project

January 21, 2026

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

[2]:
```
import pandas as pd

filename1 = "z0001.data"

# Find the line with the header (starts with #)
with open(filename1, "r") as f:
    for i, line in enumerate(f):
        if line.startswith("#"):
            header_line = i
            break
h1= pd.read_csv("z0001.data", delim_whitespace=True, comment="!", header=0)
```

```
/tmp/ipykernel_6752/3023549695.py:11: FutureWarning: The 'delim_whitespace'
keyword in pd.read_csv is deprecated and will be removed in a future version.
Use ``sep='\s+'`` instead
  h1= pd.read_csv("z0001.data", delim_whitespace=True, comment="!", header=0)
```

[3]:
```
h1.head()
```

[3]:

	model_number	num_zones	star_age	log_dt	star_mass	log_xmstar	\
0	1	1175	0.000010	-5.000000	1.0	33.298506	
1	5	1178	0.000074	-4.683275	1.0	33.298506	
2	10	1178	0.000260	-4.287369	1.0	33.298506	
3	15	1178	0.000720	-3.891463	1.0	33.298506	
4	20	1178	0.001867	-3.495556	1.0	33.298506	

	log_abs_mdot	mass_conv_core	conv_mx1_top	conv_mx1_bot	…	center_h1	\
0	-99.0	0.0	1.0	0.028148	…	0.7597	
1	-99.0	0.0	1.0	0.027087	…	0.7597	
2	-99.0	0.0	1.0	0.027175	…	0.7597	
3	-99.0	0.0	1.0	0.027352	…	0.7597	
4	-99.0	0.0	1.0	0.027632	…	0.7597	

	center_he4	center_c12	center_o16	surface_c12	surface_o16	\

```
0    0.240174    0.000017    0.000047     0.000017     0.000047
1    0.240174    0.000017    0.000047     0.000017     0.000047
2    0.240174    0.000017    0.000047     0.000017     0.000047
3    0.240174    0.000017    0.000047     0.000017     0.000047
4    0.240174    0.000017    0.000047     0.000017     0.000047

   total_mass_h1  total_mass_he4  num_retries  num_iters
0         0.7597        0.240174            0          2
1         0.7597        0.240174            0          2
2         0.7597        0.240174            0          2
3         0.7597        0.240174            0          2
4         0.7597        0.240174            0          2

[5 rows x 60 columns]
```

[4]:
```
filename2 = "z014.data"

# Find the line with the header (starts with #)
with open(filename2, "r") as f:
    for i, line in enumerate(f):
        if line.startswith("#"):
            header_line = i
            break
h2= pd.read_csv("z014.data", delim_whitespace=True, comment="!", header=0)
```

```
/tmp/ipykernel_6752/209387649.py:9: FutureWarning: The 'delim_whitespace'
keyword in pd.read_csv is deprecated and will be removed in a future version.
Use ``sep='\s+'`` instead
  h2= pd.read_csv("z014.data", delim_whitespace=True, comment="!", header=0)
```

[5]:
```
h2.head()
```

[5]:
```
   model_number  num_zones  star_age    log_dt  star_mass  log_xmstar  \
0             1       1273  0.000010 -5.000000        1.0   33.298506
1             5       1278  0.000074 -4.683275        1.0   33.298506
2            10       1278  0.000260 -4.287369        1.0   33.298506
3            15       1278  0.000720 -3.891463        1.0   33.298506
4            20       1278  0.001867 -3.495556        1.0   33.298506

   log_abs_mdot  mass_conv_core  conv_mx1_top  conv_mx1_bot  …  center_h1  \
0         -99.0             0.0           1.0      0.041552  …      0.718
1         -99.0             0.0           1.0      0.041297  …      0.718
2         -99.0             0.0           1.0      0.041387  …      0.718
3         -99.0             0.0           1.0      0.041574  …      0.718
4         -99.0             0.0           1.0      0.041629  …      0.718

   center_he4  center_c12  center_o16  surface_c12  surface_o16  \
0    0.267971    0.002413    0.006566     0.002413     0.006566
```

```
1    0.267971    0.002413    0.006566     0.002413     0.006566
2    0.267971    0.002413    0.006566     0.002413     0.006566
3    0.267971    0.002413    0.006566     0.002413     0.006566
4    0.267971    0.002413    0.006566     0.002413     0.006566

   total_mass_h1  total_mass_he4  num_retries  num_iters
0          0.718        0.267971            0          2
1          0.718        0.267971            0          2
2          0.718        0.267971            0          2
3          0.718        0.267971            0          2
4          0.718        0.267971            0          2

[5 rows x 60 columns]
```

