FI-1201 : FISIKA DASAR IIA

Kuliah 1: Pengantar

TUJUAN KULIAH

- Memperkenalkan prinsip-prinsip dasar fisika (Gaya dan muatan listrik, hukum-hukum kelistrikan & Kemagnetan, Gelombang & Optik, serta Fisika Modern)
- Mengembangkan kemampuan matematika dan penggunaan kalkulus, vektor, analisa satuan, trigonometri,dll.
- Mengembangkan kemampuan dalam menjelaskan sistem fisika secara matematika.
- Mengembangkan kemampuan dalam menyelesaikan masalah.

Cakupan Materi

1. LISTRIK:

- Muatan listrik dan hukum Coulomb
- Medan Listrik
- Hukum Gauss
- Sifat listrik bahan
- Energi Potensial dan Potensial listrik
- Kapasitor
- Arus listrik

2. MAGNET:

- Medan magnet
- GGL Imbas
- Induktansi
- Bahan Magnetik
- Arus Bolak Balik

3. GELOMBANG:

- Gejala Gelombang
- Gelombang Mekanik
- Gelombang Elektromagnetik
- Alat alat Optik

4. FISIKA MODERN:

- Penemuan Elektron
- Percobaan Rutherford
- Model Atom Bohr
- Ketidak-pastian Heisenberg

ATURAN PERKULIAHAN (1/2)

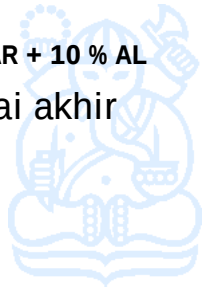
- Kehadiran minimum 80%
- Keterlambatan mahasiswa yang ditolerir adalah 15 menit. Lebih dari 15 menit dihitung tidak hadir meskipun masih diperbolehkan mengikuti kuliah

ATURAN PERKULIAHAN (2/2)

- Penilaian ditentukan dari:
  - Ujian (U1, U2, U3) (**AU1, AU2, AU3**)
  - Praktikum (**AP>50**)
  - Tugas Riset Sederhana (**AR**)
  - Tugas/PR/Quiz (**AL**)

AA1 = 30 % AU1 + 30 % AU2 + 20 % AP + 10 % AR + 10 % AL

- Tidak ada tugas tambahan setelah nilai akhir diumumkan



Jadwal Kuliah & Ujian

Jadwal Kuliah

Selasa : 09.00 - 11.00 Ruang 9138 GKU Barat
Rabu : 09.00 – 11.00 Ruang 9222 GKU Timur

Jadwal Tutorial
Kamis : 13.00 – 15.00 Ruang 9128 GKU Barat
Jadwal Ujian

Ujian 1 – 28 Maret 2008
Ujian 2 – 9 Mei 2008
Ujian 3 – 27 Mei 2008

Perkenalan ….

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TOPIK HARI INI

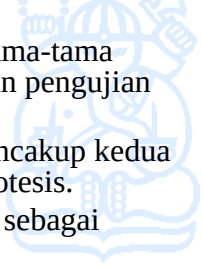
- The Scientific Enterprise
  - Scientific method
- Physics, the Foundation of Science & Engineering
  - What is Physics
  - Physical Quantity (Besaran Fisis)
  - Metric Unit, Dimension, & Measurement (Satuan, Dimensi, &Pengukuran)
  - Scope of Physics
  - Frontier Physics (example case)

The Scientific Enterprise

The greatest rewards of scientific study are the fun and excitement that come from understanding something that has not been understood before

APA ITU SAINS?

