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Advancement of plasmon waves at surface of carbon- nanotube

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Abstract - *There has been vital progress within the development of analytical techniques for analysis of receptor-ligand interaction. Surface plasmon resonance (SPR)-based optical biosensors area unit currently being employed extensively to outline the mechanics of wide range of organic compound interactions and high- and low-affinity tiny molecule interactions. The experimental style information analysis ways are a unit evolving at the side of widespread applications in substance fishing, biological science, virology, host-pathogen interaction, epitope mapping and protein-, cell-, membrane-, nucleic acid-protein interactions. SPR based mostly biosensors have sturdy impact on basic and applied analysis considerably. Collective excitations within the single and multi-walled carbon nanotubes are studied by many authors. Hydro high-v_0 modes are found a vital technique to check the properties of nanotubes. Plasma wave that propagate on the surface of nanotubes of various radius in stuff medium area unit studied on paper. This investigation shows that frequencies of Plasmon are often modification with relation to radius of nanotubes and close stuff mediums. The express of Plasmon dispersion relations between propagation constant of electromagnetic waves and frequencies of Plasmon shows the attenuation properties of nanotubes of various substances.*

***Key Words*: surface plasmon resonance, plasmon dispersion, excitation in nanotubes.**

1.INTRODUCTION

Graphene are quasi one-dimensional material which could be regarded as a rolled-up graphics layer (i.e. one atom thick layer of graphers) in the cylindrical form. It has a radius of a few nanometres and length up to centimeters. A grapher's layer is a semi metallic material. Nevertheless, when a grapher's layer is rolled up it may become either metallic or semi-conducting, depending on its geometry. The geometric structure of graphite sheets is uniquely determined by the chiral vector $R=ma_1+na_2 \equiv (m, n)$, where m and n are integers and a_1& a_2 are the elementary vectors of the dimensional graphene lattice. The radius of the graphene is given by:

$$re = \frac{a_o}{2\pi}\sqrt{m^2+mn+n^2}$$

Where $a_o = \sqrt{3}\, b_o$, is the lattice constant of the graphite sheet and bo=1.42 A° is the distance the nearest neighbouring carbon atoms. A graphene is metallic of m-n=3q where q=0, 1, 2 ... Thus, arm chair nano tubes are always metallic, whereas zigzag nano tubes are metallic only if m=3q with q = 1, 2 ...

Now it is assumed that both zig-zag (m, o) and arm chair (m, n) nano-tubes as infinitesimally thin and infinitely long cylindrical shells of radius r_c with its axis along the z-direction and regard the Semiconductors to consist of π-electrons super imposed with equilibrium densities (per unit area) n_o. In equilibrium the π-electron fluid has no velocity and n is the perturbed density (per unit area) of fluid, produced by the π-electron themselves under the action of the electric field generated by the fixed positive ions of the lattice. Hydrodynamic theory describes electronic motion in terms of two dynamical variables, namely the electron-density functions, next and 4 (x, t) = 4ϕ, 4_2). The basic equations in this linearized Hydro dynamic model are the equations of motion, the equations of continuity -

$$\frac{\partial u(x,t)}{\partial t} = - n_o \nabla_{11}\, u(x, t)$$

$$\frac{\partial\, u(x,t)}{\partial t}$$

No $= -\alpha \nabla_{11}\, n\,(x, t) -$

$$e\,\frac{no}{m_{eff.}} E_{11}\,(x,t) - \gamma n_o u(x,t)$$

The dispersion relation can be written approximately as :

$$\omega^2 = \alpha k^2 + \frac{e^2 v_F}{\xi \pi^2 \hbar}\,\frac{K}{r_c} \qquad \textbf{(1)}$$

The right hand side of eqn. (1) depends strongly on the radius of the nano tube.

