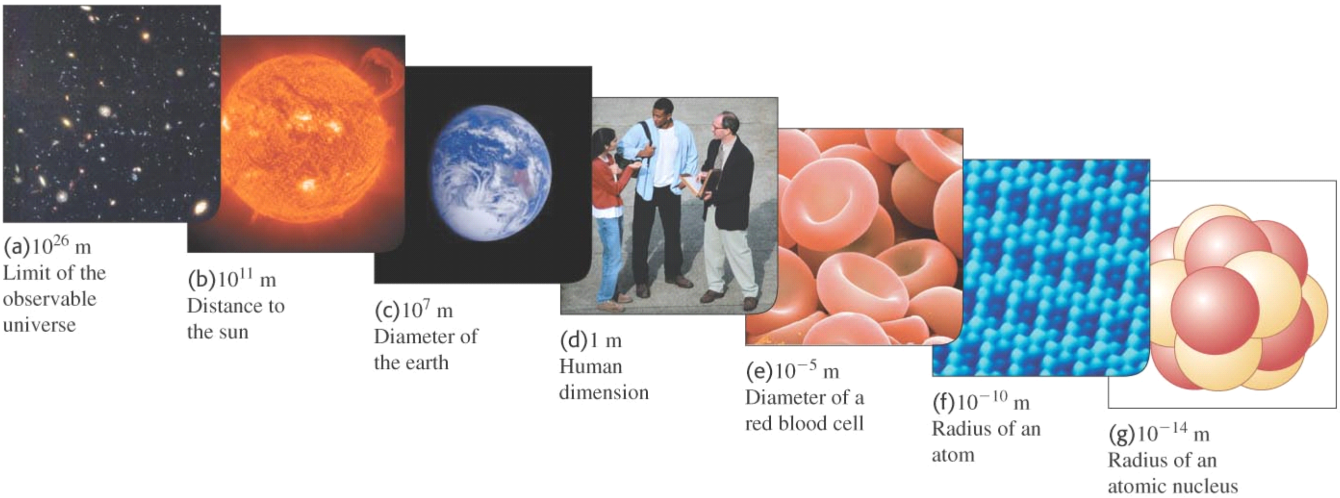
万物运行的奥秘 讲义大致要点整理

1、Introduction



The distance between earth and Vega：trigonometric parallax(三角视差法) 26.5 光年

Galaxy: (10^34)　sun:10^30　earth:10^24　atom:1.6*10^-27　Electron: (10^-31)　kg

Measure Galaxy：

$$F = \frac{G \times M_1 \times M_2}{r^2}$$

while

$$F = \frac{M_1 \times v^2}{r}$$

$$T = \frac{2\pi r}{v}$$

so

$$F = \frac{4\pi^2 \times M_1 \times r}{T^2}$$

Then

$$\frac{G \times M_1 \times M_2}{r^2} = \frac{4\pi^2 \times M_1 \times r}{T^2} \Rightarrow M_2 = \frac{4\pi^2 \times r^3}{T^2 \times G}$$

Radiation emitted by a cesium atom:f = 9192631770 1/s

2、motion in low speed

Sir Isaac Newton (1643-1727) was an English physicist, mathematician, astronomer, natural philosopher, alchemist (炼金术士) and theologian (神学者). His 《Philosophiæ Naturalis Principia Mathematica》, published in 1687, is considered to be the most influential book in the history of science. In this work, Newton described universal gravitation and the three laws of motion, laying the groundwork for classical mechanics, which dominated the scientific view of the physical universe for the next three centuries and is the basis for modern engineering.
In mechanics, Newton enunciated the principles of conservation of momentum and angular momentum. In optics, he invented the reflecting telescope and developed a theory of colors based on the observation that a prism decomposes white light into a visible spectrum. He also formulated an empirical law of cooling and studied the speed of sound.

Gottfried Wilhelm Leibniz（1646－1716）、Robert Hooke（1635－1703） Following Leibniz's death, Newton reported that he had taken great satisfaction in "breaking Leibniz's heart."

Newton's law

Relations between object's mass, force, position, speed, acceleration,furthermore, energy
Results from observations and measurements of object's motions

Description of a motion

Position、Velocity、Acceleration、Reference frame
Galileo Galilei (1564-1642), age 60, drawn by contemporary Ottavio Leoni in 1624.
Galileo was the first to analyze motion in terms of measurements and mathematics. He described acceleration, which is the **rate of change of speed** (or the rate of change of velocity, as we'll see later).

acceleration =
(final speed － initial speed)
time required

Examples：1、刚出膛的子弹要先加速再减速（加速度很大）
2、电风扇切割不危险（注意方向）
3、飞机投弹（不是正下方）

Momentum (动量)：P=MV
Examples：1、磁铁打铁球（势能转化动能）
2、后车撞前车，前车尾坏，后车头不损

Kinetic Energy (动能)：E=1/2mv^2
Examples：1、Massive Ordnance Penetrator (巨型钻地弹)
2、mantis shrimp （螳螂虾）60 km/h, a=10400g ； F=60kg ； t=1ms
3、高速限速不同车不一样
4、Energy of asteroid (小行星)V=15km/s、D=10km、 ρ=2.5×103kg/m3、E=1.47×10^23J 1kg TNT: 4.19×10^6 J Little boy (Dropped on Hiroshima): ~15000 tons of TNT