- Studi terstruktur terhadap fenomena alam
- Sains berdasarkan pada 2 prinsip yang komplementer:
  - Pendekatan induktif (*Generalizing from examples*)
  - Pendekatan deduktif (*Building complex conclusions from basic assumptions*)
- Sains menggunakan *istilah yang terdifinisi secara tepat*, dan sering berbeda dengan istilah umum. Contoh:
  - Teori = suatu penjelasan yang teruji dengan baik, yang mencakup data dari suatu kejadian dan membuat prediksi yang dapat diuji.
  - Hipotesis = Suatu "dugaan" yang terdidik. Pertama-tama merumuskan teori, yang selanjutnya memerlukan pengujian dan perbaikan.
  - Eksperimen = Suatu pengujian ilmiah, yang mencakup kedua hal: pengamatan murni dan pengujian suatu hipotesis.
- Sains dibangun dengan suatu metode yang dikenal sebagai metode ilmiah

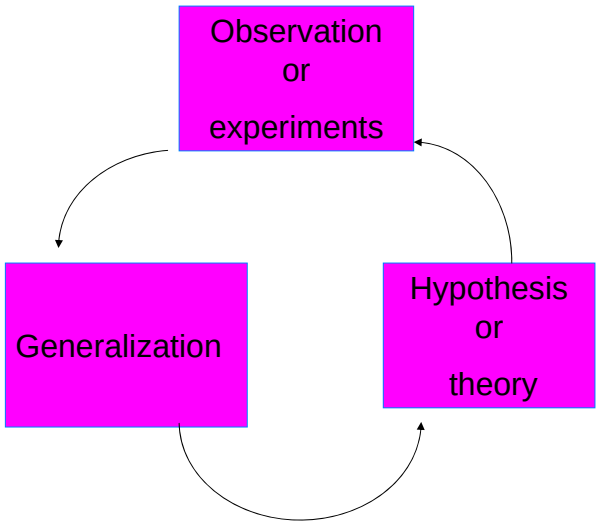


Scientific Method (Metode Ilmiah)

Langkah-langkah dalam metode ilmiah adalah:

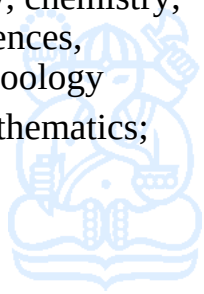
1. Pengamatan/Observasi secara teliti terhadap fenomena alam.
2. Perumusan aturan atau hukum empiris berdasarkan generalisasi dari hasil pengamatan dan pengalaman.
3. Penyusunan hipotesis-hipotesis untuk menjelaskan observasi dan hukum empiris, dan penajaman hipotesis2 menjadi teori-teori.
4. Pengujian terhadap hipotesis atau teori melalui eksperimen atau observasi lebih lanjut.

Scientific Method ...



Classification of Science
(en.wikipedia.org/wiki/ScienCes)

- Social sciences: sociology, anthropology, economics, social science, psychology, political science, education, and history
- Life sciences: Biology and related subjects about living creature
- Basic sciences: agronomy, biology, botany, chemistry, engineering, environmental health and sciences, geology, math, physics, soil science, and zoology
- Natural sciences: Biology; Chemistry; Mathematics; Physics; Psychology



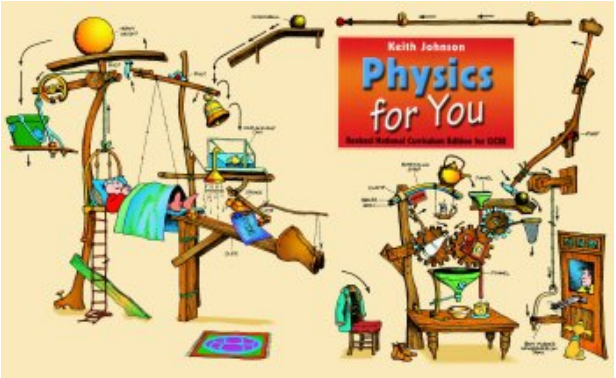
Classification of Science..
(www.portervillecollegecounseling.org/glossary.html)

- Astronomy, Astrophysics. Biology, Biochemistry, Botany, Chemistry, Earth Science, Forestry, Genetics, Geology, Mathematics, Physics, Zoology

Siapa sih Ilmuwan/Peneliti itu?