In the opposite limit $k_{rc} \to o$, where the phase velocity of the surface plasmon is comparable to the velocity of light, the surface Plasmon oscillations couple with the electromagnetic wave and radiation effects are present. The expression of Bessel functions, can be written as

$$I_m(x) = \frac{1}{\Gamma(m+1)}\left(\frac{x}{2}\right)^m$$

$K_m(x) = \frac{\Gamma(m)}{2}\left(\frac{2}{x}\right)^m$ (for $m \neq 0$) and $K_0(x) = \frac{\ln 1.123}{x}$ (for $m = 0$)

$$\omega\,(m = 0, K \approx 0) \approx \left[\frac{4e^2 v_F}{\varepsilon_o \pi^2 \hbar} In \left(\frac{1.123}{K_{rc}}\right)\right]^{1/2} K \qquad (2)$$

This is also quite sensitive to the geometric of the nanotube of graphene. Comparing the long-wavelength and short wavelength limits, it can be seen that the energy band structure play an important role in the dispersion relation, for all values of wavelength

Table number 1

k (Å^{-1})	ω x10^7 Hz
0.1	1.007
0.2	0.992
0.3	0.983
0.4	0.976
0.5	0.972
0.6	0.967
0.7	0.964
0.8	0.961

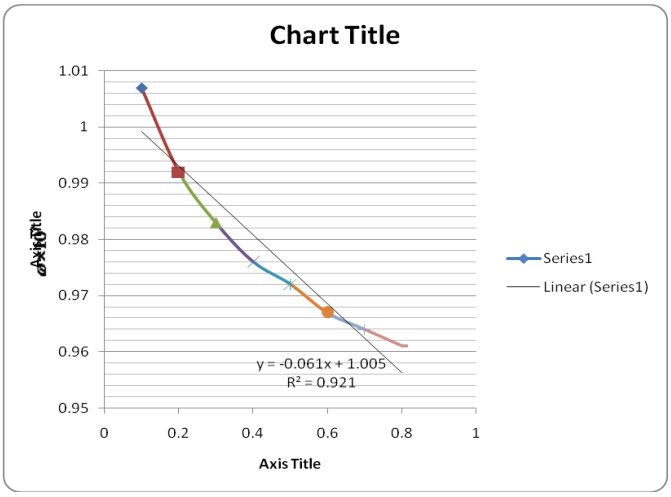

FIG.1

It is clear from fig. 1 that for zero mode of lattice vibration, the frequency of lattice vibration decreases exponentially with increasing the propagation constant k, for armchair a_0=2.459Å and b_0=1.42Å with radius r_c=3.9Å for position atom m=1o and n=0. It is also clear that for propagation constant range 0.4 to 0.6, the frequency of lattice vibration slightly increases and then slows down but the linearity of the graph shows that the propagation constant as increases the frequency of lattice vibration almost becomes constant. At higher value of propagation constant the lattice frequency becomes constant.

Table number 2

k (Å^{-1})	ω x10^7 Hz
0.1	0.9984
0.2	0.9843
0.3	0.9756
0.4	0.9693
0.5	0.9645
0.6	0.9605
0.7	0.9571
0.8	0.9542

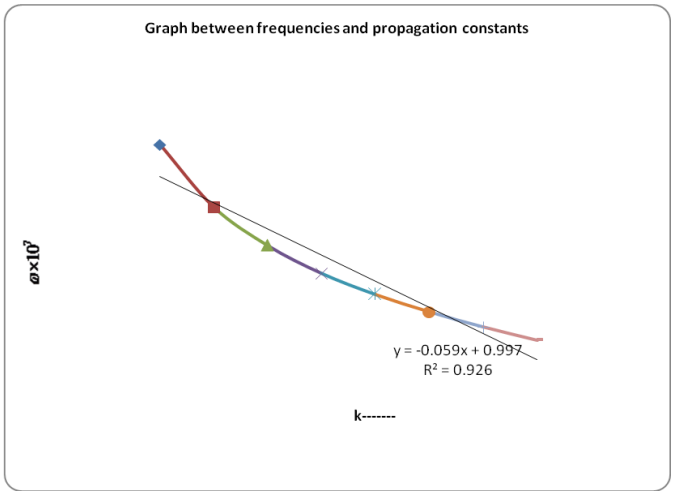

Fig. 2

As seen from above fig. 2 that for zero mode of lattice vibration and for chiral vectors a_0=2.459Å, b_0=1.42Å, radius r_c=5.40Å and for position atom m=8=n, the frequency of lattice vibration decreases exponentially with increasing the propagation constant k. It is also seen that for propagation constant range from 0.1 to 0.3, the frequency of lattice vibration decreases rapidly.
At higher value of propagation constant the frequency of lattice vibration becomes constant. It is clearly seen that the graph of fig. 1 is more linear than fig. 2.