Potential Energy(势能)=>Kinetic Energy

Friction (摩擦力)

Examples：1、Why the wheels' size are different?（different cars？Different bicycles？）

2、卡车附加的轮子（载重时减小压强、空载时增大 f）

3、bullets ：different shapes：Armor Piercing Fin Stabilized Discarding Sabot

3、Motions in High Speeds

The story of ether (以太)：Michelson interferometer

Postulations （假设） of Einstein：

1、Laws of physics are the same in every inertial frame (惯性坐标系)

2、Speed of light is c in every inertial frame

Time Dilation （膨胀）：Twins decide that one will travel to Alpha Centauri and back, while the other stays on earth. Compare their ages when they meet on earth.

Relativistic Momentum： **C**hange in momentum goes to infinite with particle's speed approaching to C 、C is the limiting speed of particle

$$E = mc^2 = \frac{m_0 c^2}{\sqrt{1 - v^2/c^2}}$$

Examples：1、静系中μ子的平均寿命为t =2.2*10^-6 秒。据报导，在一组高能物理实验中，当它的速度为 v=0.9966c 时通过的平均距离为 8km。

2、Cyclotron (回旋加速器)：不能无限加速。

General Relativity (广义相对论)：GPS 应用、水星轨道旋进等等

4、Rotational Motion

Pendulum (单摆)：

Coriolis force：1、Foucault pendulum experiment（傅科摆）

2、Clockwise or counter-clockwise?（放水：北逆南顺）

Rotational Inertia：

A body at rest tends to remain at rest.A body that's rotating tends to continue rotating.

Physical Quantities：Angular Position – an object's orientation

Angular Velocity – its change in angular position with time；Torque – a twist or spin

Examlpes：1、Gyroscope (陀螺仪)

2、Rotational shots（膛线）

3、Stabilization VS energy transition（转动能量大、细长转动效果不好可加尾翼）

4、trench mortar (迫击炮)（方便，不转了）

5、收缩身体以加大转速（Zhukovsky swivel chair）

6、自行车轮子和把手共线

7、In the air, motorcycle riders control their bikes by revving up their motors to spin the rear tire faster, or by putting on the brakes to slow the tire. This changes the angular momentum of their system internally, giving them control of the angle at which they come down.

8、Helicopter：（尾翼反向旋转：双翼）

9、No Tail Rotor (NOTAR,无尾桨直升机：尾部侧向喷气)

10、ABS（防抱死，间断性刹车）

11、Do you know the altitude of geostationary satellite (同步卫星)? 36000km

12、How to make the antenna aim at the earth?

13、Launch Rocket：Why in WenChang, HaiNan? （省燃料，利用自转，向东发射）（Israel launch rocket,to east or west?、为了安全）

Weightlessness or zero gravity ?（前者）（利用很多方法也可以达到失重）
Why the face of moon never change (not the shape)?（周期正好一样）
Saturn's ring (土星环中间有裂缝：引力)

5、Fluid

Solid （Condensed Matter）Liquid （Fluid）Gas
Boat, ship and submarine（密度比水大？）

浮力：1、上升的泡泡
2、鱼的平衡维持
3、船做成双龙骨保证稳定性

Blaise Pascal (1623—1662) P=pgh Atmospheric Pressure
Question: the weight of atmosphere? F=S*p
Siphon phenomenon(虹吸现象)
Pascal’s Principle：F1/S1=F2/S2

Surface Tension：Capillary Phenomena(毛细现象)：表面张力与附着力
Superfluidity (超流)

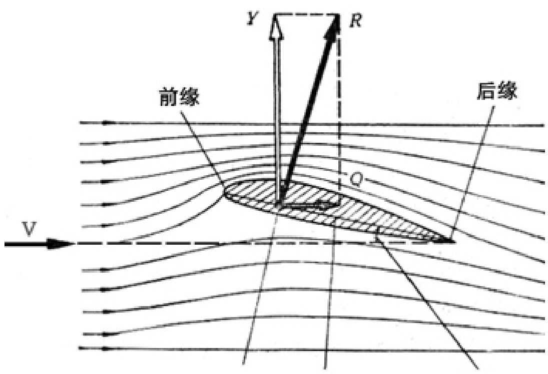
Daniel Bernoulli(1700-1782)：流速快压强小

$$\frac{1}{2}\rho v^2 + p + \rho g y = cons\tan t$$

Flap (襟翼)：降落的时候可以弯折

大飞机无法使用降落伞：太重了

Vehicle’s Wings：高速行驶时可以为车辆提供必要的稳定性，前翼可以增大压力



Turbulence (紊流)

聚能装药：提高压强

6、Heat and Thermodynamics（热力学）

Heat is the energy that flows between objects because of their difference in temperatures；Heat is thermal energy on the move；Technically: object’s don’t contain heat

Heat and Temperature：Touching objects exchange thermal energy；Microscopically, energy flows both ways；On average, energy flows one way.

