AGA5816: Galactic Chemical Evolution

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Activity 1

(Due March 18, 2025)

All results in this activity were obtained using the coded provided in: `https://colab.research.google.com/drive/16WAy1Ab0-xqM00olhc8b_NFwHtklsLmp#scrollTo=hk26Iw0Ur4rN`

1. Using the solar abundance table of Asplund et al. (2021), compute the mass fraction of oxygen.

Using the data from the table, the mass fraction of oxygen was computed considering:

$$X_O = \frac{A_i(n_i/n_H)}{1 + 4(n_He/n_H) + \sum Ai(N_i/N_H)}$$

After implementing these calculations on Python, we obtained $X_O = 5.83.10^{-3}$. Therefore, we notice the fraction of Oxygen is very small.

2. Plot in log scale, the mass fraction of all elements versus atomic number (Z).

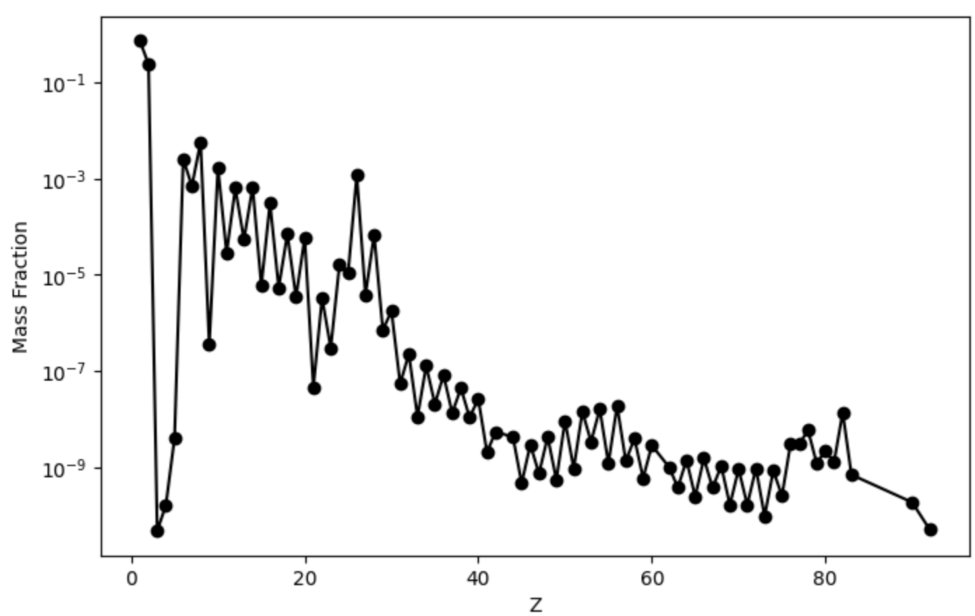

Figure 1: Mass fraction as a function of the atomic number Z.

The plot presented in figure 1 was compatible with literature and shows that the mass fraction of elements decreases with the increase of Z. In conclusion, heavier elements exist in smaller quantities than lighter ones.

3. Regarding the abundance vs. Atomic number plot, how can you explain the higher abundances of the Z-even elements relative to the neighbor Z-odd elements? This is the so-called odd-even effect.

The higher abundance of z-even elements derives from the fact that these are are more stable, since they have an even number of proton-neutron bonds. This raises the bonding energy, providing stability, which facilitates the creation of such elements.

