Plots_and_analysis

February 18, 2019

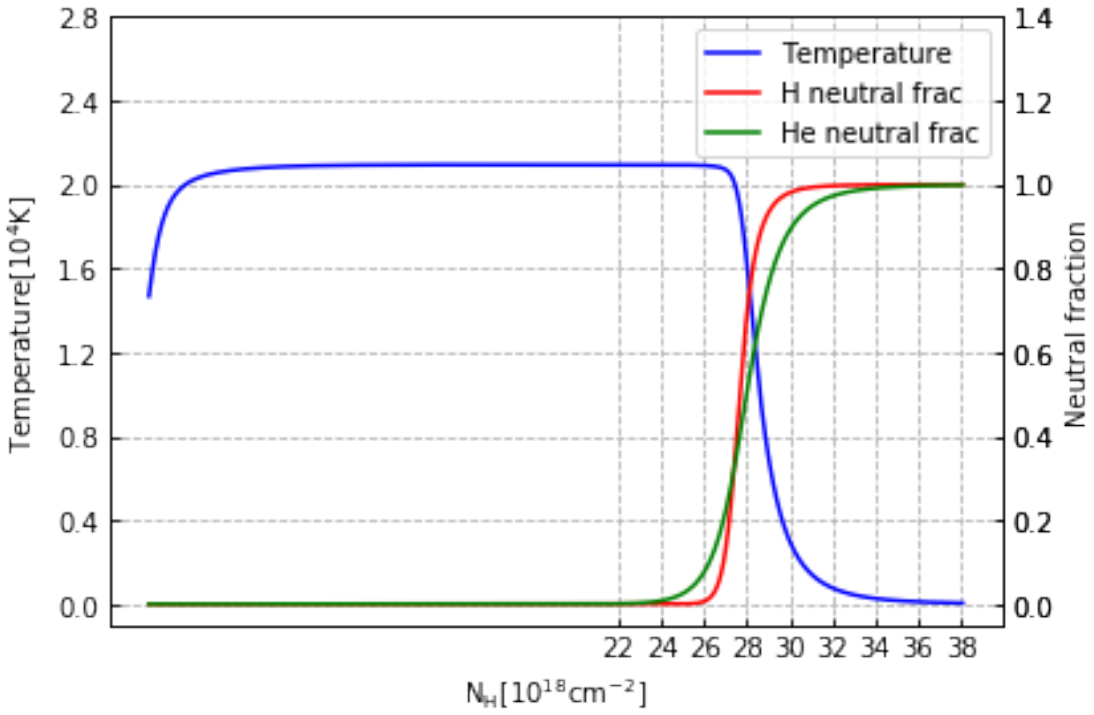
1 1. Chris's original plot

In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
import pandas

chris_table = np.loadtxt('output_chris.txt',skiprows=0)
#print chris_table

#set the upper and lower bound for reading table
lower_bound = 1
upper_bound = 1524
```

In [2]:
```
j = chris_table[lower_bound:upper_bound,0]
j5DNHI = chris_table [lower_bound:upper_bound,1]
y1H = chris_table[lower_bound:upper_bound,2]
y1He = chris_table[lower_bound:upper_bound,3]
EH = chris_table[lower_bound:upper_bound,4]
Te = chris_table[lower_bound:upper_bound,5]

j5DNHI = j5DNHI/1e+18
Te = Te/10000
```

In [3]:
```
fig, ax1 = plt.subplots()

#get the plot
list1, = ax1.plot(j5DNHI, Te, 'b-', label='Temperature')
ax1.set_xlabel("$\mathregular{N_H[10^{18}cm^{-2}]}$")
ax1.set_ylabel("$\mathregular{Temperature[10^4K]}$")
plt.grid(linestyle = '--')

#align ticks
major_tickx = np.arange(22, 39, 2)
major_ticky = np.arange(0, 3.2, 0.4)
ax1.set_xticks(major_tickx)
ax1.set_yticks(major_ticky)
```

