Glossary of Terms used in PHY320

Atmophile
: is the material of the gaseous atmosphere of the Earth. It consists of Nitrogen, Oxygen, Hydrogen, etc. and is the lightest phase in the separation of elements based on chemical affinities which is used as a model when estimating the chemical composition of the Earth.

By-passed Nuclei
: are proton rich nuclei which cannot be produced by the neutron absorption process. They may have been produced by proton absorption, neutron emission (due to the absorption of a gamma ray by the nucleus, for example) or an inverse beta process caused by the absorption of a positron in the nucleus

Carbonaceous Chondrites
: are stony meteorites which, amongst meteoric evidence, are thought to give the best guide to the original abundances of the elements in the solar system. The are so-called because they contain small spherical bodies called chondrules. They also contain 20% water and volatile compounds which suggests that they have never undergone excessive heating.

Cerenkov Effect
: is the emission of light when a charged particle passes through a medium at a velocity which is faster than the velocity of light in that medium. It is used in the detection of cosmic rays - contributing to the measurement of their charge and hence to the identification of their chemical type.

Chalcophile
: is the material of the Earth's mantle. Typical elements are Copper, Zinc, Mercury, Lead and Bismuth. It is the sulphide phase in the separation of elements based on chemical affinities which is used as a model when estimating the chemical composition of the Earth.

Cosmic Rays
: are the particles which impinge on the top of the Earth's atmosphere. They are one of the sources of information about the relative abundances of elements in the Universe. Although they are predominantly protons, their elemental composition does exhibit differences with respect to the so-called "universal" abundances, especially for light elements such as Lithium and Boron.

Curve of Growth
: is the theoretical relationship between the relative spectral absorption line intensity and the number of sbsorbing atoms. It plays an important role in the interpretation of absorption spectra in terms of chemical abundances. It includes the effects of line broadening and saturation. Such calculated curves have been verified both from laboratory experiments and stellar observations.

Doppler Broadening
: is the broadening of spectral lines due to the motion of emitting or absorbing atoms. It is important that this effect is taken into account when using the spectra of stars to estimate their chemical composition.

Electromagnetic Shower
: is the cascade production of electrons, positrons and photons which is a part of the sequence of

secondary effects which occurs when a cosmic ray interacts with an atom in the Earth's atmosphere. Measurements on the shower can be used to determine the energy of the original primary particle.

Equivalent Width

is a measure of the intensity of an absorption line. It is expression in Angstrom units (or nanometers) and signifies the removal of an amount of radiation equivalent to that contained in the neighbouring continuous spectrum over such a wavelength interval. It is used when extracting chemical abundances from stellar spectra.

Fermi Mechanism

is a suggested way in which cosmic rays are accelerated to high energies by successive collisions with magnetised dust clouds. It is reasonably successful in predicting the observed primary cosmic ray energy spectrum.

Helium Abundance

is the amount of Helium in the Universe taken as a fraction of the whole or in relation to the amount of Hydrogen. Helium is mostly attributed to production during the "Big Bang" and its measured abundance serves as a check on the standard model of that process.

Interstellar Medium

is the gas and dust from earlier stars which have exploded. The explosions are largely responsible for the creation of the chemical elements and for the spread of this matter, in the form of clouds, out of which new stars are formed.

Lithophile

is the material of the Earth's crust. Typical elements are Lithium, Sodium, Potassium, Magnesium and Silicon. It is the silicate phase in the separation of elements based on chemical affinities which is used as a model when estimating the chemical composition of the Earth.

Local Approximation

is the assumption that relative abundances produced by the s-process are inversely proportional to the neutron absorption cross-sections. This works well in the regions away from closed shell (so-called "magic number") nuclei such that the product of these two quantities is reasonably constant in those regions.

Magic Numbers

are particular numbers of protons and neutrons which produce exceptionally stable nuclei. They are the numbers required to close a nucleon shell - the nuclear equivalent to the atomic shell closures ssociated with the chemically inert noble gases. They have a marked effect on the relative abundances of elements synthesised by the r-process of neutron absorption.