4. Using the table from the GCS, make a quadratic fit of [Fe/H] vs Galactic orbital eccentricity.

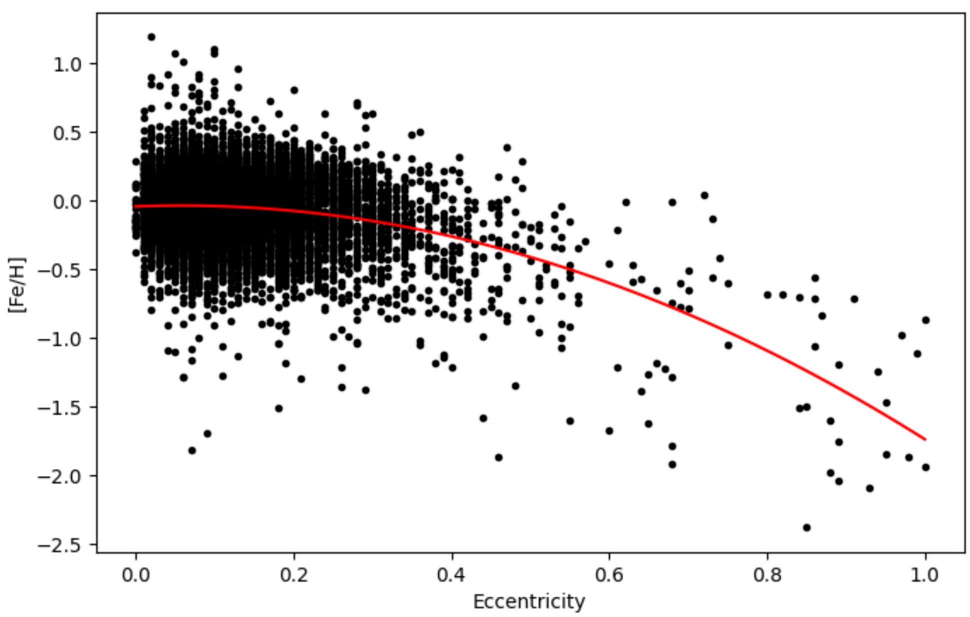

Figure 2: $[Fe/H]$ as a function of excentricity

It is noticeable that the quadratic fit was way more accurate than the linear one done in class, due to the fact that it adjusted higher eccentricities better, making the decay of $[Fe/H]$ more evident.

5. Stars with ratio $n_C/n_O(C/O) > 1$ are called carbon stars. According to Mad-

husudhan et al. (2012), if the protoplanetary disk has $C/O > 0.8$, âdiamondâ planets (dominated by carbon) could form. Assuming that the disk has the same C/O ratio as the star, determine if any of the following stars could form carbon planets. For the reference solar abundances, adopt Asplund et al. (2021). A) The Sun B) HD 75732 (also known as 55 Cnc) analyzed by Delgado Mena et al. (2010), [C/H] = 0.30, [O/H] = 0.07. C) Revised abundances of HD 75732 by Teske et al. (2013), A(C) = 8.73 and A(O) = 8.92.

For this exercise, we used

$$\frac{n_x}{n_H} = 10^{A(x)-12}$$

and then, to determine the ratio (A/B) between two elements A and B

$$\frac{A}{B} = \frac{n_A}{n_H}.\frac{n_H}{n_B}$$

The results obtained are presented in table 1.

Star	C/O Ratio	Forms Carbon Planets
Sun	0.59	No
HD 75732 (Delgado Mena)	1.00	Yes
HD 75732 (Teske)	0.65	No

Table 1: Possible Carbon Planets.

6. Using different symbols, plot the $[N/O]$ ratios vs. A(O) in the Sun, planetary nebula and HII regions. Make a linear fit for the HII regions. Discuss how the Sun fits among the HII regions and explain why nitrogen in some planetary nebula seems too high.

In this case, the fraction [N/O] was determined considering

$$[N/O] = A(N) - A(O)$$

We then obtained the results in figure 3.

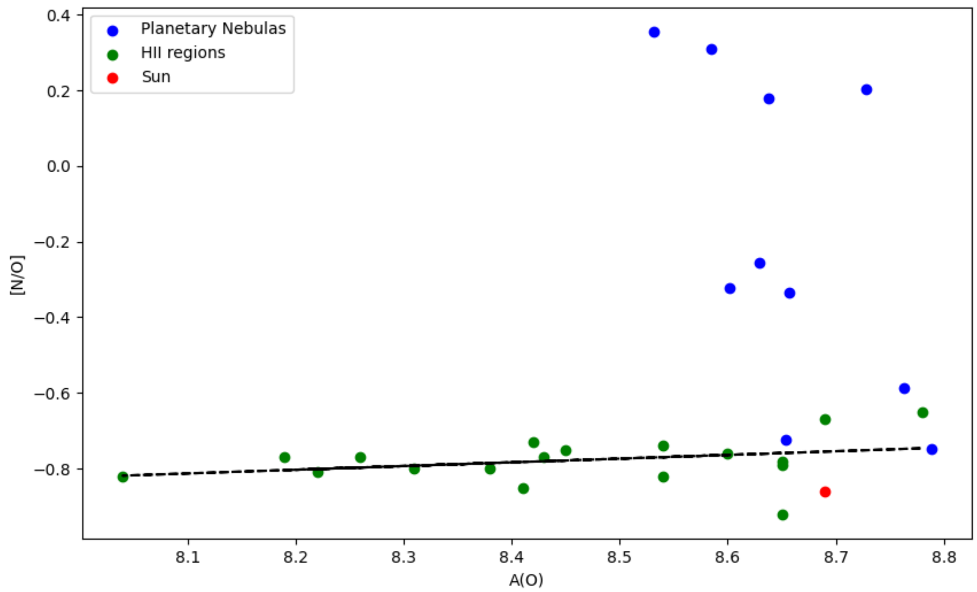

Figure 3: $[N/O]$ as a function of A(O)

Analyzing the results, it is possible to infer that the sun blends very well with the HII region, known for having youger massive stars. Since it fits in with them, we can conclude that these stars have similar chemical composition.

As to the higher levels of Nitrogen in nebulas, we can explain this considering the fact that these objects usually contain intermediate size stars at the end of their life cycle. Therefore, they belong in the AGB branch, known for its intense CNO cycle, where Carbon and Oxygen are converted in Nitrogen.