Temperature predicts energy flow direction；Energy flows from hotter to colder

Temperature turns out to be average thermal kinetic energy per particle

Heat Transfer Mechanisms: Conduction—heat flow through materials

Convection—heat flow via moving fluids

Radiation—heat flow via light waves

All three transfer heat from hot to cold

Conduction

Heat flows through material but atoms don’t

In an insulator,

1、adjacent atoms jiggle one another

2、microscopic exchanges of energy; atoms do work

3、on average, heat flows from hot to cold atoms

In a conductor,

1、mobile electrons help carry heat long distances

2、heat flows quickly from hot to cold via electrons

Convection

Fluid transports heat stored in its atoms

1、Fluid warms up near a hot object

2、Fluid flows away, carrying thermal energy with it

3、Fluid cools down near a cold object

Overall, heat flows from hot to cold

Natural buoyancy（浮力） drives convection

1、Warmed fluid rises away from hot object

2、Cooled fluid descends away from cold object

宇宙飞船中理论上没有对流、热岛效应、洋流、烟囱效应、盛满的热水先冷却

Radiation

Heat transferred by electromagnetic waves(radio waves, microwaves, light, …)

Wave types depend on temperature

cold: radio wave, microwaves, infrared light

hot: infrared, visible, and ultraviolet light

Higher temperature : more radiated heat

Black emits and absorbs light best

Question:How a CPU cooler works?

Campfires：几乎全都是辐射

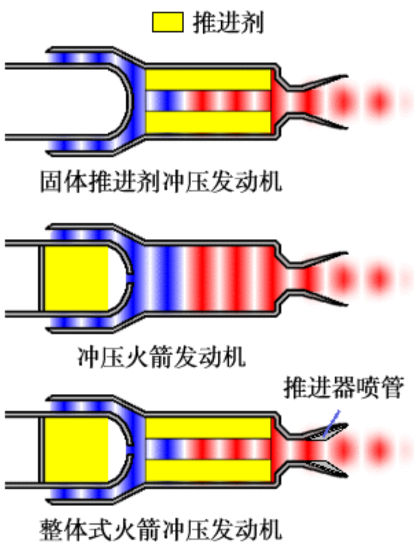
关于全球变暖：是好是坏？

7、Heat detect and application

Question: how to design a thermometer by using the Black Body Spectrum?
Answer：Methods of temperature measurement by optical pyrometers (光学温度计测温法)

Thermocouple
Question: How to design the heat sensor of the missile?
Infrared Photography (红外摄影)
Solar heating system：太阳能热水器：对流
Heat engine： As heat flows naturally from hot to cold, a heat engine diverts some heat and converts it into useful work
Natural heat flow increases entropy (熵)
Converting heat to work decreases entropy
If more entropy is created than destroyed, The overall entropy doesn’t decrease! Some heat can become work!（效率低于 100%）
Heat Pumps :（效率高于 **1**）As it converts useful work into heat, a heat pump is able to transfer some heat from cold to hot. Reverse heat flow decreases entropy
Converting work to heat increases entropy
If more entropy is created than destroyed,
The overall entropy doesn’t decrease! Some heat can be pumped from cold to hot!
Question: An air-condition is less efficiently than an electrical heater, is it right?

As the temperature difference between hot and cold increases
Heat’s change in entropy increases
A heat pump becomes less efficient
A heat engine becomes more efficient



Internal Combustion Engine(内燃机)
Athodyd engine(冲压式喷气发动机)
Turbofan engine(涡扇喷气发动机)

8、Resonance（谐振子） and Mechanical Waves

Sample（数电）
11.025kHz（telephone）
22.05kHz（radio）
44.1kHz（CD）

Velocity of Sound
In Air: V≈331.5+0.6*t, t: temperature of the air
In water (15℃): 1430m/s
Question: how to measure the velocity of sound?（压电陶瓷、示波器）

Frequency of the sound that we can hear: about 20-20000 Hz
Infrasonic: 0-20 Hz ultrasonic: >20000Hz
Sonar ： so(und) na(vigation and) r(anging)

Ultrasonic cleaner
Ultrasonic lithotriptor (超声波碎石机)

Infrasonic weapon

9、Waves

Mechanical waves： They are governed by Newton’s laws, and they can exist only within a material medium, such as water, air, and rock.

1. Transverse Waves (横波， S 波)： The direction of oscillation of medium elements is perpendicular (垂直) to the direction of travel of the wave.
2. Longitudinal Waves (纵波，P 波)：The direction of oscillation of medium elements is parallel (平行) to the direction of the wave’s travel, the motion is said to be longitudinal, and the wave is said to be a longitudinal wave.

