Today’s homework is homework #1, due 11pm, this Thursday!!

- Who am I?
- How is this class organized?
- What is Physics?
- What do we want from this class?
- Brief history of physics
- Some basics …
- Chapter 16
  - Static Electricity and Charge Conservation
  - Charges in Atom, Insulators and Conductors & Induced Charge
Announcements

• Plea to you: Please turn off your cell-phones, pagers and computers in the class
• Reading assignment #1: Read and follow through all sections in appendix A by Wednesday, June 5
  – A-1 through A-8
• There will be a quiz on this and Ch. 16 on Thursday, June 6.
Who am I?

• Name: Dr. Jaehoon Yu (You can call me Dr. Yu)
• Office: Rm 342, Chemistry and Physics Building
• Extension: x22814, E-mail: jaehoonyu@uta.edu
• My profession: High Energy Particle Physics (HEP)
  – Collide particles (protons on anti-protons or electrons on anti-electrons, positrons) at the energies equivalent to 10,000 Trillion degrees
  – To understand
    • Fundamental constituents of matter
    • Forces between the constituents (gravitational, electro-magnetic, weak and strong forces)
    • Origin of Mass
    • Search for Dark Matter
    • Creation of Universe (Big Bang Theory)
  – A pure scientific research activity
    • Direct use of the fundamental laws we find may take longer than we want but
    • Indirect product of research contribute to every day lives; eg. WWW
  – Why do we do with this?
    • Make our everyday lives better to help us live well as an integral part of the universe
We always wonder...

- What makes up the universe?
- How does the universe work?
- What holds the universe together?
- How can we live in the universe well?
- Where do we all come from?
HEP and the Standard Model

HEP: A field of physics that studies the fundamental constituents of matter and basic principles of interactions between them.

- Total of 16 particles (12+4 force mediators) make up all the visible matter in the universe! → Simple and elegant!!!
- Tested to a precision of 1 part per million!

Discovered in 1995, \( \sim 175m_p \)

Make up most ordinary matters \( \sim 0.1m_p \)
So what’s the problem?

• Why is the mass range so large (0.1\(m_p\) – 175 \(m_p\))?
• How do matters acquire mass?
  – Higgs mechanism, did we find the Higgs particle?
• Why is the matter in the universe made only of particles?
• Neutrinos have mass!! What are the mixing parameters, CP violations and mass ordering?
• Why are there only three apparent forces?
  – Can the forces be unified?
• Is the picture we present the real thing?
  – What makes up the 96% of the universe?
  – What is the dark matter and dark energy?
• Are there any other theories that describe the universe better?
  – Does the super-symmetry exist?
• How is the universe created, the Big Bang?
Accelerators are **Powerful Microscopes**.

They make high energy particle beams that allow us to see small things.

- seen by low energy beam (poorer resolution)
- seen by high energy beam (better resolution)
Accelerators are also **Time Machines**.

They make particles last seen in the earliest moments of the universe.

Particle and anti-particle annihilate.

\[ E = mc^2 \]
Fermilab Tevatron and LHC at CERN

- **World’s Highest Energy proton-anti-proton collider**
  - 4km circumference
  - \( E_{\text{cm}} = 1.96 \text{ TeV} \) (\( = 6.3 \times 10^{-7} \text{ J/p} \) \( \approx 13 \text{ M Joules on the area smaller than } 10^{-4} \text{ m}^2 \))
  - Equivalent to the kinetic energy of a 20t truck at the speed 81mi/hr \( \approx 130 \text{ km/hr} \)
    - \( \approx 100,000 \) times the energy density at the ground 0 of the Hiroshima atom bomb
  - **Was shut down on Sept. 30, 2011**
  - **Vibrant other programs running, including the search for dark matter!!**

- **World’s Highest Energy p-p collider**
  - 27km circumference, 100m underground
  - Design \( E_{\text{cm}} = 14 \text{ TeV} \) (\( = 44 \times 10^{-7} \text{ J/p} \) \( \approx 362 \text{ M Joules on the area smaller than } 10^{-4} \text{ m}^2 \))
    - Equivalent to the kinetic energy of a B727 (80tons) at the speed 193mi/hr \( \approx 312 \text{ km/hr} \)
    - \( \approx 3\text{M} \) times the energy density at the ground 0 of the Hiroshima atom bomb
  - First 7TeV collisions 2010 \( \rightarrow \) The highest energy humans ever achieved!!
  - Large amount of data accumulated in 2011 – 2013
  - Shutdown in Feb. 2013 for 18mo for upgrade
The ATLAS and CMS Detectors

• Fully multi-purpose detectors with emphasis on lepton ID & precision E & P
• Weighs 7000 tons and 10 story tall
• Records 200 – 400 collisions/second
• Records approximately 350 MB/second
• Record ~2 PB per year ➔ 200*Printed material of the US Lib. of Congress
Computers put together a picture from Digital data. Data Reconstruction
What is the Higgs and What does it do?

