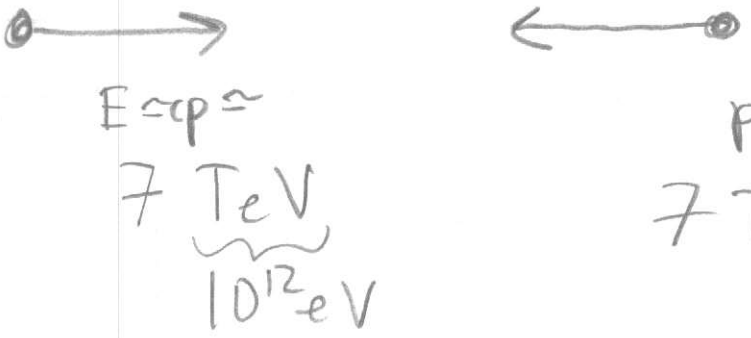
(2) LHC (Large Hadron Collider)

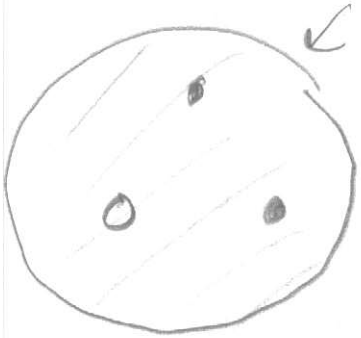


a u quark $\bar{u}$ quark

sometimes, matter & antimatter meet, even though to the casual observer, it's a matter/matter collider!

(3) The GLUE

quarks like ball bearings in "gelatin"



ground state of gluons

called (≈1970) the "glue" (What is it??)

(photon analog)
photon - neutral (e+m)
gluon - (color) charged

How.. imagine trying to pull a quark out of a nucleon

Terminology:

Baryon: 3 quarks (valence)
(Antibaryon 3 antiquarks)

Meson: { quark / antiquark } always unstable

1 Baryon (the Proton) is stable, the rest unstable.

Given a choice of quarks/antiquarks, still must specify total angular momentum (spin + orbital)

Proton/Neutron: $L = 0$ (no orbital)

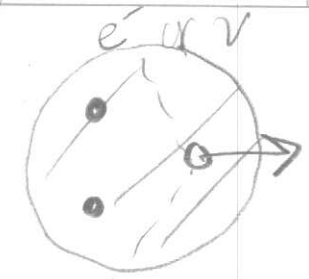
Spin: ↑↑↓

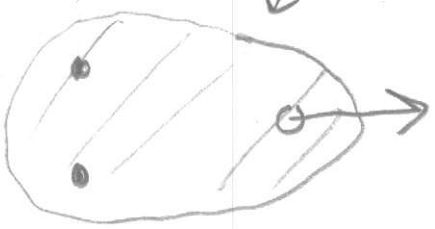
3 spin-$\frac{1}{2}$ ....

↑ which one?

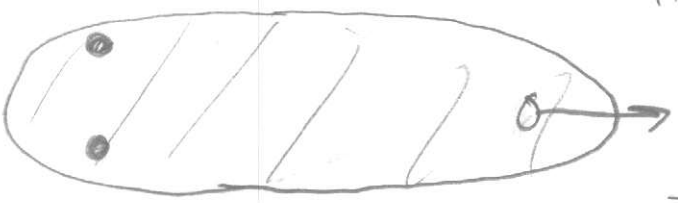
LATER.

u u u
↑ ↑ ↓ } gets into Pauli Principal. Issues!





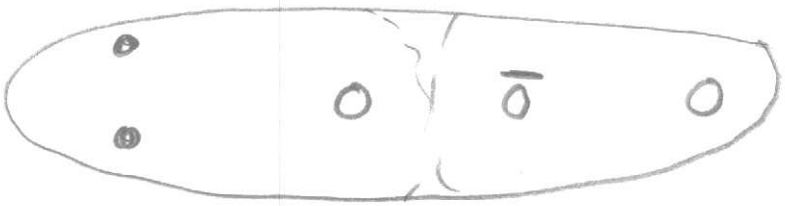
increasing "energy"



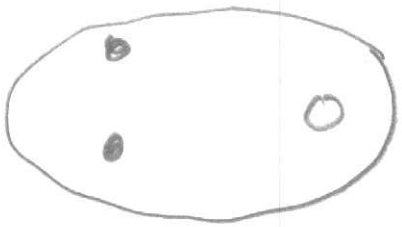
energy kind of linear with distance (but not fundamental)

⇒ "INFRARED SLAVERY"

but quark/antiquark pairs always around



"pop"



nucleon

MESON.

