PHYS 3313 – Section 001
Lecture #1

Wednesday, Jan. 21, 2015
Dr. Jaehoon Yu

- Who am I?
- From Higgs to Dark Matter!!
- How is this class organized?
- What do we want from this class?
- What is Physics?
- Brief history of modern physics

Announcements

- Plea to you: Please turn off your cell-phones, pagers and computers in the class
- Reading assignment #1: Read and follow through appendices 3, 5, 6 and 7 by Monday, Jan. 26
  - There will be a quiz next Wednesday, Jan. 28, on these reading assignments
- Special colloquium next week:
  - 4pm Tuesday, Jan. 27, in SH101: Dr. James Siegrist of US Department of Energy
  - Special triple extra credit

Who am I?

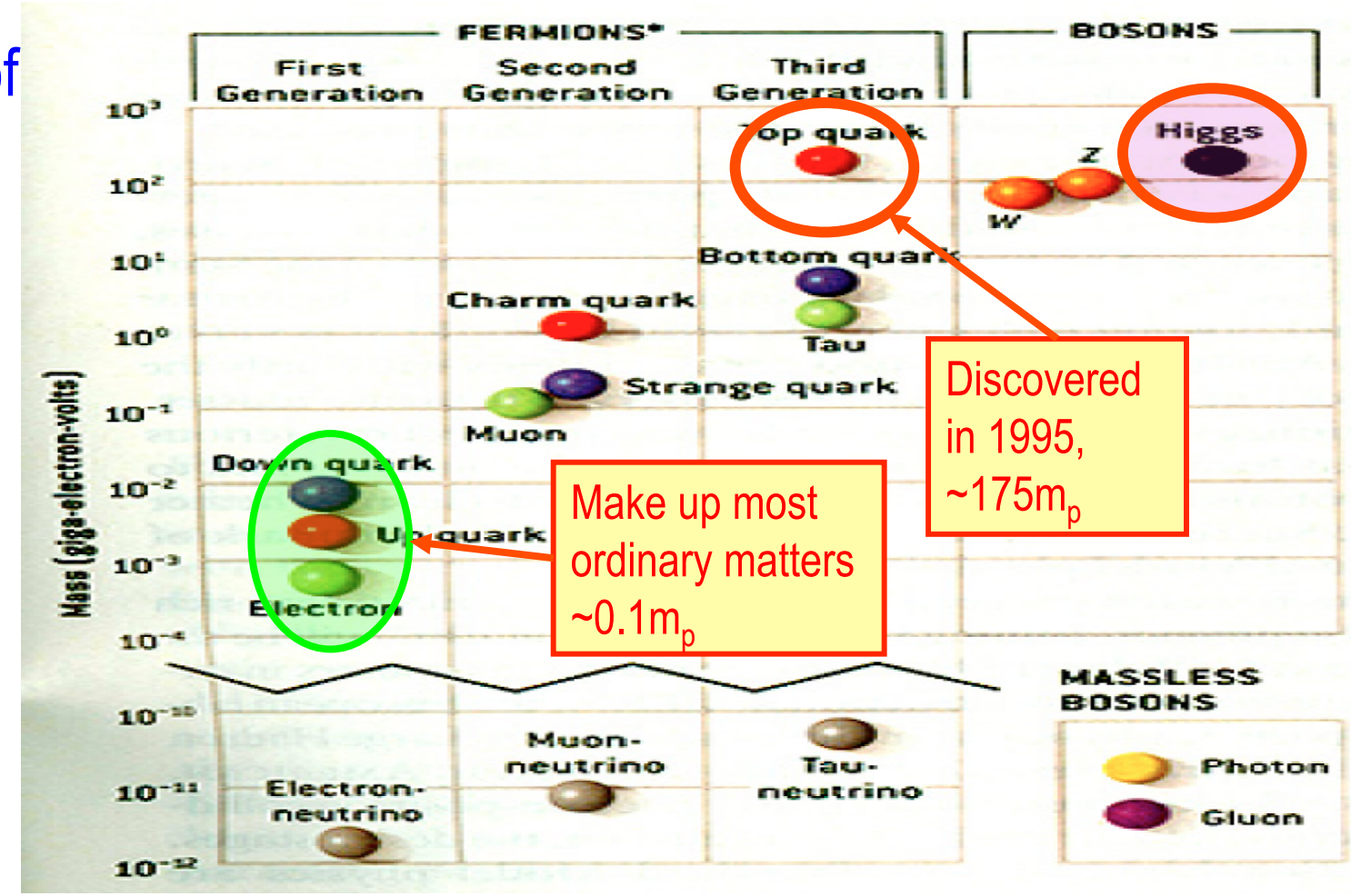
- Name: Dr. Jaehoon Yu (You can call me **Dr. Yu**)
- Office: Rm 342, Chemistry and Physics Building
- Extension: x22814, E-mail: *jaehoonyu@uta.edu*
- My profession: High Energy Particle Physics (HEP)
  - Collide particles (protons on anti-protons or electrons on anti-electrons, positrons) at the energies 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