Table number 3

k (Å^{-1})	ω x10^7 Hz
0.1	0.9826

0.2	0.9677
0.3	0.9588
0.4	0.9525
0.5	0.9476
0.6	0.9435
0.7	0.9401
0.8	0.9371

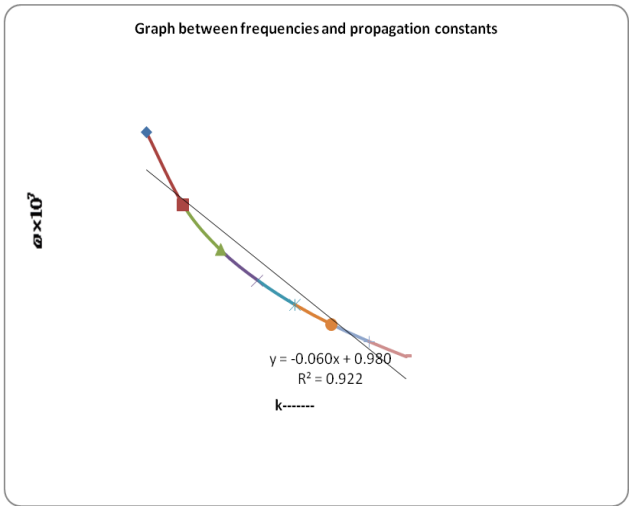

Fig. 3

It is clear from fig. 3 that for zero mode of lattice vibration and for position atom m=30, n=0 with r_c=11.7Å, the frequency of lattice vibration decreases exponentially with increasing the propagation constant k and finally becomes almost constant at higher value of propagation constant. It should be noted here that the frequency decreases rapidly in the region of propagation constant from 0.1 to 0.2.

Table number 4

k (Å^{-1})	ω x10^7 Hz
0.1	0.9904
0.2	0.9756
0.3	0.9668
0.4	0.9605
0.5	0.9556
0.6	0.95165
0.7	0.94824
0.8	0.9452

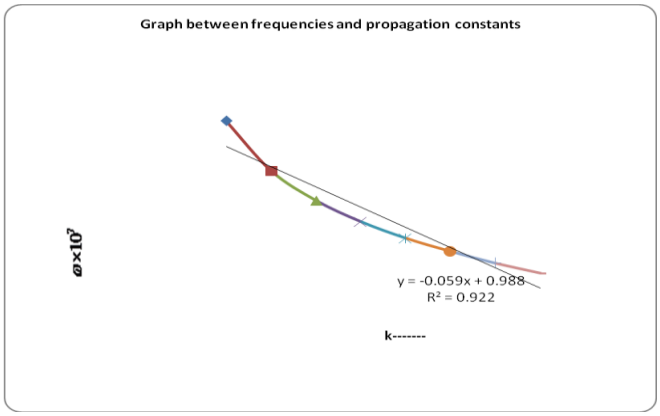

Fig. 4

Fig. 4 shows the variation of frequency of lattice vibration with respect to the propagation constant for zero mode of lattice vibration and for m=12=n with radius r_c=8.106Å. It has been seen that the frequency of lattice vibration deceases exponentially with increasing propagation constant k. It is clear from fig. that at propagation constant range from 0.1 to 0.3, the frequency of lattice vibration decreases gradually. As compare to fig.3, the linearity fig.4 is almost similar.