[6]:
```
filename3 = "z03.data"

# Find the line with the header (starts with #)
with open(filename3, "r") as f:
    for i, line in enumerate(f):
        if line.startswith("#"):
            header_line = i
            break
h3= pd.read_csv("z03.data", delim_whitespace=True, comment="!", header=0)
```

```
ERROR! Session/line number was not unique in database. History logging moved to
new session 13

/tmp/ipykernel_6752/1287060507.py:9: FutureWarning: The 'delim_whitespace'
keyword in pd.read_csv is deprecated and will be removed in a future version.
Use ``sep='\s+'`` instead
  h3= pd.read_csv("z03.data", delim_whitespace=True, comment="!", header=0)
```

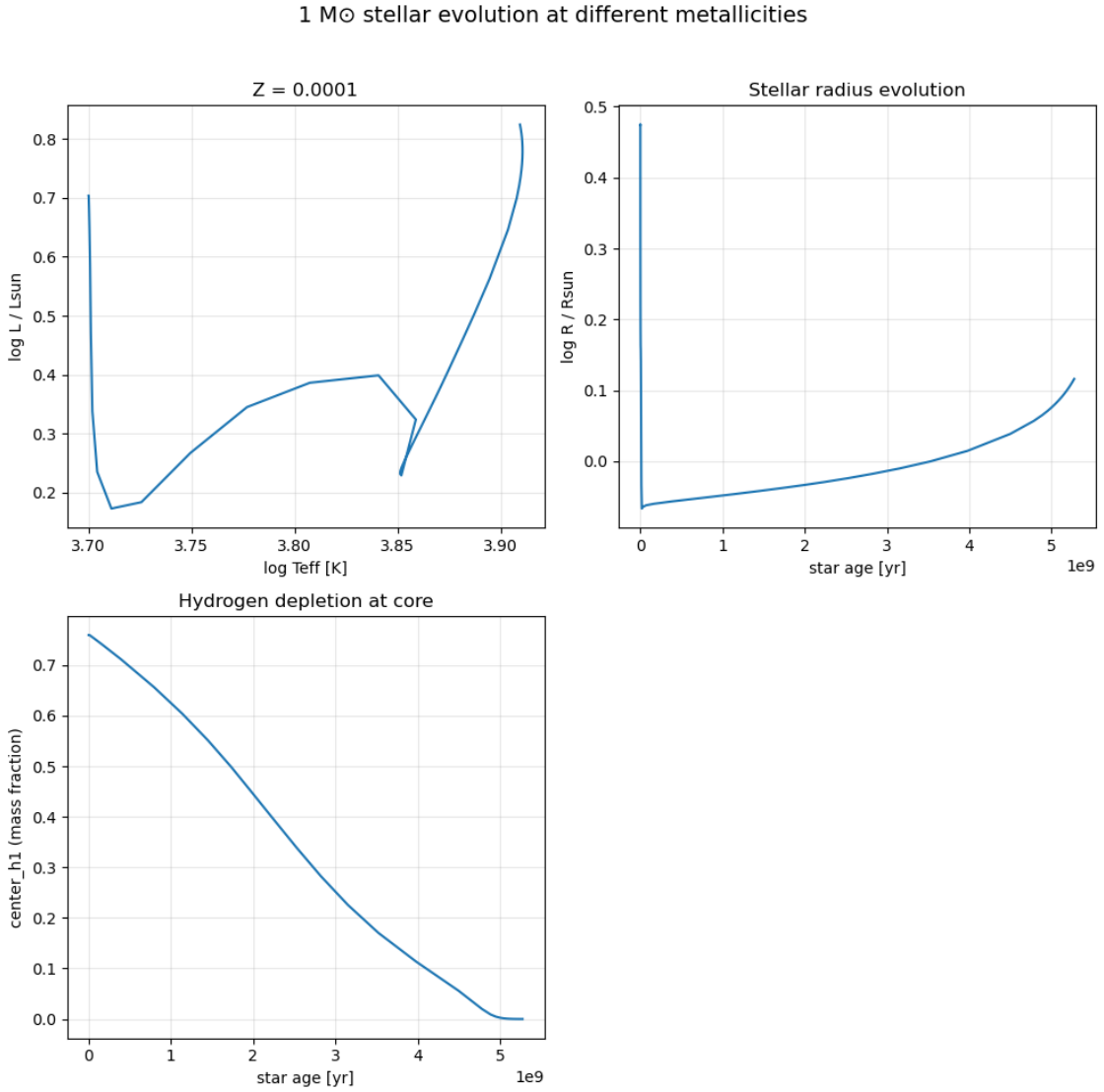
[7]:
```
h3.head()
```

[7]:
```
   model_number  num_zones  star_age    log_dt  star_mass  log_xmstar  \
0             1       1302  0.000010 -5.000000        1.0   33.298506
1             5       1310  0.000074 -4.683275        1.0   33.298506
2            10       1310  0.000260 -4.287369        1.0   33.298506
3            15       1310  0.000720 -3.891463        1.0   33.298506
4            20       1310  0.001867 -3.495556        1.0   33.298506

   log_abs_mdot  mass_conv_core  conv_mx1_top  conv_mx1_bot  …  center_h1  \
0         -99.0             0.0           1.0      0.029946  …       0.67
1         -99.0             0.0           1.0      0.028937  …       0.67
2         -99.0             0.0           1.0      0.028865  …       0.67
3         -99.0             0.0           1.0      0.028851  …       0.67
4         -99.0             0.0           1.0      0.028859  …       0.67
```

```
   center_he4  center_c12  center_o16  surface_c12  surface_o16  \