- Anggota dari komunitas peneliti (*community of scholars*). Ilmuwan tidak pernah bekerja sendiri. Gambaran bahwa Einstein bekerja sendiri di kantor paten adalah mitos – Ia berkomunikasi dengan sejumlah koleganya (*incl. Mileva Einstein, his first wife*).
- Proses sosial menjadi sangat penting dalam perkembangan sains karena seorang peneliti harus mengkomunikasikan teori & hasil eksperimennya kepada koleganya.
- Scientists are expected to be *objective*, *rational*, and *skeptical*.
  - "Prove it!", either experimentally or mathematically.
  - Natural phenomena requires natural explanations
  - "Extraordinary claims require extraordinary proofs" - Carl Sagan.
  - However, when there is sufficient evidence for a change in basic theories, we have to accept it, even it we don't *like* it!

Physics, the Foundation of Science & Engineering



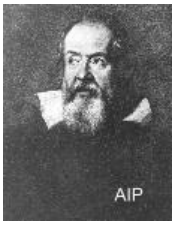
Thinking Like a Physicist

What is physics, why do we have to study it, how is it different from engineering,…?

So…what is "physics" anyway?

Word Problems!

Study of nature!



Mathematical Description of the Forces and Components of the Universe

Natural philosophy

Foundation of Engineering, Chemistry, Geology, ...

So…what is "physics" anyway??

- *Physics is the study of the basic nature of matter and the interactions that govern its behavior.*

The Major Subfields of Physics

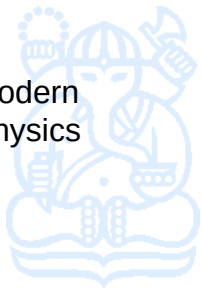
(*the physics of everyday phenomena*, W. Thomas Griffith)

- Mechanics
- Thermodynamics
- Electricity & Magnetism
- Optics

Classical Physics

- Atomic Physics
- Nuclear Physics
- Particles Physics
- Condensed-Matter Physics

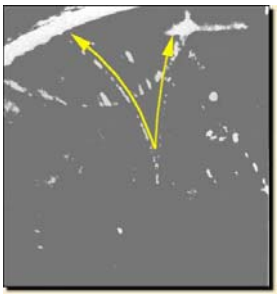
Modern Physics

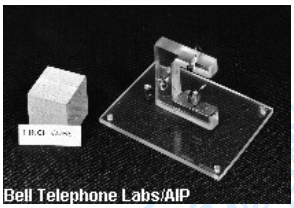


Apa yang dilakukan Fisikawan ketika mempelajari Fisika?

- Membuat model dari suatu Fenomena
  (Inti atom, Tata surya, DNA, Stock Market)
- Mengembangkan peralatan untuk mengukur Fenomena

(X-rays, MRI, Cathode Ray Tubes, LCDs, Reactors…)

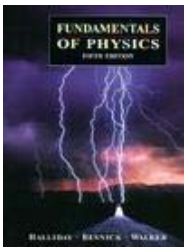




- Menjawab pertanyaan ttg suatu fenomena
- Membuat prediksi yang dapat diuji
- Menyelesaikan masalah

Mengapa belajar fisika penting?

"Tidak inginkah anda mengetahui *bagaimana alam semesta bekerja*?"



Kemampuan PENYELESAIAN MASALAH FISIKA sangat berguna dalam engineering, medicine, architecture, others sciences

Semua ilmu sains dan rekayasa dasarnya adalah FISIKA

So one more time... Apa itu Fisika?

- Studi tentang proses fisis – dasar dari penyusun materi (pada setiap skala/ukuran) dan interaksinya.
- Bidang utama mencakup: astrophysics, biophysics, chemical physics, geophysics, nuclear physics, particle physics, solid-state physics.
- Fisika Modern (abad 20 dst.) sangat berbeda dengan fisika klasik.
  - Fisika klasik adalah suatu pendekatan pada jawaban persoalan umum tentang jarak, kecepatan, gaya.
  - Sekarang era NANO TECHNOLOGY (nanoscale devices), pemahaman tentang *fisika modern* mutlak diperlukan.

