TODAY : FINALS LOGISTICS
QUESTIONS
LIES MY PROFESSOR TOLD

- continue material from LEC 17 & 18

nonexaminable

Lies that I've told inadvertently on the HW — not on final exam

THE WORST ONE :

DIRAC 4 component spinor $= \Psi^a = \begin{pmatrix} \psi_L{}^\alpha \\ \psi_R{}^{\dot\alpha} \end{pmatrix}$

a: 1,2,3,4 $\qquad$ $\alpha, \dot\alpha$: 1,2

encodes 4 physical degrees of freedom that are related by Lorentz transformations

UPPER/LOWER INDICES ARE A CONVENTION CHOICE

"PARTICLE" ; type of wiggle in "spring theory"

SO FAR SO GOOD. THE PROBLEM IS THE CONJUGATE SPINOR

$$\bar\Psi \equiv \Psi^\dagger \gamma^0 \qquad \gamma^0 = \begin{pmatrix} & \mathbb{1} \\ \mathbb{1} & \end{pmatrix}$$

$$= \begin{pmatrix} \psi_L^\dagger & \psi_R^\dagger \end{pmatrix} \begin{pmatrix} & \mathbb{1} \\ \mathbb{1} & \end{pmatrix}$$

$$= \begin{pmatrix} \psi_R^\dagger & \psi_L^\dagger \end{pmatrix}$$

antiparticle of ψ_L
BUT NOW IN "LOWER" 2 COMPONENTS

Why? arrange them this way for convenience when forming invariants.

where I screwed up: SPIN INDICES :(

$$\bar{\Psi} = \left((\psi_R^\dagger)^\alpha \varepsilon_{\alpha\beta} \ , \ (\psi_L^\dagger)^{\dot\alpha} \varepsilon_{\dot\alpha\dot\beta} \right)$$

had to lower spin indices

so that:

$$\bar{\Psi}\Psi = (\psi_R^\dagger)^\alpha \varepsilon_{\alpha\beta} \psi_L^\beta + (\psi_L^\dagger)^{\dot\alpha} \varepsilon_{\dot\alpha\dot\beta} \psi_R^{\dot\beta}$$

WHAT THIS MEANS IS THAT:

$$\bar{\Psi} = \left((\psi_R^\dagger)^\alpha \varepsilon_{\alpha 1} , (\psi_R^\dagger)^\alpha \varepsilon_{\alpha 2}, \cdots \right)$$

$$= \left(\underbrace{(\psi_R^\dagger)^2 (-)}_{-\psi_R^{\downarrow *}} , \underbrace{(\psi_R^\dagger)^1 (+)}_{+\psi_R^{\uparrow *}} , \cdots \right)$$

$$= \boxed{\left(-\psi_R^{\downarrow *} , +\psi_R^{\uparrow *}, -\psi_L^{\downarrow *}, +\psi_L^{\uparrow} \right)}$$

signs aren't important for our current purposes, but order of ↑ ↓ is.

(affects HW7 & 8

(you were graded assuming the wrong thing that I gave)

SO: VECTOR INTERACTION

$$\bar{\Psi}\gamma^\mu \Psi A_\mu$$

SCALAR INTERACTION

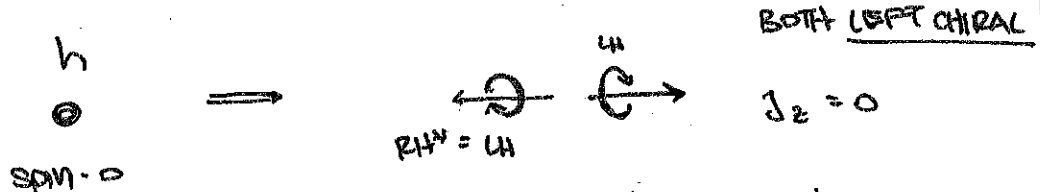
$$\bar{\Psi}\Psi h$$

scalar:

$$h\left(-\psi_R^{\downarrow *}\ \psi_R^{\uparrow *}\ -\psi_L^{\downarrow *}\ \psi_L^{\uparrow *}\right)\begin{pmatrix}\psi_L^{\uparrow}\\ \psi_L^{\downarrow}\\ \psi_R^{\uparrow}\\ \psi_L^{\downarrow}\end{pmatrix}$$

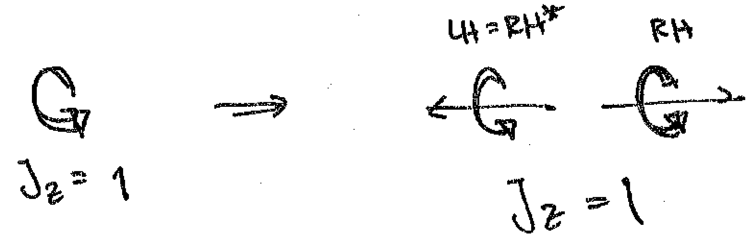
$$= h\left(\underbrace{-\psi_R^{\downarrow *}\psi_L^{\uparrow}}, \ \cdots\right)$$

makes sense: imagine $h \to \underbrace{\psi_R^{*}\psi_L}_{\text{BOTH LEFT CHIRAL}}$