• When there is perfect symmetry, one cannot tell directions!
• Only when symmetry is broken, can one tell directions
• Higgs field works to break the perfect symmetry and gives mass to all fundamental particles
• In this process, this field spontaneously generates a particle, the Higgs particle
• So the Higgs particle is a piece of evidence of the existence of the Higgs field!
What? What’s the symmetry?

- Where is the head of the table?
- Without a broken symmetry, one cannot tell directional information!!
So how does Higgs Field work again?

- Person in space ➔ no symmetry breaking
- Person in air ➔ symmetry can be broken
- Sometimes, you get

Just like a tornado is a piece of evidence of the existence of air, Higgs particle is a piece of evidence of Higgs mechanism.
How do we look for the Higgs?

- Identify Higgs candidate events
- Understand fakes (backgrounds)
- Look for a bump!!
  - Large amount of data absolutely critical
ATLAS and CMS Mass Bump Plots ($H \rightarrow \gamma\gamma$)

**ATLAS Preliminary**

Selected diphoton sample

- Data 2011+2012
- Sig+Bkg Fit ($m_H = 126.8$ GeV)
- Bkg (4th order polynomial)

$\sqrt{s} = 7$ TeV, $L = 4.8$ fb$^{-1}$

$\sqrt{s} = 8$ TeV, $L = 20.7$ fb$^{-1}$

**CMS Preliminary**

$\sqrt{s} = 7$ TeV, $L = 5.1$ fb$^{-1}$

$\sqrt{s} = 8$ TeV, $L = 5.3$ fb$^{-1}$

**LOOK, Ma! Bumps!!**

Monday, June 3, 2013

Dr. Jaehoon Yu
What did statistics do for Higgs?

\[ \sqrt{s} = 7 \text{ TeV} \int \text{L} \text{d}t = 0.02 \text{ fb}^{-1} \quad \text{Apr 18, 2011} \]

\[ M_{\gamma\gamma} [\text{GeV}] \]

ATLAS Preliminary

H\rightarrow\gamma\gamma channel
So have we seen the Higgs particle?

