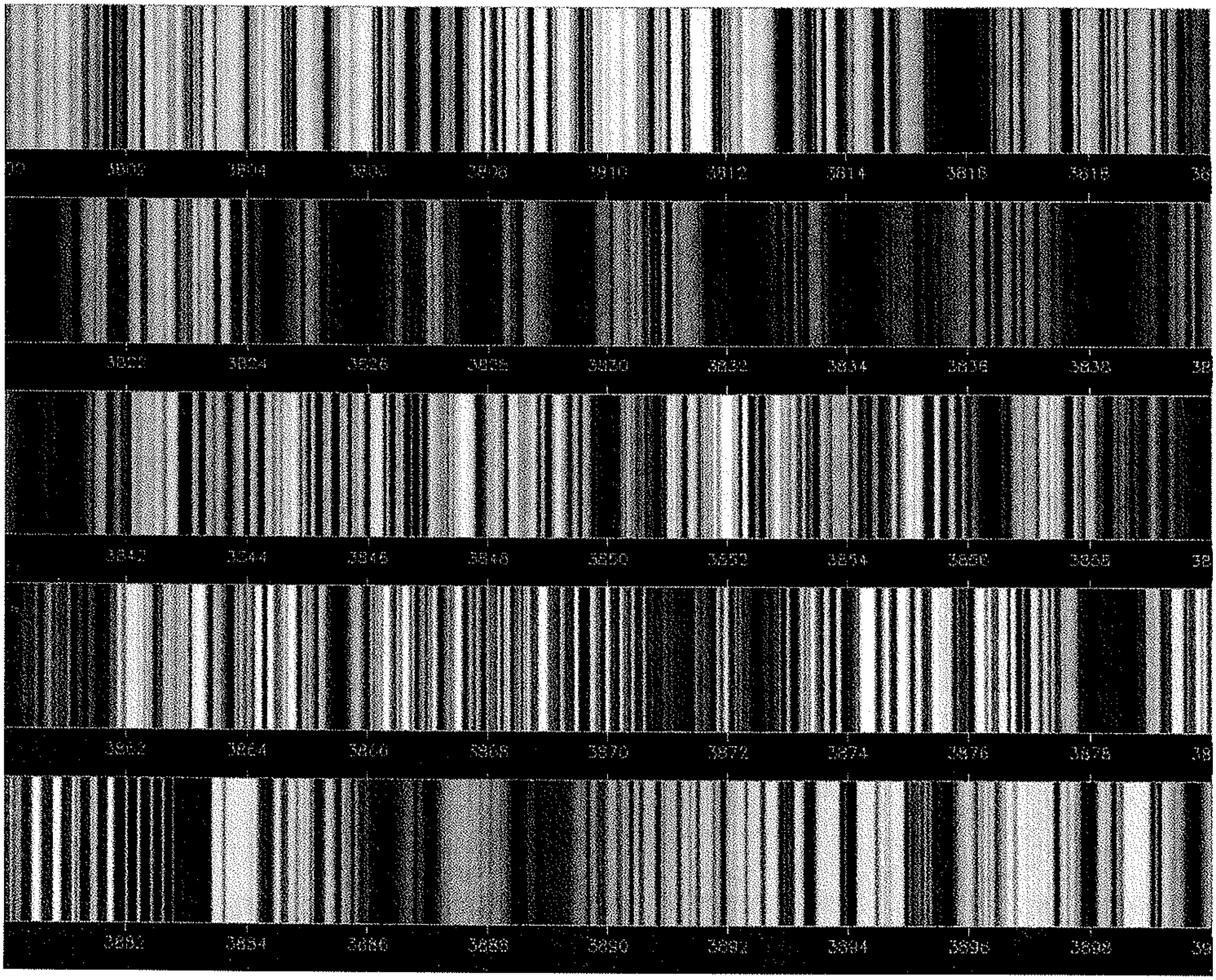
