In [91]:
```
import numpy as np
import os
import matplotlib.pyplot as plt
```

In [116]:
```
os.chdir("C:/Users/Owner/Documents/Classes/F2021/PHYS 512/emacs")
chain = np.loadtxt("planck_chain.txt")
chain = np.transpose(chain)
best_pars = [np.mean(lst) for lst in chain]
best_par_errs = [np.std(lst) for lst in chain]
```

In [117]:
```
print(best_pars)
```

```
[68.49389620279608, 0.02241757691235227, 0.11690187826414158, 0.00754040796
4428365, 1.897254723909272e-09, 0.9721495138985322]
```

In [118]:
```
print(best_par_errs)
```

```
[0.02394434356072987, 1.4645866469529741e-05, 4.487708352873318e-05, 0.0001
0357740940729068, 3.867007990237383e-13, 0.0002569814062151348]
```

As indicated above, the best-fit parameters are [68.49389620279608, 0.02241757691235227, 0.11690187826414158, 0.00754040796442836 5, 1.897254723909272e-09, 0.9721495138985322],

and the errors on these parameters are [0.02394434356072987, 1.4645866469529741e-05, 4.487708352873318e-05, 0.00010357740940729068, 3.867007990237383e-13, 0.0002569814062151348].

Note that I set my code to run for 20,000 iterations, but I realized after a few hours that it would not finish running before the deadline of this assignment. Thus, I extracted the values being printed to planck_chain.txt, and I calculated what I could from there.

Also note that I could not save this as a PDF, so I printed to PDF instead. My apologies if the quality is worse.

In [119]:
```
print(len(chain[0]))
```

```
7986
```

Only 7,986 of the 20,000 iterations have run thus far. However, the chains seem to have converged. Indeed, as per the plots below, each parameter seems to oscillate around a given value after some time.

In [120]:

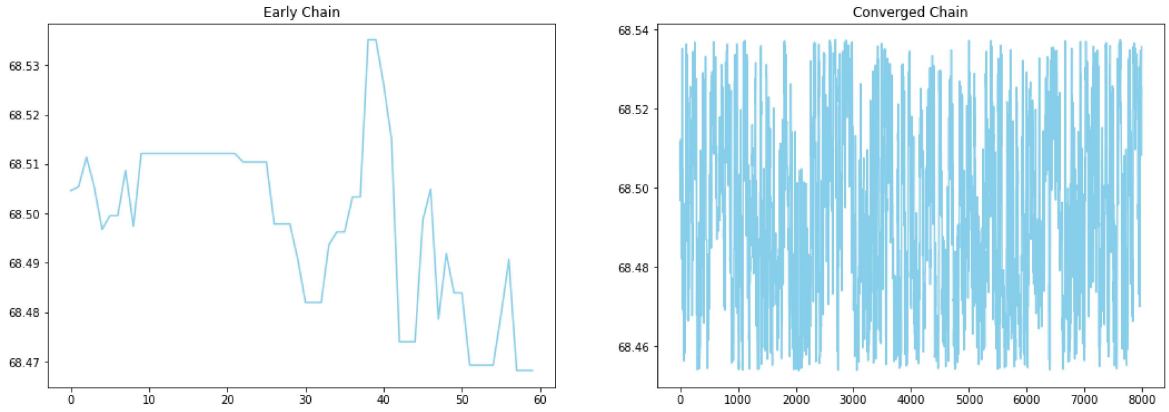
```
n = len(chain[0])
x = range(0, n)

fig, ax = plt.subplots(1, 2, figsize = (18, 6))

ax[0].plot(x[:60], chain[0][:60], c="skyblue")
ax[0].set_title("Early Chain")

ax[1].plot(x, chain[0], c="skyblue")
ax[1].set_title("Converged Chain")

fig.savefig("q3.png")
```