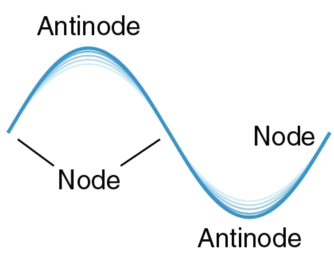
The Tides
The moon’s gravity acts on the earth
The moon’s gravity isn’t uniform
The earth’s oceans are pulled out of round
There are two tidal bulges in the oceans
As the earth rotates, these bulges shift
Almost 2 high and 2 low tides per day
Strongest tides near equator
Weakest tides near poles
Strongest tides when moon and sun are aligned
Weakest tides when moon and sun are at right angles
Only the wave travels, the water circles
Crests are formed from local water
Objects：circle as waves pass but not progress toward shore
Wavelength
The longer the wavelength of a surface wave,
1、the faster it travels
2、The deeper water moves as it passes
3、The more energy it contains for a given amplitude
Tsunamis（海啸） are very long wavelength, very deep, very high energy waves

Breaking Waves： Surface waves slow down in shallow water. Waves bunch as the water gets shallower. Waves get taller as the water gets shallower. Waves break when water can’ t form crest
Gradually sloping bottom: rolling surface
Steeply sloping bottom: plunging breakers
Changing Wave Speeds:
Reflection（反射）Bounce off surface (or medium of different density)
Wave speed change causes partial reflection
The bigger the change, the more reflection
Refraction（折射）:Bend towards “slower” medium: Mirage (海市蜃楼)
Wave speed change can redirect wave
Waves bend toward shore as they slow
Diffraction（衍射）: Bend around barrier

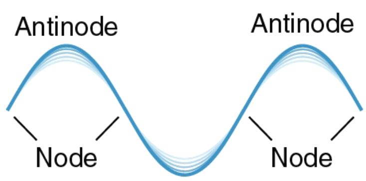
10、Vibration

Sound can break glass. Which breaks most easily:A crystal glass exposed to a certain loud tone
Strings as Harmonic Oscillators
<u>A string is a harmonic oscillator</u>
Its mass gives it inertia
Its tension gives it a restoring force
It has a stable equilibrium
Restoring forces are proportional to displacement
<u>Stiffness of restoring forces determined by</u>
String’ s curvature
String’ s tension
Fundamental Vibration
<u>String vibrates as a single arc, up and down</u>
velocity antinode occurs at center of string
This is the fundamental vibrational mode
<u>Pitch (frequency of vibration) is</u>
proportional to tension
inversely proportional to string length
inversely proportional to mass/length
Overtone Vibrations
In addition, string can vibrate as
two half-strings
three third-strings
etc.
These are higher-order vibrational modes
These modes have higher pitches – overtones

Second harmonic



Third harmonic



Harmonics in a String
In a string, the overtone pitches are
-two times the fundamental frequency

-three times the fundamental frequency
etc.
These integer multiples are called harmonics
Bowing or plucking a string tends to excite a mixture of fundamental and harmonic vibrations, giving character to the sound

Projecting Sound
Thin objects don’t project sound well
-Air flows around objects
-Compression and rarefaction is minimal
Surfaces project sound much better
-Air can’t flow around surfaces easily
-Compression and rarefaction is substantial
Many instruments use surfaces for sound

Air as a Harmonic Oscillator
A column of air is a harmonic oscillator
-Its mass gives it inertia
-Pressure gives it a restoring force
-It has a stable equilibrium
-Restoring forces are proportional to displacement
Stiffness of restoring forces determined by
-pressure
-pressure gradient

Sympathetic Vibration（共振）
“鱼洗”、Airfoil flutter (机翼振颤)、翅痣、
共振的防止：自行车、汽车等等

Stabilization VS Vibration
Question: How to keep the tank stable?（一个很复杂的仪器保证了炮口不动）

11、Light source

Incandescent Light Bulbs（白炽灯泡）
Features:
-Tungsten filament produces light
-Electrical connections deliver power to filament
-Glass envelope protects filament
-Nitrogen/Argon/Krypton gas fill prolongs life

Thermal Radiation
All materials contain electric charges

Thermal energy makes these charges accelerate
Accelerating charges emit electromagnetic waves
All materials emit electromagnetic waves

Black Body Spectrum
The spectrum and intensity of electromagnetic waves from a black body depend ONLY on its temperature

Halogen (卤素) Bulbs
Features:
Bromine/Iodine/Oxygen gas added to bulb
Small, high temperature glass envelope on bulb
Yields a filament recycling process

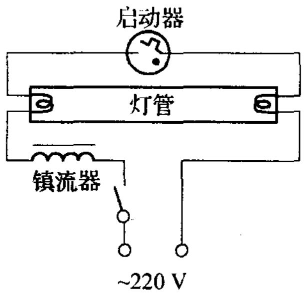
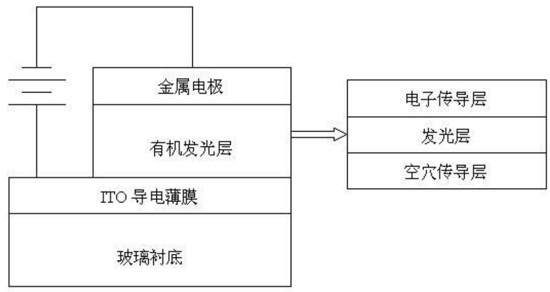