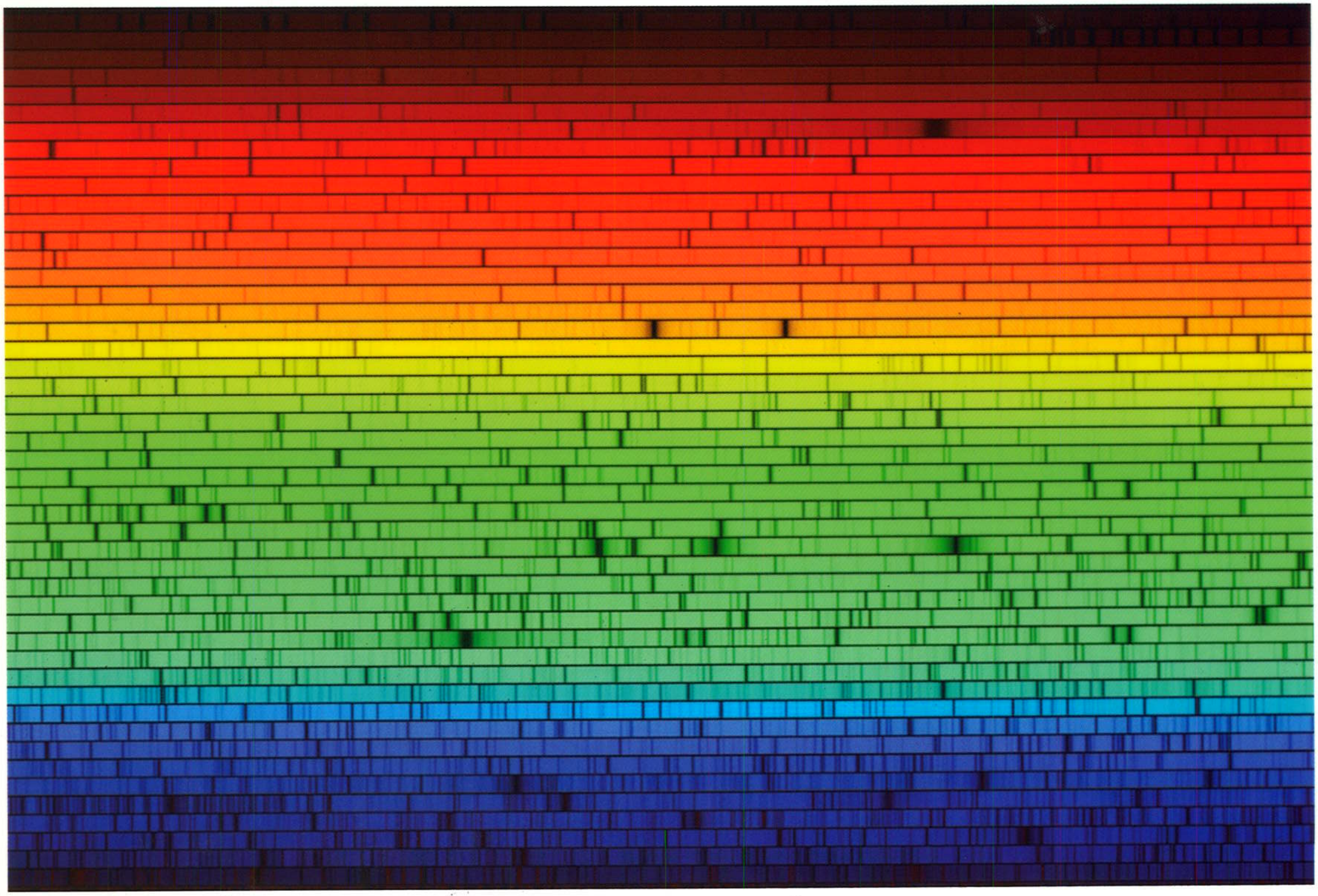


