Physics 102 – Spring 2014 – Recitation module 10

Review why it is that uranium makes a good fuel for nuclear reactors and bombs. Why do you think a neutron is a more efficient "bullet" for causing a nucleus to fission than is a proton?

Baryons are particles made up of three quarks (not necessarily the same type of quark). Mesons are particles made up of a quark and an anti-quark (not necessarily the same type of quark)

Suppose there are only three types of quarks (and their corresponding antiquarks):

Up quark, with electric charge of +2/3

Down quark, with electric charge of -1/3

Strange quark, with electric charge of -1/3

How many baryons, with what electric charges, could you make from these three quarks?

How many mesons, with what electric charges, could you make from these three quarks?

See the particle tables (from Intro. To Elementary Particles by David Griffiths) on the next page to see how many of those you listed you are able to find on the tables. These tables show just a few of the known particles.

If you get a chance, go to the wikipedia articles on "baryons" and "mesons and check them out.

http://en.wikipedia.org/wiki/List_of_baryons

http://en.wikipedia.org/wiki/Meson

Note that things are more complicated than simply adding together quarks and getting the correct charge. Things like spin and excited states come into play as well. The tables in the wikipedia pages can give you a sense of the richness of the spectrum of subatomic particles.

BARYONS (Spin $\frac{1}{2}$)

Baryon	Quark content	Charge	Mass	Lifetime	Principal decays
N p	uud	+1	938.280	∞	—
N n	udd	0	939.573	900	$pe\bar{\nu}_e$
Λ	uds	0	1115.6	2.63×10^{-10}	$p\pi^-$, $n\pi^0$
Σ^+	uus	+1	1189.4	0.80×10^{-10}	$p\pi^0$, $n\pi^+$
Σ^0	uds	0	1192.5	6×10^{-20}	$\Lambda\gamma$
Σ^-	dds	−1	1197.3	1.48×10^{-10}	$n\pi^-$
Ξ^0	uss	0	1314.9	2.90×10^{-10}	$\Lambda\pi^0$
Ξ^-	dss	−1	1321.3	1.64×10^{-10}	$\Lambda\pi^-$
Λ_c^+	udc	+1	2281	2×10^{-13}	not established

BARYONS (Spin $\frac{3}{2}$)

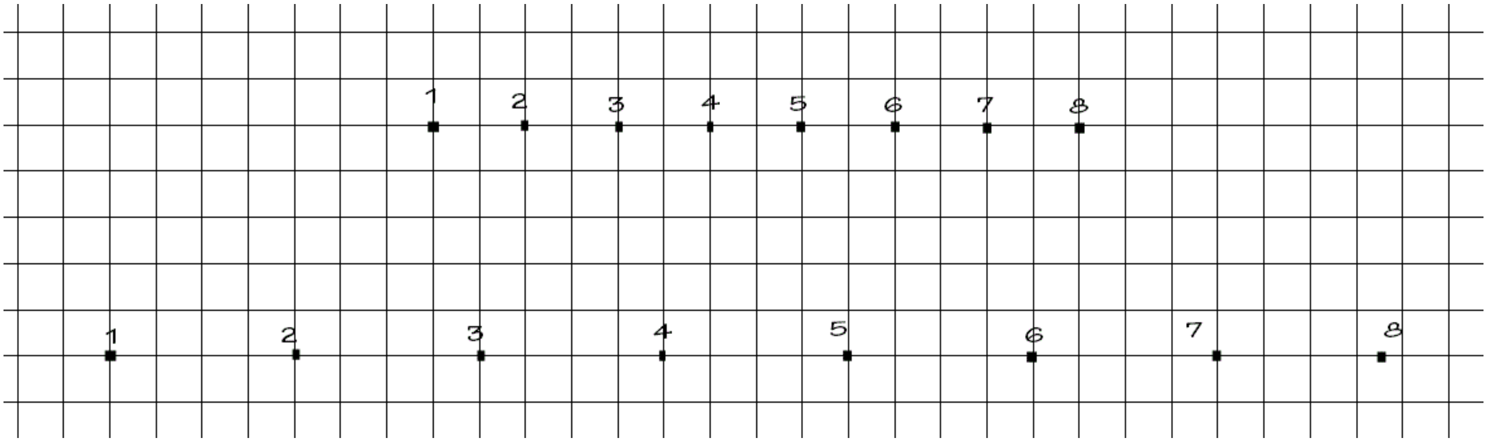
Baryon	Quark content	Charge	Mass	Lifetime	Principal decays
Δ	uuu, uud, udd, ddd	+2, +1, 0, −1	1232	0.6×10^{-23}	$N\pi$
Σ^*	uus, uds, dds	+1, 0, −1	1385	2×10^{-23}	$\Lambda\pi$, $\Sigma\pi$
Ξ^*	uss, dss	0, −1	1533	7×10^{-23}	$\Xi\pi$
Ω^-	sss	−1	1672	0.82×10^{-10}	ΛK^-, $\Xi^0\pi^-$, $\Xi^-\pi^0$