Physical Quantity (Besaran fisis)

Ilmu Fisika didasarkan pada pengukuran *besaran fisis*.

- Besaran fisis terdiri atas 7 besaran pokok dan besaran turunannya:
- 7 Besaran pokok:

  - panjang (meter), - massa (kilogram), - waktu (second), - arus listrik (ampere), - temperatur mutlak (kelvin), - intensitas cahaya (candela) - jumlah zat (mol)
- Besaran lain diturunkan dari besaran pokok:
  - Kecepatan = jarak/waktu = m/s.
  - Percepatan = jarak/waktu / waktu = m/s^2.
  - gaya = massa x percepatan = 1 $kg*m/s^2$ = 1 Newton = 1 N

Besaran

- Ada dua jenis besaran: besaran skalar dan besaran vektor
  - Besaran skalar: massa, waktu, temperatur,…

    Besaran yang mempunyai nilai saja dan operasinya memenuhi aljabar biasa.
  - Besaran vektor: perpindahan, kecepatan, gaya,…

    Besaran yang mempunyai nilai dan arah serta operasinya memenuhi aljabar vektor.

Metric unit (satuan pengukuran)

- Besaran fisis diukur dan dinyatakan dalam satuan tertentu
- Semua sistem satuan berdasarkan pada suatu *standard satuan* tertentu.
- Dalam System International (SI):

  meter (length), kilogram (mass), second (time), ampere (electrical current), kelvin (temperature), candela (light intensity)
- Satuan lain:

  * British System (BE, British Engineering), berdasarkan pada:

    foot, slug (atau pound), dan second,

    hanya dipakai di United States, Liberia, dan Myanmar.

  * CGS (cm, g, s)

AKRONIM

Awalan Nama		Simbol awalan	Nilai awalan
micro	µ	1/1 000 000 or 0.000 001	10^{-6}
milli	m	1/1000 or 0.001	10^{-3}
centi	c	1/100 or 0.01	10^{-2}
kilo	k	1 thousand or 1000	10^{3}
mega	M	1 million or 1 000 000	10^{6}
giga	G	1 000 000 000	10^{9}

Contoh:

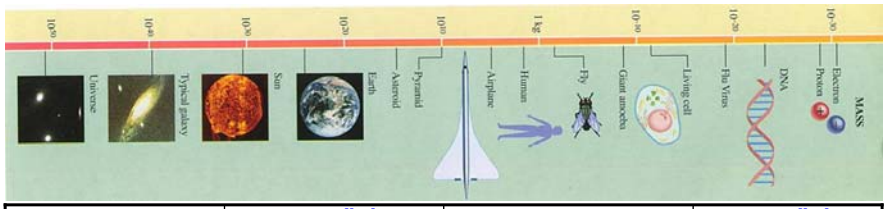
1 micrometer (a.k.a 1 micron) = 1 x 10^{6} meters

Measurement (Pengukuran)

- Semua pengukuran memiliki ketidakpastian.
- Dalam makalah atau presentasi ilmiah para ilmuwan secara hati-hati melaporkan nilai-nilai hasil penelitian/pengukurannya.
- Bentuk standarnya: “Value ± Error”

  Contoh: 12.45 ± 0.12 kg

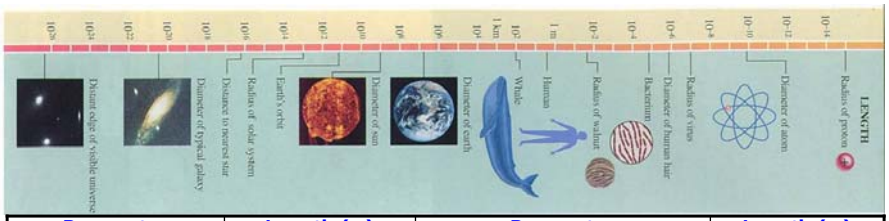
Orders of Magnitude : Mass (kg)



