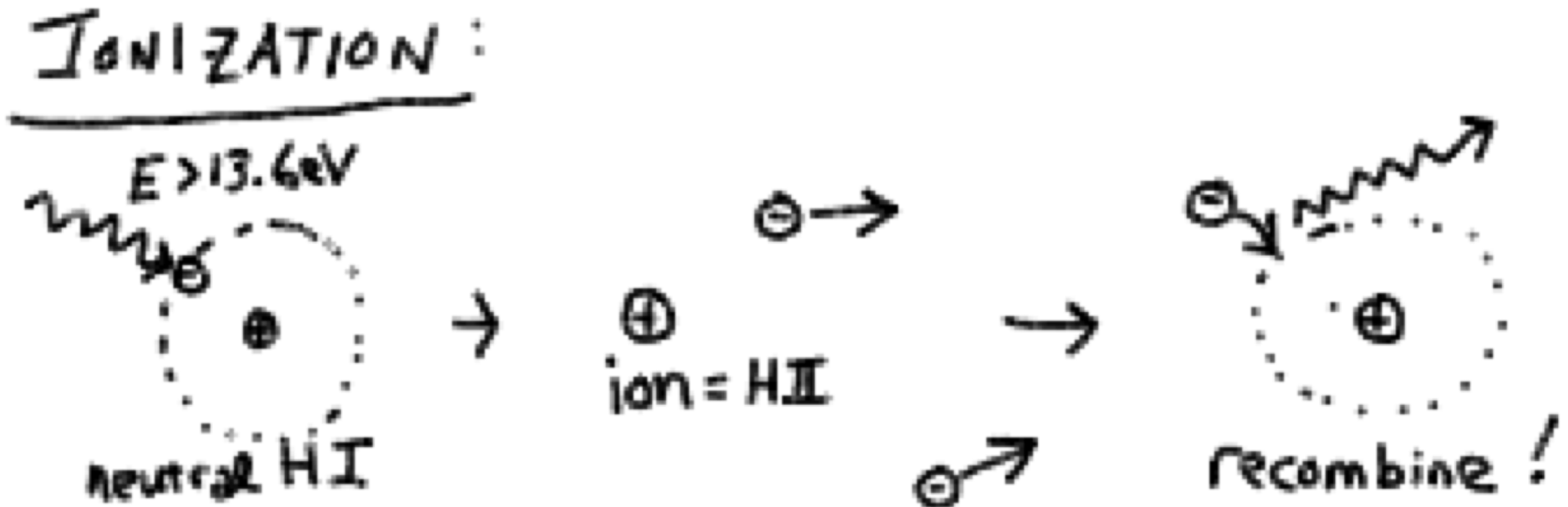


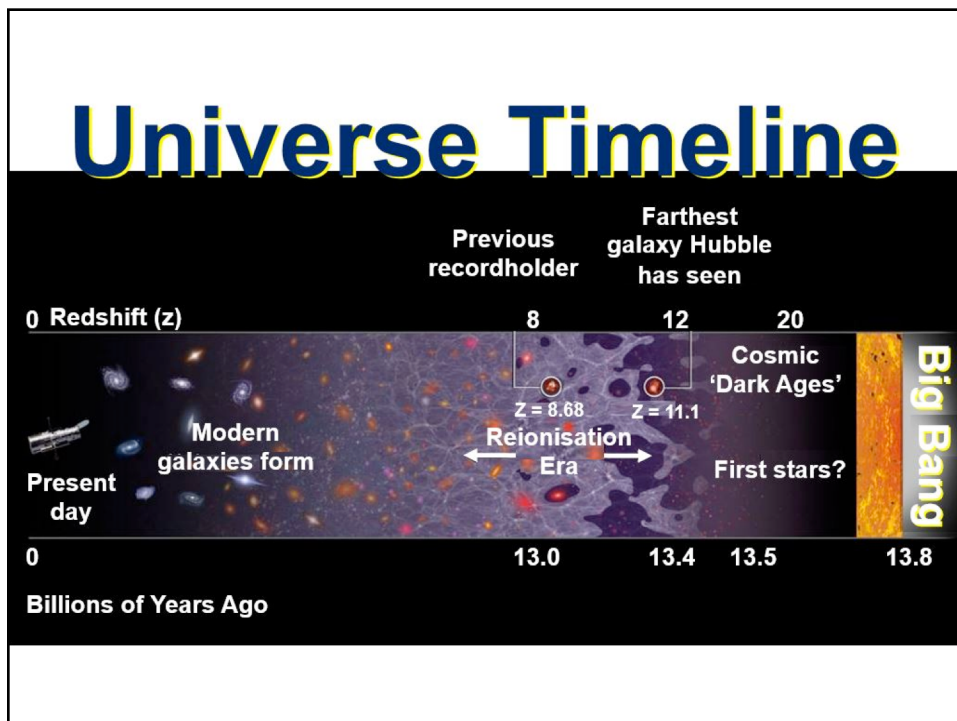
