ASTR507 HW2

problem 2

In [2]:
```
from numpy import pi,exp,sqrt,conj,array
from astropy import units as u
```

Initialize Constants and test out units package.

In [3]:
```
m = 9.1 * 10**(-28)*u.gram #mass of electron
k = 1.4 * 10**(-16)*u.erg / u.Kelvin #boltzmann constant
T = 10**(6)*u.Kelvin #temperature
#V = (40 * 10**(3)*u.parsec**3).to(u.centimeter**3)
n = 0.01 * u.centimeter**(-3) #density
c = 2.99 * 10**10 *u.cm / u.s #speed of light
```

Define the normalizion constants.

In [4]:
```
A = (4*pi*m**(3./2.)*n)/(2*pi*k*T)**(3./2.)
b = 0.5*m/(k*T)
```

Using the given solution to the integral we are solving equation: $\frac{Axe^{-bx^2}}{2b} = 1$ since we are solving for the single fastest electron in the distribution.

In [5]:
```
print "A = ",(A*(u.cm/u.s)**2)
print "b = ",(b)
```

```
A =  1.32223940717e-28 g(3/2) / (cm erg(3/2) s2)
b =  3.25e-18 g / erg
```

Stuff in front:

In [6]:
```
A/(2*b)
```

Out[6]: $2.0342145 \times 10^{-11}\ \frac{\mathrm{g^{1/2}}}{\mathrm{erg^{1/2}\ cm^{3}}}$

Via Wolfram, the root to this equation is:

In [7]:
```
r = 1.95*10**(8) #real
j = 1.1*10**(9) #imaginary
```

therefore the speed is the modulus of (r-j)

In [8]:
```
v = sqrt(r**2 + j**2)
```

In [9]:
```
print "speed is",v
print "v = {}c".format(v/c.value)
```

```
speed is 1117150392.74
v = 0.0373628893893c
```

so no, the cosmic rays cannot be of thermal origin, since this speed is so much less than the speed of cosmic rays.

problem 3d

for H_2:

In [229]:
```
#constants
T = 1000 #K
g = 980 #cm/s^2
r = 637.1 * 10**6 # cm
m = 2 * 1.6737236 * 10**(-24) #for Hydrgen Molecule = 2 * m_H
G = 6.7*10**(-8) #cgs
M = 5.972 * 10**27 #g

#composite constants
sigma = pi * (10**(-8))**2
n = m*g / (sigma * k.value * T)
v_s = sqrt(2*k.value*T/m)
v_esc = sqrt(2*G*M / r)
lam = (v_esc/v_s)**2
```

In [230]:
```
C = (n * v_s) / (2. * sqrt(pi))
```

In [231]:
```
Flux = C *exp(-lam)*(lam + 1)
```

In [232]:
```
print Flux # num particles / s cm^2
```

```
29322950.6884
```

In [233]:
```
t = (1 * 10**9) * (365*24*60*60) # s/Gyr
```

Rate of loss of hydrogen over the entire area of exosphere:

In [234]:
```
N_exo = Flux * 4*pi*r**2 #amount lost thermally over entire area of exosphere
```

Amount of hydrogen lost thermally over 1Gyr

In [235]:
```
N_esc = N_exo * t
```

In [236]:
```
print "number of H2 molecules lost thermally over 1Gyr over entire area of exosphere is", N_esc
print "number of H atoms lost (2*N_H2)/N_H2_atmosphere", (2 * N_esc/10**43)
```

```
number of H2 molecules lost thermally over 1Gyr over entire area of exosphere is 4.71671191201e+42
number of H atoms lost (2*N_H2)/N_H2_atmosphere 0.943342382402
```

number of H2 lost thermally over 1Gyr over entire area of exosphere 4.71671191201e+42 molecules

number of H atoms lost is $2N_{H2}$

$$\frac{N_{H_{atoms escaped}}}{N_{H_{atoms in atmosphere}}} \approx 0.94$$

problem 3e

for O_2:

In [245]:
```
mo = 2. * 2.6567626 * 10**(-23) # O2 in g
v_s = sqrt(2.*k.value*T/mo)
v_esc = sqrt(2.*G*M / r)
lam = (v_esc/v_s)**2
```

In [246]:
```
n = mo*g / (sigma * k.value * T)
```

In [247]:
```
C = (n * v_s) / (2 * sqrt(pi))
Flux_o2 = C * exp(-lam)*(lam + 1.) #num particles / s cm^2
```

In [248]:
```
print Flux_o2 #num particles / s cm^2
```

```
1.75087645658e-88
```

Rate of loss of molecular Oxygen over the entire area of exosphere:

In [250]:
```
N_exo_o = Flux_o2 * 4.*pi*r**2. #amount escaping over entire exosph
ere / s
print N_exo_o
```

```
8.93059875204e-70
```

Number of O2 lost over 1Gyr

In [224]:
```
N_o = N_exo_o * t
```

In [251]:
```
print "Number of O2 molecules escaping over 1Gyr over entire exosph
ere is",N_o
```

```
Number of O2 molecules escaping over 1Gyr over entire exosphere is
2.81635362244e-53
```

$$N_{O_{2escaped}} \approx 0$$

In [252]:
```
4.71671191201e+42 / 2.81635362244e-53
```

Out[252]:
```
1.6747584090394123e+95
```

Flux of H_2 escaping $\approx 3x10^7 \frac{particles}{cm^2 s}$

Flux of O_2 escaping $\approx 2x10^{-53} \frac{particles}{cm^2 s}$

Assuming no sources or sinks of H_2 or O_2 the amount of O_2 should stay the same while the amount of H_2 will decrease rapidly unless it is locked up into H_2O very quickly.

```
In [ ]:
```