6.640
19700	1.7307	7.174	4.682	-11.368	-1.966	0.000	-6.648
19800	1.7368	7.184	4.701	-11.265	-1.954	0.000	-6.655
19900	1.7428	7.193	4.720	-11.163	-1.943	0.000	-6.663
20000	1.7489	7.202	4.738	-11.063	-1.932	0.000	-6.670

MAXIMUM $T_{\text{eff}} = 9000 \text{ K}$

