Week 1, Lecture 2 – Overview

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Introduction

-- Goals, roll back the fog

-- Nomenclature

-- General Properties of Nuclei

-- Chart of Nuclides

-- Nuclear Processes, overview

--- decay equations

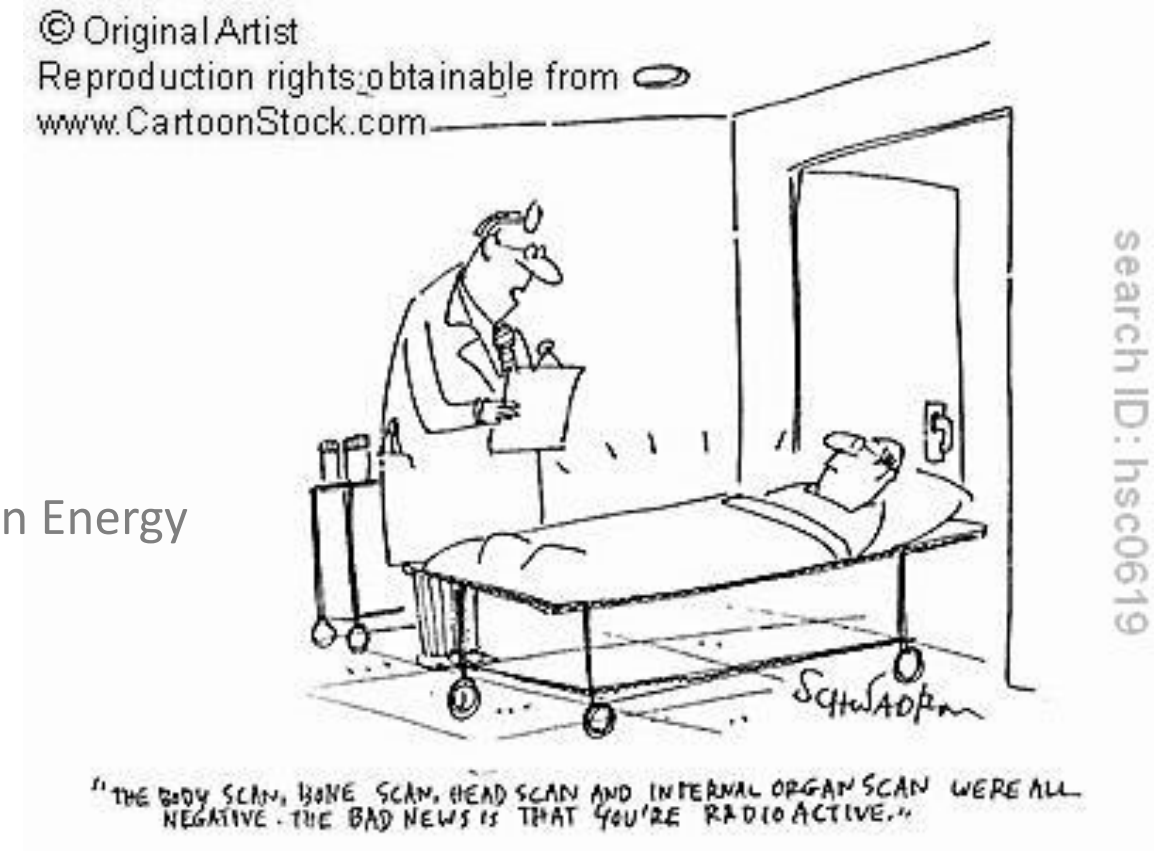
--- conservation laws

-- Nuclear "Activity"

Mass and Energy

-- Einstein's cliché

-- Binding Energy viz. Separation Energy



Nuclear vs. Atomic

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Atomic

Sizes … atoms are spherical with radii in “angstroms” determined by electron orbits

Processes … electron excitation & relaxation

chemical reactions & bonding

E.g, solid Silicon:

Nuclear

Sizes … nuclear are spherical (or nearly so) with radii of “fermis”

in general, $r = r_0 A^{1/3}$ .. Packing nucleons with uniform density ..

Processes … proton & neutron excitation & relaxation

radioactive decay (often leads to nuclear and/or atomic excitation)

nuclear reactions (nuclear collisions, essentially all extraterrestrial)

Nuclear Processes - 1

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Internal Processes …

relaxation of excited (*metastable*) states via photon emission:

e.g., proton, neutron excited states, nuclear vibration or rotation

E.g. $^{99m}Tc \rightarrow {}^{99}Tc + \gamma$ (*gamma* is used to indicate that the photon is "nuclear")

two-bodies in final state, $E_\gamma = 142.7$ keV

1st order kinetics,

half-life is constant, $T_{½} = 6.015$ hr,

or mean-life = $\tau = T_{½} / \ln 2$

or decay constant = $\lambda = 1/\tau = \ln 2/T_{½}$

This isomer is used extensively in nuclear medicine to highlight parts of the body that are biologically more active than surrounding tissue in a SPECT scan (single-photon emission computerized tomography).

Mayo Clinic link on SPECT scan

This material is in short supply at the moment due to a reactor problem in Canada.

http://www.nytimes.com/2009/07/24/science/24isotope.html

Nuclear Processes - 2

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Internal Processes …

relaxation of excited states via photon emission:

e.g., proton, neutron excited states, nuclear vibration or rotation

radioactive decay (often leads to nuclear and/or atomic excitation)

1) Nucleus has too much Coulomb energy
   nuclear conversion/change through the "strong force" … alpha decay, fission

$$^{252}_{98}Cf \rightarrow {}^{248}_{96}Cm + {}^{4}_{2}He + KE_{recoils} \qquad \left[{}^{252}_{98}Cf^{0} \rightarrow {}^{248}_{96}Cm^{2-} + {}^{4}_{2}He^{2+} + KE_{recoils}\right]$$

$$^{252}_{98}Cf \rightarrow {}^{107}_{42}Mo + {}^{141}_{56}Ba + 4n + KE_{f} \qquad [most\ likely\ split]$$

2) Nucleus is unbalanced with respect to neutron/proton number
   nuclear conversion/change through the "weak force" … beta-decay