图 17-6-1

Fluorescent lamp （日光灯）

Light Amplification of Stimulated Emission of Radiation (LASER)

Structures of OLEDs



Spectrum of the sunlight

12 Electric and Magnetic Force

Electric Charge
Two types: positive & negative
Like charges repel, opposites attract
-Forces consist of a matched pair:
----Each charge pushes or pulls on the other
----Forces have equal magnitudes, opposite directions
-Forces increase with decreasing separation
Charge is measured in coulombs（库仑）

Charge is conserved
Charge is quantized（量子）
-One fundamental charge is 1.6×10-19 coulomb
Charge is an intrinsic property of matter
-Electrons are negatively charged
-Protons（质子） are positively charged
-Each has one fundamental charge

Bobert Andrew Millikan(密立根油滴实验)won the Nobel prize in 1923.

Net Charge

Net charge is the sum of an object’s charges

Most objects have zero net charge (neutral)

Neutral objects contain equal + & － charges

Voltage

Charge has electrostatic potential energy (EPS)

-Voltage measures the EPS per unit of charge-

-Raising the voltage of positive charge takes work

Lowering the voltage of negative charge takes work

Voltage is measured in joules（焦耳）/coulomb or volts

Charging Objects

Like charge separate whenever possible

-They disperse on the outside of a conductor

-They accumulate on an outside point or thin wire

Polarizing（极化） Objects

Nearby charges can shift an object’s charges

应用：石墨打印机、Electronic Air Cleaners

Discharge

Charging is limited by charge escape

-Severe repulsion leads to corona discharge （电晕放电）

-Charges leap onto air molecules and escape

-Air molecules often glow during corona discharge

If ionization（离化） occurs, a spark or arc forms

Benjamin Franklin(1706～1790)

Lightning rod (避雷针)

13 Electric Energy

Magnetic Poles（极）

Two types: north & south

Like poles repel, opposites attract

-Forces consist of a matched pair

-Forces increase with decreasing separation

Analogous to electric charges EXCEPT:

-No isolated magnetic poles ever found!

-Net pole on an object is always zero!

Magnetic Fields

A magnetic field is a structure in space that pushes on magnetic pole

The magnitude of the field is proportional to the magnitude of the force on a test pole

The direction of the field is the direction of the force on a north test pole

Electromagnetism(电磁学)
Electric fields
-Push only on electric charges
-Produced by electric charges
-Can be produced by changing magnetism
Magnetic fields
-Push only on magnetic poles
-Produced by magnetic poles
-Can be produced by changing electricity
Magnetism created by
-Poles (but isolated poles don’t seem to exist)
-Moving electric charges
-Changing electric fields
Electricity created by
-Charges
-Moving magnetic poles
-Changing magnetic fields

Current
Current measures the electric charge passing through a region per unit of time
Current is measured in coulombs/second or amperes (amps)
Electric fields cause currents to flow
Currents are magnetic

Electromagnetic Induction（电磁感应、科拉顿 1825（failed）、法拉第 1831、1791-1867）
Electromotor（电动机）
What will happens if the diameter of electromotor increase to infinitude (∞)：直线电机
Magnetically Levitated Trains(磁悬浮列车、坏了不能移动，没有轮子)
某科学的超电磁炮：electromagnetic gun

Eddy Current（涡流）
Transformer（变压器）
Question: Guess the structure of a mine detector
Hall effect(霍尔效应)

14 Electromagnetic Waves

Light waves（hooks） or particles（newton） ?
Thomas Young （1773～1829 ）
Poisson, Simeon-Denis（1781—1840）泊松亮斑
Augustin-Jean Fresnel （1788-1827)
Photoelectric effect(光电效应)：Albert Einstein won the Noble Prize in 1921

Quantum Physics

All things travel as waves

All things interact as particles

Example 1: Light

Travels as waves – electromagnetic waves

Emitted and absorbed as particles – photons

Example 2: Electrons

Detected as particles

Travel as waves

1927年第五届索尔威会议

De Broglie won the Noble Prize in 1929,

Erwin Schrdinger won the Noble Prize in 1933.

Cliton Joseph Davisson and George Paget Thomson won the Nobel prize in 1937（电子的波动性）

Scanning electron microscope（SEM，扫描电子显微镜)

