ASTR 792 HW 1

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1a

Let

$$M_{gal} = 4 \cdot 10^9 M_\odot \qquad M_\odot \approx 2 \cdot 10^{30} kg$$

$$r_{disk} = 15\ kpc = 15000\ pc \qquad H_{disk} = 200pc \qquad \frac{He}{H} = .1$$

$$V_{gas} = \pi \cdot r_{disk} H_{disk} = \pi (1.5 * 10^4)^2 (200\ pc) = 1.41 \cdot 10^(11) pc^3$$

The total mass fraction of hydrogen is

$$f(H) = \frac{N_H}{N_{total}} = \frac{N_H}{N_H + N_{He}} = \frac{N_H}{N_H + .1 N_H}$$
$$= \frac{1}{1 + .1} \approx .91$$

The mass of H nucleus - $1.67 \cdot 10^{-27}\ kg$, so the number density of hydrogen nuclei n_H is

$$n_H = \frac{7.2 \cdot 10^{39} kg}{1.67 \cdot 10^{-27} kg \cdot 1.41 \cdot 10^{11} pc^3} = 3.1 \cdot 10^{55} pc^{-3}$$

1b

The total mass of dust = $.007 M_{gas}$

$$\rightarrow 7 \cdot 10^{-3} \cdot 4 \cdot 10^9\ M_\odot = 2.8 \cdot 10^7 M_\odot \cdot 2 \cdot 10^{30} kg$$
$$\approx 5.6 \cdot 10^{37}\ kg = 5.6 \cdot 10^{40} g$$

$\rho_{dust} = 2\ g\ cm^{-3}$ and $r_{dust} = .1\ \mu m = 10^{-5}\ cm$

$$\rightarrow m_{dust} = V \cdot \rho_{dust} = (10^{-5}\ cm)(2\ g\ cm^{-3})$$
$$= 2 \cdot 10^{-5}\ g \rightarrow N_{dust} = \frac{M_{total}}{m_{dust}} = \frac{5.6 \cdot 10^{40}}{2 \cdot 10^{-5}\ g}$$
$$= 2.8 \cdot 10^{45}\ dust\ grains$$

1d

$V_{clouds} = \frac{4\pi}{3}(15\ pc^3) = 1.41 \cdot 10^4\ pc^3$
$V_{gal} = 1.41 \cdot 10^{11}\ pc^3$
$n(H_2) = 100cm^{-3} \rightarrow n(H) = 200\ cm^{-3}$
$n(He) = .1 \cdot 200\ cm^{-3} = 20cm^{-3}$

$$\rightarrow \rho_{cloud} = n(H) \cdot m_H + n(He)m_{He}$$
$$200cm^{-3} \cdot (1.67 \cdot 10^{27}) + 20cm^{-3} \cdot 4 \cdot (1.67 \cdot 10^{27})$$
$$= 4.7 \cdot 10^{-25} kg\ cm^{-3} \rightarrow M_{cloud} = 4.7 \cdot 10^{-25}\ kg\ cm^{-3} \cdot 1.41 \cdot 10^4\ pc^3$$
$$\rightarrow 4.7 \cdot 10^{-25}\ kg\ cm^{-3} \cdot 4.1 \cdot 10^{59} cm^3$$
$$= 19.3 \cdot 10^{34}\ kg = 1.9 \cdot 10^{35}\ kg$$

Thr number of cloud N_{cloud} is

$$N_{cloud} = \frac{.3 \cdot M_{gas}}{M_{cloud}}$$
$$= \frac{.3 \cdot 4 \cdot 10^9 \cdot 2 \cdot 10^30}{1.9 \cdot 10^{35}}$$
$$= 1.23 \cdot 10^4\ or \approx 12000\ clouds$$