```
#twinx to create multiple y axis
ax2 = ax1.twinx()
list2, = ax2.plot(j5DNHI, y1H, 'r-', label='H neutral frac')
ax2.set_ylabel("Neutral fraction")
minor_ticky = np.arange(0, 1.6, 0.2)
ax2.set_yticks(minor_ticky)

ax3 = ax1.twinx()
list3, = ax3.plot(j5DNHI, y1He, 'g-', label = 'He neutral frac')
ax3.set_yticks(minor_ticky)

# #add top tick
# ax4 = ax3.twiny()
# ax4.plot(j5DNHI, y1He)
# ax4.set_xticks(major_tickx)
# ax4.set_yticks(minor_ticky)
# ax4.cla()

#change tick direction
axs = [ax1, ax2, ax3]
for ax in axs:
    ax.tick_params(direction = 'in')

#add legend
lists = [list1, list2, list3]
ax1.legend(lists, [list.get_label() for list in lists], loc='upper right')


fig.tight_layout()
plt.savefig("chris.pdf")
plt.show()
```



2 2. NaN bug

2.1 The NaN bug comes from negative temperature when subtracting a temperature constant.

3 dEH inconsistent issue

3.0.1 For dEH[3], we track the difference between the one with cooling function and the one without.

In [4]:
```
dEH3_cool_file = '../output/grid3/020419_5/2y_0_dEH50_dEHgrid3.txt'
dEH3_cool = np.genfromtxt(dEH3_cool_file, dtype = 'f16', skip_header = 1, usecols = (2
print(dEH3_cool)

dEH3_no_cool_file = '../output/grid3/020419_6/2y_0_dEH50_dEHgrid3_no_cool.txt'
dEH3_no_cool = np.genfromtxt(dEH3_no_cool_file, dtype = 'f16', skip_header=1, usecols=
print(dEH3_no_cool)
```

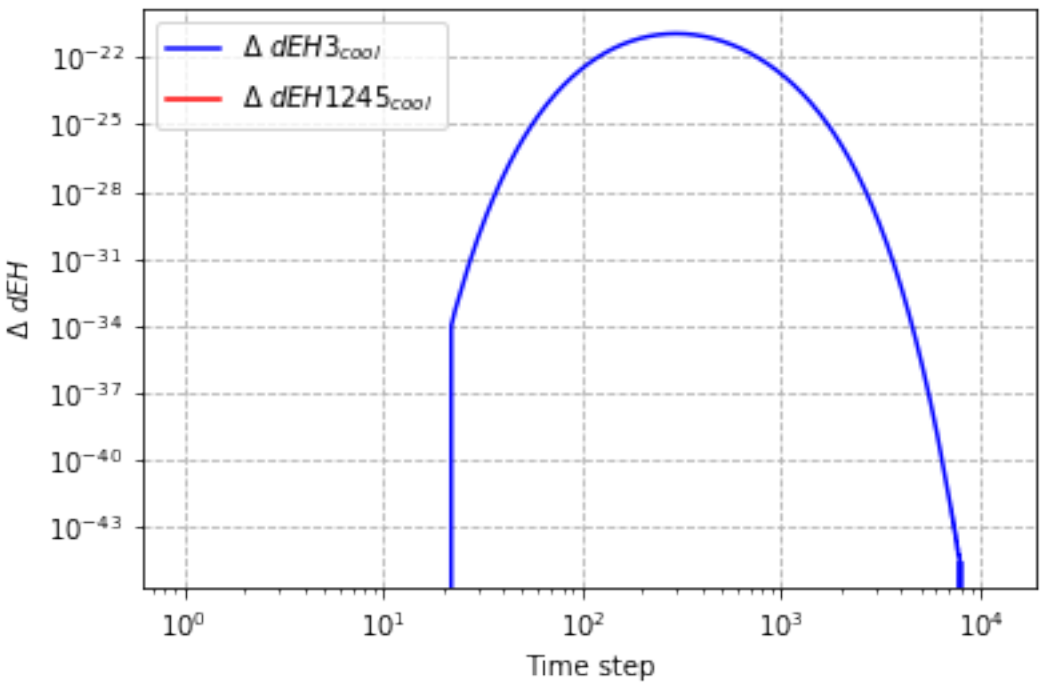
```
[6.57527062e-19 6.54969356e-19 6.52411180e-19 ... 5.57753988e-34
 5.56287144e-34 5.54824158e-34]
[6.57527062e-19 6.54969356e-19 6.52411180e-19 ... 5.57753988e-34
 5.56287144e-34 5.54824158e-34]
```

3.0.2 For dEH[1245], we track the difference between the one with cooling function and the one without.

In [5]:
```
dEH1245_cool_file = '../output/grid1245/020419_1/2y_0_dEH50_dEHgrid1245.txt'
dEH1245_cool = np.genfromtxt(dEH1245_cool_file, dtype = 'f16', skip_header = 1, usecols
print(dEH1245_cool)