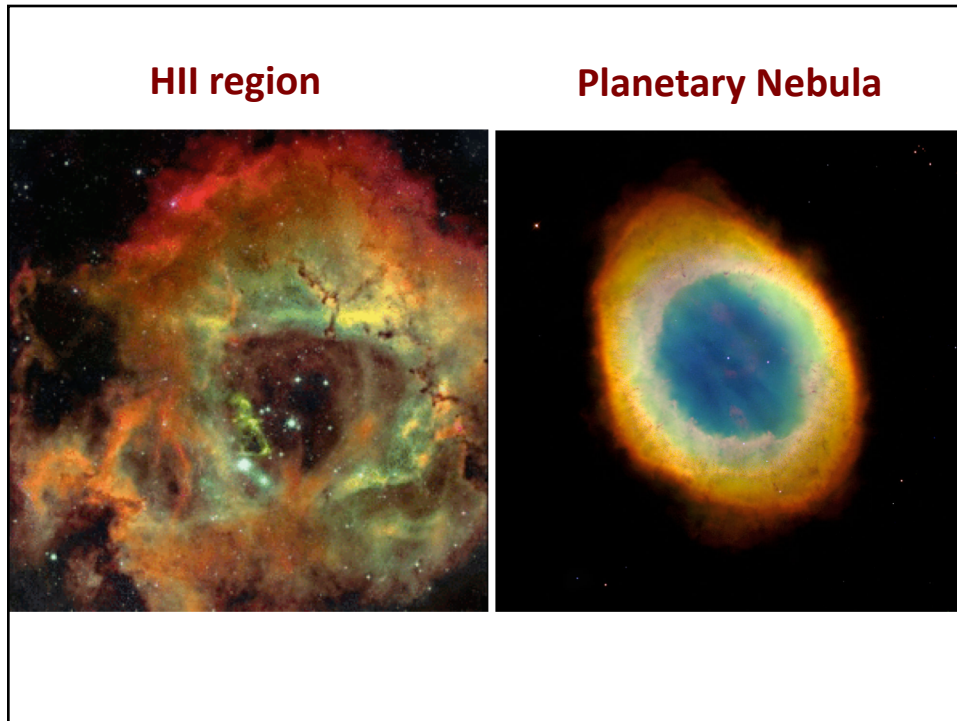
# Photoionization and Recombination