0    0.299968     0.00517    0.014071      0.00517     0.014071
1    0.299968     0.00517    0.014071      0.00517     0.014071
2    0.299968     0.00517    0.014071      0.00517     0.014071
3    0.299968     0.00517    0.014071      0.00517     0.014071
4    0.299968     0.00517    0.014071      0.00517     0.014071

   total_mass_h1  total_mass_he4  num_retries  num_iters
0           0.67        0.299968            0          2
1           0.67        0.299968            0          2
2           0.67        0.299968            0          2
3           0.67        0.299968            0          2
4           0.67        0.299968            0          2

[5 rows x 60 columns]
```

[43]:
```python
import matplotlib.pyplot as plt

fig, ax = plt.subplots(2, 2, figsize=(10, 10))

# HR diagram (top-left)
ax[0, 0].plot(h1['log_Teff'], h1['log_L'], linestyle='-')
ax[0, 0].set_xlabel('log Teff [K]')
ax[0, 0].set_ylabel('log L / Lsun')
ax[0, 0].invert_xaxis()
ax[0, 0].set_title('Z = 0.0001')

# Radius evolution (top-right)
ax[0, 1].plot(h1['star_age'], h1['log_R'], linestyle='-')
ax[0, 1].set_xlabel('star age [yr]')          # or /1e9 for Gyr
ax[0, 1].set_ylabel('log R / Rsun')
ax[0, 1].set_title('Stellar radius evolution')

# Central H vs age (bottom-left)
ax[1, 0].plot(h1['star_age'], h1['center_h1'], linestyle='-')
ax[1, 0].set_xlabel('star age [yr]')
ax[1, 0].set_ylabel('center_h1 (mass fraction)')
ax[1, 0].set_title('Hydrogen depletion at core')

# Turn off empty subplot
ax[1, 1].axis('off')

# Optional: overall title
fig.suptitle('1 M  stellar evolution at different metallicities', fontsize=14)

for a in ax.flat:
    a.grid(True, alpha=0.3)
```