- The statistical significance of the finding is way over 7 standard deviations
<table>
<thead>
<tr>
<th>$z\sigma$</th>
<th>Percentage within Cl</th>
<th>Percentage outside Cl</th>
<th>Fraction outside Cl</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.674 490σ</td>
<td>50%</td>
<td>50%</td>
<td>1 / 2</td>
</tr>
<tr>
<td>0.994 458σ</td>
<td>68%</td>
<td>32%</td>
<td>1 / 3.125</td>
</tr>
<tr>
<td>1σ</td>
<td>68.268 9492%</td>
<td>31.731 0508%</td>
<td>1 / 3.151 4872</td>
</tr>
<tr>
<td>1.281 552σ</td>
<td>80%</td>
<td>20%</td>
<td>1 / 5</td>
</tr>
<tr>
<td>1.644 854σ</td>
<td>90%</td>
<td>10%</td>
<td>1 / 10</td>
</tr>
<tr>
<td>1.959 964σ</td>
<td>95%</td>
<td>5%</td>
<td>1 / 20</td>
</tr>
<tr>
<td>2σ</td>
<td>95.449 9736%</td>
<td>4.550 0264%</td>
<td>1 / 21.977 895</td>
</tr>
<tr>
<td>2.575 829σ</td>
<td>99%</td>
<td>1%</td>
<td>1 / 100</td>
</tr>
<tr>
<td>3σ</td>
<td>99.730 0204%</td>
<td>0.269 9796%</td>
<td>1 / 370.398</td>
</tr>
<tr>
<td>3.290 527σ</td>
<td>99.9%</td>
<td>0.1%</td>
<td>1 / 1,000</td>
</tr>
<tr>
<td>3.890 592σ</td>
<td>99.99%</td>
<td>0.01%</td>
<td>1 / 10,000</td>
</tr>
<tr>
<td>4σ</td>
<td>99.993 666%</td>
<td>0.006 334%</td>
<td>1 / 15,787</td>
</tr>
<tr>
<td>4.417 173σ</td>
<td>99.999%</td>
<td>0.001%</td>
<td>1 / 100,000</td>
</tr>
<tr>
<td>4.891 638σ</td>
<td>99.9999%</td>
<td>0.0001%</td>
<td>1 / 1,000,000</td>
</tr>
<tr>
<td>5σ</td>
<td>99.999 942 6697%</td>
<td>0.000 057 3303%</td>
<td>1 / 1,744,278</td>
</tr>
<tr>
<td>5.326 724σ</td>
<td>99.999 99%</td>
<td>0.000 01%</td>
<td>1 / 10,000,000</td>
</tr>
<tr>
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<td>99.999 999%</td>
<td>0.000 001%</td>
<td>1 / 100,000,000</td>
</tr>
<tr>
<td>6σ</td>
<td>99.999 999 8027%</td>
<td>0.000 000 1973%</td>
<td>1 / 506,797,346</td>
</tr>
<tr>
<td>6.109 410σ</td>
<td>99.999 9999%</td>
<td>0.000 0001%</td>
<td>1 / 1,000,000,000</td>
</tr>
<tr>
<td>6.466 951σ</td>
<td>99.999 999 99%</td>
<td>0.000 000 01%</td>
<td>1 / 10,000,000,000</td>
</tr>
<tr>
<td>6.806 502σ</td>
<td>99.999 999 999%</td>
<td>0.000 000 001%</td>
<td>1 / 100,000,000,000</td>
</tr>
<tr>
<td>7σ</td>
<td>99.999 999 999 7440%</td>
<td>0.000 000 000 256%</td>
<td>1 / 390,682,215,445</td>
</tr>
</tbody>
</table>
So have we seen the Higgs particle?

- The statistical significance of the finding is over 7 standard deviations
  - Level of significance: 99.999 999 999 7% (eleven 9s!!)
  - We can be wrong once if we do the same experiment 391,000,000,000 times

- So did we find the Higgs particle?
  - We have discovered a new particle, the heaviest boson we’ve seen thus far
  - It has many properties consistent with the Standard Model Higgs particle
  - We, however, do not have enough data to precisely measure all the properties – mass, lifetime, the rate at which this particle decays to certain other particles, etc – to definitively determine

- UTA had a lecture by Nobel Laureate, prof. Steven Weinberg, which was attended by 1200 people!!
What next? Future Linear Collider

• Now that we have found a new boson, precision measurement of the particle’s properties becomes important
• An electron-positron collider on a straight line for precision measurements
• 10~15 years from now (In Dec. 2011, Japanese PM announced that they would bid for a LC in Japan and reaffirmed by the new PM in 2013
  • Our Japanese colleagues have declared that they will bid for building a 250GeV machine in Japan!!
• Takes 10 years to build a detector

Circumference ~6.6km
~300 soccer fields
GEM Application Potential

Using the lower GEM signal, the readout can be self-triggered with energy discrimination:

F. Sauli, Nucl. Instr. and Meth. A 461(2001)47

9 keV absorption radiography of a small mammal (image size ~ 60 x 30 mm²)
Can you see what the object is?
And in not too distant future, we could do ...
Information & Communication Source

• **My web page:** [http://www-hep.uta.edu/~yu/](http://www-hep.uta.edu/~yu/)
  - Contact information & Class Schedule
  - Syllabus
  - Homework
  - Holidays and Exam days
  - Evaluation Policy
  - Class Style & Communication
  - Other information

• **Primary communication tool is e-mail:** Make sure your e-mail address on your registration points to the most favorite one that you read at least once a day

• **Office Hours:** 12:30 – 1:30pm, Monday - Thursday or by appointments
Evaluation Policy

- **Homework:** 25%
- **Exams**
  - Final Comprehensive Exams (7/8): 23%
  - Mid-term Comprehensive Exam (6/19): 20%
  - One better of the two term Exams: 12%
    - Total of two non-comprehensive term exams (6/11 and 6/27)
    - One better of the two exams will be used for the final grade
  - Missing an exam is not permissible unless pre-approved
    - No makeup test
    - You will get an F if you miss any of the exams without a prior approval no matter how well you’ve been doing in class!
- **Lab score:** 10%
- **Pop-quizzes:** 10%
- **Extra credits:** 10% of the total
  - Random attendances
  - Strong participation in the class discussions
  - Special projects (BIGGGGGG!!)
  - Planetarium shows and Other many opportunities
- **Grading will be done on a sliding scale**
Homework