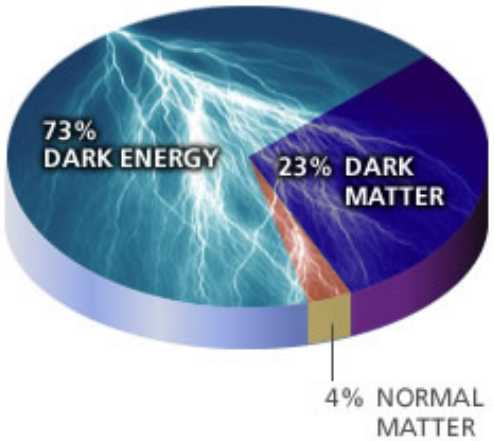
HEP: A field of physics that studies the fundamental constituents of matter and basic principles of interactions between them.



- 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!

So what's the problem?

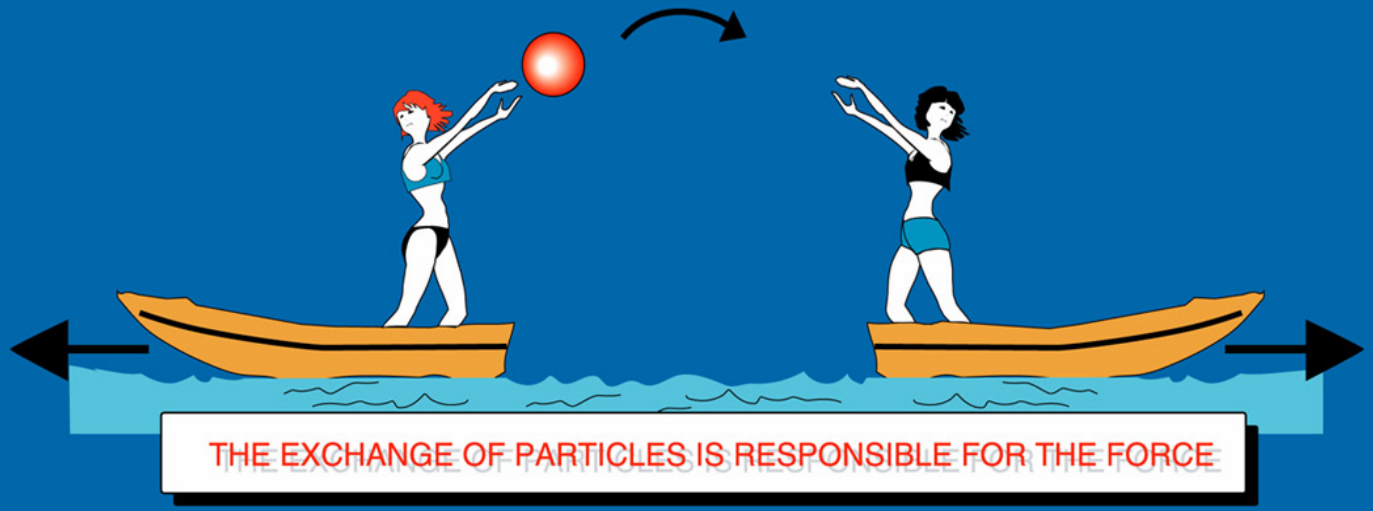
- Why is the mass range so large ($0.1m_p$ – $175\ m_p$)?
- How do matters acquire mass?
  - Higgs mechanism! Did we find the Higgs particle?
- Why is the matter in the universe made only of particles?
- Neutrinos have mass!! What are the mixing parameters, CP violations and mass ordering?
- Why are 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?