Parameter	Mass (kg)	Parameter	Mass (kg)
Electron	10^{-30}	Battleship	10^{8}
Hydrogen Atom	10^{-27}	Moon	10^{23}
Uranium Atom	10^{-24}	Earth	10^{25}
Dust Particle	10^{-13}	Sun	10^{30}
Raindrop	10^{-6}	Our galaxy (Milky Way)	10^{41}
Piece of paper	10^{-2}	Observable Universe	10^{52}
Man	10^{2}		

Source: Physics, Fishbane, 1996

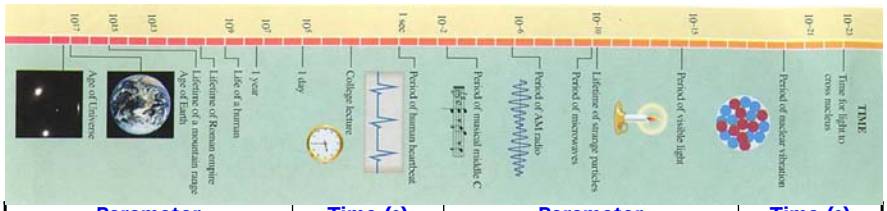
Orders of Magnitude : Length (m)



Parameter	Length (m)	Parameter	Length (m)
Proton	10^{-15}	Earth-Moon distance	10^{9}
Hydrogen Atom	10^{-10}	Earth-Sun distance	10^{11}
Flu virus	10^{-7}	Diameter of Solar System	10^{13}
Raindrop	10^{-3}	Distance to nearest star (Proxima Centauri)	10^{17}
Height of Person	10^{0}	Diameter of our galaxy	10^{21}
One mile	10^{3}	Distance to nearest galaxy	10^{22}
Diameter of Earth	10^{7}	Distance to the edge of observable universe	10^{26}

Source: Physics, Fishbane, 1996

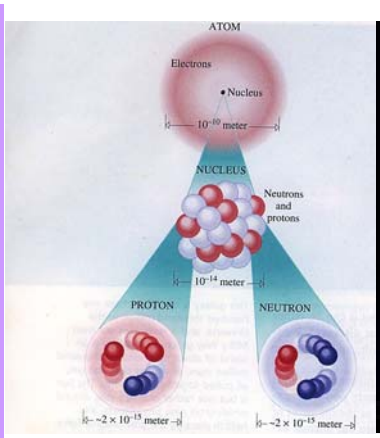
Orders of Magnitude : Time (s)



Parameter	Time (s)	Parameter	Time (s)
Time for light to cross proton	10^{-23}	Period of human heartbeat	10^{0}
Time for light to cross atom	10^{-19}	Class lecture	10^{3}
Period of visible light wave	10^{-15}	One Earth day	10^{5}
Period of vibration for standard cesium clock	10^{-10}	One Earth year	10^{7}
Half-life of muon	10^{-6}	Age of Greek antiquities	10^{11}
Period of highest audible sound	10^{-4}	Age of Earth	10^{17}
		Age of universe	10^{18}