**Photoionization**

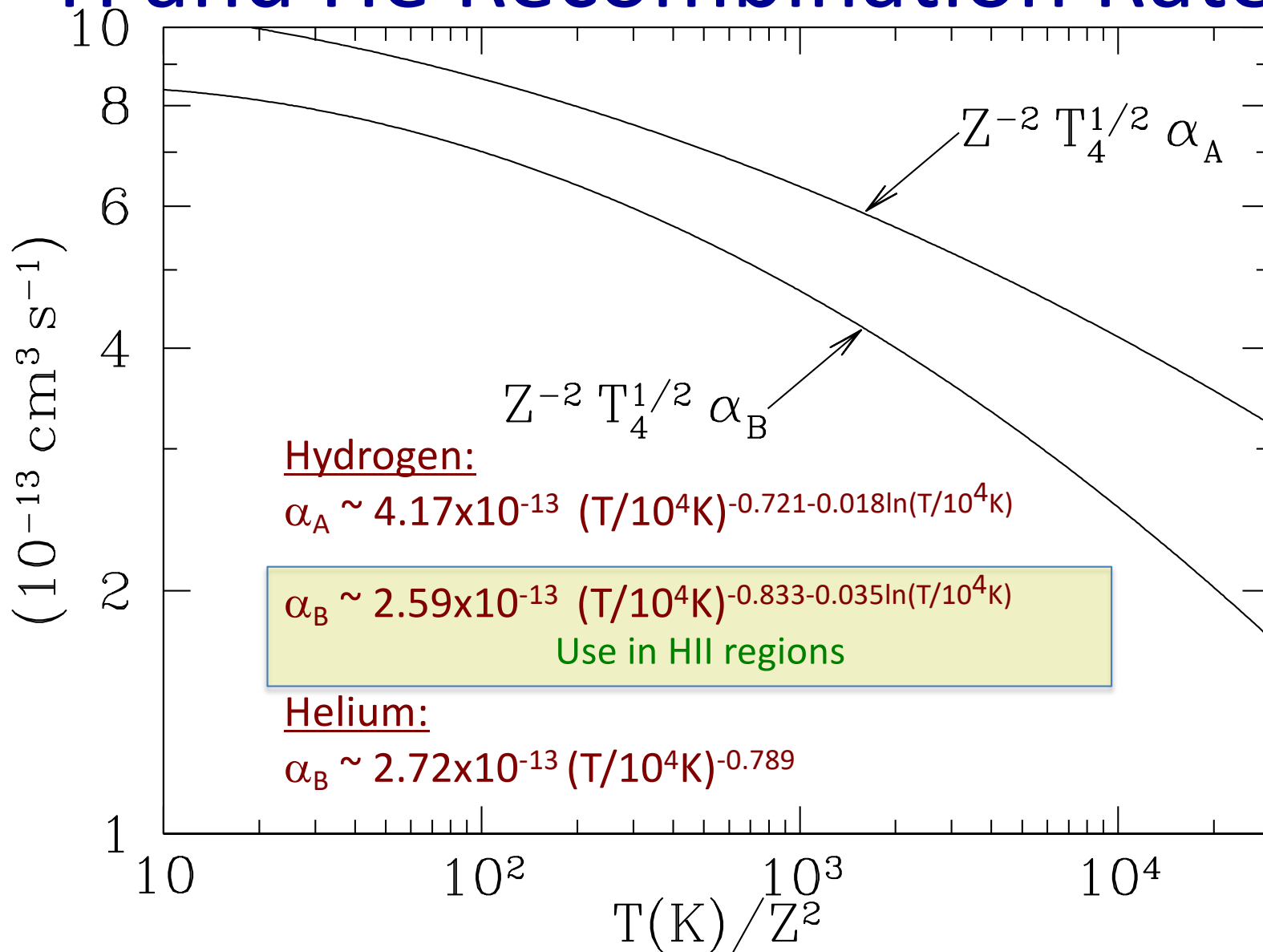


**Radiative recombination**





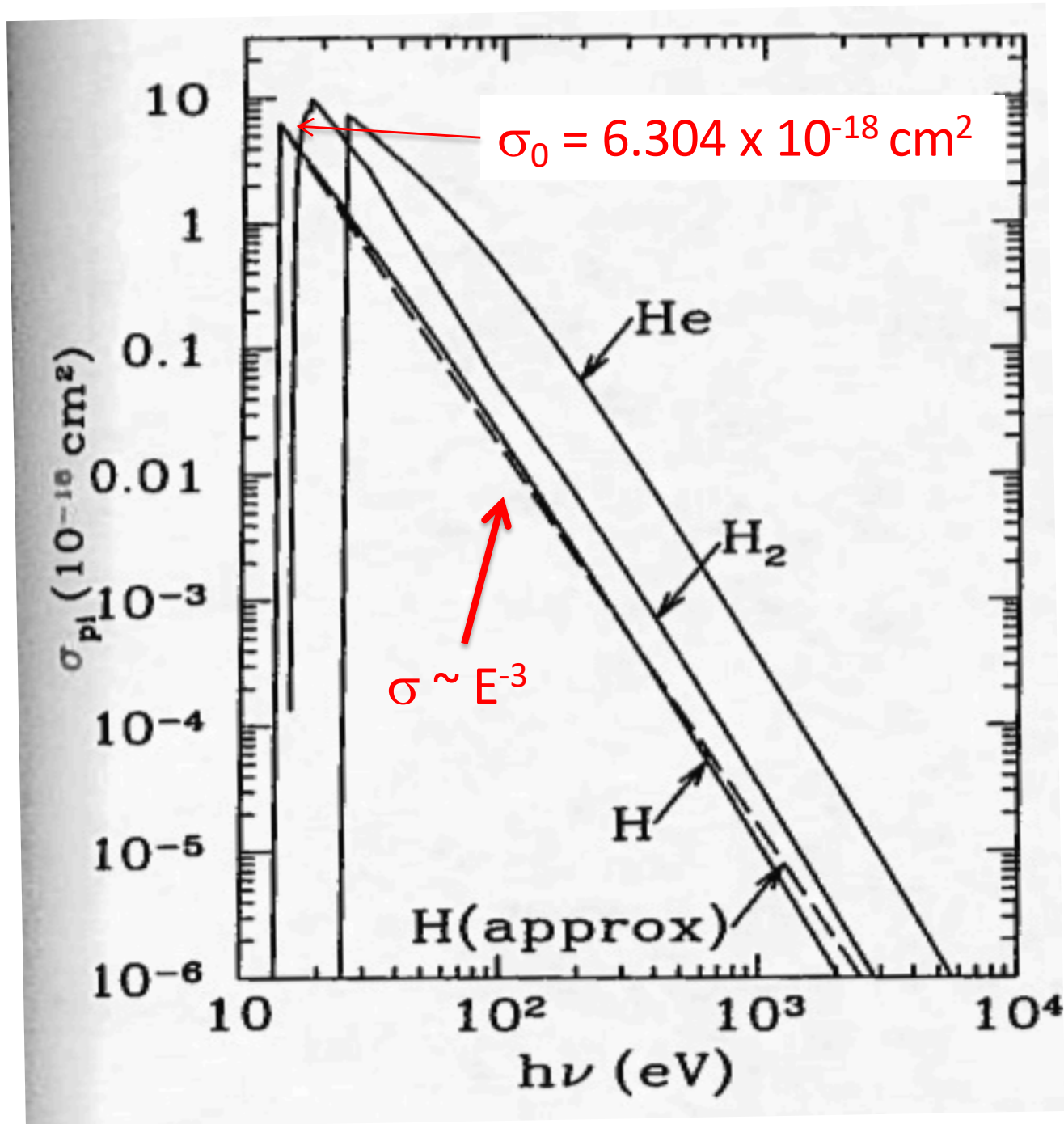
# H and He Recombination Rates



**Figure 14.1** Case A and Case B rate coefficients  $\alpha_A$  and  $\alpha_B$  for radiative recombination of hydrogen, multiplied by  $T_4^{1/2}$  (equations 14.5, 14.6). Note that no single power-law fit can reproduce the  $T$ -dependence over a wide range in  $T$ .