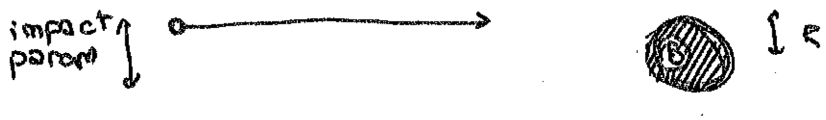
eg in massless limit where chirality = helicity

COMPARE TO VECTOR:



CROSS SECTION

COLLIDER "ROSETTA STONE"

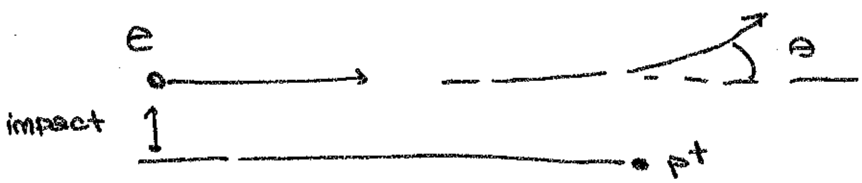


the cross section is $\pi R^2 \leftarrow \sigma$

↳ gives a target area for which a scattering occurs

some deflection.

MORE SUBTLE: scattering off a force field (classical)



eg. X-SEC IS FORMALLY ∞ for COULOMB POTENTIAL

~~FOR~~ QUANTUM / PARTICLE PHYSICS:

"the cross section for ____ is ____"

some specific process

eg $e^+e^- \to \mu^+\mu^-$
w/ SOME SPECIFIED KINEMATICS

w/ dimension of AREA

one time that we use not-natural units.

pico-barn

$$pb = 3 \times 10^{-9}\ GeV^{-2} = 10^{-36}\ cm^2$$

WHAT THE CALCULATION LOOKS LIKE: $A + B \rightarrow \sum_f \varphi_f$

$$d\sigma = \underbrace{\frac{1}{2E_A}\,\frac{1}{2E_B}}_{\text{energies of initial particles}}\;\underbrace{\frac{1}{|V_A - V_B|}}_{\text{REL. VEL.}}\;\underbrace{\prod_f}_{\text{PROD OVER FINAL STATE PARTICLES}}\;\underbrace{\frac{d^3p_f}{(2\pi)^3}\,\frac{1}{2E_f}}_{\text{INTEGRAL OVER FINAL STATE 4-MOMENTA}}\;\underbrace{|\mathcal{M}|^2}_{\text{AMPLITUDE}^2\text{ (Feynman diagram)}}\;\underbrace{(2\pi)^4\delta^4(\Sigma)}_{\text{TOTAL 4 MOMENTUM CONSERVATION}}$$

$\sim d^4p_f\,\delta(p_f^2 - m_f^2)$

DIMENSIONAL ANALYSIS: total dim +2

differential: integrate over final state config.

↑ INTEGRATION <u>LIMITS</u> ARE AN ART.

WHEN WE PLOT "RATES" ⟷ cross section

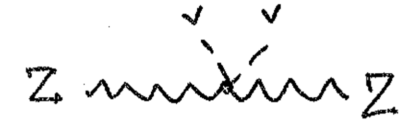
how many <u>events</u>?

↳ multiply σ by <u>LUMINOSITY</u>, $\mathcal{L}$ ← not LAGRANGIAN

$[\mathcal{L}] = \text{AREA}^{-1}$, eg "inverse picobarns"

PROBLEM OF MASS

GAUGE BOSON MASS



$\sim g^2 v^2$

$\overset{?}{\sim} g^2 \underbrace{\int d^4k \, \frac{1}{k^2 - m^2}}$

$k^2 \to$ BIG?? (Λ^2)

$\Delta m_z^2 \propto m_z^2$

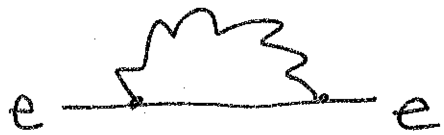
not "infinite"
we know that mass comes from gauge symm. breaking $\to$ MUST BE PROPORTIONAL TO v^2

$\langle |H|^2 \rangle$

@ HIGH MOMENTA, YOU DON'T "SEE" v^2. SO HIGH MOMENTUM LOOP CONTRIBUTIONS DON'T REALIZE THAT SYMMETRY IS BROKEN.

FERMION MASS

$\frac{k + m}{k^2 - m^2}$



$\sim g^2 \int d^4k \, \frac{1}{k^2 - M_W^2} \left(\frac{1}{k - m} \right)$

$\sim g^2 k \to$ BIG? (Λ)

BUT! THIS IS A CHIRALITY-FLIPPING TERM

$\sim yv$

=

$g \int d^4k \, \frac{1}{k^2} \, \frac{m}{k^2 - m^2}$

or $g \int d^4k \, \frac{1}{k^2} \, \frac{1}{k} \, \frac{1}{k}$