Source: Physics, Fishbane, 1996

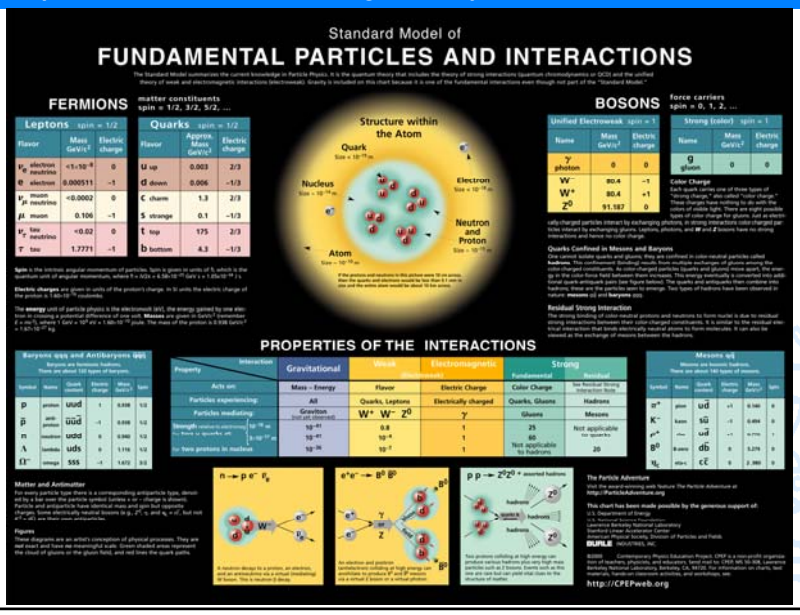
Scope of Physics



From sub-nuclear particles to universe

Frontier Physics, the standard model

(Deep view on order of magnitude)



4 Gaya di Alam

TABLE 1.1 The Four Forces

Force	Couples with	Strength*	Range
Strong	Quarks and particles composed of them	10^{4}	$\approx 10^{-15}$ meter
Electromagnetic	Electrically charged particles	10^{2}	Unlimited
Weak	Most particles	10^{-2}	$\approx 10^{-17}$ meter
Gravitational	All particles	10^{-34}	Unlimited

*Strengths listed are the forces (in newtons) between two protons separated by a distance equal to their diameter (≈2 femtometers). See Appendix A-2 for scientific notation.

The Beginning of Time

Current theory on the history of the universe – *The Big Bang Theory*

According to *The Big Bang Theory*, the universe started in a single moment in time (thus the title of this chapter – *The Beginning of Time*) about 14 billion years ago in an infinitely dense condition that we refer to as a ***singularity***.

The history of the universe according to the Big Bang Theory

- What was the condition like in the early universe?
- How did matter come about?

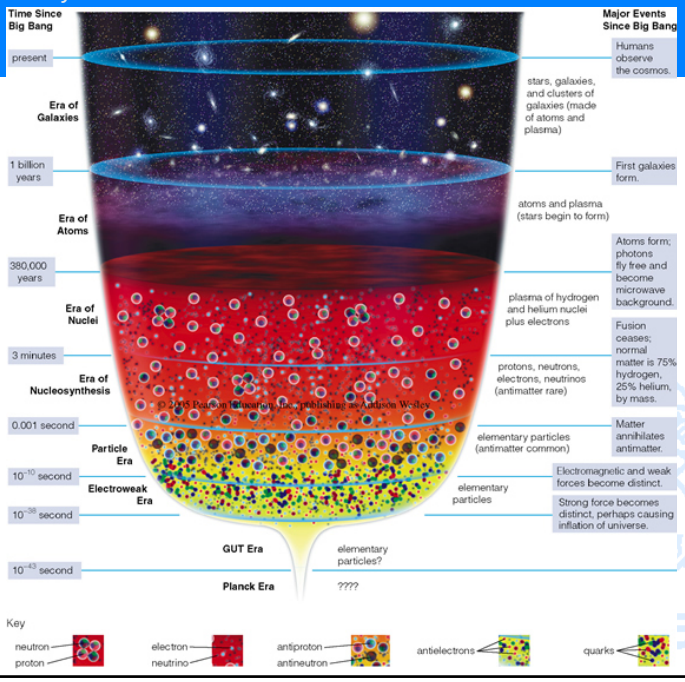
Observational Evidences supporting the Big Bang Theory