# Photoionization Cross-section

Photoionization Cross-section  $10^{-18} \text{ cm}^2$





# Ionizing Properties of Massive Stars

SpTp	$M/M_{\odot}$	$T_{\text{eff}}(\text{K})$	$\log_{10}(Q_0/\text{s}^{-1})^b$	$Q_1/Q_0^c$	$\log_{10}(L/L_{\odot})^d$
O3V	58.0	44850	49.64	0.251	5.84
O4V	46.9	42860	49.44	0.224	5.67
O5V	38.1	40860	49.22	0.209	5.49
O5.5V	34.4	39870	49.10	0.204	5.41
O6V	31.0	38870	48.99	0.186	5.32
O6.5V	38.0	37870	48.88	0.162	5.23
O7V	25.3	36870	48.75	0.135	5.14
O7.5V	22.9	35870	48.61	0.107	5.05
O8V	20.8	34880	48.44	0.072	4.96
O8.5V	18.8	33880	48.27	0.0347	4.86
O9V	17.1	32830	48.06	0.0145	4.77
O9.5V	15.6	31880	47.88	0.0083	4.68
O3III	56.0	44540	49.77	0.234	5.96
O4III	47.4	42420	49.64	0.204	5.85
O5III	40.4	40310	49.48	0.186	5.73
O5.5III	37.4	39250	49.40	0.170	5.67
O6III	34.5	38190	49.32	0.158	5.61
O6.5III	32.0	37130	49.23	0.141	5.54
O7III	29.6	36080	49.13	0.129	5.48
O7.5III	27.5	35020	49.01	0.105	5.42
O8III	25.5	33960	48.88	0.072	5.35
O8.5III	23.7	32900	48.75	0.0417	5.28
O9III	22.0	31850	48.65	0.0257	5.21
O9.5III	20.6	30790	48.42	0.0129	5.15
O3I	67.5	42230	49.78	0.204	5.99
O4I	58.5	40420	49.70	0.182	5.93
O5I	50.7	38610	49.62	0.158	5.87
O5.5I	47.3	37710	49.58	0.151	5.84
O6I	44.1	36800	49.52	0.141	5.81
O6.5I	41.2	35900	49.46	0.132	5.78
O7I	38.4	34990	49.41	0.115	5.75
O7.5I	36.0	34080	49.31	0.100	5.72
O8I	33.7	33180	49.25	0.079	5.68
O8.5I	31.5	32270	49.19	0.065	5.65
O9I	29.6	31370	49.11	0.0363	5.61
O9.5I	27.8	30460	49.00	0.0224	5.57

<sup>a</sup> After Martins et al. (2005).

<sup>b</sup>  $Q_0$  = rate of emission of  $h\nu > 13.6$  eV photons.

<sup>c</sup>  $Q_1$  = rate of emission of  $h\nu > 24.6$  eV photons.

<sup>d</sup>  $L$  = total electromagnetic luminosity.

# Ionization Potentials (eV)

Element	I→II	II→III	III→IV	IV→V	V→VI	VI→VII	VII→VIII
1 H	13.5984						
2 He	24.5874	54.416					
3 Li	5.3917	75.640	122.454				
4 Be	9.3227	18.211	153.894	217.719			
5 B	8.2980	25.155	37.931	259.375	340.226		
6 C	11.2603	24.383	47.888	64.494	392.089	489.993	
7 N	14.5341	29.601	47.449	77.474	97.890	552.072	667.046
8 O	13.6181	35.121	54.936	77.414	113.899	138.120	739.293
9 F	17.4228	34.971	62.708	87.140	114.243	147.163	185.189
10 Ne	21.5645	40.963	63.423	97.117	126.247	154.214	207.271
11 Na	5.1391	47.286	71.620	98.91	138.40	172.183	208.50
12 Mg	7.6462	15.035	80.144	109.265	141.270	186.76	225.02
13 Al	5.9858	18.829	28.448	119.992	153.825	190.477	241.76
14 Si	8.1517	16.346	33.493	45.142	166.767	205.267	246.481
15 P	10.4867	19.769	30.203	51.444	65.025	220.422	263.57
16 S	10.3600	23.338	34.790	47.222	72.594	88.053	280.948
17 Cl	12.9676	23.814	39.911	53.465	67.819	97.030	114.201
18 Ar	15.7596	27.630	40.735	59.686	75.134	91.00	124.328
19 K	4.3407	31.628	45.806	60.913	82.66	99.4	117.6
20 Ca	6.1132	11.872	50.913	67.27	84.51	108.8	127.2