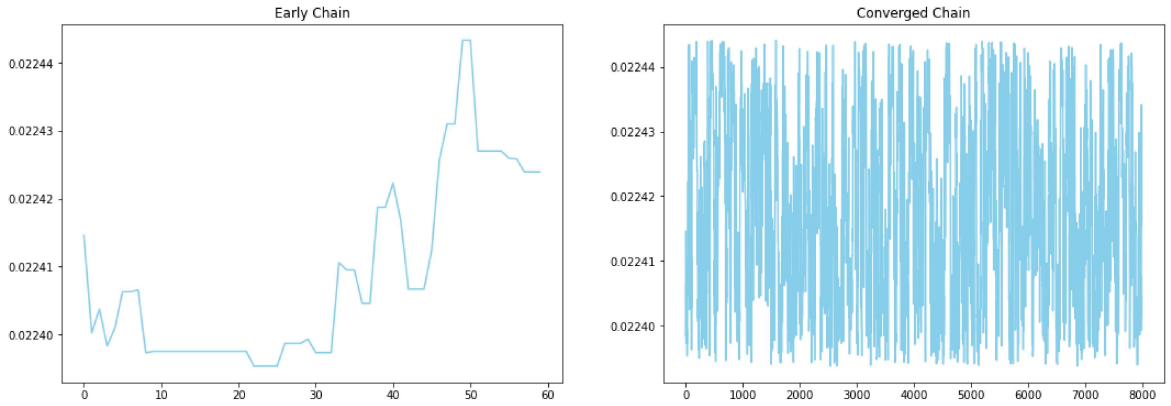


In [121]:
```
fig1, ax1 = plt.subplots(1, 2, figsize = (18, 6))

ax1[0].plot(x[:60], chain[1][:60], c="skyblue")
ax1[0].set_title("Early Chain")

ax1[1].plot(x, chain[1], c="skyblue")
ax1[1].set_title("Converged Chain")
```

Out[121]: Text(0.5, 1.0, 'Converged Chain')

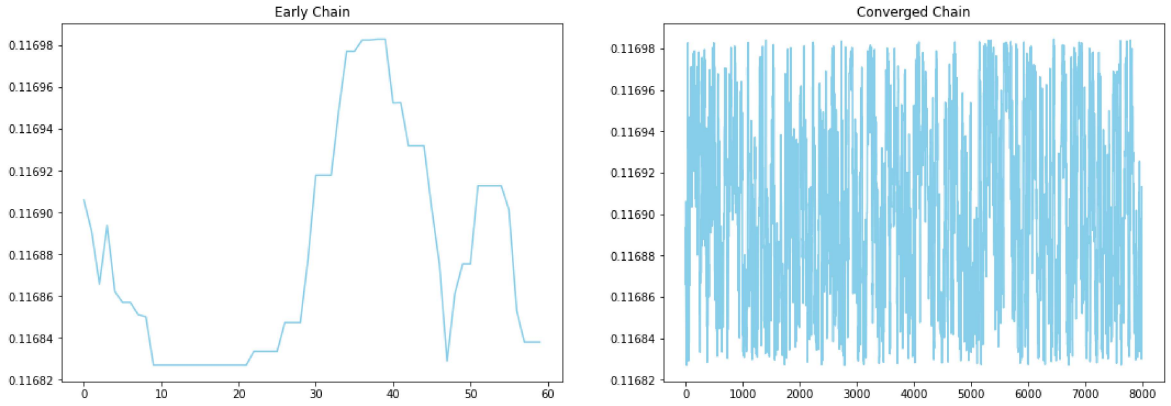


In [122]:
```
fig2, ax2 = plt.subplots(1, 2, figsize = (18, 6))

ax2[0].plot(x[:60], chain[2][:60], c="skyblue")
ax2[0].set_title("Early Chain")

ax2[1].plot(x, chain[2], c="skyblue")
ax2[1].set_title("Converged Chain")
```

Out[122]: Text(0.5, 1.0, 'Converged Chain')