- The Cosmic Microwave Background Radiation
- The Abundances of Elements

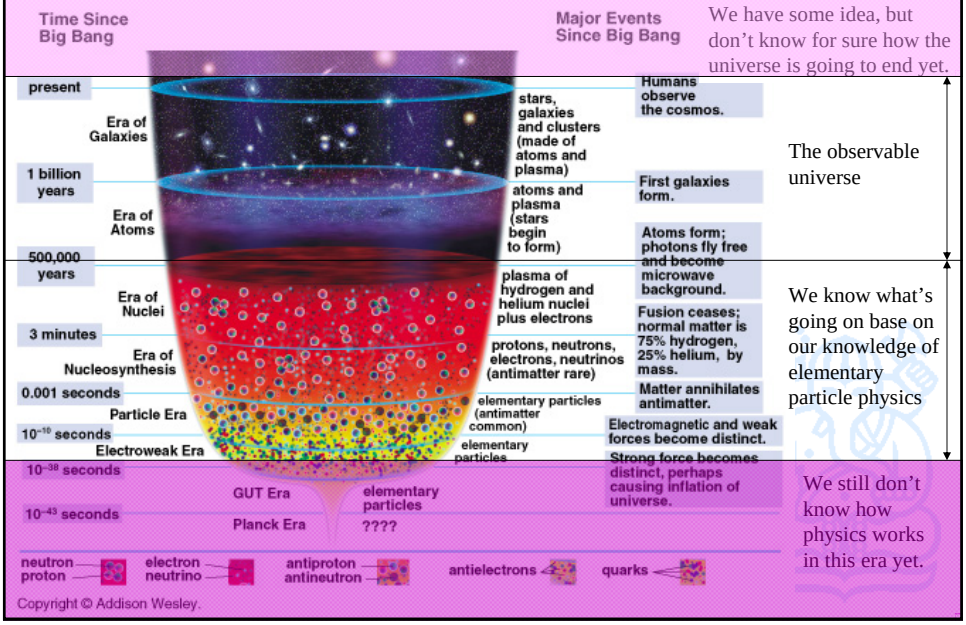
Weakness of the initial Big Bang Theory and the *Inflation*

- Where does structure come from?
- Why is the large-scale universe so uniform
- Why is the density of the universe close to the critical density?

The Scientific History of the Universe



History of the Universe



We have some idea, but don't know for sure how the universe is going to end yet.

The observable universe

We know what's going on base on our knowledge of elementary particle physics

We still don't know how physics works in this era yet.

BANG!

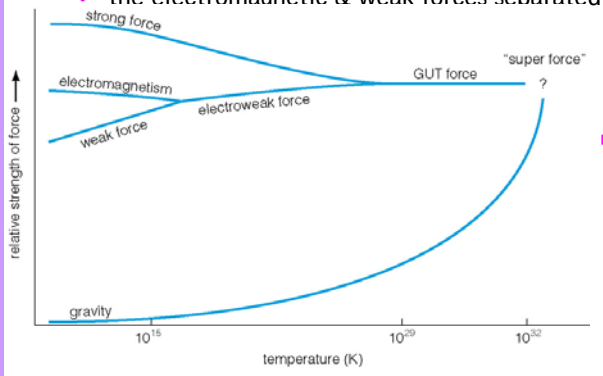
- This era, the "first instant", lasted for 10^{-43} sec.
- Because we are as yet unable to link…
  - quantum mechanics (our successful theory of the very small)
  - general relativity (our successful theory of the very large)
- We are powerless to describe what happened in this era.
- 10^{-43} sec after the Big Bang is as far back as our current science will allow us to go.
- We suppose that all four natural forces were unified during this era.