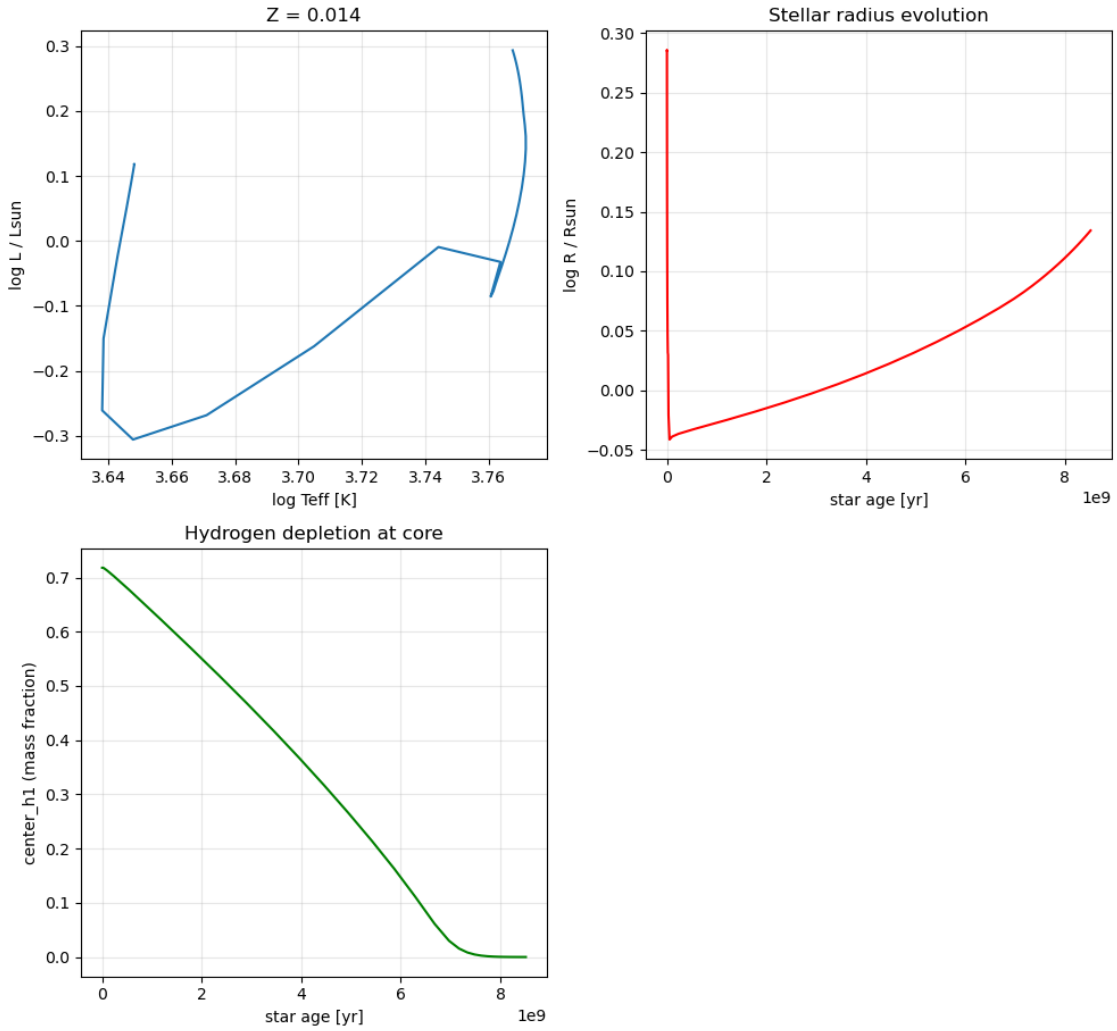
```
    try:
        if 'Teff' in a.get_xlabel():
            a.invert_xaxis()
    except:
        pass

plt.tight_layout(rect=[0, 0, 1, 0.96])
plt.show()
```




```
<Figure size 640x480 with 0 Axes>
```

