

The Standard Model

Pre-Class Questions

Problem Set (due next time)
Standard Model Problems 1,2,3,4

Lecture Outline


1. Our Current Universe - Particles and Forces
2. The Early Universe and Particle Accelerators
3. The Particle Zoo
4. The Standard Model – Quarks and Leptons

What Are You Made Of?


You are made mostly of water, but what is water (and for that "matter" everything else) made of. Fill in the table below. The answers are below, but not in the correct order. Once you write the answer on a line, rewrite it as indicated by the blue arrow to begin the next line.


A Water Droplet is made of _____

_____ are made of _____

_____ are made of _____ 

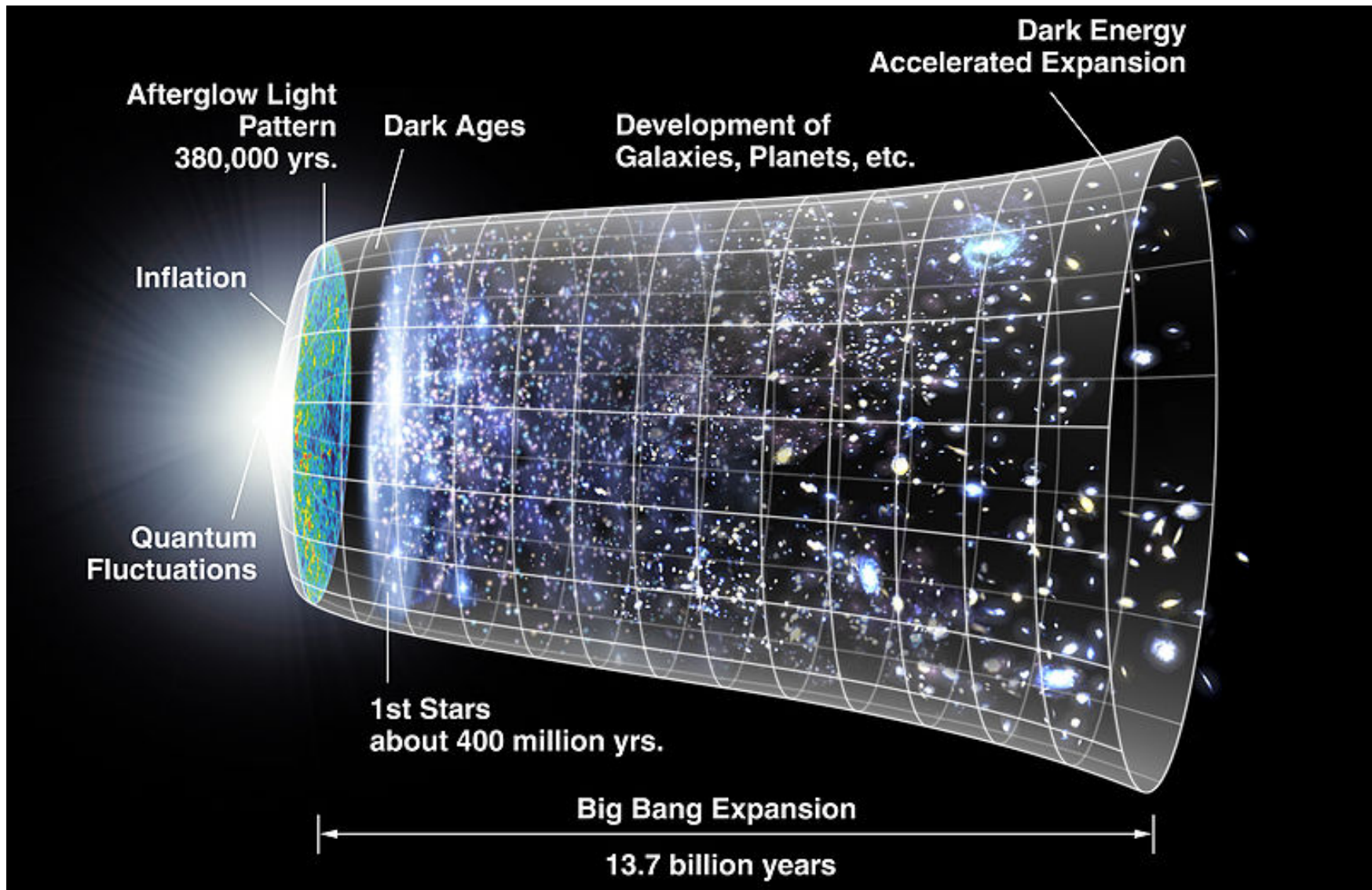
_____ and the _____

_____ is made of _____ 

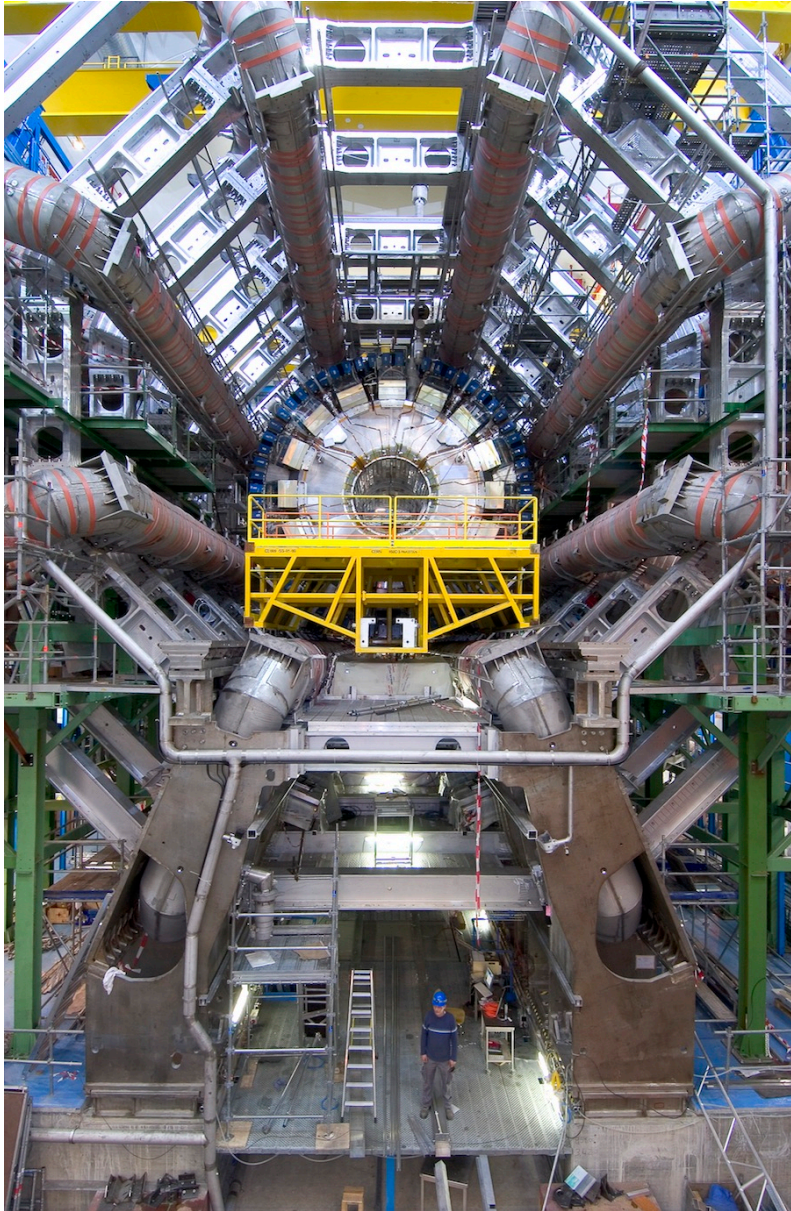
_____ and _____ 

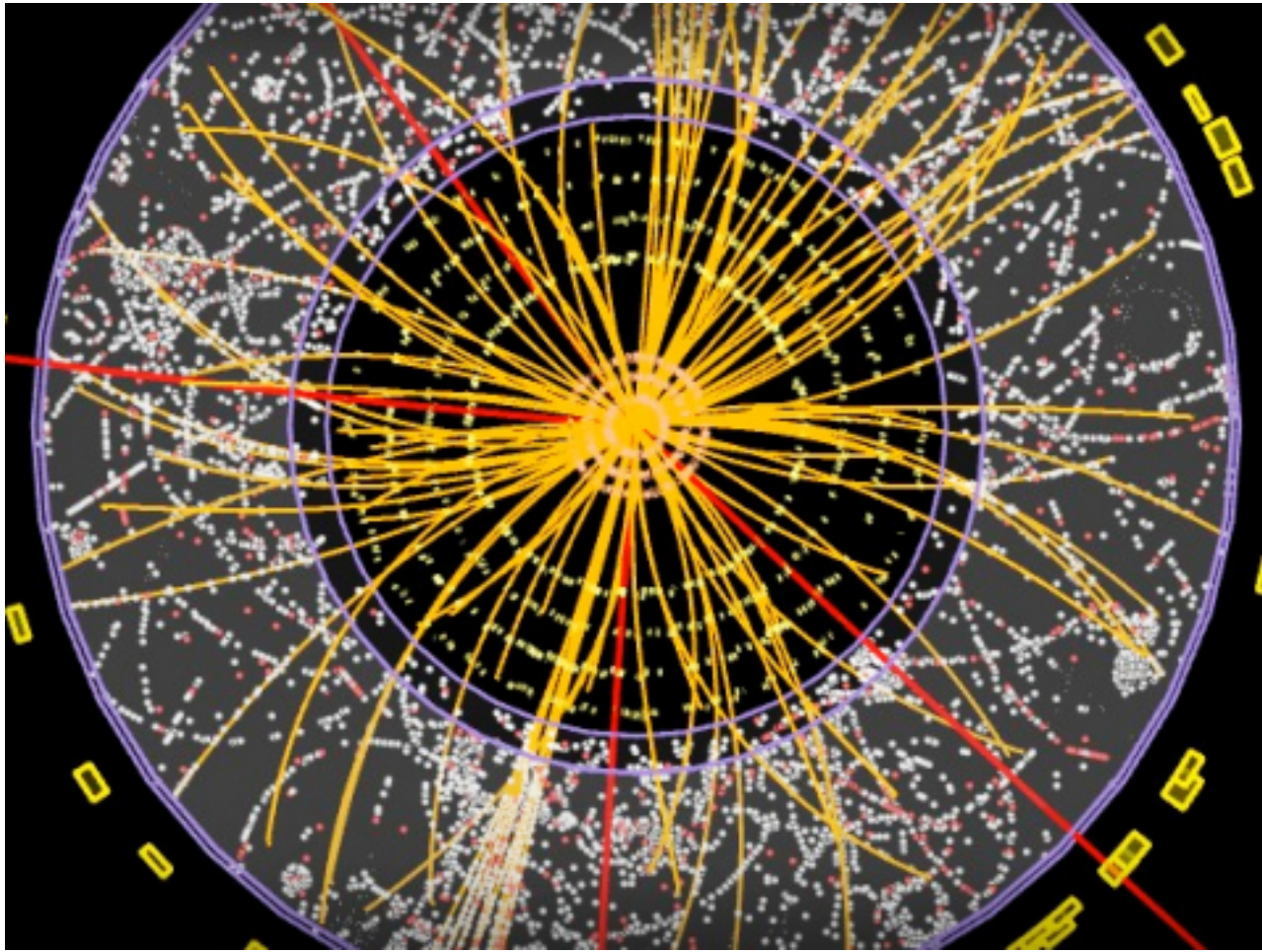
Answers: Atoms, Neutrons, Nucleus, Molecules, Protons, Electrons

Fundamental Force	Strength	Example
Gravitational	1	Solar System
Electromagnetic	10^{36}	Hydrogen Atom
Weak Nuclear	10^{25}	Beta Decay
Strong Nuclear	10^{38}	Stability of the Nucleus



Example 1: In order for light to be able to travel after the Big Bang, the temperature had to be low enough for protons to exist. Estimate this temperature by assuming the kinetic energy of a proton is equal to its mass energy.





Periodic Table of the Elements

1A	2B	NOT 2B	3D	4F	R2-D2	
Li LINT 1					Sc SCUM 2	A
De DENIM 3	To TOFU 4			Hy HYDROX 5	Cl CLOROX 6	B-C
Ny NYLON 7	Je JELL-O 8	Al ALIMONY 9	Ph PHLEGM 10	Ch CHOCOLATE 11	Wd WD-40 12	D-H
Te TEFLON 13	Ve VELVEETA 14	Feh IRONY 15	Me MENTHOLATUM 16	Bi BISMARCK 17	Or DRANO 18	I-M
Ve VELCRO 19	Mz MARZIPAN 20	Ar ARGOT 21	Ln LANOLIN 22	Ga GARLIC 23	Lm LINOLEUM 24	N-W
Xe XEROX 25*	Pa PASTA 30	Po POLONIUS 31	Pr PRELL 32	Zi ZINFANDEL 33	Ma MASONITE 34	X-Y-Z
Ko KODACHROME 35†	Gr GRANOLA 40	Pd PANDEMONIUM 41	Lb LIBRIUM 42			Other
*Insecticides	Fl FLIT 26	Ra RAID 27	Bu BUGGETA 28	St STEPONUM 29		
†Fantasides	Kr KRYPTONITE 36	Di DILITHIUM 37	Ca CAVORITE 38	La LAETRILE 39		

Periodic Table of the Elements

	I A																										0
1	1 H 1.00794															2 He 4.0026											
2	3 Li 6.941	II A														4 Be 9.01218	5 B 10.811	6 C 12.011	7 N 14.0067	8 O 16.00	9 F 18.9984	10 Ne 20.1797					
3	11 Na 22.98976	12 Mg 24.305											13 Al 27.98	14 Si 28.086	15 P 30.974	16 S 32.066	17 Cl 35.453	18 Ar 39.948									
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr									
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe									
6	55 Cs	56 Ba	57 * La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn									
7	87 Fr	88 Ra	89 + Ac	104 Rf	105 Ha	106 106	107 107	108 108	109 109	110 110																	

* Lanthanide Series

+ Actinide Series

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Particle	Mass	Charge
Proton	1	+1
Neutron	1	0
Electron	0	-1

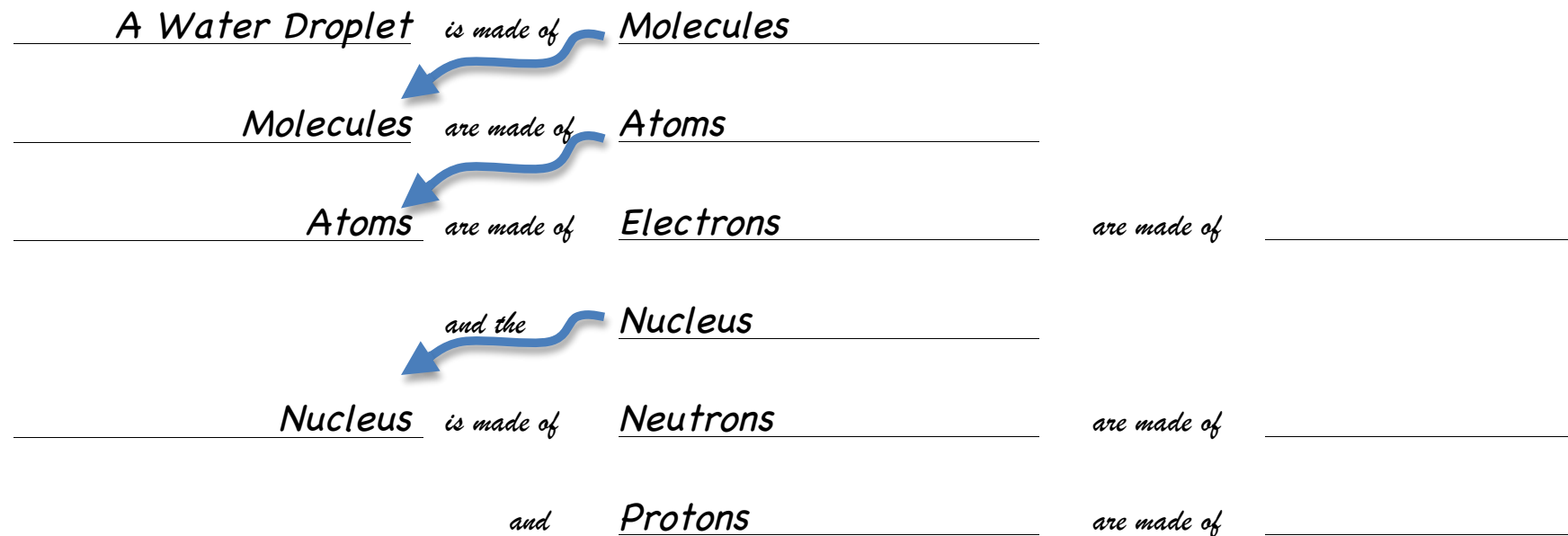
Example 2: Lithium is the third element on the periodic table. List each component part of a lithium atom by filling in the chart below.

Particle	Mass	Charge
TOTAL		

Leptons spin = 1/2			Quarks spin = 1/2		
Flavor	Mass GeV/c ²	Electric charge	Flavor	Approx. Mass GeV/c ²	Electric charge
ν_e electron neutrino	$<1 \times 10^{-8}$	0	u up	0.003	2/3
e electron	0.000511	-1	d down	0.006	-1/3
ν_μ muon neutrino	<0.0002	0	c charm	1.3	2/3
μ muon	0.106	-1	s strange	0.1	-1/3
ν_τ tau neutrino	<0.02	0	t top	175	2/3
τ tau	1.7771	-1	b bottom	4.3	-1/3

What Are You Made Of?

Now, fill in the last three blanks.



Example 3: Using just three up or down quarks, make as many integer charged particles as you can.

Combo	Charge	Particle Name

Lecture 39 - Summary

- Physics seeks to answer the question, “What is the universe made of and how do the parts interact?”
- As of today, we believe the universe is made up of quarks and leptons.
- The quarks and leptons interact via the Four Forces.

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