GUT Era (10^{-43} < t < 10^{-38} sec)

- The Universe contained two natural forces:
  - gravity
  - Grand Unified Theory (GUT) force
    - electromagnetic + strong (nuclear) + weak forces unified
- This lasted until the Universe was 10^{-38} sec old.
  - at this time, the Universe had cooled to 10^{29} K
  - the strong force "froze out" of the GUT force
  - the energy released by this caused a sudden and dramatic **inflation** of the size of the Universe

Electroweak Era (10^{-38} < t < 10^{-10} sec)

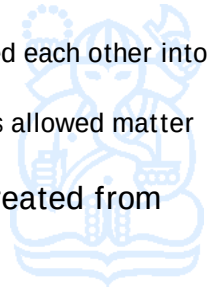
- The Universe contained three natural forces:
  - gravity, strong, & electroweak
- This lasted until the Universe was 10^{-10} sec old.
  - at this time, the Universe had cooled to 10^{15} K
  - the electromagnetic & weak forces separated



- This was experimentally verified in 1983:
  - discovery of W & Z bosons
  - electroweak particles predicted to exist above 10^{15} K

Particle Era (10^{-10} < t < 10^{-3} sec)

- The four natural forces were now distinct.
- Particles were as numerous as photons.
- When the Universe was 10^{-4} sec old…
  - quarks combined to form protons, neutrons, & their anti-particles
- At 10^{-3} sec old, the Universe cooled to 10^{12} K.
  - protons, antiprotons, neutrons, & antineutrons could no longer be created from two photons (radiation)
  - the remaining particles & antiparticles annihilated each other into radiation
  - slight imbalance in number of protons & neutrons allowed matter to remain
- But electrons & positrons were still being created from photons.

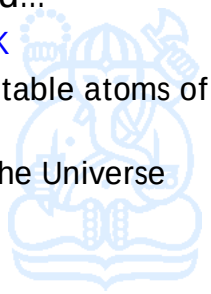


Era of Nucleosynthesis (10^{-3} sec < t < 3 min)

- During this era, protons & neutrons started fusing…
  - but new nuclei were also torn apart by the high temperatures
- When the Universe was 3 min old, it had cooled to 10^{9} K.
  - at this point, the fusion stopped
- Afterwards, the baryonic matter leftover in the Universe was:
  - 75% Hydrogen nuclei (i.e. individual protons)
  - 25% Helium nuclei
  - trace amounts of Deuterium (H isotope) & Lithium nuclei

Era of Nuclei (3 min < t < 3.8 x 10^5 yr)

- The Universe was a hot plasma of H & He nuclei and electrons.
  - photons bounced from electron to electron, not traveling very far
  - the Universe was opaque
- When the Universe was 380,000 yrs old…
  - it had cooled to a temperature of 3,000 K
  - electrons combined with nuclei to form stable atoms of H & He
  - the photons were free to stream across the Universe
  - the Universe became **transparent**



Era of Atoms (3.8 x 10^5 < t < 10^9 yr)

- The Universe was filled with atomic gas.
  - sometimes referred to as the "Cosmic Dark Ages"
- Density enhancements in the gas and gravitational attraction by dark matter…
  - eventually form protogalactic clouds
  - the first star formation lights up the Universe
  - this provokes the formation of galaxies
  - and reionizes the intergalactic and interstellar gas

Era of Galaxies (t > 10^9 yr)

- The first galaxies formed ca. 1 billion years after the Big Bang.
- This is the current era of the Universe.

Challenges for the Big Bang Model

- Many evidences in support of the Big Bang theory.
- But prior to 1980, cosmologists had identified three major questions that the basic theory was unable to answer:
  1. Where does structure come from?
  2. Why is the large-scale Universe so smooth?
  3. Why is the density of matter almost critical?
- In 1981, physicist Alan Guth realized that the Grand Unified Theories could hold the answers to these questions.
- When the strong force froze out of the GUT force…
  it released enough energy to expand the Universe by 10^{30} times in less than 10^{-36} sec!!
- We call this dramatic expansion **inflation**

Epilog

- Masih banyak sekali hal-hal yang belum diketahui tentang alam raya ini
- Fisika akan terus berkembang seiring dengan berkembangnya peradaban manusia
- Apakah kita sudah merasa cukup dengan apa yang telah kita ketahui sampai saat ini?

References

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