PSEUDOSCALAR MESONS (Spin 0)

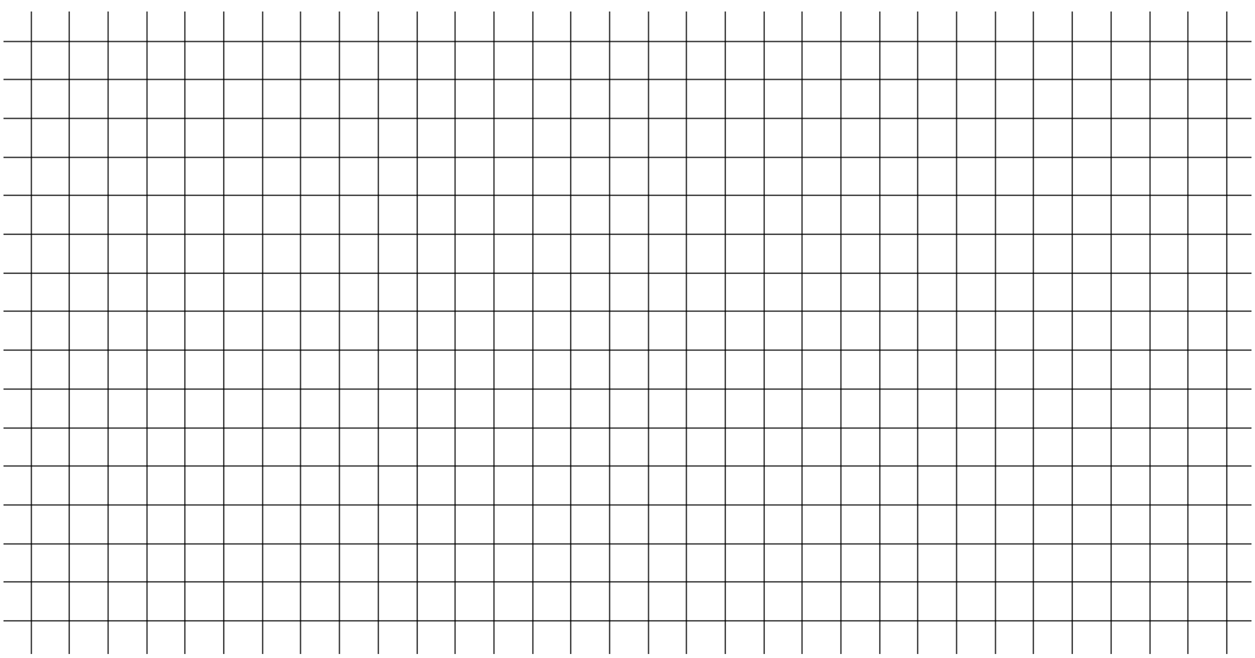
Meson	Quark content	Charge	Mass	Lifetime	Principal decays
$\pi^\pm$	$u\bar{d}$, $d\bar{u}$	+1, −1	139.569	2.60×10^{-8}	$\mu\nu_\mu$
π^0	$(u\bar{u} - d\bar{d})/\sqrt{2}$	0	134.964	8.7×10^{-17}	$\gamma\gamma$
$K^\pm$	$u\bar{s}$, $s\bar{u}$	+1, −1	493.67	1.24×10^{-8}	$\mu\nu_\mu$, $\pi^\pm\pi^0$, $\pi^\pm\pi^+\pi^-$
K^0, $\bar{K}^0$	$d\bar{s}$, $s\bar{d}$	0, 0	497.72	K_S^0 0.892×10^{-10} K_L^0 5.18×10^{-8}	$\pi^+\pi^-$, $\pi^0\pi^0$ $\pi e\nu_e$, $\pi\mu\nu_\mu$, $\pi\pi\pi$
η	$(u\bar{u} + d\bar{d} - 2s\bar{s})/\sqrt{6}$	0	548.8	7×10^{-19}	$\gamma\gamma$, $\pi^0\pi^0\pi^0$, $\pi^+\pi^-\pi$
η'	$(u\bar{u} + d\bar{d} + s\bar{s})/\sqrt{3}$	0	957.6	3×10^{-21}	$\eta\pi\pi$, $\rho^0\gamma$
$D^\pm$	$c\bar{d}$, $d\bar{c}$	+1, −1	1869	9×10^{-13}	$K\pi\pi$
D^0, $\bar{D}^0$	$c\bar{u}$, $u\bar{c}$	0, 0	1865	4×10^{-13}	$K\pi\pi$
$F^\pm$ (now $D_s^\pm$)	$c\bar{s}$, $s\bar{c}$	+1, −1	1971	3×10^{-13}	not established
$B^\pm$	$u\bar{b}$, $b\bar{u}$	+1, −1	5271	14×10^{-13}	$D + ?$
B^0, $\bar{B}^0$	$d\bar{b}$, $b\bar{d}$	0, 0	5275		
η_c	$c\bar{c}$	0	2981	6×10^{-23}	$KK\pi$, $\eta\pi\pi$, $\eta'\pi\pi$