- Solving homework problems is the only way to comprehend class material ➔ 2 homeworks per week
- An electronic homework system has been setup for you
  - Details are in the material distributed today and on the web
  - [https://quest.cns.utexas.edu/student/courses/list](https://quest.cns.utexas.edu/student/courses/list)
  - Choose the course 1442-Summer13, unique number 42013
  - Download homeworks, solve the problems and submit them online
  - Multiple unsuccessful tries will deduct points
  - Roster will close at tpm Wednesday, June 4
  - You need a UT e-ID: Go and apply at the URL [https://idmanager.its.utexas.edu/eid_self_help/?createEID&qwicap-page-id=EA027EFF7E2DA39E](https://idmanager.its.utexas.edu/eid_self_help/?createEID&qwicap-page-id=EA027EFF7E2DA39E) if you don’t have one.

- Each homework carries the same weight
- Home work problems will be slightly ahead of the class
- **No** homework will be dropped from the final grade!!
- Home work will constitute **25% of the total** ➔ A good way of keeping your grades high
- Strongly encouraged to collaborate ➔ Does not mean you can copy
Attendances and Class Style

- **Attendances:**
  - Will be taken randomly
  - Will be used for extra credits

- **Class style:**
  - Lectures will be on electronic media
    - The lecture notes will be posted on the web **AFTER** each class
  - Will be mixed with traditional methods
  - Active participation through questions and discussions are **STRONGLY** encouraged ➔ Extra credit....
  - Communication between you and me is extremely important
    - If you have problems, please do not hesitate talking to me
Lab and Physics Clinic

• Physics Labs:
  – Intro-labs on Wednesday and Thursday, June 5 and 6 (official beginning June 10)
  – Important to understand physical principles through experiments
  – 10% of the grade
  – Prelab questions can be obtained at www.uta.edu/physics/labs
  – Lab syllabus is available in your assigned lab rooms.

• Physics Clinic:
  – Free service
  – They provide general help on physics, including help solving homework problems
    • Do not expect solutions of the problem from them!
    • Do not expect them to tell you whether your answers are correct!
    • It is your responsibility to make sure that you have done everything correctly!
  – 11am – 6pm, Mon – Thu in SH 007
  – This service begins today!
  – Please take full advantage of this service!!
Extra credit

• 10% addition to the total
  – Could boost a B to A, C to B or D to C
• What constitute for extra credit?
  – Special projects (biggest!!)
  – Random attendances
  – Strong participation in the class discussions
  – Watch the valid planetarium shows
  – Many other opportunities
Valid Planetarium Shows

• Regular running shows
  – We Are Astronomers - Wednesdays at 2:00 and Saturdays at 5:30
  – Time Space – Fridays at 2:00 and Saturdays at 2:30

• Shows that need special arrangements
  – Astronaut; Bad Astronomy; Black Holes (can watch up to 2 times)
  – Experience the Aurora IBEX; Ice Worlds; Magnificent Sun; Mayan Prophecies
  – Nano Cam; Stars of the Pharaohs; Two Small Pieces of Glass
  – Unseen Universe: The Vision of SOFIA; Violent Universe

• How to submit for extra credit?
  – Obtain the ticket stub that is signed and dated by the planetarium star lecturer of the day
  – Collect the ticket stubs
  – Tape one edge of all of the ticket stubs on a sheet of paper with your name and ID written on it
  – Submit the sheet at the end of the semester at the final exam
What can you expect from this class?

• All A’s?
  – This would be really nice, wouldn’t it?
  – But if it is too easy it is not fulfilling or meaningful….  

• This class is not going to be a stroll in the park!!

• You will earn your grade in this class.
  – You will need to put in sufficient time and sincere efforts
  – Exams and quizzes will be tough!!
    • Sometimes problems might not look exactly like what you learned in the class
    • Just putting the right answer in free response problems does not work!