3802 3804 3806 3808 3810 3812 3814 3816 3818
3822 3824 3826 3828 3830 3832 3834 3836 3838
3842 3844 3846 3848 3850 3852 3854 3856 3858
3862 3864 3866 3868 3870 3872 3874 3876 3878
3882 3884 3886 3888 3890 3892 3894 3896 3898

Figure 4.4 Solar Spectrum



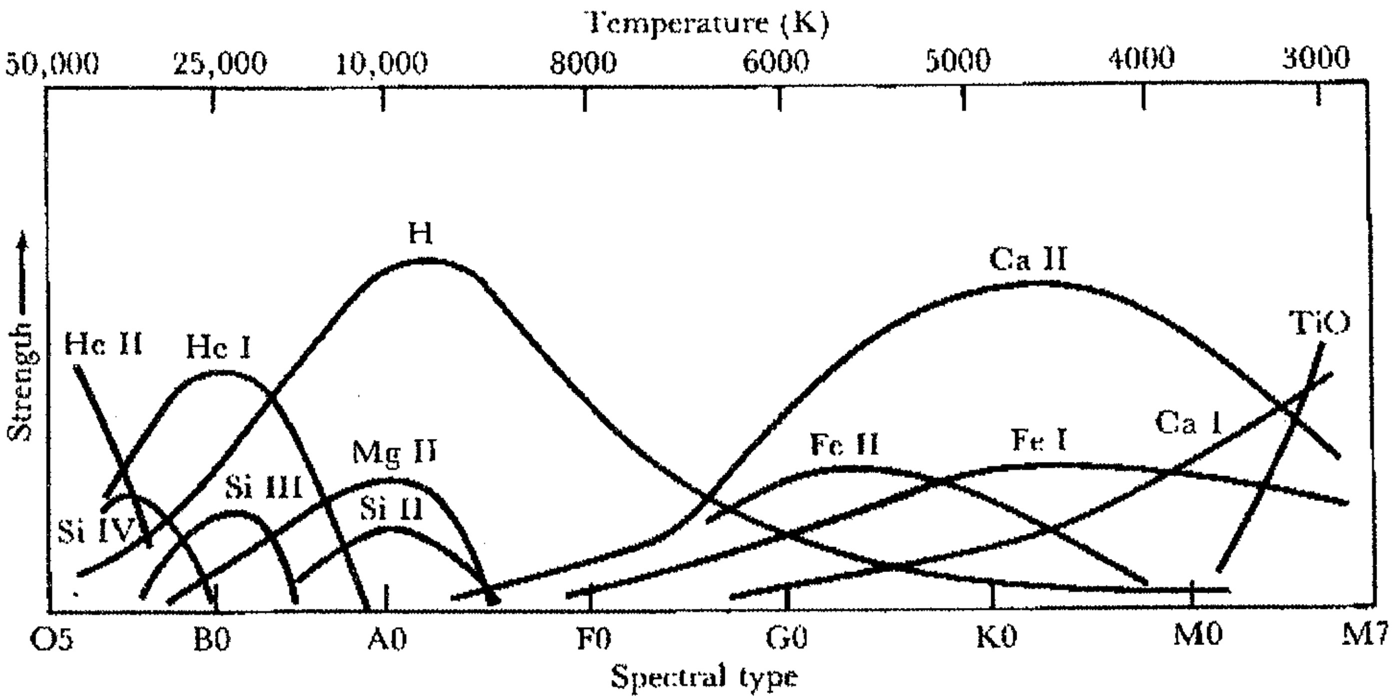
