Monday, Oct. 6

Syllabus, class notes, and homeworks are at:
www.as.utexas.edu → courses → AST 301, Lacy

Reading for this week: chapter 8

The Wednesday help session is in GRG 424 at 5:00 (for the entire semester).

Forces that cause nuclear reactions

We know of four types of forces or interactions between particles:

gravitational: an attraction between any masses

electromagnetic: an attraction or repulsion between charged particles. (opposites attract)

weak: an interaction which can convert one kind of a particle into another. e.g., $p^+ \rightarrow n + e^+ + \nu$

strong: an attraction between the particles (protons and neutrons) in a nucleus. only occurs if the particles are very close together.

Steven Weinberg (in U.T. Physics department) showed that electromagnetic and weak forces are related.

Others are trying to find a theory combining all forces.

Is it 'Just a Theory'?

Fusion only occurs very close to the center of the Sun.

How can we be sure this is how the Sun generates energy?

The neutrinos created when protons became neutrons and positrons during fusion are very unlikely to collide with anything while leaving the Sun.

When they get to the Earth they can cause neutrons to become protons and electrons.

Since 1965 Ray Davis has been observing the solar neutrinos through the conversion of neutrons into protons in a tank of dry cleaning fluid (C_2Cl_4) in a gold mine in South Dakota.

He received the Nobel prize in Physics for this work.

Detection of Solar Neutrinos

$n + \nu \rightarrow p^+ + e^-$

$^{37}Cl + \nu \rightarrow {}^{37}Ar + e^-$

…with a half-life of 34 days

$^{37}Ar + e^- \rightarrow {}^{37}Cl + \nu + 0.82$ MeV

By bubbling Ar through the tank of cleaning fluid every week or so, the ^{37}Ar can be collected and measured through its radioactive decay.

But the number of neutrinos detected is only about 1/3 the number expected.

What happened to the other neutrinos?

Neutrino Oscillations

The favored explanation for the lack of solar neutrinos is that they changed to something else before getting to Davis's tank of dry cleaning fluid.

There are 3 families of leptons (light-weight particles):

electron	e^-	ν_e
muon	μ	ν_μ
tau	τ	ν_τ

Just like there are 3 families of quarks:

u	d
s	c
t	b

Maybe some of the electron neutrinos turn into the other types on their way here.

Quantum Field Theory

Neutrinos can transform from one type into another if the neutrinos formed from electrons, muons, and taus are not the mass eigenstates (the normal modes) of the neutrino field.

Whatever that means.

Proportions

What does it mean to say that one quantity is proportional to another?

For example, success is proportional to effort.

If you double your effort you will double your success.

Or success equals some number times effort.

Or area is proportional to width squared.

If you triple the width you will multiply the area by 9 (3^2).

For a square, $A = w^2$, so the number equals 1.

For a circle, $A = \pi r^2 = (\pi/4)d^2$, so the number equal $\pi/4$.

But if we are comparing two objects we don't need to know the number in the equation.

$A_1 / A_2 = (d_1 / d_2)^2$

Quiz

Three of you go into Double Dave's to buy some pizza.

You all like anchovies and garlic, and you are willing to share one anchovy and garlic pizza if you get more to eat that way.

You each have $5 to spend. They are selling 6-inch pizzas for $5 each and 12-inch pizzas for $15 each.

Should you buy three 6-inch pizzas or one 12-inch pizza?

(Assume all pizzas have the same thickness, so the area determines how much you get to eat.)

A. Three 6-inch pizzas

B. One 12-inch pizza.

Pizzas

B. Buy the 12-inch pizza.

Since area is proportional to width squared, it has 4 times the area of a 6-inch pizza, so you get 4 times as much to eat for 3 times as much money.

$A_{12"} / A_{6"} = (12/6)^2 = 2^2 = 4$

Or if you want to keep π in the formula,

$A_{12"} / A_{6"} = (\pi\ 6^2) / (\pi\ 3^2) = (36\ \pi) / (9\ \pi) = 36 / 9 = 4$

But the answer is the same, so why bother?

Topics for this week

How do astronomers use parallax to measure the distances to stars? Why does parallax vary inversely with distance?

Describe and explain the relationship between a star's apparent brightness (or flux), its absolute brightness (or luminosity), and its distance from us.

Describe and explain the relationship between a star's luminosity, its radius, and its temperature, and how this relationship is used to measure radii of stars.

Sketch an H-R diagram, showing the location of main sequence stars, red giants, and white dwarfs.

Explain how astronomers measure masses of stars.

Describe how the luminosities of main sequence stars are related to their masses.