Final Project

You will use python to extract data from stellar evolution tracks and use them to understand the evolution of habitable zones.

You will use the files you downloaded of evolutionary tracks for different masses, metallicities, *or* O/Fe (choose one variable).

Extract the time, luminosity, and effective temperature for each timestep from each track. This makes use of the code from the last coding exercise.

Using the following equations, calculate the distances from the star of the inner and outer edges of the habitable zone as a function of time. The distance d_{HZ} of the HZ boundary in AU is defined by

$$d_{HZ} = \left(\frac{L/L_{\odot}}{S_{eff}} \right)^{1/2}$$

where S_{eff} is an effective flux received by the planet. It is based on radiative transfer calculations for different stellar spectra corresponding to different T_{eff} passing through a planetary atmosphere. Note that $L/L_{\odot}$ is not in log in this expression.

$$S_{eff} = S_{eff\odot} + aT_{\star} + bT_{\star}^2 + cT_{\star}^3 + dT_{\star}^4$$

where $T_* = T_{eff} - 5780$ K, $S_{eff\odot}$ is the effective flux for Earth from the Sun at the solar T_{eff} value, and a, b, c, and d are coefficients to a polynomial fit. The coefficients for calculating the inner and outer edges of the habitable zone for a particular set of planetary atmosphere models are below

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Constant	Inner edge	Outer edge
$S_{eff\odot}$	1.107	0.356
a	1.332E-04	6.171E-05
b	1.580E-08	1.698E-09
c	-8.308E-12	-3.198E-12
d	-1.931E-15	-5.575E-16

You will need to:

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- plot the position of the habitable zone edges as a function of time for each model
- submit a copy of your code
- write an explanation of what trends you see in the evolution of habitable zones with the variable you chose (M, Z, or O/Fe). Explain how the variable affects the physical properties and evolution of the star, and how that changes the position of the habitable zone and the rate at which it evolves over time. This explanation should include the physical processes involved. This must be between 2000 and 2500 words. Include an introduction section with basic background information and motivation, a methods section, and a results/conclusions section. The paper will be graded on clarity of presentation (including adequate background and motivation, appropriateness of figures used, etc.) for 30%, being within the length limit for 10%, and understanding of the topic as demonstrated by effective coding, accurate analysis, and explanation of the results for 60%.
- The final project will be due the last day of class, December 3rd.

Filename key:

Masses

hr.5A 0.5 Msol
hr.6A 0.6 Msol
hr.7A 0.7 Msol
hr.8A 0.8 Msol
hr.9A 0.9 Msol
hr.0A 1.0 Msol
hr.1A 1.1 Msol
hr.2A 1.2 Msol

Metallicities

hr.0G 0.1 Zsol
hr.0H 0.2 Zsol
hr.0I 0.3 Zsol
hr.0J 0.4 Zsol
hr.0K 0.5 Zsol
hr.0L 0.6 Zsol
hr.0M 0.7 Zsol
hr.0N 0.8 Zsol
hr.0O 0.9 Zsol
hr.0A 1.0 Zsol
hr.0Q 1.1 Zsol
hr.0R 1.2 Zsol
hr.0S 1.3 Zsol

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hr.0T 1.4 Zsol
hr.0F 1.5 Zsol

O/Fe

hr.0E 0.44 O/Fe_sol
hr.0D 0.67 O/Fe_sol
hr.0A 1.0 O/Fe_sol
hr.0B 1.48 O/Fe_sol
hr.0C 2.28 O/Fe_sol