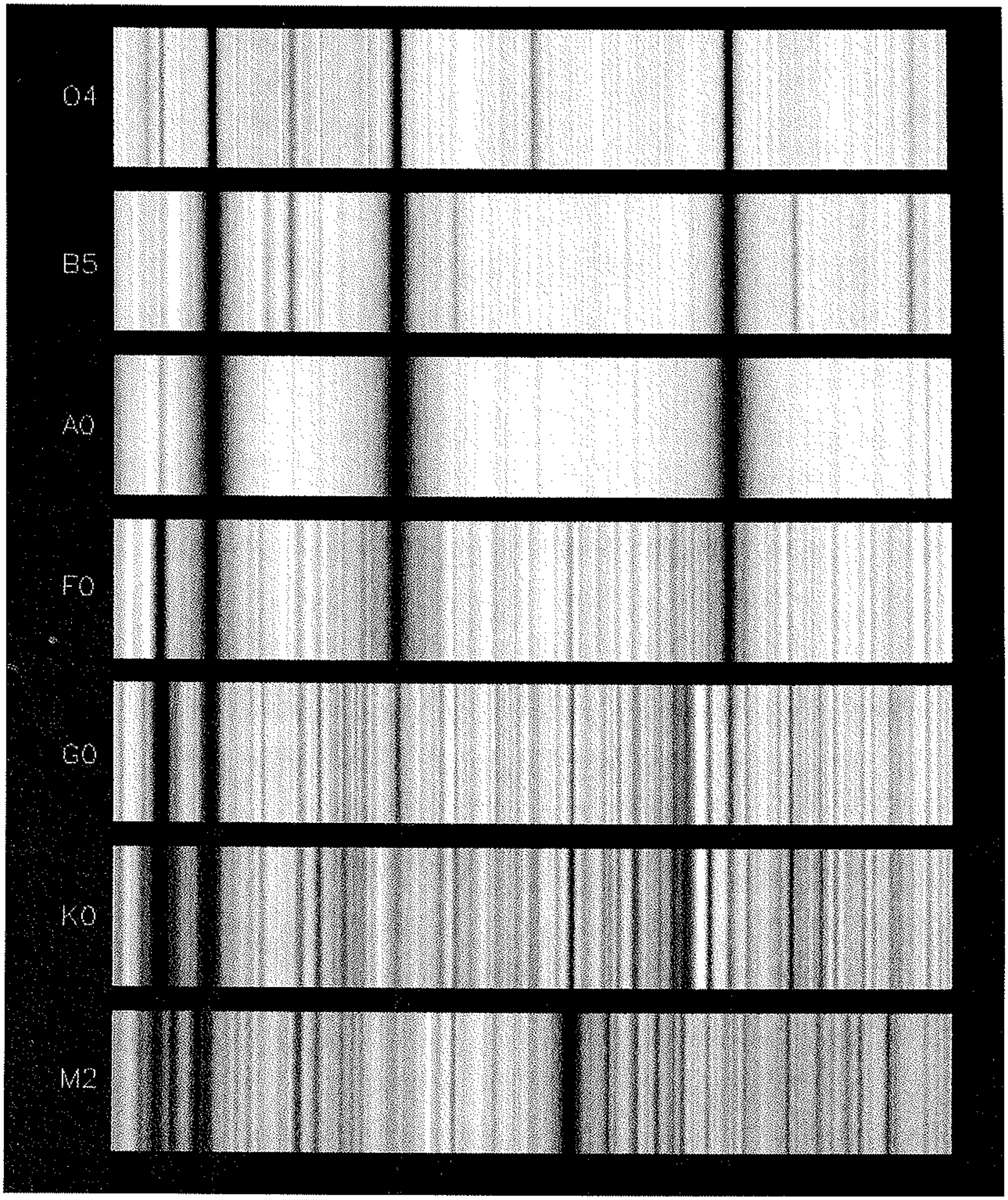
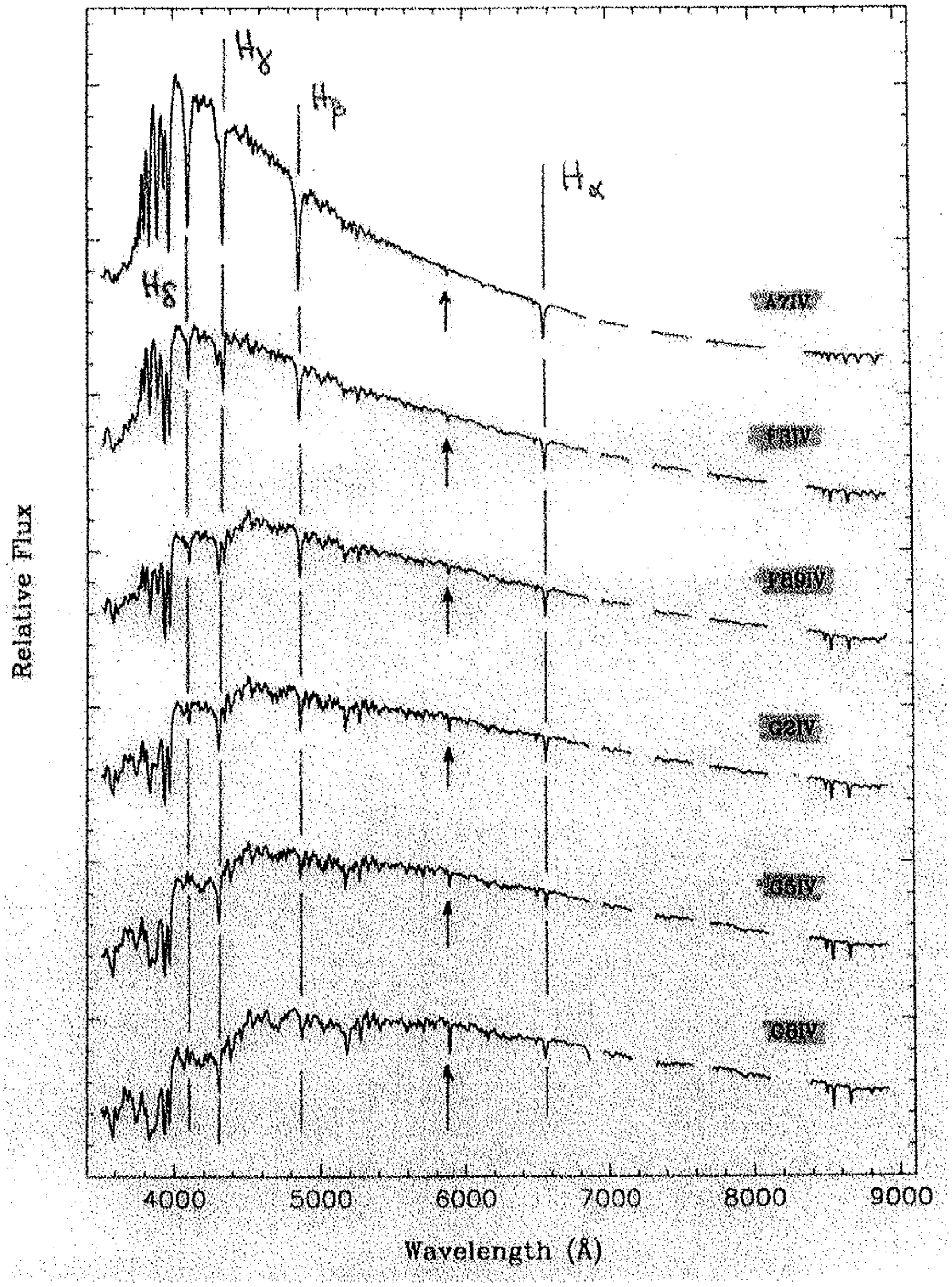
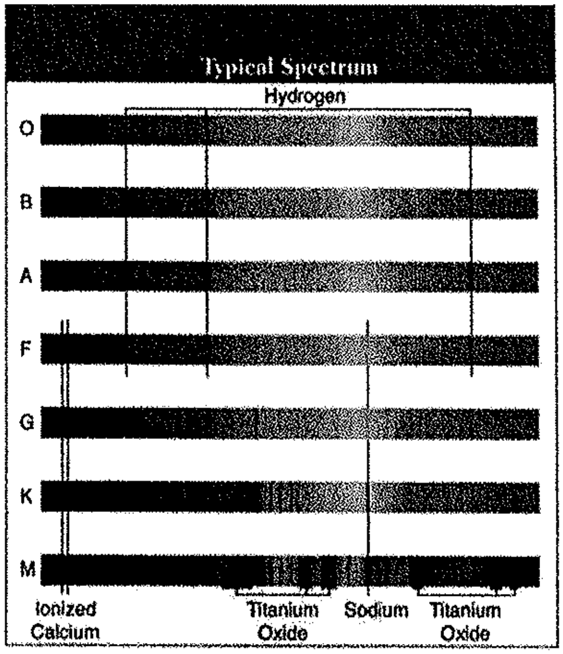


