GNC_Exercise4_3

May 6, 2024

1 Exercise 4

1.0.1 Question 3

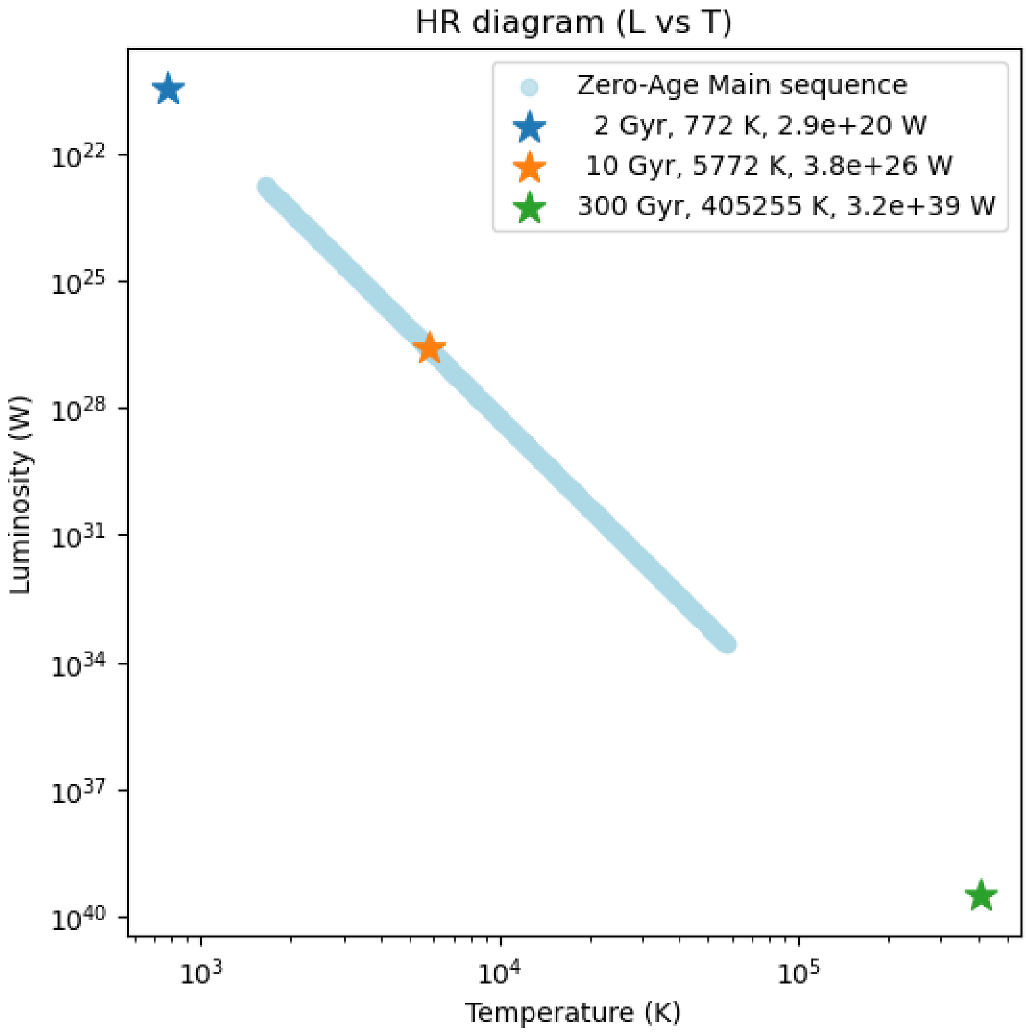
(c)

[ ]:
```
import numpy as np
import matplotlib.pyplot as plt
import astropy.constants as const
```

[ ]:
```
def L(mass):
    """ L   M^3.5 """
    return ((mass / const.M_sun) ** 3.5) * const.L_sun

def R(mass):
    """ R   M^0.75 """
    return ((mass / const.M_sun) ** 0.75) * const.R_sun

def T(L, R):
    """ L = 4 R^2 T_eff^4 """
    return (L / (4 * np.pi * R**2 * const.sigma_sb)) ** 0.25

def M(age):
    """ M   age^0.4, solar lifetime = 10 Gyr """
    return (age / 10e9) ** (1/0.4) * const.M_sun

print("checking out the validity of the scaling relations:")
print(L(1 * const.M_sun))
print(R(1 * const.M_sun))
print(T(L(1 * const.M_sun), R(1 * const.M_sun)))
print(M(10e9))
```

```
checking out the validity of the scaling relations:
3.828e+26 W
695700000.0 m
5772.003429098914 K
1.988409870698051e+30 kg
```

[ ]:
```python
masses = np.logspace(np.log10(0.08*const.M_sun.value), np.log10(100*const.M_sun.
 ↪value), 500)
luminosities = L(masses)
radii = R(masses)
temperatures = T(luminosities, radii)

plt.figure(figsize=(6, 6))
plt.scatter(temperatures, luminosities, color = "lightblue", label="Zero-Age␣
 ↪Main sequence", marker='o', alpha=0.7)
plt.yscale("log")
plt.xscale("log")
plt.gca().invert_yaxis()
plt.legend()
plt.xlabel("Temperature (K)")
plt.ylabel("Luminosity (W)")


point_ages = [2e9,10e9,300e9]
for age in point_ages:
    mass = M(age)
    luminosity = L(mass)
    radius = R(mass)
    temperature = T(luminosity, radius)
    plt.scatter(temperature, luminosity, label=f"{age/1e9:3.0f} Gyr,␣
 ↪{temperature:.0f}, {luminosity:.1e}", marker='*',s = 150)
plt.legend()
plt.title("HR diagram (L vs T)")
plt.show()
```


HR diagram (L vs T)
Zero-Age Main sequence
2 Gyr, 772 K, 2.9e+20 W
10 Gyr, 5772 K, 3.8e+26 W
300 Gyr, 405255 K, 3.2e+39 W
Luminosity (W)
10^{22}
10^{25}
10^{28}
10^{31}
10^{34}
10^{37}
10^{40}
10^3
10^4
10^5
Temperature (K)