dEH1245_no_cool_file = '../output/grid1245/020419_2/2y_0_dEH50_dEHgrid1245_no_cool.txt
dEH1245_no_cool = np.genfromtxt(dEH1245_no_cool_file, dtype = 'f16', skip_header=1, use
print(dEH1245_no_cool)
```

```
[1.36621218e-25 1.36715173e-25 1.36809211e-25 ... 8.43112538e-21
 8.44738860e-21 8.46368973e-21]
[1.36621218e-25 1.36715173e-25 1.36809211e-25 ... 8.43112538e-21
 8.44738860e-21 8.46368973e-21]
```

In [6]:
```
#dEH1245_cool = [x - 1e-38 for x in dEH1245_cool]
fig_cool, ax_cool = plt.subplots()
ax_cool.set_yscale('log')
ax_cool.set_xscale('log')
list_dEH3, = ax_cool.plot(dEH3_no_cool[0:] - dEH3_cool[0:], 'b-', label='$\Delta dEH3_
list_dEH1245 = ax_cool.plot(dEH1245_no_cool[0:] - dEH1245_cool[0:],'r-',label='$\Delta
ax_cool.set_xlabel("Time step")
ax_cool.set_ylabel("$\Delta\ dEH$")
ax_cool.legend(["$\Delta\ dEH3_{cool}$","$\Delta\ dEH1245_{cool}$"])
plt.grid(linestyle = '--')
plt.show()
```

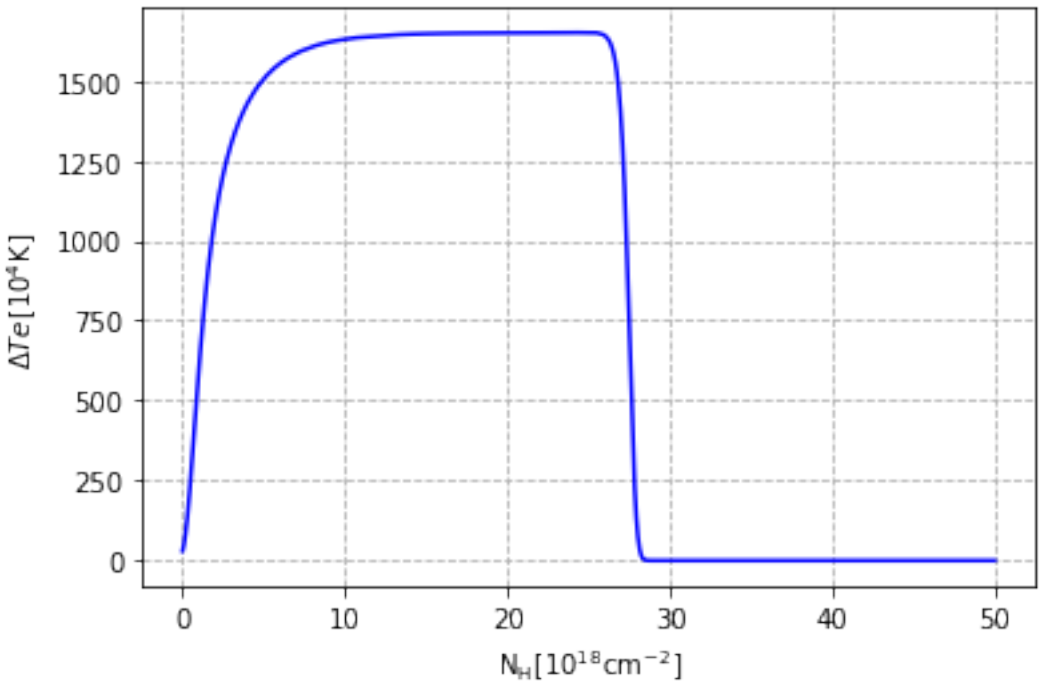


3.0.3 Cooling function comparison for all grids at time step 12000