Figure 12-9
Kaufmann
DISCOVERING THE UNIVERSE
Second Edition


O4
B5
A0
F0
G0
K0
M2



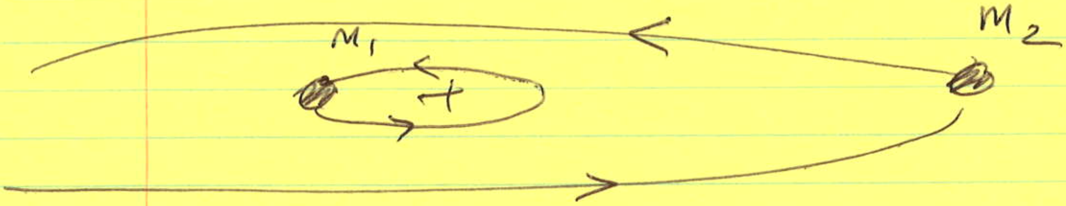
Hγ
Hβ
Hα
Hδ
A7IV
F8IV
F89IV
G2IV
G5IV
G8IV
Relative Flux
4000
5000
6000
7000
8000
9000
Wavelength (Å)



Spectral Type	Example(s)	Temperature Range	Key Absorption Line Features	Brightest Wavelength (color)
O	Stars of Orion's Belt	>30,000	Lines of ionized helium, weak hydrogen lines	<97 nm (ultraviolet)*
B	Rigel	30,000 K–10,000 K	Lines of neutral helium, moderate hydrogen lines	97–290 nm (ultraviolet)*
A	Sirius	10,000 K–7,500 K	Very strong hydrogen lines	290–390 nm (violet)*
F	Polaris	7,500 K–6,000 K	Moderate hydrogen lines, moderate lines of ionized calcium	390–480 nm (blue)*
G	Sun, Alpha Centauri A	6,000 K–5,000 K	Weak hydrogen lines, strong lines of ionized calcium	480–580 nm (yellow)
K	Arcturus	5,000 K–3,500 K	Lines of neutral and singly ionized metals, some molecules	580–830 nm (red)
M	Betelgeuse, Proxima Centauri	<3,500 K	Molecular lines strong	>830 nm (infrared)

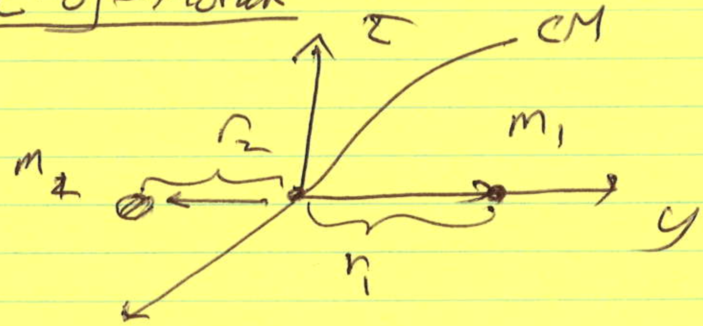
* All stars above 6,000 K look more or less white to the human eye because they emit plenty of radiation at all visible wavelengths.

