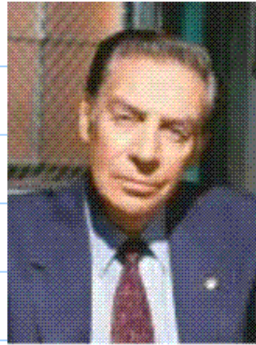


# PHY100S - The Magic of Physics - Class 24

## Separated at birth?



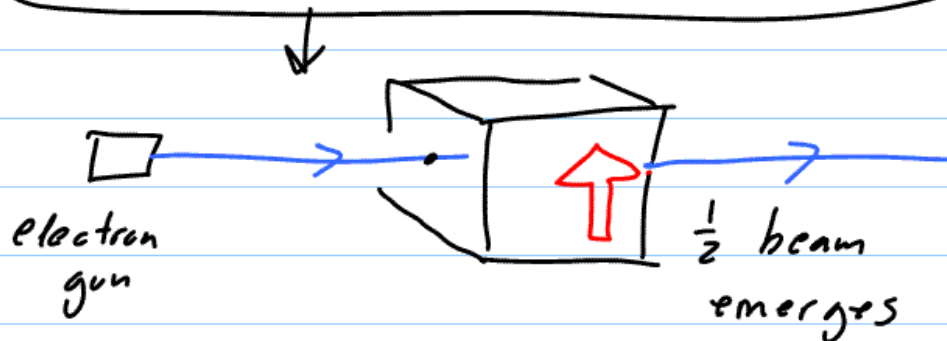
Schwinger (text Fig.18.1.c)



Lenny Briscoe  
(Law & Order)

2 Nitrogen-13 atoms!  
 1 decays } in 10 minutes  
 1 does not }

Is there a hidden variable?



whether or not a single  
electron emerges is  
random.

What Bell proved in 1964



"entangled quantum pair"

if hidden variable for spin,  
associated with both members  
of the pair

No local hidden variables.

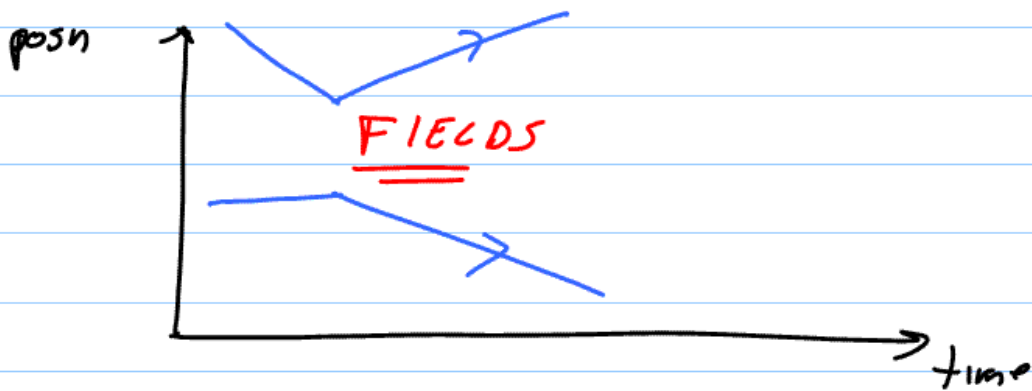
CHAPTER 18

§ 18.1 - 18.2

electron-electron scattering

Before:

○ stationary

After:Describe!

19<sup>th</sup> century language.

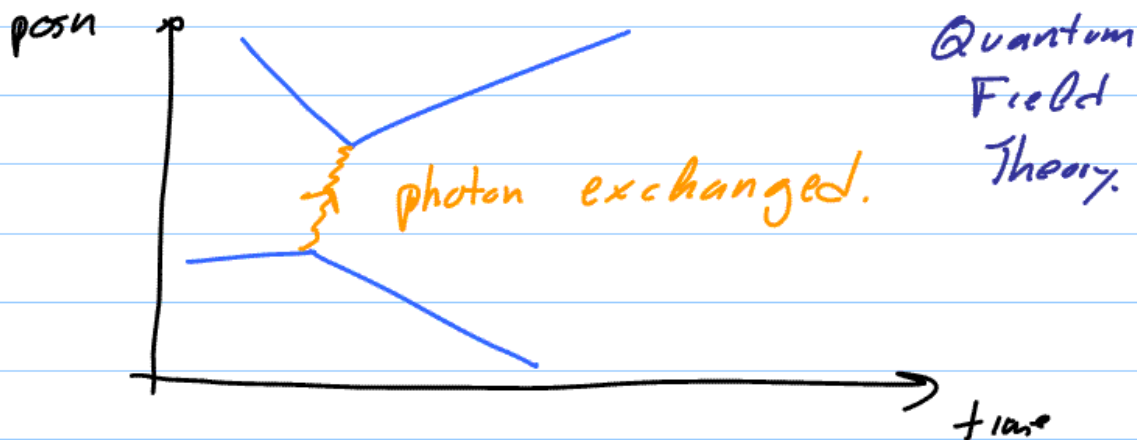
Each electron creates an electromagnetic field  
Field causes a force on other electron.

20<sup>th</sup> century language!

electrons exchanging photons.