Table number 5

k (Å^{-1})	ω x10^7 Hz
0.1	0.74498
0.2	0.5267
0.3	0.4381
0.4	0.3708
0.5	0.333
0.6	0.3041
0.7	0.2815
0.8	0.2633

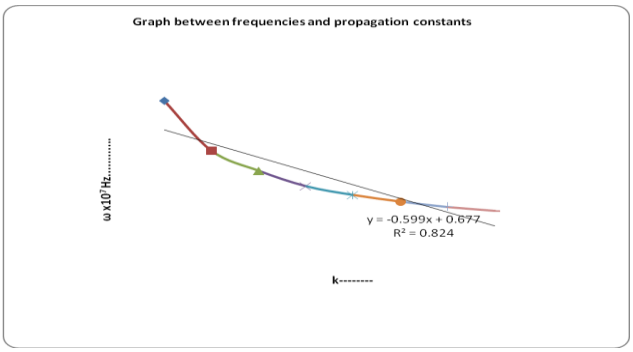

Fig. 5

Above fig.5 shows the variation of frequency of lattice vibration with respect to the propagation constant k for non-zero mode of lattice vibration and for $\alpha=0.378\times10^{12}$, with radius $r_c=5.40$Å. It has been seen that the frequency of lattice vibration deceases exponentially with increasing propagation constant k. It is also seen that there is small increment in the frequency of lattice vibration at propagation constant 0.3. After that the frequency of lattice vibration slows down and finally becomes constant at higher value of propagation constant.

Table number 6

k (Å^{-1})	ω x10^7 Hz
0.1	0.1459
0.2	0.1032
0.3	0.08426
0.4	0.073
0.5	0.06526
0.6	0.05958
0.7	0.05556
0.8	0.05159

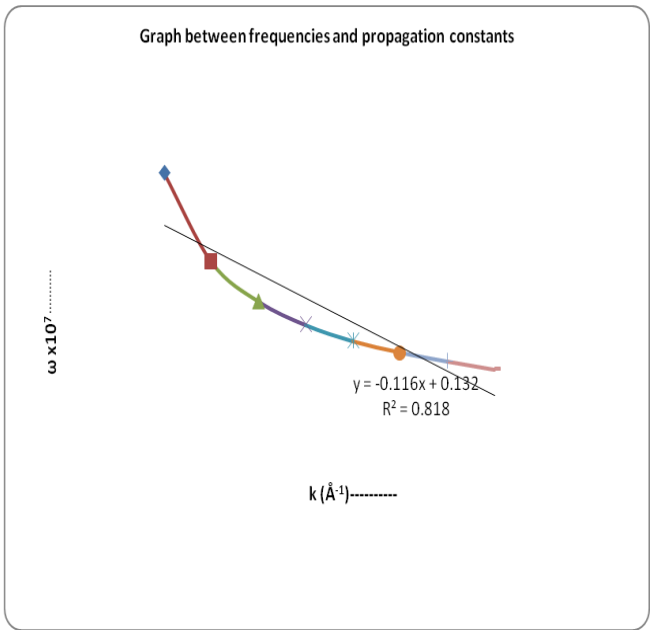

Fig. 6

Fig.6 shows the variation of frequency of lattice vibration versus the propagation constant k for non-zero mode of lattice vibration with radius $r_c=11.7$Å. It has been seen that the frequency of lattice vibration deceases exponentially with increasing propagation constant k. It is also seen that the frequency of lattice vibration decreases regularly with increasing propagation constant from 0.1 to 0.2. The linearity of fig.6 is more than fig.5. At a sufficient high value of propagation constant the frequency of lattice vibration becomes constant.

In the presence of the magnetic field, the dielectric function $\varepsilon(\omega)$ is no longer a scalar. It is now a tensor ε_{ij} with non-zero off diagonal elements and is given by:

$$\varepsilon_{ij} = \varepsilon_L\delta_{ij} - \frac{\omega_p^2}{\omega^2\left(\omega^2-\omega_c^2\right)}\left[\omega^2\,\delta_{ij} - \omega_{ci}\omega_{cj} \pm i\delta_{ijk}\omega\omega_{ck}\right] \quad \textbf{(3)}$$

To study the surface Plasmon optical phonon mode in the presence of magnetic field in the non-retarded limit the graph is plotted between ω_c/ω_t and ω/ω_t. The equation is used as:

$$\varepsilon_0+\varepsilon_L-\frac{\omega_p^{\,2}}{\omega\left(\omega-\omega_c\right)}=0$$

After simplification, we have:

$$\omega=\left(\frac{\omega_p^2}{\varepsilon_0+\varepsilon_L}+\frac{\omega_c^2}{4}\right)^{1/2}+\frac{\omega_c}{2}$$