Stellar Masses From Binary ☆s



a_1 a_2 semi-major axes of orbits

E-of-Motion



$\vec{r} = \vec{r}_1 - \vec{r}_2$

relative separation

$\vec{r}_1$ & $\vec{r}_2$ are always opposite

① $\underline{m_1}$ $\quad m_1 \ddot{\vec{r}}_1 = -G \dfrac{m_1 m_2 \vec{r}}{r^3}$

② $\underline{m_2}$ $\quad m_2 \ddot{\vec{r}}_2 = +G \dfrac{m_1 m_2 \vec{r}}{r^3}$

subtract ② from ①

$$(\ddot{\vec{r}}_1 - \ddot{\vec{r}}_2) = -G \frac{\hat{r}}{r^2}(m_2 + m_1)$$

$$\boxed{\ddot{\vec{r}} = -G(m_1 + m_2)\frac{\hat{r}}{r^2}}$$

multiply by $m_1 m_2$ & divide by $(m_1 + m_2)$

$$\Rightarrow \frac{m_1 m_2}{(m_1 + m_2)} \ddot{\vec{r}} = -\frac{G m_1 m_2 \hat{r}}{r^2}$$

define reduced mass, $\mu = \frac{m_1 m_2}{m_1 + m_2}$

$$\Rightarrow \boxed{\mu \ddot{\vec{r}} = -\frac{G m_1 m_2}{r^2}\hat{r}}$$

2-body problem looks like 1 body problem w/ m replaced by μ and $\vec{r}$ replacing $\vec{r}_1, \vec{r}_2$

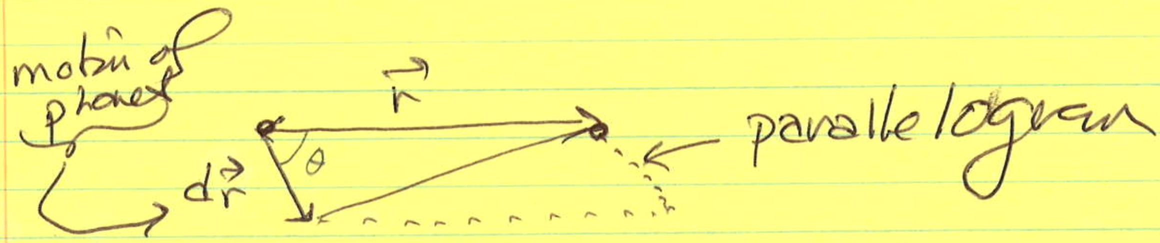
Kepler's laws

✓ (I) orbits are ellipses w/ Sun at 1 focus

(II) Equal Areas in Equal times

(III) Harmonic law, $P^2(y) = a^3(A.U.)$

✓ (II) Equal areas



$$\Rightarrow \frac{\vec{r} \times d\vec{r}}{2} = \text{area of triangle} = d\vec{A}$$

for a given time interval dt, $d\vec{A} = \frac{1}{2}\left(\vec{r} \times \frac{d\vec{r}}{dt}\right) dt$

if $d\vec{A}$ is constant for given dt

$\Rightarrow \left(\vec{r} \times \frac{d\vec{r}}{dt}\right)$ is also constant

$$\Rightarrow \vec{r} \times m_p \left(\frac{d\vec{r}}{dt} \right) = \text{constant}$$

$$\underline{\vec{r} \times \vec{p} = \text{constant} = \text{angular momentum}}$$

✓ (III) $\mu \ddot{\vec{R}} = -G \frac{m_1 m_2}{R^2} \hat{R}$

$$\Rightarrow \frac{\mu (R\Omega)^2}{R} - \frac{G m_1 m_2}{R^2} = 0$$

$\vec{V} = \vec{\Omega} \times \vec{R}$,
$|\vec{V}| = (\Omega R)$

centrifugal term ↑ ↑ force

$$R^3 = G \frac{m_1 m_2}{\mu} \frac{1}{\Omega^2} = \frac{G(m_1 + m_2) P^2}{4\pi^2}$$

if $m_1 = M_\odot$, $m_2 = m_p \Rightarrow M_\odot >> m_p$

and $\boxed{R^3 \simeq \frac{G M_\odot}{4\pi^2} P^2}$

Kepler's Harmonic Law