Neutron Absorption

see Neutron Capture

Neutron Capture

is the process whereby elements heavier than Iron are synthesised. It is linked to the conversion of neutrons into protons (via beta decay) in this element-producing sequence. Slow or rapid neutron absorption (s-process and r-process) get their names from the rate of neutron absorption relative to the beta decay lifetime.

Nuclear Fission

is the breakup of heavy nuceli into two medium mass nuclei with an accompanying release of energy. This form of nuclear instability ultimately limits the extent to which heavy nuclei can be synthesised. It places an upper limits on the atomic number (A) of nuclei produced by the r-process.

Nuclear Fusion

see Thermonuclear Fusion

Photodisintegration

is the breakup of nuclei by the absorption of energetic photons. This can occur in the core of a massive star which has proceeded to the end of the fusion sequence. With no further energy-producing fusion reactions taking place, the iron core shrinks and heats up until there are thermal photons with sufficient energy to break up the ^{56}Fe nuclei.

Primordial Nucleosynthesis

is the production of chemical elements in the early stages of the development of the Universe before the formation of stars and galaxies. The so-called "Big bang" production of ^{2}H, ^{3}He, ^{4}He and ^{7}Li. Measurements of the abundances of these nuclear species provides a valuable cross-check on the standard model of the early evolution of the Universe.

Red Giants

are stars which have just left the main sequence after completing the consumption of hydrogen in their cores. They are thought to be sites where the production of heavy elements through slow neutron absorption (s-process) occurs. The neutrons are produced in a series of thermonuclear fusion reactions involving hydrogen, helium and carbon.

r-process

is the creation of elements by neutron absorption at a rate which is rapid compared to the beta decay lifetime of the nuclei produced. This process produces nuceli which lie on the neutron rich side of the line of beta stability on the chart of nuclides.

Siderophile

is the material of the Earth's core. Typical elements are Iron, Cobalt, Nickel, Gold and Palladium. It is the iron phase in the separation of elements based on chemical affinities which is used as a model when estimating the chemical composition of the Earth.

Solar Neutrinos

are neutrinos resulting from the energy-producing reactions within the Sun. Measurements of their flux at the Earth's surface are not in agreement with the predictions of the standard model of the Sun. Since these neutrinos are emitted as a part of the element-producing processes this is an important unresolved problem in the study of nucleosynthesis. One interpretation of the deficit of observed solar neutrinos compared to the predicted flux is that the neutrinos are "oscillating" or changing to other neutrino species on their journey from the Sun to the Earth.

Spallation

is the production of light nuclei in collisions between either an energetic heavy nucleus and a low energy proton of the interstellar medium or an energetic proton and a low energy heavy nucleus of the interstellar medium. This process accounts for the relatively high abundance of Be, Li and B in cosmic rays.

s-process

is the creation of elements by neutron absorption at a rate which is slow compared to the beta decay lifetime of the nuclei produced. This process produces nuclei which are close to the line of beta stability on the chart of nuclides.

Thermonuclear Fusion

is the fusing together of light nuclei to produce medium mass nuclei. The process is exothermic and is responsible for the production of elements up to iron. it is the process which powers stars as light sources - for example the production of helium from hydrogen is the process which maintains stars while they are on the main sequence.

Supernovae

signal the explosive end of a massive star's life. They are thought to be responsible for most of the element production in the Universe. They are also the means whereby this synthesised material is dispersed in clouds out of which new stars are formed by gravitational collapse.

Waiting Point

is the point on the chart of nuclides where a nucleus will not undergo further neutron absorption until beta decay has occured. This is a feature of the r-process of element synthesis and leads to enhanced production of certain nuclei.

alpha-beta-gamma theory

is the theory of primordial nucleosynthesis put forward by Alpher, Bethe and Gamov in the late 1940's. The theory attempted to explain nuclear abundances by a single process, namely successive neutron capture in the early Universe. The theory broke down due to the lack of stable nuclide with atomic numbers 5 and 8.