```
In [7]: Te_cool = np.genfromtxt(dEH3_cool_file, dtype = 'f16', skip_header = 12008, usecols =
        Te_no_cool = np.genfromtxt(dEH3_no_cool_file, dtype = 'f16', skip_header = 12008, usec
        NH = chris_table[: , 1]/1e+18
        print(Te_cool[:20])
        print(Te_no_cool[:20])
        print(NH[:20])
```

```
[14467.4 14676.9 14881.1 15080.  15273.5 15461.5 15643.9 15820.7 15991.9
 16157.4 16317.5 16472.  16621.1 16764.9 16903.5 17036.9 17165.3 17288.9
 17407.8 17522. ]
[14497.2 14711.9 14922.1 15127.7 15328.4 15524.3 15715.4 15901.5 16082.7
 16258.9 16430.3 16596.8 16758.4 16915.3 17067.6 17215.2 17358.3 17497.
 17631.3 17761.4]
[0.0125 0.0375 0.0625 0.0875 0.1125 0.1375 0.1625 0.1875 0.2125 0.2375
 0.2625 0.2875 0.3125 0.3375 0.3625 0.3875 0.4125 0.4375 0.4625 0.4875]
```

```
In [8]: fig_cool_Te, ax_cool_Te = plt.subplots()
        ax_cool_Te.set_yscale('linear')
        ax_cool_Te.plot(NH[:], abs(Te_cool[:] - Te_no_cool[:]), 'b-')
        ax_cool_Te.set_xlabel("$\mathregular{N_H[10^{18}cm^{-2}]}$")
        ax_cool_Te.set_ylabel("$\Delta Te\mathregular{[10^4K]}$")
        plt.grid(linestyle = '--')
        plt.show()
```



4 3. Plot tauHIIe

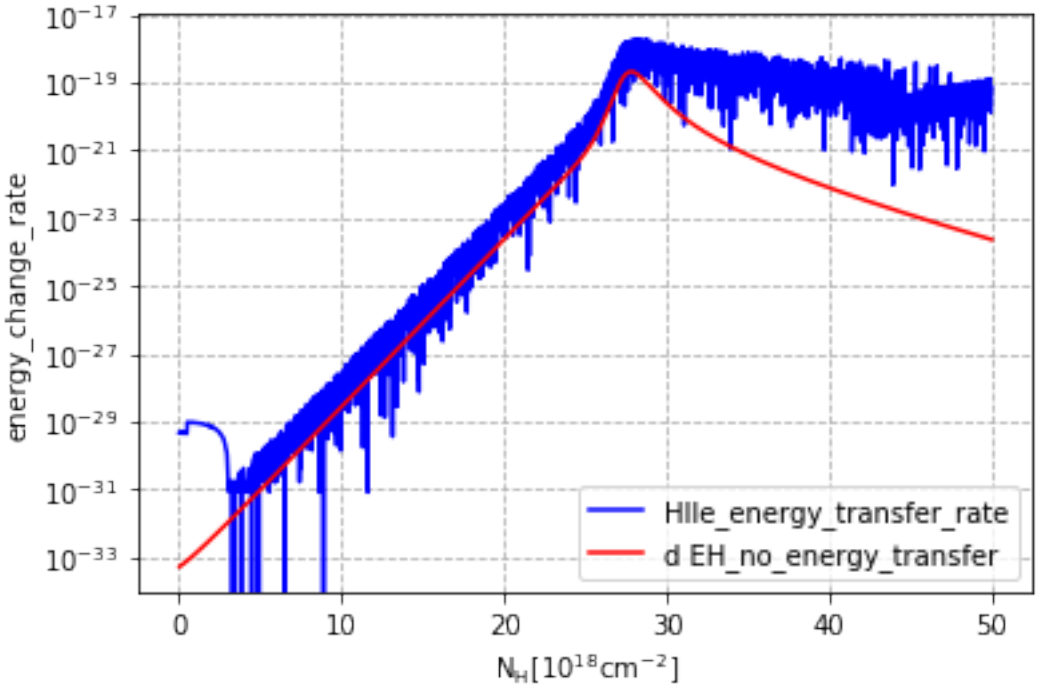
4.1 At timestep 12000