[46]:
```
fig, ax = plt.subplots(2, 2, figsize=(10, 10))
```

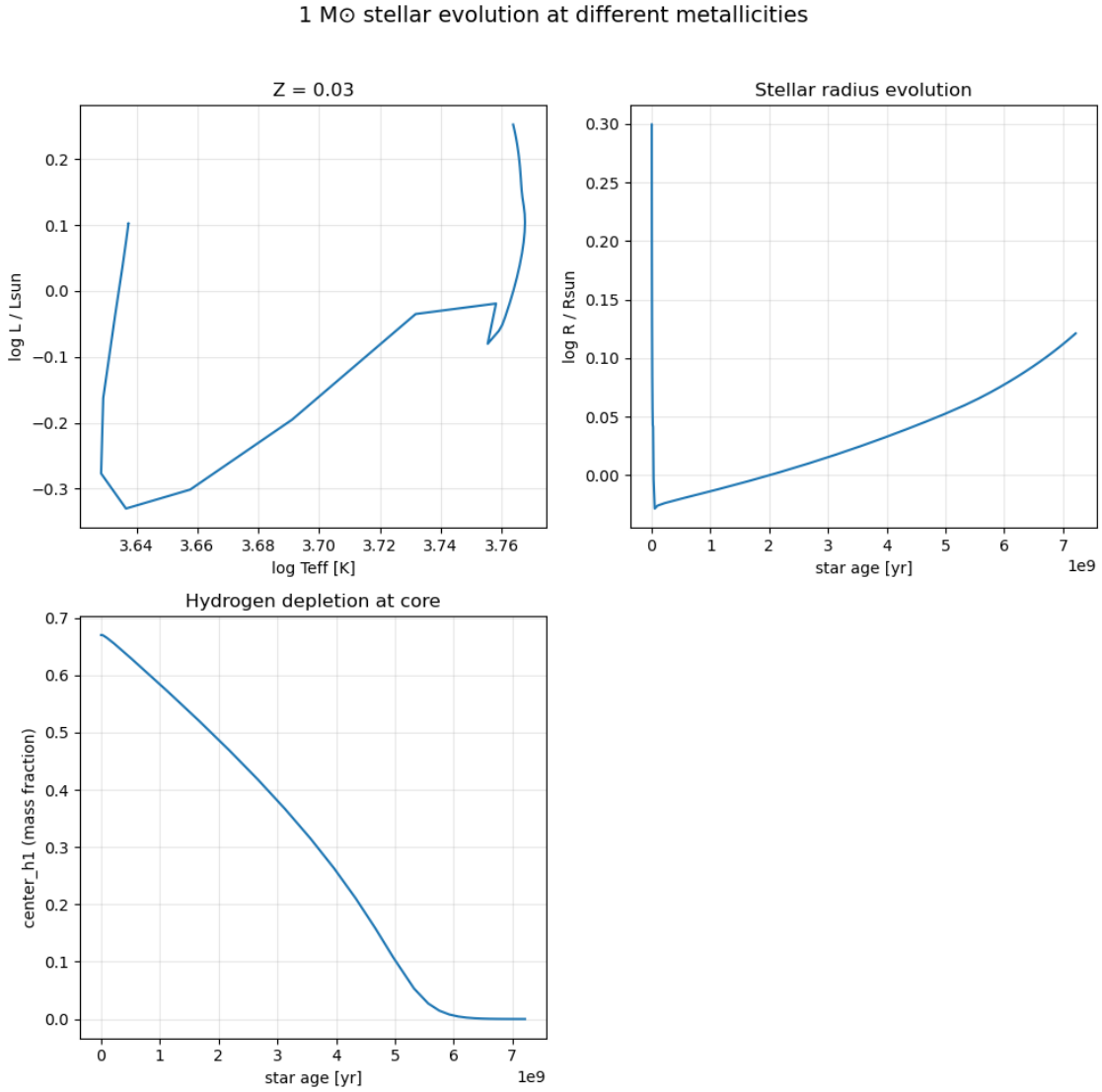
```
# HR diagram (top-left)
ax[0, 0].plot(h2['log_Teff'], h2['log_L'], linestyle='-')
ax[0, 0].set_xlabel('log Teff [K]')
ax[0, 0].set_ylabel('log L / Lsun')
ax[0, 0].invert_xaxis()
ax[0, 0].set_title('Z = 0.014')


# Radius evolution (top-right)
ax[0, 1].plot(h2['star_age'], h2['log_R'], linestyle='-', color="r")
ax[0, 1].set_xlabel('star age [yr]')
ax[0, 1].set_ylabel('log R / Rsun')
ax[0, 1].set_title('Stellar radius evolution')

# Central H vs age (bottom-left)
ax[1, 0].plot(h2['star_age'], h2['center_h1'], linestyle='-', color="g")
ax[1, 0].set_xlabel('star age [yr]')
ax[1, 0].set_ylabel('center_h1 (mass fraction)')
ax[1, 0].set_title('Hydrogen depletion at core')

ax[1, 1].axis('off')


fig.suptitle('1 M  stellar evolution at different metallicities', fontsize=14)

for a in ax.flat:
    a.grid(True, alpha=0.3)
    try:
        if 'Teff' in a.get_xlabel():
            a.invert_xaxis()
    except:
        pass

plt.tight_layout(rect=[0, 0, 1, 0.96])
plt.show()
```




```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
Cell In[46], line 38
     36 plt.tight_layout(rect=[0, 0, 1, 0.96])
     37 plt.show()
---> 38 plt.imsave("z014.jpg")

TypeError: imsave() missing 1 required positional argument: 'arr'
```