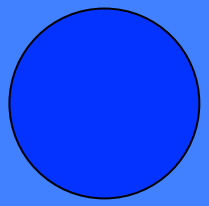
The forces in Nature

TYPE	INTENSITY OF FORCES (DECREASING ORDER)	BINDING PARTICLE (FIELD QUANTUM)	OCCURS IN :
STRONG NUCLEAR FORCE	~ 1	GLUONS (NO MASS)	ATOMIC NUCLEUS
ELECTRO -MAGNETIC FORCE	~ 10^{-3}	PHOTONS (NO MASS)	ATOMIC SHELL ELECTROTECHNIQUE
WEAK NUCLEAR FORCE	~ 10^{-5}	BOSONS Z^{o} , W^{+} , W^{-} (HEAVY)	RADIOACTIVE BETA DESINTEGRATION
GRAVITATION	~ 10^{-38}	GRAVITONS (?)	HEAVENLY BODIES

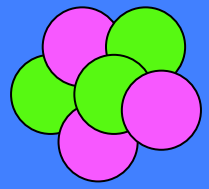


Accelerators are Powerful Microscopes.

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.

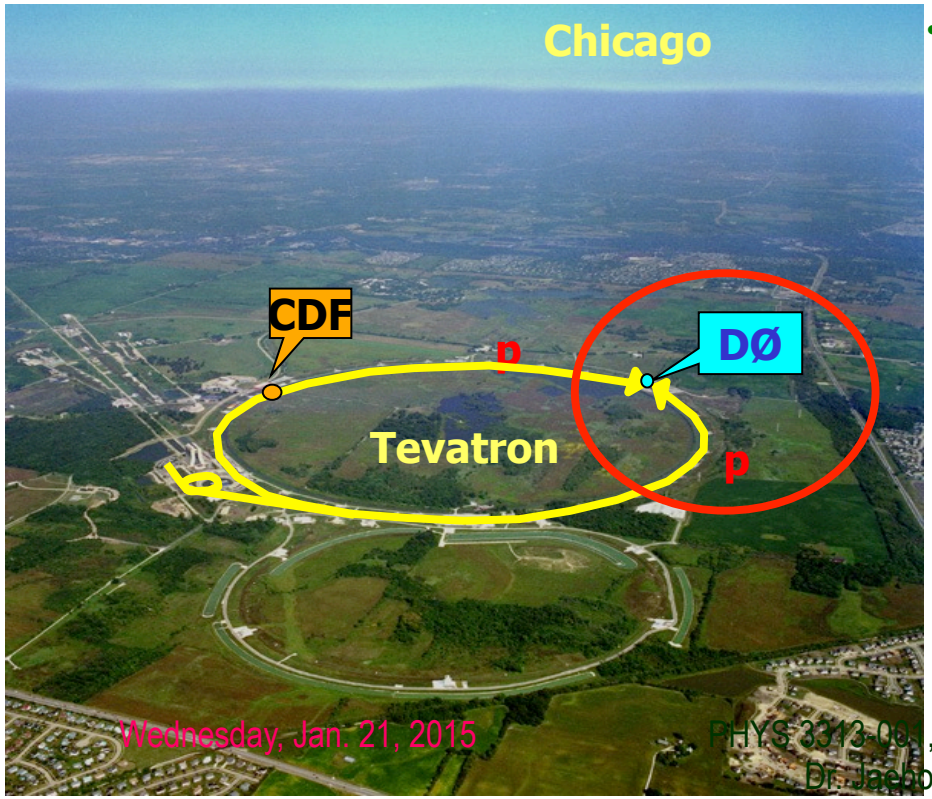
Particle and anti-particle annihilate.

