Modern Physics

2002/04

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: $M_p=1.67\times10^{-27}$ *Kg*

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%) Describe the significance of the following terms:

(A) Blackbody Radiation. (5%)

(B) Photoelectric Effect. (5%)

(C) Lamb Shift. (5%)

(D) Bohr Magneton. (5%)

(E) Zero-point Energy. (5%)

(F) Holography. (5%)

Problem 2 (15%)

(A) In the Hall Effect experiment, a strip of copper 150 μm thick is placed in a magnetic field B=0.65 T perpendicular to the plane of the strip, and a current i = 23 A is set up in the strip. The Hall potential measured is V = 5.6 μV. What would be the density charge carrier per atom? (Cu : 8.49×10^{28} atoms/m^3) (10%)

(B) Explain briefly the Quantum Hall Effect and the usage of this effect. (5%)

Problem 3 (20%)

(A) The eigen-values of a diatomic molecular around its equilibrium position can be approximated by $E(v,J)=(v+\frac{1}{2})\hbar\omega+B_vJ(J+1)$, where v and J are vibration and rotational quantum number, $\hbar$, ω and B_v are constants. Describe a simple model and the meaning of these constants ($\hbar$, ω and B_v) in your model to derive these eigen-values. (10%)

(B) Estimate the ratio of energy contribution from the vibration and rotational energy. (10%)

(背面仍有題目,請繼續作答)

2-21-00

Problem 4 (20%)

(A) The Royal Swedish Academy of Sciences award the Nobel Prize in Physics for 2001 jointly to Eric A. Cornell, Wolfgang Ketterle, Carl E. Wieman, for the achievement of Bose-Einstein condensation in dilute gases of alkali atoms, and for early fundamental studies of the properties of the condensates. What is Bose-Einstein condensation? (5%)

(B) Fig. 4.1 (from web: http://jilawww.colorado.edu/bec/) shows the first achievement of Bose-Einstein condensation in ^{87}Rb atoms. It is a two-dimensional number density of atoms per unit velocity-space volume distributions of the trapped ^{87}Rb cloud for three runs with different amount of cooling. (i)Explain the key points of observing the Bose-Einstein condensation of ^{87}Rb atoms from this figure. (ii)If the density of the ^{87}Rb cloud is n = 1×10^{14} atoms/cm^3, estimate the critical temperature of observing the Bose-Einstein condensation of ^{87}Rb atoms. (^{87}Rb : atomic mass 86.909 g/mole) (10%)

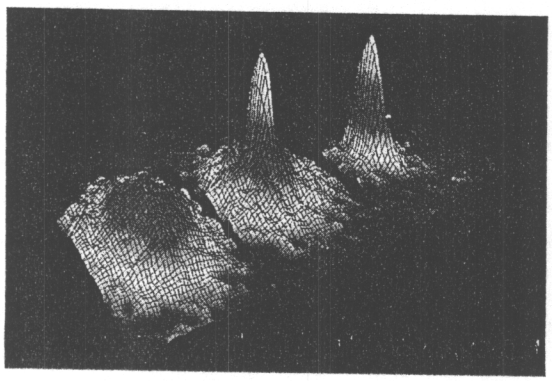

Fig. 4.1

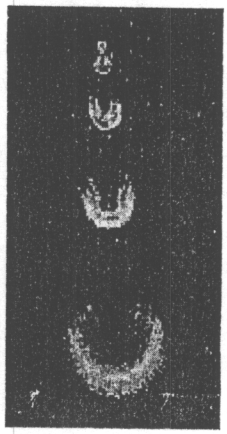

Fig. 4.2

(C) Fig. 4.2 (from web: http://cua.mit.edu/ketterle_group/Nice_pics.htm) demonstrates the atom laser with Na condensate for the first time. What is atom laser? (5%)

Problem 5 (15%)

(A) Using arguments concerning curvature, wavelength, and amplitude, sketch very carefully the wave function corresponding to a particle with energy E in the finite potential barrier shown in Fig. 5.1,

$$V(x)=\begin{cases} V_0 & for\ 0<x<a \\ 0 & for\quad 0>x \quad and\ x>a \end{cases}$$, where $0<E<V_0$. (10%)

(B) Re-sketch the wave function if (i) a $\rightarrow$ 2a, and (ii) $0<V_0<E$. (5%)

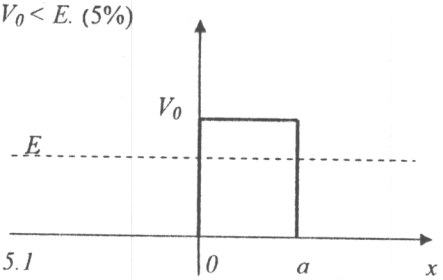

Fig.5.1