"Quantum Exchange Force" when

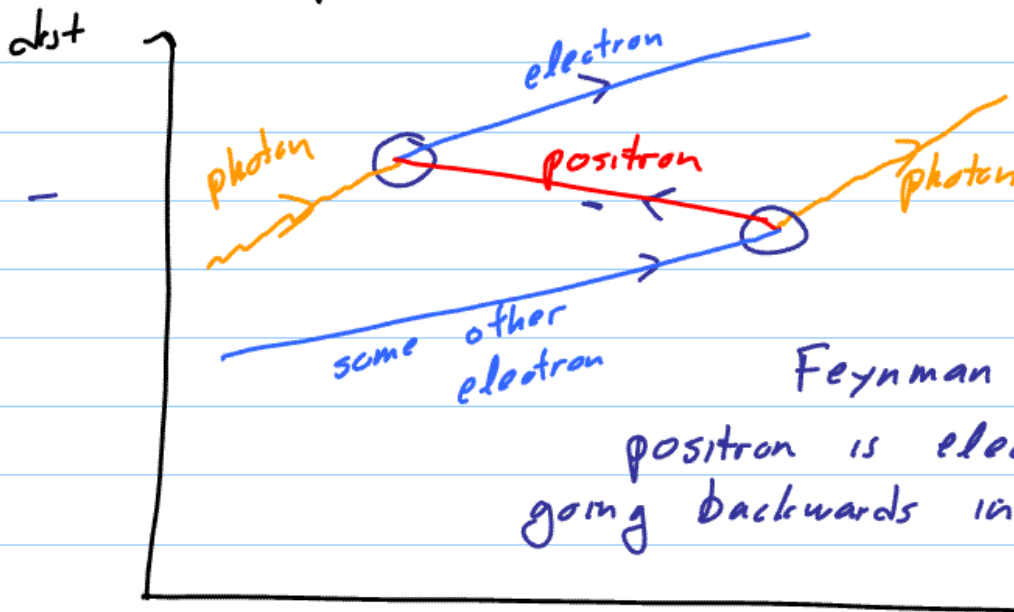
2 particles exchanging some other particle.



## Simplest electromagnetic interaction

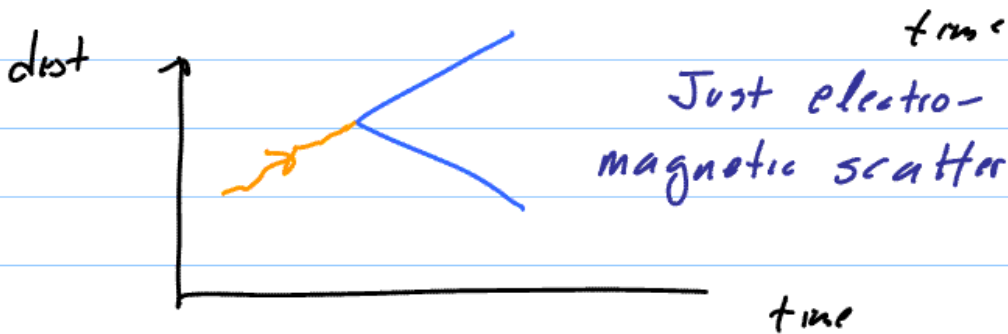


## Pair production & annihilation



Feynman (1949):

positron is electron  
going backwards in time.



Just electro-  
magnetic scattering.

"One electron in universe"



Positron discovered by Anderson  
in 1932.

neutrons  $\rightarrow$  protons & electrons  
 $\leftarrow$  made of protons & electrons?

protons made of neutrons & positrons?

Neutrons } made of each other.  
 Protons }  
SYMMETRY!


§ 18.4

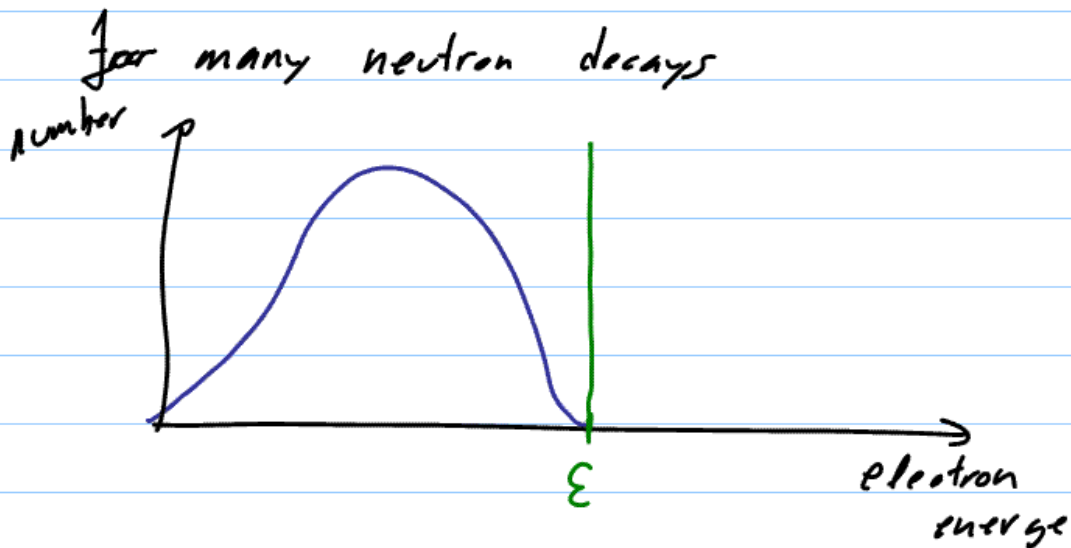
## ① Neutrino (cf § 6.5)

Before!

  
neutron

$$E = mc^2$$

After:

  
proton


  
electron
Cons of  $E$  & inertia (momentum)Energy of electron is fixed!  $\epsilon$ 

Cons. of  $E \Rightarrow$  3<sup>rd</sup> decay product  
"neutrino"