Transmission Electron Microscopy（TEM，透射电镜）

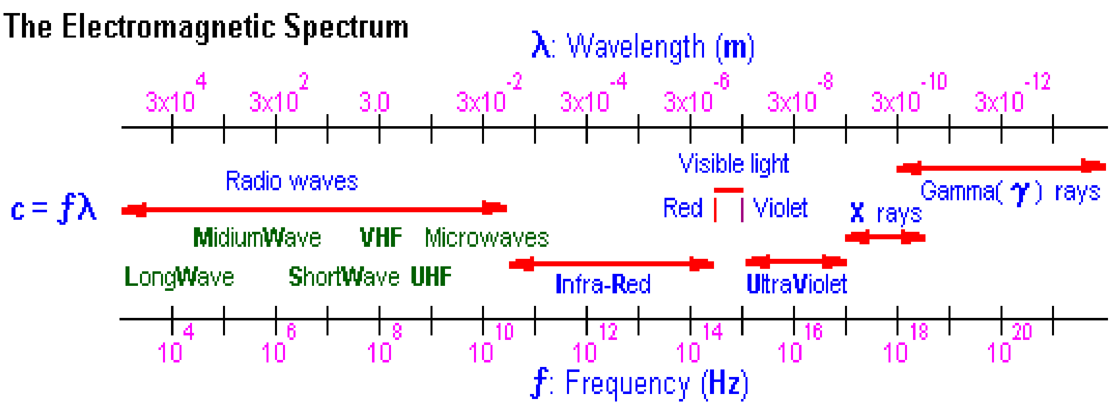
PhotoEmission Electron Microscope (PEEM，光发射电子显微镜)

The history of Electromagnetic Waves

1873: J. C. Maxwell

Antenna

The Electromagnetic Spectrum



Hertz, 1887

（观测电磁波）

James Clerk Maxwell (1831-1879)

$$
\begin{cases}
\oint\!\!\oint_S \boldsymbol{D} \cdot \mathrm{d}\boldsymbol{S} = q \\
\oint\!\!\oint_S \boldsymbol{B} \cdot \mathrm{d}\boldsymbol{S} = 0 \\
\oint_L \boldsymbol{E} \cdot \mathrm{d}\boldsymbol{l} = -\iint_S \dfrac{\partial \boldsymbol{B}}{\partial t} \cdot \mathrm{d}\boldsymbol{S} \\
\oint_L \boldsymbol{H} \cdot \mathrm{d}\boldsymbol{l} = I + \iint_S \dfrac{\partial \boldsymbol{D}}{\partial t} \cdot \mathrm{d}\boldsymbol{S}
\end{cases}
$$

Marconi (1874—1937), won the Noble Prize in 1909.

FM (Frequency Modulation)

Radar ： ra(dio) d(etecting) a(nd) r(anging)

China EWR (early-warning radar) aircraft

Synthetic Aperture Radar

Stealth aircraft (隐形飞机)

Question: In a dark room, you can find the target with the help of a flashlight, why?
Answer: We can see the target because the light from flashlight was reflect from the target to our eyes.
Question: What will happen if the target is black or a mirror?

Other application of Electromagnetic Waves
Microwave Oven：Frequency: 915 MHz, 2450M Hz

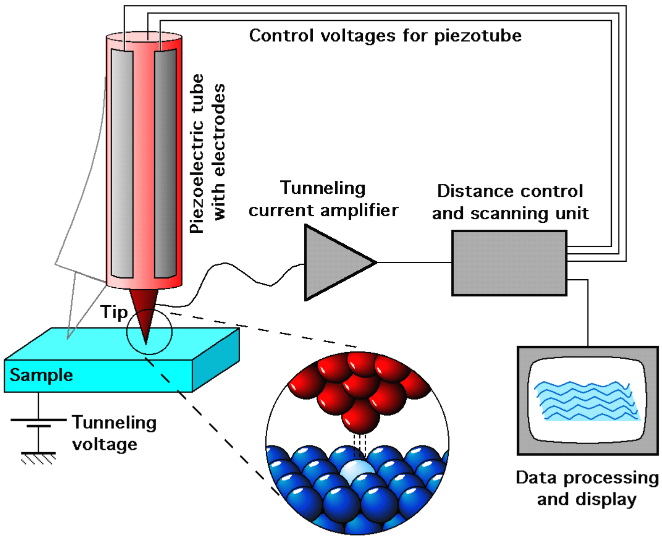
15 atom

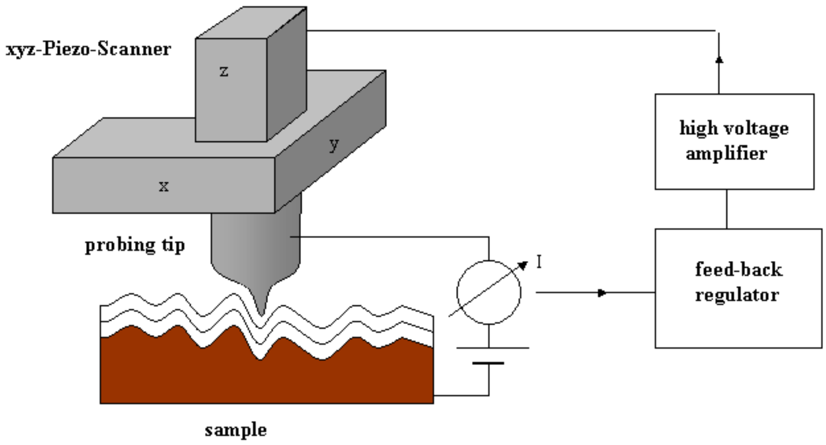
Joseph John Thomson (1856—1940) Won the Nobel prize in 1906.（1897 发现电子）
H. R. Hertz, experiment failed because of the bad vacuum.
A. Schuster, experiment succeeded, but thought the result was unbelievable.
W. Kaufman, experiment succeeded (1897), better data, but had no bravery to publish the result till 1901.