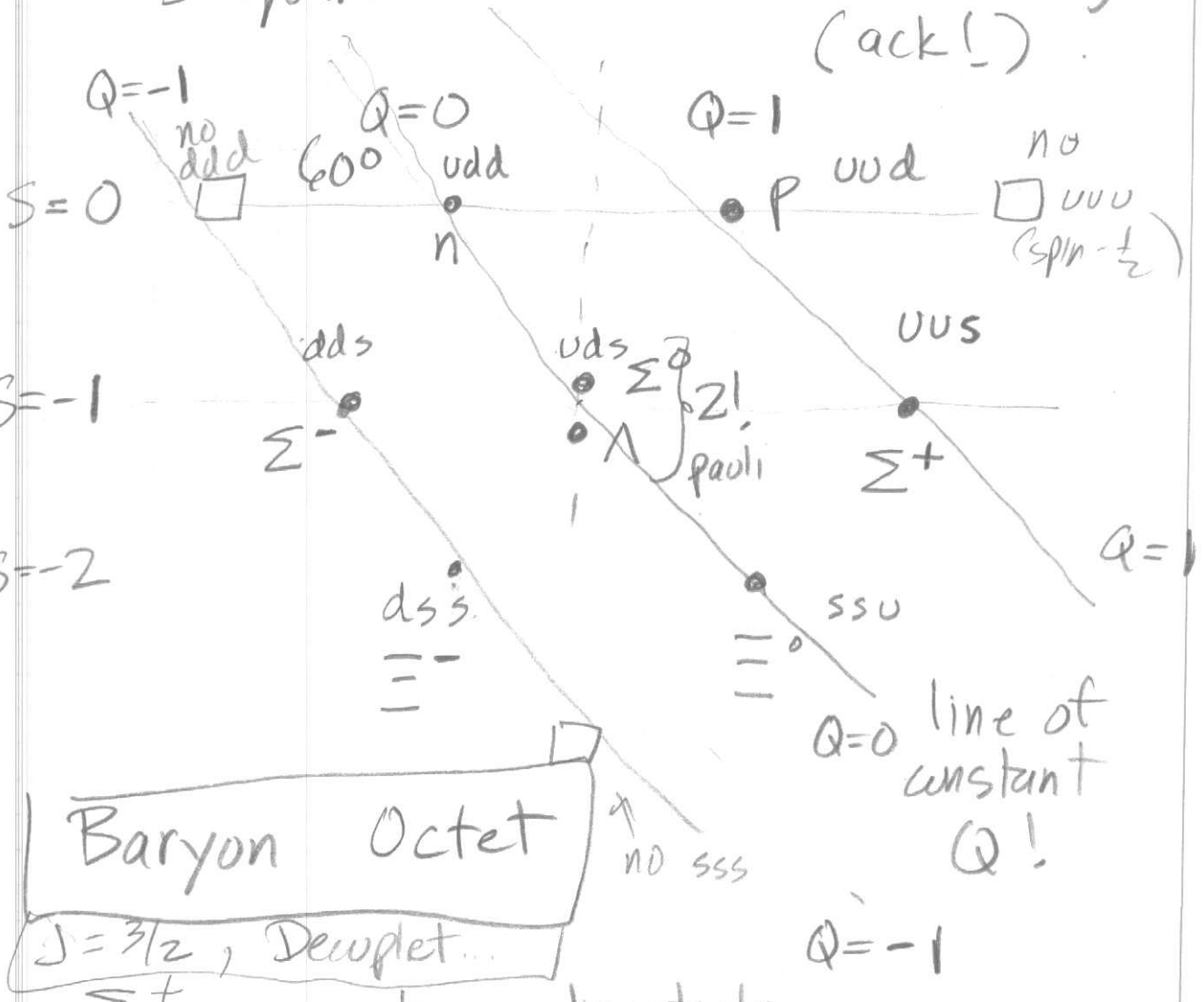
In the 1950's a third quark (s for strange) was discovered

$m_s \approx 120\ MeV \sim p, u, d$ in nucleon

spin-$\frac{1}{2}$ Baryons (with strangeness)

s quark ... -1 units of "strangeness"

$\bar{s}$ quark 1 unit of strangeness (ack!)



Baryon Octet

$J = 3/2$, Decuplet...

Σ^+ is not antiparticle of Σ^-

Σ^+ (uus)

Σ^- (dds)

Both $\Sigma^0 + \Lambda$ ... no Pauli principle problems

Mesons

	$J=0$ $L=0$ $\uparrow\downarrow$ spin	$J=1$ $L=0$ $\uparrow\uparrow$ spin
$u\bar{u}$	π^0	ρ^0
$d\bar{d}$	η	ω
$u\bar{d}$	π^+	ρ^+
$\bar{u}d$	π^-	ρ^-
$Mc^2 \sim$	140 MeV	770 MeV

WOW!

$s\bar{s}$	η'	ϕ
$u\bar{s}$	K^+	K^{*+}
$d\bar{s}$	K^0	K^{*0}
$\bar{u}s$	K^+	K^{*+}
$\bar{d}s$	$\overline{K^0}$	$\overline{K}^{*0}$

add $L \neq 0$ .. Big Fun!
"Meson Spectroscopy"