```
In [9]: dEH_cool = np.genfromtxt(dEH3_cool_file, dtype = 'f16', skip_header = 12008, usecols =
        tauHIIe_cool = np.genfromtxt('../output/tauHIIe/tau_1_time_12000.txt', dtype = 'f16', s
        print(dEH_cool[:])
        print(tauHIIe_cool[:])
        print(len(NH))
        print(len(tauHIIe_cool))
```

```
[5.23168547e-34 5.33405851e-34 5.43954697e-34 ... 2.34918980e-24
 2.33024405e-24 2.31145651e-24]
[-4.73545359e-30 -4.66637009e-30 -4.60069139e-30 ... -3.19991373e-20
 -5.13054954e-20 -7.07959026e-20]
2000
2000
```

```
In [10]: fig_tauHIIe_cool, ax_tauHIIe_cool = plt.subplots()
         list_tauHIIe_cool, = ax_tauHIIe_cool.plot(NH[:], abs(tauHIIe_cool[:]),'b-', label='HI
         list_dEH_cool, = ax_tauHIIe_cool.plot(NH[1:], dEH_cool[1:],'r-', label='d EH_no_energy

         ax_tauHIIe_cool.set_xlabel("$\mathregular{N_H[10^{18}cm^{-2}]}$")
```

```
ax_tauHIIe_cool.set_ylabel("energy_change_rate")

lists=[list_tauHIIe_cool, list_dEH_cool]
ax_tauHIIe_cool.legend(lists, [list.get_label() for list in lists], loc='lower right')

plt.grid(linestyle = '--')

ax_tauHIIe_cool.set_yscale('log')
plt.show()
```



4.2 Compare Temperature evolution when including tauHIIe

```
In [11]: Te_HIIe = np.genfromtxt('../output/tauHIIe/tau_1_time_12000.txt', dtype='f16', skip_he
         THII_HIIe = np.genfromtxt('../output/tauHIIe/tau_1_time_12000.txt', dtype='f16', skip_
         print(len(Te_HIIe), len(THII_HIIe), len(NH), len(Te_cool))
```

```
(2000, 2000, 2000, 2000)
```

```
In [12]: fig_T_HIIe, ax_T_HIIe = plt.subplots()
         start_index = 800
         list_original_Te, = ax_T_HIIe.plot(NH[start_index:], Te_cool[start_index:]/1e4,'g-',la
         list_Te, = ax_T_HIIe.plot(NH[start_index:],Te_HIIe[start_index:]/1e4,'b-',label='Te')
         list_THII, = ax_T_HIIe.plot(NH[start_index:],THII_HIIe[start_index:]/1e4,'-r',label='T
```

```
ax_T_HIIe.set_xlabel("$\mathregular{N_H[10^{18}cm^{-2}]}$")
ax_T_HIIe.set_ylabel("$\mathregular{Temperature[10^4K]}$")

lists=[list_original_Te, list_Te, list_THII]
ax_T_HIIe.legend(lists,[list.get_label() for list in lists], loc='upper right')

plt.grid(linestyle='--')
ax_T_HIIe.set_yscale('log')
plt.show()
```