Carroll & Ostlie - An Introduction to Modern Astrophysics

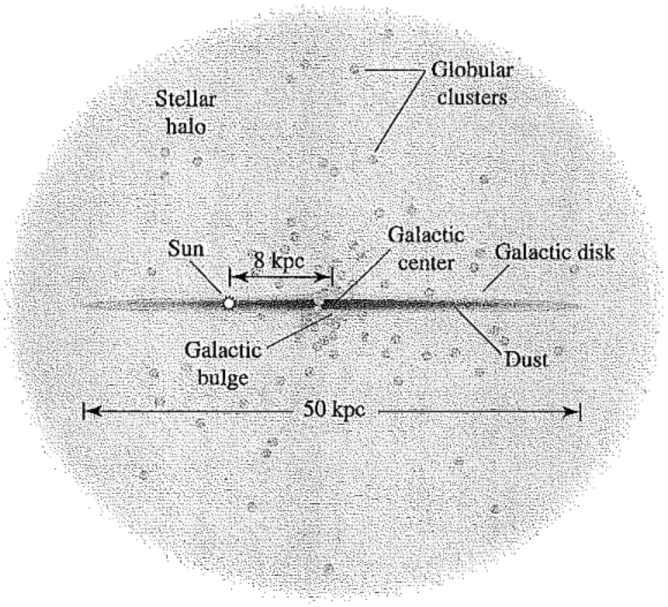

FIGURE 24.6 An edge-on diagram of the Galaxy, not strictly to scale; see Table 24.1.

common use of 8 kpc in the literature, in this text we will adopt a value of

$$R_0 = 8 \text{ kpc} \tag{24.8}$$

for the solar Galactocentric distance.

The full diameter of the disk, including the dust, gas, and stars, is believed to be roughly 50 kpc, with estimates ranging from 40 to 50 kpc. Furthermore, it appears that the disk may not be completely cylindrically symmetric. Rather, the disk may be somewhat elliptical, with a ratio of the lengths of the minor and major axes of about 0.9. The Sun is probably located near the major axis of the disk. The **solar circle** is defined to be a perfect circle of radius R_0.

The Structure of the Thin and Thick Disks

The disk is actually composed of two major components. The **thin disk**, which is composed of relatively young stars, dust, and gas, has a vertical scale height of $z_{\text{thin}} \simeq 350$ pc and is the region of current star formation (recall that one scale height is the distance over which the number density decreases by e^{-1}). A portion of the thin disk (sometimes referred to as the young thin disk) also corresponds to the central plane of the Galactic dust and gas distribution; it has a scale height of perhaps 90 pc, although some researchers have found a scale height as small as 35 pc. The **thick disk**, which is probably an older population of stars, has a scale height of approximately $z_{\text{thick}} \simeq 1000$ pc. The number of stars per unit volume in the thick disk is only about 8.5% of that in the thin disk at the Galactic midplane. When the thin and thick disks are combined, empirical fits to the stellar number density derived from star count data give

$$n(z, R) = n_0 \left(e^{-z/z_{\text{thin}}} + 0.085e^{-z/z_{\text{thick}}}\right) e^{-R/h_R}, \tag{24.9}$$

TABLE 24.1 Approximate Values for Various Parameters Associated with the Components of the Milky Way Galaxy. Definitions and details are discussed in the text.

	Disks		
	Neutral Gas	Thin Disk	Thick Disk
M (10^{10} $M_\odot$)	0.5[a]	6	0.2 to 0.4
L_B (10^{10} $L_\odot$)[b]	—	1.8	0.02
M/L_B ($M_\odot/L_\odot$)	—	3	—
Radius (kpc)	25	25	25
Form	e^{-z/h_z}	e^{-z/h_z}	e^{-z/h_z}
Scale height (kpc)	< 0.1	0.35	1
σ_w (km s^{-1})	5	16	35
[Fe/H]	$> +0.1$	-0.5 to $+0.3$	-2.2 to -0.5
Age (Gyr)	$\lesssim 10$	8[c]	10[d]

	Spheroids		
	Central Bulge[e]	Stellar Halo	Dark-Matter Halo
M (10^{10} $M_\odot$)	1	0.3	190^{+360}_{-170}[f]
L_B (10^{10} $L_\odot$)[b]	0.3	0.1	0
M/L_B ($M_\odot/L_\odot$)	3	~ 1	—
Radius (kpc)	4	> 100	> 230
Form	boxy with bar	$r^{-3.5}$	$(r/a)^{-1}(1+r/a)^{-2}$
Scale height (kpc)	0.1 to 0.5[g]	3	170
σ_w (km s^{-1})	55 to 130[h]	95	—
[Fe/H]	-2 to 0.5	< -5.4 to -0.5	—
Age (Gyr)	< 0.2 to 10	11 to 13	~ 13.5

[a] $M_{\rm dust}/M_{\rm gas} \simeq 0.007$.

[b] The total luminosity of the Galaxy is $L_{B,\rm tot} = 2.3 \pm 0.6 \times 10^{10}$ $L_\odot$, $L_{\rm bol,tot} = 3.6 \times 10^{10}$ $L_\odot$ ($\sim 30\%$ in IR).

[c] Some open clusters associated with the thin disk may exceed 10 Gyr.

[d] Major star formation in the thick disk may have occurred 7–8 Gyr ago.

[e] The mass of the black hole in Sgr A* is $M_{\rm bh} = 3.7 \pm 0.2 \times 10^6$ $M_\odot$.

[f] $M = 5.4^{+0.2}_{-3.6} \times 10^{11}$ $M_\odot$ within 50 kpc of the center.

[g] Bulge scale heights depend on age of stars: 100 pc for young stars, 500 pc for old stars.

[h] Dispersions increase from 55 km s^{-1} at 5 pc to 130 km s^{-1} at 200 pc.

where z is the vertical height above the midplane of the Galaxy, R is the radial distance[2] from the Galactic center, $h_R > 2.25$ kpc is the disk scale length, and $n_0 \sim 0.02$ stars pc^{-3} for the absolute magnitude range $4.5 \leq M_V \leq 9.5$. It should be pointed out that the relative density coefficient, the scale heights, and the disk scale length are all somewhat uncertain;

[2] In general, we reserve the use of R to denote the cylindrical coordinate radius within the disk and the use of r to represent the spherical coordinate radius, both measured from the Galactic center.