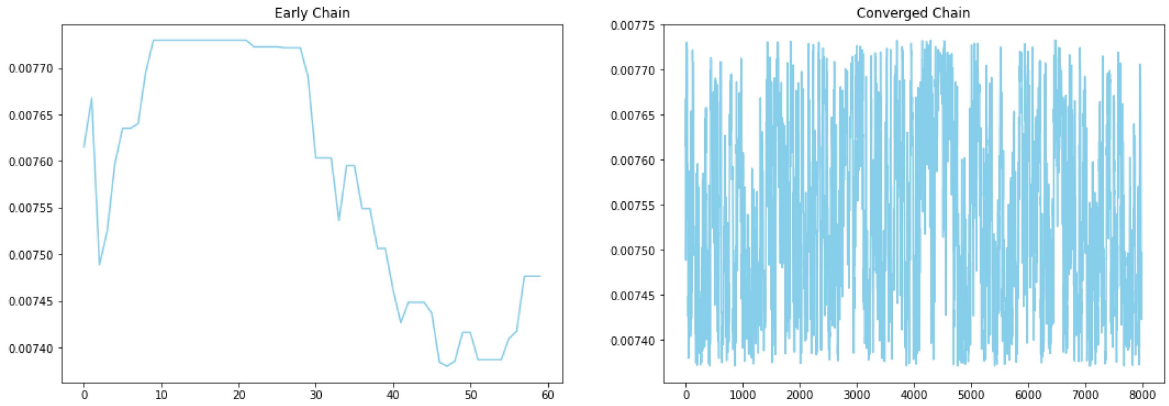


In [123]:
```
fig3, ax3 = plt.subplots(1, 2, figsize = (18, 6))

ax3[0].plot(x[:60], chain[3][:60], c="skyblue")
ax3[0].set_title("Early Chain")

ax3[1].plot(x, chain[3], c="skyblue")
ax3[1].set_title("Converged Chain")
```

Out[123]: Text(0.5, 1.0, 'Converged Chain')

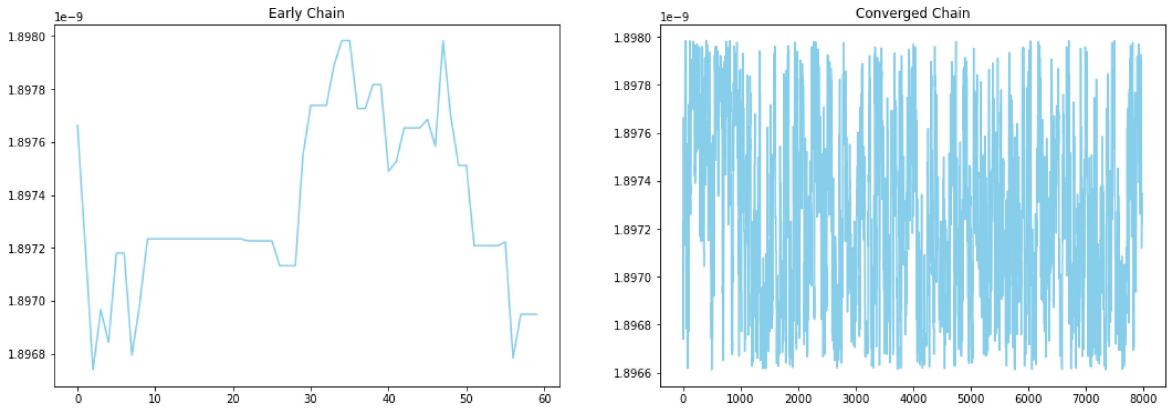


In [124]:
```
fig4, ax4 = plt.subplots(1, 2, figsize = (18, 6))

ax4[0].plot(x[:60], chain[4][:60], c="skyblue")
ax4[0].set_title("Early Chain")

ax4[1].plot(x, chain[4], c="skyblue")
ax4[1].set_title("Converged Chain")
```

Out[124]: Text(0.5, 1.0, 'Converged Chain')



In [126]:
```
fig5, ax5 = plt.subplots(1, 2, figsize = (18, 6))

ax5[0].plot(x[:60], chain[5][:60], c="skyblue")
ax5[0].set_title("Early Chain")

ax5[1].plot(x, chain[5], c="skyblue")
ax5[1].set_title("Converged Chain")
```

Out[126]:
```
Text(0.5, 1.0, 'Converged Chain')
```