VECTOR MESONS (Spin 1)

Meson	Quark content	Charge	Mass	Lifetime	Principal decays
ρ	$u\bar{d}$, $d\bar{u}$, $(u\bar{u} - d\bar{d})/\sqrt{2}$	+1, −1, 0	770	0.4×10^{-23}	$\pi\pi$
K^*	$u\bar{s}$, $s\bar{u}$, $d\bar{s}$, $s\bar{d}$	+1, −1, 0, 0	892	1×10^{-23}	$K\pi$
ω	$(u\bar{u} + d\bar{d})/\sqrt{2}$	0	783	7×10^{-23}	$\pi^+\pi^-\pi^0$, $\pi^0\gamma$
ϕ	$s\bar{s}$	0	1020	20×10^{-23}	K^+K^-, $K^0\bar{K}^0$
J/ψ	$c\bar{c}$	0	3097	1×10^{-20}	e^+e^-, $\mu^+\mu^-$, 5π, 7π
D^*	$c\bar{d}$, $d\bar{c}$, $c\bar{u}$, $u\bar{c}$	+1, −1, 0, 0	2010	$>1 \times 10^{-22}$	$D\pi$, $D\gamma$
Υ	$b\bar{b}$	0	9460	2×10^{-20}	$\tau^+\tau^-$, $\mu^+\mu^-$, e^+e^-



Consider the one-dimensional “universe” above that is pictured at two different times (t=0 on the top, t=1 hour on the bottom). Suppose each mark on the grid represents one kilometer. Determine Hubble’s constant for this universe by plotting distance versus speed of recession for an observer standing on point 3. Do the same for an observer standing on point 6.



Suppose you were immortal and had no need to take breaks, sleep or eat. How long would it take you to run a distance of one light year?

Check out the start of the wikipedia page on the “cosmological principle”.

http://en.wikipedia.org/wiki/Cosmological_principle

Cosmological principle

From Wikipedia, the free encyclopedia

See also: Friedmann–Lemaître–Robertson–Walker metric and Observable universe#Large-scale structure

This article **may be too technical for most readers to understand**. Please help improve this article to make it un non-experts, without removing the technical details. The talk page may contain suggestions. *(January 2013)*

In modern physical cosmology, the **cosmological principle** is an axiom that embodies the working assumption or premise that the distribution of matter in the universe is homogeneous and isotropic when viewed on a large enough scale, since the forces are expected to act uniformly throughout the universe, and should, therefore, produce no observable irregularities in the large scale structuring over the course of evolution of the matter field that was initially laid down by the Big Bang.

Astronomer William Keel explains:

> The cosmological principle is usually stated formally as 'Viewed on a sufficiently large scale, the properties of the Universe are the same for all observers.' This amounts to the strongly philosophical statement that the part of the Universe which we can see is a fair sample, and that the same physical laws apply throughout. In essence, this in a sense says that the Universe is knowable and is playing fair with scientists.[1]

The cosmological principle contains three implicit qualifications and two testable consequences. The first implicit qualification is that "observers" means any observer at any location in the universe, not simply any human observer at any location on Earth: as Andrew Liddle puts it, "the cosmological principle [means that] the universe looks the same whoever and wherever you are."[2]

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For your Hubble constant study above, what is the difference between the observations of the observer on point 3 and the observer on point 6? Does this support the “cosmological principle”?

What do you think about the cosmological principle?

Is the cosmological principle something that is consistent with the idea that humanity is “special” in some sense?