$$E = mc^2$$

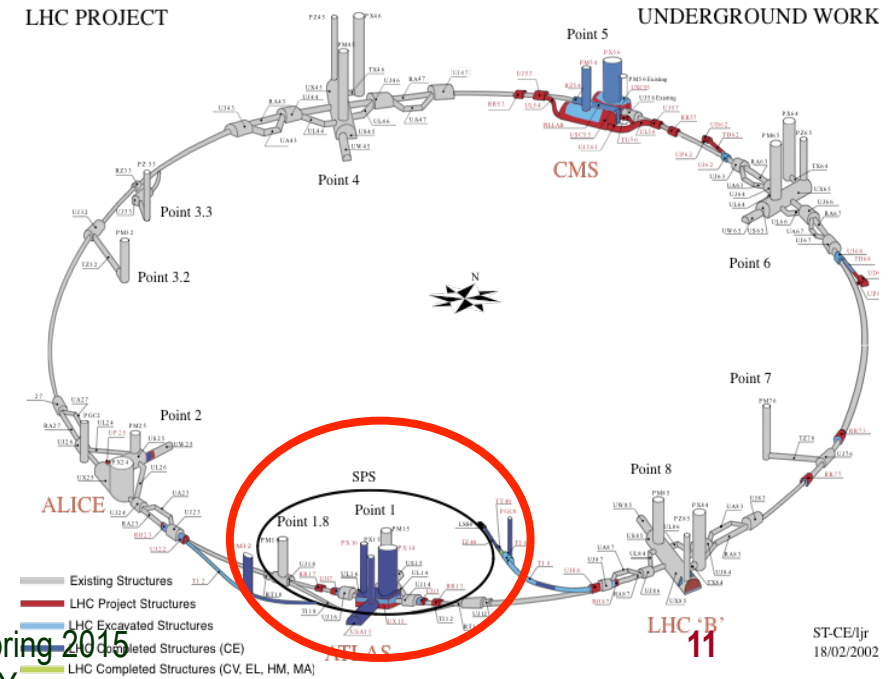
LHC @ CERN Aerial View

Fermilab Tevatron and LHC at CERN

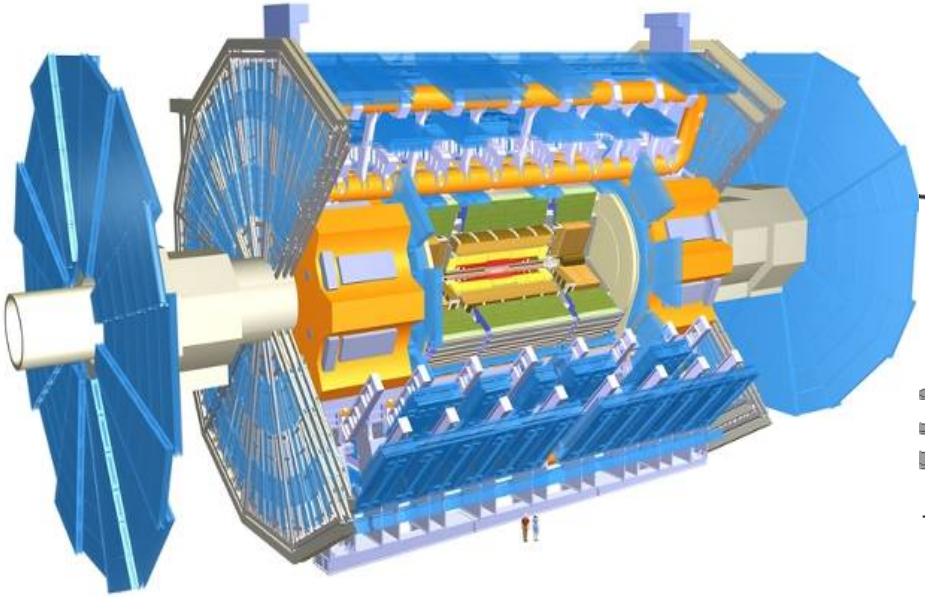
- World's Highest Energy proton-anti-proton collider
  - 4km (2.5mi) circumference
  - E_{cm}=1.96 TeV (=6.3x10^{-7}J/p➔ 13M Joules on the area smaller than $10^{-4}m^2$)
  - Equivalent to the kinetic energy of a 20t truck at the speed 81mi/hr
    - ~100,000 times the energy density at the ground 0 of the Hiroshima atom bomb
  - **Tevatron was shut down in 2011**
  - **Vibrant other programs running, including the search for dark matter with beams!!**