Ernest Rutherford (1871—1937)
Lord Ernest Rutherford H. Geiger E. Marsden (1909)
α-particle scattering experiment (α粒子散射实验)
Diameter of atomic nucleus: about 10-14m
Diameter of atomic:3.2×l0-10m

Ernest Rutherford Won the Nobel chemistry prize in 1908 (not for the atom model (1911))
The Nobel prize winners list of Cavendish Laboratory under the lead of Rutherford
1921 年，卢瑟福的助手索迪（Frederick Soddy）获诺贝尔化学奖；
1922 年，卢瑟福的学生阿斯顿获诺贝尔化学奖；
1922 年，卢瑟福的学生玻尔（Niels Henrik David Bohr, 1885-1962）获诺贝尔物理奖；
1927 年，卢瑟福的助手威尔逊（Charles Thomson Rees Wilson, 1869-1959）获诺贝尔物理奖；
1935 年，卢瑟福的学生查德威克(James Chadwick, 1891-1974) 获诺贝尔物理奖；
1948 年，卢瑟福的助手布莱克特(Baron Patrick Maynard Stuart Blackett, 1897-1974)获诺贝尔物理奖；
1951 年，卢瑟福的学生科克拉夫特（Sir John Douglas Cockcroft, 1897-1967） 和瓦耳顿（Ernest Thomas Sinton Walton, 1903-1995），共同获得诺贝尔物理奖；
1978 年，卢瑟福的学生卡皮茨获（Pyotr Leonidovich Kapitsa, 1894-1984）诺贝尔物理奖。

Tunneling Effect (隧道效应)：STM Scanner





Gerd Binning and Heinrich Rohrer won the Noble Prize in 1986（for STM）

Proton（质子）：Rutherford (1919)　$^{14}_{7}N+^{4}_{2}He\rightarrow^{17}_{8}O+^{1}_{1}H$

Neutron（中子）Sir James Chadwick Won the Nobel prize in 1935.　$^{9}_{4}Be+^{4}_{2}He\rightarrow^{12}_{6}C+^{1}_{0}n$

Isotopes (同位素)　：the number of proton is same　；the number of neutron is different

Electron Energy Level：Exciting the atom－＞electron transition　（电子跃迁）

The inside of proton and neutron：Quarks and the Strong Force
Large Hadron Collider（LHC，大型强子对撞器）

16 Radiation

Wilhelm Roentgen（1845-1923）Won the Noble Prize in 1901.（X-ray）
H. A.　Becquerel　(1852-1908) Won the Noble Prize in 1903.（铀的天然放射现象）
α　ray,　β　ray (1897),　（卢瑟福）γ　ray (1900) Paul Villard (1860-1934)

Irenr Joliot-Curie and Feredierick Joliot-Curie Won the Noble Prize in 1934 at last!

$$\alpha + {}^{27}Al \rightarrow n + {}^{30}P \qquad {}^{30}P \rightarrow {}^{30}Si + \beta^{+} + \nu$$

Carl David Anderson won the Noble Prize in 1936 (positron[正电子]).
James Chadwick won the Noble Prize in 1935 (neutron[中子]).

Nuclear reaction Albert Einstein (1879-1955) Mass-Energy Equivalence

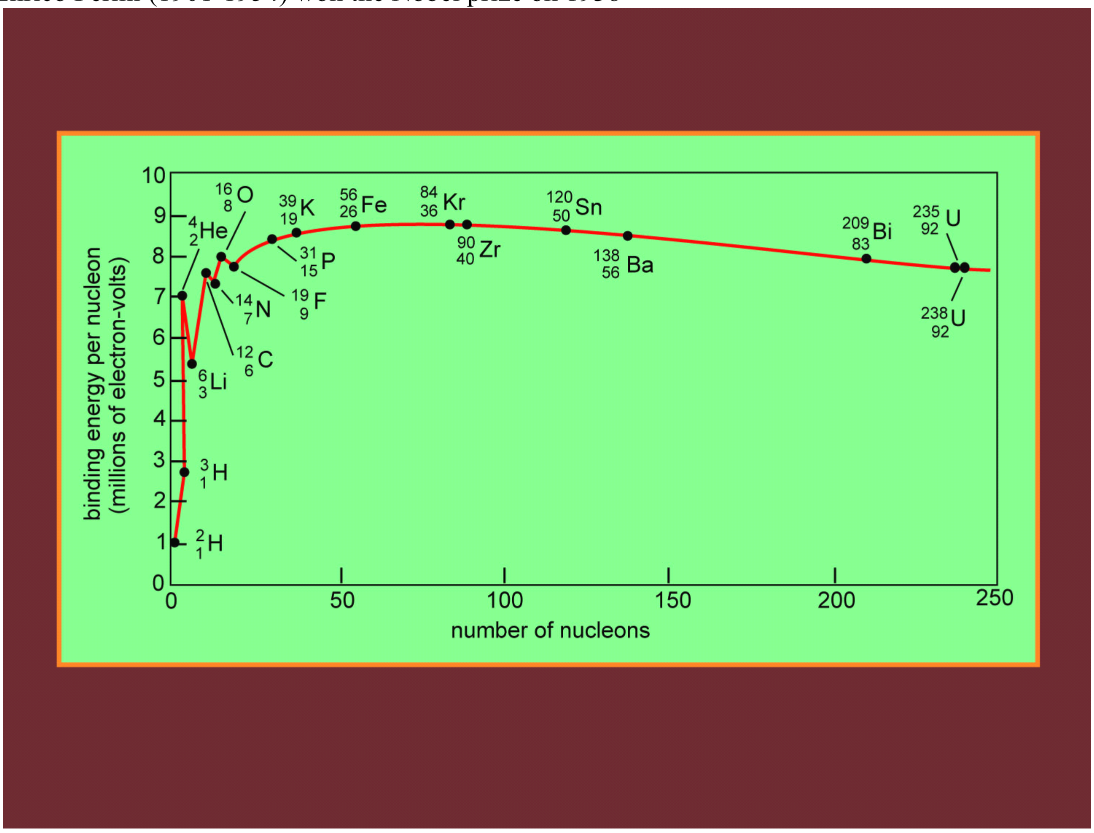
J. D. Cockcroft and E. T. S. Walton (1932)

