



RADBOUD UNIVERSITEIT NIJMEGEN
AFDELING STERRENKUNDE
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Chemical Evolution of the Universe – 2010/11

Werkcollege 3 – 16.05.2012

1. Valley of stability

In the chart of nuclides the stable isotopes are situated in a particular region, the valley of stability. Derive analytically from the Weizsäcker mass formula $m(Z, A)$ the charge number Z of stable isotopes as function of the mass number A . Assume Z and A to be continuous. Neglect the pairing term in the mass formula.

Obtain $Z(A)$ through differentiation of the Weizsäcker mass formula $\partial m / \partial Z = 0$.

2. Age of the solar system

Estimate the age of the solar system based on the isotope ratio of uranium. The ratio of the isotopes ^{238}U to ^{235}U in all natural uranium deposits is almost constant

$$\frac{N(^{238}\text{U})}{N(^{235}\text{U})} = \frac{1}{0.0072}.$$

Both isotopes are not stable and decay with the following half-life times

$$^{238}\text{U} : T_1 = 4.51 \cdot 10^9 \text{ a} \text{ and } ^{235}\text{U} : T_2 = 7.13 \cdot 10^8 \text{ a.}$$

Models of nuclear synthesis yield about equal abundances for both uranium isotopes at the time of synthesis, i.e. $N(^{238}\text{U})/N(^{235}\text{U}) = 1$. How much time has passed to obtain the observed ratio? Use this value as an estimate for the age of the solar system.

3. Metallicity of stars

Observations indicate a dependence of the abundance of "metals" (elements heavier than helium) in stars on the location of the stars within a galaxy.

- For the Milky Way it has been observed that stars with high stellar orbital eccentricity have a lower content of metals. Explain why.
- How does the metallicity of stars depend on their distance to the center of the galaxy? Explain why.
- How does the metallicity of a galaxy depend on its total mass? Explain why.

The solutions will be discussed on 16.05.2011 at 10:30 in HG 01.057.
Course web site: <http://particle.astro.ru.nl/goto.html?elements1112>