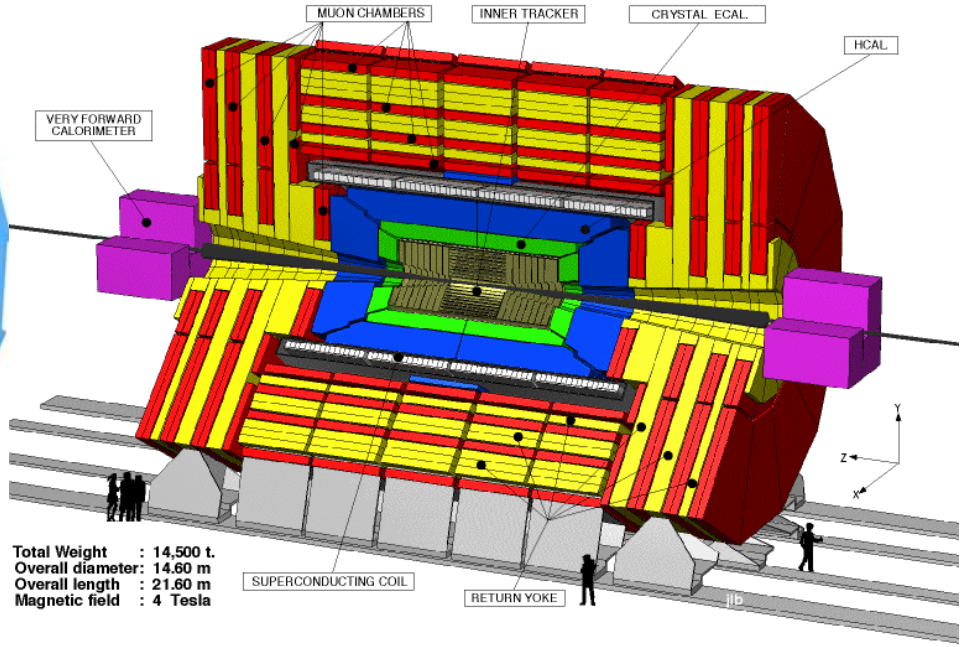


- World's Highest Energy p-p collider
  - 27km (17mi) circumference, 100m (300ft) underground
  - Design E_{cm}=14 TeV (=44x10^{-7}J/p➔ 362M Joules on the area smaller than $10^{-4}m^2$)
  - ➢ Equivalent to the kinetic energy of a B727 (80tons) at the speed 193mi/hr
    - ➢ ~3M times the energy density at the ground 0 of the Hiroshima atom bomb
- **Large amount of data accumulated in 2010 – 2013**
- **Shutdown in Feb. 2013 & on track to resume Mar. 2015**



The ATLAS and CMS Detectors





- **Weighs 7000 tons and ~10 story tall**
- Records **200 – 400 collisions/second (out of 50million)**
- Records approximately **350** MB/second
- Records ~2 PB per year ➔ **200*Printed material of the US Lib. of Congress**