• But you have a great control (up to 45%) of your grade in your hands
  – Homework is 25% of the total grade!!
    • Means you will have many homework problems
      – Sometimes much more than any other classes
      – Sometimes homework problems will be something that you have yet to learn in class
      – Exam’s problems will be easier that homework problems but same principles!!
  – Lab 10%
  – Extra credit 10%

• I will work with you so that your efforts are properly rewarded
What do we want to learn in this class?

• Physics is everywhere around you.
• Skills to understand the fundamental principles that surrounds you in everyday lives…
• Skills to identify what laws of physics applies to what phenomena and use them appropriately
• Understand the impact of physical laws and apply them
• Learn skills to think, research and analyze observations.
• Learn skills to express observations and measurements in mathematical language
• Learn skills to express your research in systematic manner in writing
• But most importantly the confidence in your physics ability and to take on any challenges laid in front of you!!

Most importantly, let us have a lot of FUN!!
In this course, you will learn...

- Fundamentals of Electricity and Magnetism
- Electric and Magnetic Forces and Fields
- Electric charge and magnetic poles
- Electric and magnetic potential, energy and power
- Propagation of electric and magnetic fields
- Relationship between electro-magnetic forces and light
- Behaviors of light and optics
- Special relativity and quantum theories
How to study for this course?

• Keep up with the class for comprehensive understanding of materials
  – Come to the class and participate in the discussions and problems solving sessions
  – Follow through the lecture notes
  – Work out example problems in the book yourself without looking at the solution
  – Have many tons of fun in the class!!!!!

• Keep up with the homework to put the last nail on the coffin
  – One can always input the answers as you solve the problems. Do not wait till you are done with all the problems.
  – Form a study group and discuss how to solve problems with your friends, then work the problems out yourselves!

• Prepare for upcoming classes
  – Read the textbook for the material to be covered in the next class

• The extra mile
  – Work out additional problems in the back of the book starting the easiest problems to harder ones
Extra Credit Special Project #1

• Compare the Coulomb force to the Gravitational force in the following cases by expressing Coulomb force ($F_C$) in terms of the gravitational force ($F_G$)
  – Between two protons separated by 1m
  – Between two protons separated by an arbitrary distance $R$
  – Between two electrons separated by 1m
  – Between two electrons separated by an arbitrary distance $R$

• Five points each, totaling 20 points

• BE SURE to show all the details of your work, including all formulae, and properly referring them

• Please staple them before the submission

• Due at the beginning of the class Monday, June 10
Brief History of Physics

• AD 18th century:
  – Newton’s Classical Mechanics: A theory of mechanics based on observations and measurements

• AD 19th Century:
  – Electricity, Magnetism, and Thermodynamics ➔ unification of forces

• Late AD 19th and early 20th century (Modern Physics Era)
  – Einstein’s theory of relativity: Generalized theory of space, time, and energy (mechanics)
  – Quantum Mechanics: Theory of atomic phenomena

• Physics has come very far, very fast, and is still progressing, yet we’ve got a long way to go
  – What is matter made of?
  – How do matters get mass? ➔ Better than before since Higgs was found
  – How and why do matters interact with each other?
  – How is universe created?
  – What are Dark Matter and Dark Energy?
Needs for Standards and Units

• Three basic quantities for physical measurements
  – Length, Mass, and Time
• Need a language that everyone can understand each other
  – Consistency is crucial for physical measurements
  – The same quantity measured by one must be comprehensible and reproducible by others
  – Practical matters contribute
• A system of unit called **SI** *(System International)* established in 1960
  – Length in meters *(m)*
  – Mass in kilo-grams *(kg)*
  – Time in seconds *(s)*
## SI Base Quantities and Units

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>Meter</td>
<td>m</td>
</tr>
<tr>
<td>Time</td>
<td>Second</td>
<td>s</td>
</tr>
<tr>
<td>Mass</td>
<td>Kilogram</td>
<td>kg</td>
</tr>
<tr>
<td>Electric current</td>
<td>Ampere</td>
<td>A</td>
</tr>
<tr>
<td>Temperature</td>
<td>Kelvin</td>
<td>k</td>
</tr>
<tr>
<td>Amount of substance</td>
<td>Mole</td>
<td>mol</td>
</tr>
<tr>
<td>Luminous Intensity</td>
<td>Candela</td>
<td>cd</td>
</tr>
</tbody>
</table>

*There are prefixes that scale the units larger or smaller for convenience (see pg. 7)*
Prefixes, expressions and their meanings

- deca (da): $10^1$
- hecto (h): $10^2$
- kilo (k): $10^3$
- mega (M): $10^6$
- giga (G): $10^9$
- tera (T): $10^{12}$
- peta (P): $10^{15}$
- exa (E): $10^{18}$

- deci (d): $10^{-1}$
- centi (c): $10^{-2}$
- milli (m): $10^{-3}$
- micro (µ): $10^{-6}$
- nano (n): $10^{-9}$
- pico (p): $10^{-12}$
- femto (f): $10^{-15}$
- atto (a): $10^{-18}$
How do we convert quantities from one unit to another?

