近代物理

Physical constants:

Avogadro's number: $N_a=6.02\times10^{23}$ *particles/mol*

Boltzmann's constant: $k=1.38\times10^{-23}$ *J/K*

Coulomb constant: $k=8.987\times10^{9}\ N\cdot m^2/C^2$

Fundamental charge: $e=1.6\times10^{-19}$ *C*

Mass of electron: $m_e=9.1\times10^{-31}$ *Kg*

Mass of proton: $M_p=1.672623\times10^{-27}$ *Kg = 938.3 MeV*

Mass of neutron: $M_n=1.674929\times10^{-27}$ *Kg = 939.6 MeV*

Mass of pion: M_{Π^-} *= 139.6 MeV*

Mass of unit: $u=1.66\times10^{-27}$ *Kg*

Planck's constant: $h=6.6\times10^{-34}\ J\cdot s$

Speed of light: $c=299792458$ *m/s*

Constant of gravitation: $G=6.67\times10^{-11}N\cdot m^2/Kg^2$

Fine structure constant: $\alpha=7.297\times10^{-3}$

Gas constant: $R=8.3\ J/mol\cdot K$

Permeability of free space: $\mu_0=4\pi\times10^{-7}\ N/A^2$

Problem 1 (30%) Briefly describe the following terms.

(a) Single-Channel analyzer

(b) Fabry-Perot

(c) Franck-Hertz tube

(d) "Trigger" knob on the oscilloscope

(e) Laser

(f) Black body radiation

Problem 2 (15%) The Royal Swedish Academy of Sciences has decided to award the 2002 Nobel Prize in Physics jointly to Professor Raymond Davis Jr. and Professor Masatoshi Koshiba for pioneering contributions to astrophysics, in particular for the detection of cosmic neutrinos and to Professor Riccardo Giacconi for pioneering contributions to astrophysics, which have led to the discovery of cosmic X-ray sources.

(a)In which decay process, Wolfgang Pauli suggested that there is a third particle called neutrino emitted for conservation of angular momentum and energy?

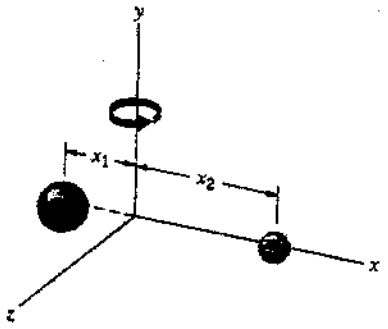
(b)How did Professor Raymond Davis Jr. and Professor Masatoshi Koshiba detect the cosmic neutrinos?

(c)What is the significant of X-ray astronomy?

(背面仍有題目,請繼續作答)

Problem 3 (10%) For what range of velocities for a particle of mass m can we use the classical expression for kinetic energy $\frac{1}{2}mv^2$ to within accuracy of 1 percent?

Problem 4 (20%) A diatomic molecule (e. g. HCl) can be simplified as a two point mass rigid rotator as shown in figure below. This molecule can change its state of motion when absorbs or emits radiation by rotating about its center of mass.

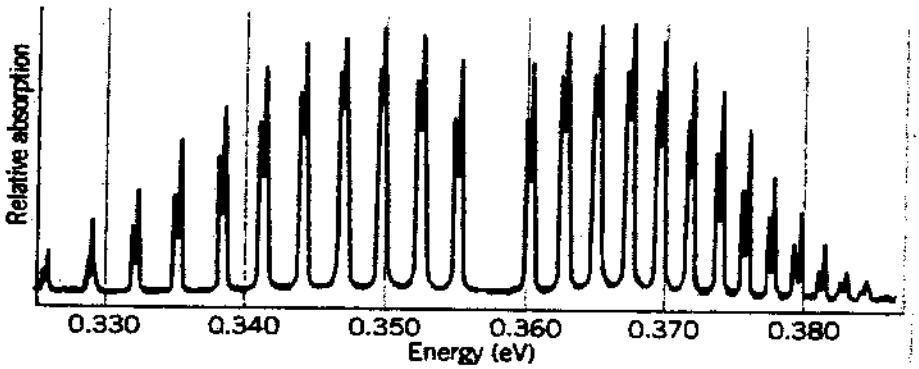


(a) What is the rotational kinetic energy of the diatomic molecule with angular velocity ω?

(b) Without going through the solution to the Schrödinger equation, try to quantize the rotational kinetic energy of this system.

(c) Figure shown below is the absorption spectrum of diatomic molecule HCl. Can you explain this spectrum from the result of (b)?

(d) How to explain the doublet of each peak?



The molecular absorption spectrum of HCl.

Problem 5 (15%) A particle is confined in a two dimensional harmonic oscillator with the same spring constant.

(a) Write down the eigen values of this system.

(b) Sketch the energy-level diagram from ground state up to $5\hbar\omega_0$, showing the eigen energy E and the quantum number for each level.

(c) Show how that each level is degenerate and calculate the degeneracy.

Problem 6 (10%) (a)Why does the electrical conductivity of a metal decrease as the temperature is increased?

(b)How would you expect the conductivity of a semiconductor to change with temperature?