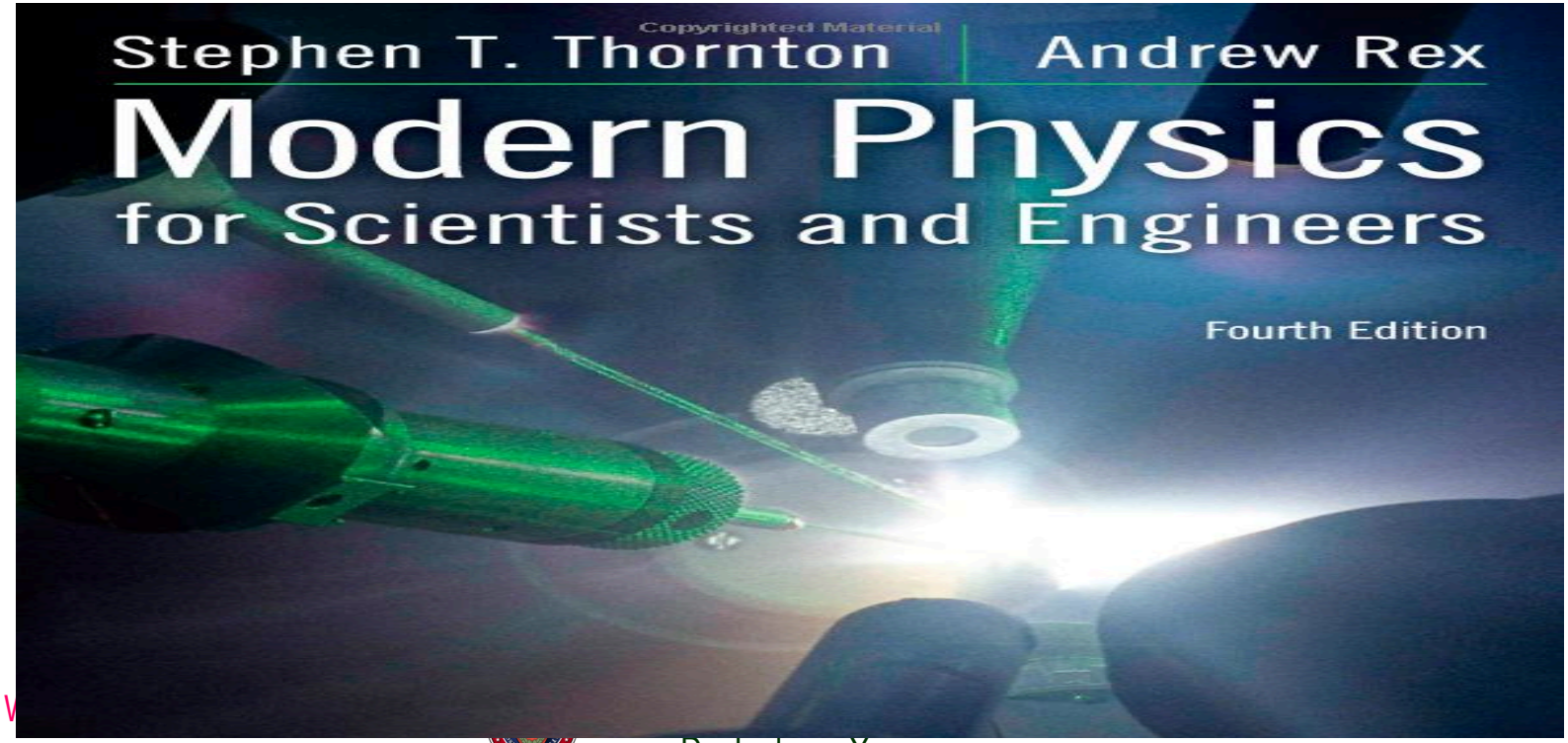
200x

Information & Communication Source

- Course web page: http://www-hep.uta.edu/%7Eyu/teaching/spring15-3313-001/spring15-3313-001.html
  - 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 that your e-mail at the time of course registration is the one you most frequently read!!
- Office Hours: 2:30 – 3:40pm, Mondays and Wednesdays or by appointments

Textbook

- Title: Modern Physics for Scientists and Engineers
  - 4th edition
- Authors: S.T. Thornton and A. Rex
- ISBN: 978-1-133-10372-1



Evaluation Policy

- Homework: 30%
- Exams
  - Mid-term Exam (Wed., Mar. 4): 20%
  - Final Comprehensive Exam (11 – 1:30pm, Mon, May. 11): 25%
  - 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
- Group Research Project: 15%
- Pop-quizzes: 10%

100%

- Extra credits: 10% of the total
- Grading will be done on a sliding scale
- 55% of the grade is in your hand!!

Homework

- Solving homework problems is the only way to comprehend class material
- Consists of a lot of reading, deriving and writing
- Each homework carries the same weight
- **ALL** homework grades will be used for the final grade
- Home work will constitute **30% of the total**
  - A good way of keeping your grades high
- Strongly encouraged to collaborate
  - Just make sure to submit your own answers written in your OWN way!!

Research Topics

1. Black body radiation
2. Michelson–Morley Experiment
3. The Photoelectric Effect
4. The Property of Molecules, Brownian Motion
5. Compton Effect
6. Discovery of Electron
7. Rutherford Scattering
8. Super-conductivity
9. The Discovery of Radioactivity

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

Extra credit

- Up to 10% addition to the total
  - Could boost a B to A, C to B or D to C
- What constitute for extra credit?
  - Random attendances
  - Physics Colloquium Participations
  - Strong participation in the class discussions
  - Special projects
  - Watch the valid planetarium shows
  - Many other opportunities
- First extra credit opportunity
  - Subscribe to the class e-mail distribution list
    - 5 points if subscribed by this Friday, Jan. 23
    - 3 points if done by next Monday, Jan.26

Valid Planetarium Shows

- Regular running shows
  - Black Holes (up to 2 times) – Thursdays at 6:00, Saturdays at 2:30pm
  - Dynamic Earth– Fridays at 6:00pm, Saturdays at 5:30pm and Sundays at 1:30pm
- Shows that need special arrangements
  - Astronaut
  - Bad Astronomy
  - Experience the Aurora
  - IBEX
  - Ice Worlds
  - Magnificent Sun
  - Mayan Prophecies
  - Nanocam
  - Stars of Pharaoes
  - Two Small Pieces of Glass
  - Unseen Universe: The Vision of SOFIA
  - Violent Universe
  - We Are Astronomers
- 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 all of them on a sheet of paper with your name and ID written on it
  - Submit the sheet at the end of the semester when asked

What can you expect from this class?

- All A's would be perfect for you, wouldn't it?
  - But easy come easy go
  - Must put in efforts to make it last and meaningful….
- This class is going to be challenging!!
- 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 of your grade in your hands, up to 45%!!!
  - Homework is 30% 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 the same principles!!
  - Extra credit 10%
- I will work with you so that your efforts are properly rewarded