<table>
<thead>
<tr>
<th>Unit 1</th>
<th>Conversion factor X</th>
<th>Unit 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 inch</td>
<td>2.54</td>
<td>cm</td>
</tr>
<tr>
<td>1 inch</td>
<td>0.0254</td>
<td>m</td>
</tr>
<tr>
<td>1 inch</td>
<td>2.54x10^{-5}</td>
<td>km</td>
</tr>
<tr>
<td>1 ft</td>
<td>30.3</td>
<td>cm</td>
</tr>
<tr>
<td>1 ft</td>
<td>0.303</td>
<td>M</td>
</tr>
<tr>
<td>1 ft</td>
<td>3.03x10^{-4}</td>
<td>km</td>
</tr>
<tr>
<td>1 hr</td>
<td>60</td>
<td>minutes</td>
</tr>
<tr>
<td>1 hr</td>
<td>3600</td>
<td>seconds</td>
</tr>
<tr>
<td>And many</td>
<td>More</td>
<td>Here…</td>
</tr>
</tbody>
</table>
What does the Electric Force do?

- Electric force froms the bases of modern technology
  - Virtually everything we use every day uses the electric force
    - Can you give a few examples?
- But this force also affects many others
  - Making up materials with atoms and molecules
  - Biological metabolic processes
    - Nerve signals, heart pumping, etc
Human Nerve System Wiring

• Nerve signals sent to the entire body via nerve wiring, just like any electronic gadgets we use
What does the Electric Force do?

• **Electric force froms the bases of modern technology**
  – Virtually everything we use every day uses the electric force
    • Can you give a few examples?

• **But this force also affects many others**
  – Making up materials with atoms and molecules
  – Biological metabolic processes
    • Nerve signals, heart pumping, etc

• **Virtually all the forces we have learned in Physics I:**
  – Friction, normal force, elastic force and other contact forces
    are the results of electric forces acting at the atomic level
Static Electricity; Electric Charge and Its Conservation

• Electricity is from Greek word *elecktron* = amber, a petrified tree resin that attracts matter when rubbed

• Static Electricity: an amber effect
  – An object becomes charged or “possesses a net electric charge” due to rubbing
  – Can you give some examples?

• Two types of the electric charge
  – Like charges repel while unlike charges attract
  – Benjamin Franklin referred the charge on glass rod as the positive, arbitrarily. Thus the charge that attracts glass rod is negative. ➔ This convention is still used.
Static Electricity; Electric Charge and Its Conservation

• Ben Franklin argued that when a certain amount of charge is produced on one body in a process, an equal amount of opposite type of charge is produced on another body.
  – The positive and negative are treated algebraically so that at any time in the process the net change in the amount of produced charge is 0.
    • When you comb your hair with a plastic comb, the comb acquires a negative charge and the hair an equal amount of positive charge.

• This is the law of conservation of electric charge.
  – The net amount of electric charge produced in any process is ZERO!!
  – No net electric charge can be created or destroyed
    • If one object or one region of the space acquires a positive charge, then an equal amount of negative charge will be found in neighboring areas or objects.
    • No violations have ever been observed.
    • This conservation law is as firmly established as that of energy or momentum.
Electric Charge in the Atom

- It has been understood through the past century that an atom consists of
  - A positively charged heavy core ➔ What is the name?
    - This core is nucleus and consists of neutrons and protons.
  - Many negatively charged light particles surround the core ➔ What is the name of these light particles?
    - These are called electrons
    - How many of these? As many as the number of protons!!
- So what is the net electrical charge of an atom?
  - Zero!!! Electrically neutral!!!
- Can you explain what happens when a comb is rubbed on a towel?
  - Electrons from towel get transferred to the comb, making the comb negatively charged while leaving positive ions on the towel.
  - These charges eventually get neutralized primarily by water molecules in the air.