AST 383 NUCLEOSYNTHESIS -- Assignment 2

Due Thursday February 4 in class

Attempt Q1 and Q2.

Q1. Helium, the second most abundant `cosmic' element, often provides interesting astrophysical puzzles. Here is one - an old one!

The solar He abundance, as we discussed in class, according to Lodders et al. (2009) corresponds to the mass fraction Y(present) = 0.2469 and if diffusion of He out of the surface layers is estimated, the higher initial mass fraction is, again according to Lodders et al., Y(then) = 0.2735. Helioseismology gives the mass fraction at the base of the convection zone as 0.2485+/-0.0034 (see the useful review on this and other topics by Serenelli (astro-ph 1601.07179).

The primordial (Big Bang) mass fraction according to recent evaluations is Y(p)= 0.2551+/-0.0022 (Izotov et al. 2014, MNRAS, 445, 778) or 0.2470+/- 0.0002 (Aver et al.2015, JCAP, 07, 011).

Given that the H-burning and the conversion of H to He is undertaken by almost all stars and is responsible for much of the luminosity of the Galaxy over its history, is the SLIGHT enhancement of Y from Y(p) to Y(then) plausibly attributable to synthesis by stars over the life of the Galaxy?

Please provide a SHORT and more than qualitative discussion of this matter.

You may wish to begin by reading the classic paper by Hoyle & Tayler from 1964 (Nature 203, 1108).

I think you will find entertainnment in several contributions to the book Finding the Big Bang (ed. PJE Peebles, published by the CUP in 2009).

Q2. In standard abundance tables, abundances are obtainable for many elements from both meteorites (CI1 carbonaceous chondrites) and the solar photosphere. When correctly normalized, the two sources yield consistent results for many elements (see Lodders et al. 2009, Figures 4 and 5). However, there are several elements for which neither meteorites not the photosphere can provide a reliable abundance.

These elements include He, Ne, Ar, Kr and Xe.

For one of these elements:

-- i) Explain why its `cosmic' abundance is not obtainable either from CI1 meteorites or from the solar photosphere;

-- ii) Describe briefly the sources used by Lodders et al. to obtain the element's abundance;

-- iii) Describe briefly how Lodders et al. obtain the isotopic abundance ratios for the element.