[45]:
```
import matplotlib.pyplot as plt

fig, ax = plt.subplots(2, 2, figsize=(10, 10))
```

```
# HR diagram (top-left)
ax[0, 0].plot(h3['log_Teff'], h3['log_L'], linestyle='-')
ax[0, 0].set_xlabel('log Teff [K]')
ax[0, 0].set_ylabel('log L / Lsun')
ax[0, 0].invert_xaxis()
ax[0, 0].set_title('Z = 0.03')

# Radius evolution (top-right)
ax[0, 1].plot(h3['star_age'], h3['log_R'], linestyle='-')
ax[0, 1].set_xlabel('star age [yr]')          # or /1e9 for Gyr
ax[0, 1].set_ylabel('log R / Rsun')
ax[0, 1].set_title('Stellar radius evolution')

# Central H vs age (bottom-left)
ax[1, 0].plot(h3['star_age'], h3['center_h1'], linestyle='-')
ax[1, 0].set_xlabel('star age [yr]')
ax[1, 0].set_ylabel('center_h1 (mass fraction)')
ax[1, 0].set_title('Hydrogen depletion at core')


ax[1, 1].axis('off')


fig.suptitle('1 M  stellar evolution at different metallicities', fontsize=14)

for a in ax.flat:
    a.grid(True, alpha=0.3)
    try:
        if 'Teff' in a.get_xlabel():
            a.invert_xaxis()
    except:
        pass

plt.tight_layout(rect=[0, 0, 1, 0.96])
plt.show()
```



<Figure size 640x480 with 0 Axes>

[ ]: