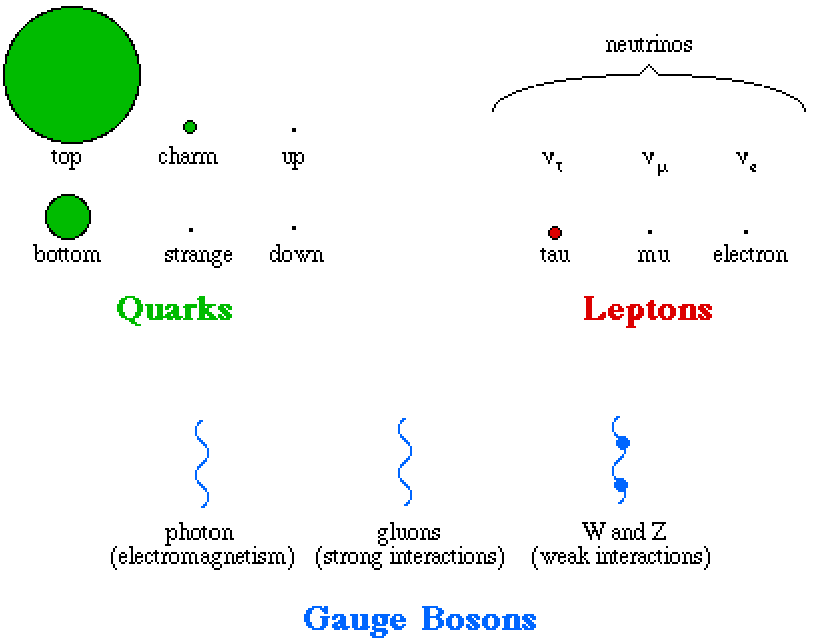
The Basic Building Blocks of Elementary Particles



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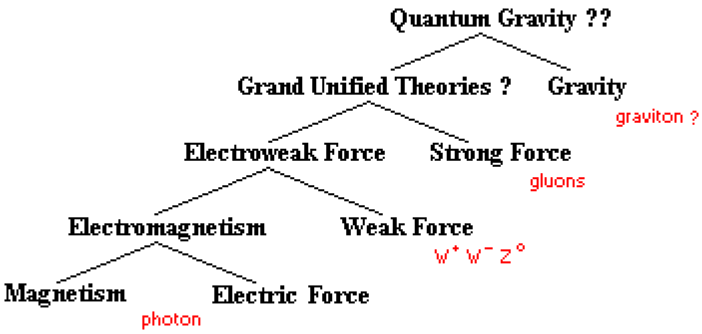
- . Fundamental Fermions (spin 1/2)

Leptons	**family**	**Quarks**	**family**
e^-, electron	1	$d^{-1/3}$, down quark	1
$_L\nu^e$, electron neutrino	1	$u^{+2/3}$, up quark	1
μ^-, muon	2	$s^{-1/3}$, strange quark	2
$_L\mu^\nu$, muon neutrino	2	$c^{+2/3}$, charm quark	2
τ^-, tau	3	$b^{-1/3}$, bottom (beauty) quark	3
$_L\nu^\tau$, tau neutrino	3	$t^{+2/3}$, top (truth) quark	3
Anti-Leptons	**family**	**Anti-Quarks**	**family**
$\bar{e}^+$, positron	1	$\underline{d}^{+1/3}$, anti-down quark	1
$_R\bar{\nu}^e$, electron anti-neutrino	1	$\underline{u}^{-2/3}$, anti-up quark	1
$\bar{\mu}^+$, anti-muon	2	$\underline{s}^{+1/3}$, anti-strange quark	2
$_R\bar{\nu}^\mu$, muon anti-neutrino	2	$\underline{c}^{-2/3}$, anti-charm quark	2



$\bar{\tau}^+$, anti-tau	3	$\underline{b}^{+1/3}$, anti-bottom quark	3
R $\bar{\tau}$ $^{\tau}$, tau anti-neutrino	3	$\underline{t}^{-2/3}$, anti-top quark	3

- III. Other Particles & Recent Theories

New theories, super-gravity, super-symmetry, super-strings, etc. (Grand Unified Theories, "G.U.T.'s"), predict further particles (e.g. spin 1 and spin 0 versions of the graviton -- "graviphoton" and "graviscalar"), especially whole classes of fermions that correspond to every boson (the gravitino, Wino, Zino, photino, gluino, & higgsino) and bosons that correspond to every fermion (the squarks & sleptons). There are also possible massive magnetic monopoles, long predicted.

None of these particles has ever been verifiably observed, and the principal prediction of the GUT's, the decay of the proton, after more than twenty years of observation in large scale experiments, has been, to general distress, *discomfirmed*. That the graviton itself has not been detected is symbolic of the incompleteness of physics, as a division remains between Einstein's successful Relativistic theory of gravity and the successful quantum theories of all the other interactions. What must be regarded as the actual failure of the unification of the strong and electroweak force puts the whole business of particle physics at the awkward moment. The String theories now seem to be the rage, but it is not clear what sorts of predictions, if any, they make -- physicists are getting positively defensive about it. It is still necessary to postulate the decay of the proton, if the predominance of matter over anti-matter in the universe is to be economically explained, but how and under what conditions this would occur is pretty much up in the air.

Much now seems to rest on the detection of the Higgs particles and their field. One of the great mysteries of particle physics is why *charge* and other quantum attributes occur in *integer quantities* while *mass*, the most fundamental property of all matter and energy (and, not coincidentally, the basis of gravitation), does not. The Higgs field is supposed to handle this, though it remains an obscure area little explained in population presentations. Until the String theories make some testable predictions, the key experimental test for particle physics may be the detection of a Higgs boson. After decades in which whole families of new particles spilled out of the accelerators, the well now seems to have dried up, and we await in hushed anticipation the appearance of even one....

ORDINARY AND STRANGE BARYONS & MESONS

Spin: The spin of baryons and mesons is determined by the addition of the spin of constituent quarks. Quarks are 1/2 spin fermions; the spin of each may reinforce or may cancel the spin of the others. Thus, three quarks may all reinforce to produce a 3/2 spin baryon, or one may cancel another out to produce a 1/2 spin baryon. A quark and an anti-quark may reinforce each other to produce a 1 spin meson, or they may cancel out to produce a 0 spin meson. These systems with different spin are *different* particles with *different* masses. Nor are the 3/2 spin particles always mere "resonances" (called "star" particles, as with the star Sigmas, Σ^{*+}, etc.) of the 1/2 spin ones -- where resonances are particles that are simply excited to a higher state by the addition of energy (various 5/2, 7/2, & higher resonances count as separate particles but are nothing more mysterious than excitations): For some 3/2 spin particles do *not* have 1/2 spin counterparts, and one 3/2 spin particle has *two* 1/2 spin counterparts. This peculiarity occurs because of the question of the *identity* of the quark that may be the odd one out in canceling the spin of another. A different odd quark makes for a different particle. But against this is the quantum principle that identical quarks are *absolutely* identical, so that if there are two or three identical quarks in a baryon, it is impossible to decide, if one quark is the odd one, which is which. This means in such a case that there cannot be different odd quarks and so there cannot be different particles. The alternatives can be displayed by examining the possible "magnetic substates" of the particles: when a particle is put in a magnetic field, its spin breaks down into a preferential orientation in the field. The number of possible magnetic orientations is simply the number of integer steps from the positive value of the spin to the negative value of the spin (or 2x+1 states, where x is the spin). Thus 1/2 spin breaks down into 2 substates (+1/2 & -1/2); 3/2 spin into 4 (+3/2, +1/2, -1/2, & -3/2); 0 spin into 1 (0); 1 spin into 3 (+1, 0, -1); 2 spin into 5 (+2, +1, 0, -1, -2), etc. The magnetic substates of excited electrons are responsible for the number of members in each grouping within the period table of chemical elements. Although all the spins reinforce in 3/2 spin baryons, nevertheless, in the +1/2 and -1/2 spin magnetic substates, there will be an odd quark (where R stands for a right-handed or +1/2 quark and L for a left-handed or -1/2 quark):

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3/2          1/2          1/2
RRR=+3/2
RLR=+1/2     RRL=+1/2     LRR=+1/2
LRL=-1/2     LLR=-1/2     RLL=-1/2
LLL=-3/2

qqq
qqr          qqr
qrs          qrs          qrs
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Where the baryon consists of three identical quarks (qqq), the RLR, RRL, and LRR states are indistinguishable, and so only one particle will exist, the 3/2 spin one. Where the baryon contains two identical quarks (qqr), only the RLR and LRR states are indistinguishable, so two particles are possible, one 3/2 spin and one 1/2 spin. However, where the baryon contains three different quarks (qrs), no states are indistinguishable and three different particles are possible. Hence the seemingly anomalous presence of the Lambda, $\Lambda(uds)^0$, in the 1/2 spin baryon Octet. No such issues arise with the mesons, where none contain identical particles.

Baryons

Ω^-(sss) Omega Minus

Ξ^{*0}(uss) Ξ^{*-}(dss) Cascade (Xi) Resonances

Σ^{*+}(uus) Σ^{*0}(uds) Σ^{*-}(dds) Star Sigmas

Δ^{++}(uuu) Δ^+(uud) Δ^0(udd) Δ^-(ddd) Delta Particles

3/2 Spin Decimet

Ξ^0(uss) Ξ^-(dss) Cascade (Xi) Particles

Σ^+(uus) Σ^0/Λ^0(uds) Σ^-(dds) Lambda & Sigmas

N^+(uud) N^0(udd) Nucleons (proton & neutron)

1/2 spin Octet

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Anti-Baryons

$\bar{\Omega}^{+}(\overline{sss})$ Anti-Omega

$\bar{\Xi}^{*0}(\overline{uss})$ $\bar{\Xi}^{*+}(\overline{dss})$ Anti-Cascade Resonances

$\bar{\Sigma}^{*-}(\overline{uus})$ $\bar{\Sigma}^{*0}(\overline{uds})$ $\bar{\Sigma}^{*+}(\overline{dds})$ Star Anti-Sigmas

$\bar{\Delta}^{--}(\overline{uuu})$ $\bar{\Delta}^{-}(\overline{uud})$ $\bar{\Delta}^{0}(\overline{udd})$ $\bar{\Delta}^{+}(\overline{ddd})$ Anti-Delta Particles

3/2 spin Decimet

$\bar{\Xi}^{0}(\overline{uss})$ $\bar{\Xi}^{+}(\overline{dss})$ Cascade Anti-Particles

$\bar{\Sigma}^{-}(\overline{uus})$ $\bar{\Sigma}^{0}/\Lambda^{0}(\overline{uds})$ $\bar{\Sigma}^{+}(\overline{dds})$ Anti-Lambda & Anti-Sigmas

$\bar{N}^{-}(\overline{uud})$ $\bar{N}^{0}(\overline{udd})$ Anti-Nucleons

1/2 spin Octet

Mesons

$K^{0}(d\bar{s})$ $K^{+}(u\bar{s})$ Kaons

$\pi^{-}(d\bar{u})$ $\pi^{0}/\eta^{0}(u\bar{u}/d\bar{d})$ $\eta^{\prime 0}(s\bar{s})$ $\pi^{+}(u\bar{d})$ Pions & Etas

$K^{-}(s\bar{u})$ $\bar{K}^{0}(s\bar{d})$ Kaon/Anti-Kaon

0 spin

$K^{*0}(d\bar{s})$ $K^{*+}(u\bar{s})$ Star Kaons

$\rho^{-}(d\bar{u})$ $\rho^{0}/\omega^{0}(u\bar{u}/d\bar{d})$ $\phi^{0}(s\bar{s})$ $\rho^{+}(u\bar{d})$ Rhos, Omega Meson, Phi

$K^{*-}(s\bar{u})$ $\bar{K}^{*0}(s\bar{d})$ Star Kaon/Anti-Kaon

1 spin

CHARMED AND BOTTOM BARYONS AND MESONS

The elaborate Greek designations of particles cease when we come to the much more shortlived, elusive, and imperfectly studied charmed and bottom particles. Although more than 15 years has passed since the first charmed particle was identified (the $c\underline{c}^{0}$), the priority of discovery has still has not been resolved, and the particle continues to bear two designations -- as the J particle, or as the ψparticle.

We might ask at this point what qualities like "strangeness," "charm," or "bottom" really *mean*. Electric charge and mass are things whose effects we can actually see, but strangeness, etc. only seem to exist in so far as they differentiate separate groups of particles. Indeed, that is about as far as we can go. The predicted "top" particles have recently been discovered, but the very large number of such particles has not been indicated here.

043 - baryony + cizí pyramidy + různé,
Often the names "top" and "bottom" are replaced by "truth" and "beauty." This is because there is a distinction between "bare" and "hidden" properties: charm in the $c\underline{c}^0$ particle is "hidden" because anti-charm cancels out all the properties of charm, while in the $c\underline{s}^+$ particle charm is "bare" because it is not canceled out. Those locutions mean that physicists end up talking about "bare bottom" and "bare top," which some think sounds too sexually suggestive to occur in scientific discussions. Indeed, in this day and age, someone, including whole universities, might get sued for "sexual harassment" for tolerating terms like "bare bottom" in front of ready-to-be-offended feminists.

I. Charmed Baryons & Anti-Baryons

3/2	1/2	1/2
$(uuc)^{++}$ $(udc)^{+}$ $(ddc)^{0}$	$(uuc)^{++}$ $(udc)^{+}$ $(ddc)^{0}$	Λ_c^{+} (udc)
$(ucc)^{++}$ $(dcc)^{+}$	$(ucc)^{++}$ $(dcc)^{+}$	Charmed Lambda
$(ccc)^{++}$		
$(ssc)^{0}$	$(ssc)^{0}$	
$(usc)^{+}$ $(dsc)^{0}$	$(usc)^{+}$ $(dsc)^{0}$	$(usc)^{+}$ $(dsc)^{0}$
$(scc)^{+}$	$(scc)^{+}$	

3/2	1/2	1/2
$(\overline{uuc})^{--}$ $(\overline{udc})^{-}$ $(\overline{ddc})^{0}$	$(\overline{uuc})^{--}$ $(\overline{udc})^{-}$ $(\overline{ddc})^{0}$	$\overline{\Lambda}_c^{-}$ $(\overline{udc})$
$(\overline{ucc})^{--}$ $(\overline{dcc})^{-}$	$(\overline{ucc})^{--}$ $(\overline{dcc})^{-}$	Charmed Anti-Lambda
$(\overline{ccc})^{--}$		
$(\overline{ssc})^{0}$	$(\overline{ssc})^{0}$	
$(\overline{usc})^{-}$ $(\overline{dsc})^{0}$	$(\overline{usc})^{-}$ $(\overline{dsc})^{0}$	$(\overline{usc})^{-}$ $(\overline{dsc})^{0}$
$(\overline{scc})^{-}$	$(\overline{scc})^{-}$	

II. Bottom & Charmed Baryons & Anti-Baryons

3/2	1/2	1/2
$(uub)^{+}$ $(udb)^{0}$ $(ddb)^{-}$	$(uub)^{+}$ $(udb)^{0}$ $(ddb)^{-}$	$\Lambda_b^0\,(udb)$
$(ubb)^{0}$ $(dbb)^{-}$	$(ubb)^{0}$ $(dbb)^{-}$	Bottom Lambda
$(bbb)^{-}$		
$(ssb)^{-}$	$(ssb)^{-}$	
$(usb)^{0}$ $(dsb)^{-}$	$(usb)^{0}$ $(dsb)^{-}$	$(usb)^{0}$ $(dsb)^{-}$
$(sbb)^{-}$	$(sbb)^{-}$	
$(ucb)^{+}$ $(dcb)^{0}$	$(ucb)^{+}$ $(dcb)^{0}$	$(ucb)^{+}$ $(dcb)^{0}$
$(scb)^{0}$	$(scb)^{0}$	$(scb)^{0}$
$(ccb)^{+}$	$(ccb)^{+}$	
$(cbb)^{0}$	$(cbb)^{0}$	

3/2	1/2	1/2
$(\overline{uub})^{-}$ $(\overline{udb})^{0}$ $(\overline{ddb})^{+}$	$(\overline{uub})^{-}$ $(\overline{udb})^{0}$ $(\overline{ddb})^{+}$	$\overline{\Lambda}_b^0\,(\overline{udb})$
$(\overline{ubb})^{0}$ $(\overline{dbb})^{+}$	$(\overline{ubb})^{0}$ $(\overline{dbb})^{+}$	Bottom Anti-Lambda
$(\overline{bbb})^{+}$		
$(\overline{ssb})^{+}$	$(\overline{ssb})^{+}$	
$(\overline{usb})^{0}$ $(\overline{dsb})^{+}$	$(\overline{usb})^{0}$ $(\overline{dsb})^{+}$	$(\overline{usb})^{0}$ $(\overline{dsb})^{+}$
$(\overline{sbb})^{+}$	$(\overline{sbb})^{+}$	
$(\overline{ucb})^{-}$ $(\overline{dcb})^{0}$	$(\overline{ucb})^{-}$ $(\overline{dcb})^{0}$	$(\overline{ucb})^{-}$ $(\overline{dcb})^{0}$
$(\overline{scb})^{0}$	$(\overline{scb})^{0}$	$(\overline{scb})^{0}$
$(\overline{ccb})^{-}$	$(\overline{ccb})^{-}$	
$(\overline{cbb})^{0}$	$(\overline{cbb})^{0}$	

III. Charmed Mesons

$(cs)^{+}$

$D^{0}(c\bar{u})$ $D^{+}(c\bar{d})$

$[\mathbf{J}/\psi]^{0}(c\bar{c})$ [**J** & ψ, different names for same particle]

$D^{-}(d\bar{c})$ $\bar{D}^{0}(u\bar{c})$

$(s\bar{c})^{-}$

IV. Bottom & Charmed Mesons

043 - baryony + cizí pyramidy + různé,

$(c\bar{b})^{+}$

$B^{0}(b\bar{d})$ $B^{+}(u\bar{b})$

$(b\bar{s})^{0}$ $U^{0}(b\bar{b})$ $(s\bar{b})^{0}$

$B^{-}(b\bar{u})$ $\bar{B}^{0}(d\bar{b})$

$(b\bar{c})^{-}$