$$p: 0.5MeV(InputEnergy)$$
$$\alpha: (8.9\times 2)MeV(OutputEnergy)$$
$$OutputEnergy > InputEnergy!!!!!$$

Fission and Fusion（裂变和聚变）

$$n + {}^{235}U \rightarrow {}^{140}Ce + {}^{94}Br + 2n \text{（}\beta\text{衰变）}$$

Enrico Fermi (1901-1954) won the Nobel prize on 1938



Energy output of one atom in Chemic reaction: less than 10eV
Total Energy Output of one U atom: about 185MeV!!!!!

Question: How to detect the radiation?
Geiger Counter (盖格计数器)、威尔逊云室
应用：荧光、金属探测、烟雾探测、放射治疗、辐射灭菌、C14 年代检测

17 Nuclear Power

critical mass of 235U : ~ 52 kg
Fusion Bomb (H-Bomb, Thermonuclear Bomb)
Tsar (USSR), the most powerful nuclear weapon of the world, 26 tons, Blast equaled ~58 million tons TNT , 30 Oct, 1961
Julius Robert Oppenheimer

1964 年 10 月 16 日，中国原子弹爆炸成功！1967 年 6 月 17 日，氢弹爆炸成功！
InterContinental Ballistic Missile (ICBM,洲际弹道导弹)

邓稼先 1924.06.25-1986.07.29 China’s last nuclear weapon test, 1996.07.29

Pu (plutonium)

Isotopes and compounds of plutonium are dangerous due to their radioactivity.

Based on chemical toxicity (毒性) alone, the element is less dangerous than arsenic（砒霜） or cyanide（氰化物） and about the same as caffeine（咖啡因）.

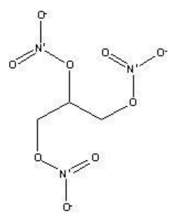
Plutonium is not absorbed into the body efficiently when ingested; only 0.04% of plutonium oxide is absorbed after ingestion.

Plutonium has a metallic taste.

Tokamak 国际热核聚变实验堆（ITER）
Experimental Advanced Superconducting Tokamak (EAST)
Nuclear Magnetic Resonance

18 Wonderful Materials

Nitroglycerine (硝化甘油)



Kevlar (Aramid fiber, 凯夫拉)

水立方：聚四氟乙烯

Composite materials (复合材料)
Stainless Steel （不锈钢）
Semiconductor（半导体）
Transistor: Diode and Dynatron
Integrate Circuit(IC，集成电路)
Shape memory metal (记忆合金)

Inside of materials

Structures and Properties

Diamond — tetrahedral structure
Eg>5.0 eV，excellent thermal conductance
Super-hardness
Graphite — layer structure
Eg = 0.0 eV，excellent electrical conductance
Van de Waals interaction between layers

Crystalline structures depend on electronic structures of atoms
Human’s goal: Controlling Materials at atomic scale

Materials with fcc (hcp) structures
Most of transition metals and noble metals, such as Cu, Ni, Au, Ag

Materials with bcc structures
Some metals: Fe (magnetic material)

Giant Magneto Resistive (GMR, 巨磁阻)

Si based devices：Realization of “0” and “1”

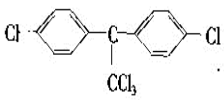
Light-emitting diodes（p-n 结）

Optical communications
Diamond: super-hard
Superconducting Materials

Advanced materials-Nano-materials
Why nano?
in 2004, 0.15 ｍ um
10 years ago， 1.50 ｍ um
Dimensions of devices decrease one magnitude every 10 years
At present, devices based on macroscopic properties of materials

Nano structures
Application—single electron (quantum) device

Graphene (石墨烯)：Graphite to Graphene

Surface：
Question: What is the best material?


（DDT）

整理：brighturan 2013,4,27 15:40