Now applicable equation is:

$$\frac{\omega}{\omega_t}=\left\{\frac{\left(\omega_p/\omega_t\right)^2}{\varepsilon_0+\varepsilon_L}+\frac{\left(\omega_c/\omega_t\right)^2}{4}\right\}^{1/2}+\frac{\omega_c/\omega_t}{2} \quad \textbf{(4)}$$

Table For RbI

ω_c/ω_t	ω/ω_t
1.0	1.16609
1.5	1.619583
2.0	2.092555
2.5	2.575208
3.0	3.063226
3.5	3.554488
4.0	4.047847
4.5	4.542635
5.0	5.03844
5.5	5.534991
6.0	6.032107
6.5	6.529661
7.0	7.027559
7.5	7.525735

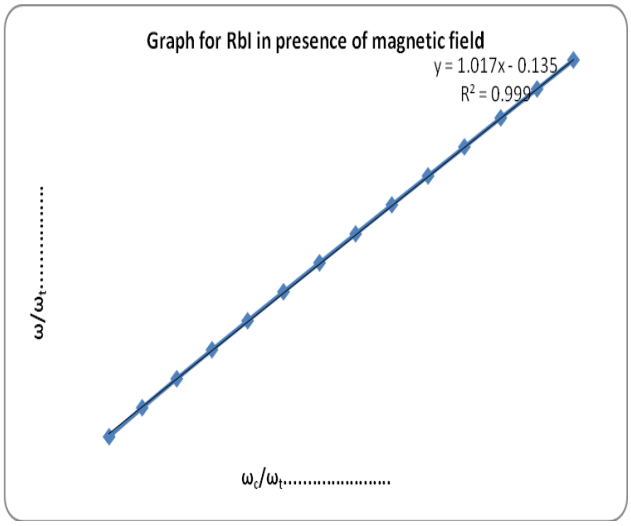

Fig. 7

Fig.7 shows the variation ofω_c/ω_t versus ω/ω_t for constant value ofω_p/ω_tforRbI. It is seen from above figthat the value of lattice vibration frequency ratio increases gradually with increasing the value of cyclotron frequency ratio. It is also seen that the graph is very smooth and linear for the condensed material RbI.

Table ForNaBr

ω_c/ω_t	ω/ω_t
1.0	1.187943
1.5	1.636434
2.0	2.106014
2.5	2.586326
3.0	3.072662
3.5	3.562668
4.0	4.055059
4.5	4.549079
5.0	5.044261
5.5	5.540299
6.0	6.036983
6.5	6.534169
7.0	7.031751
7.5	7.529652

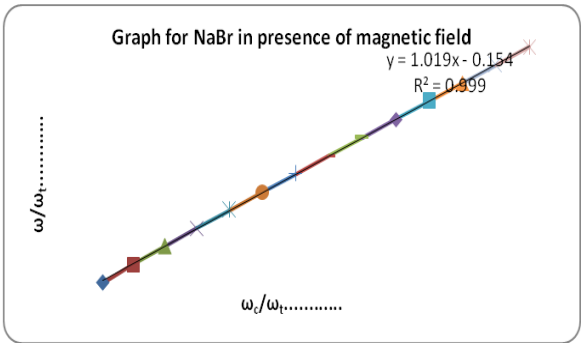

Fig.8

Above fig.8 shows the variation ofω_c/ω_t versus ω/ω_t for constant value of$\omega_p/\omega_t$for NaBr. It is seen from above fig. that the value of lattice vibration frequency ratio increases gradually with increasing the value of cyclotron frequency ratio. It is also seen linearity of the graph for the condensed material, i.e. NaBr is nearly equal to one.

Table LiF

ω_c/ω_t	ω/ω_t
1.0	*1.241379*
1.5	*1.678517*
2.0	*2.140019*
2.5	*2.614604*
3.0	3.09676
3.5	3.583615
4.0	4.073558
4.5	4.56563
5.0	5.059227
5.5	5.553951
6.0	6.049532
6.5	6.545777
7.0	7.042548
7.5	7.539742

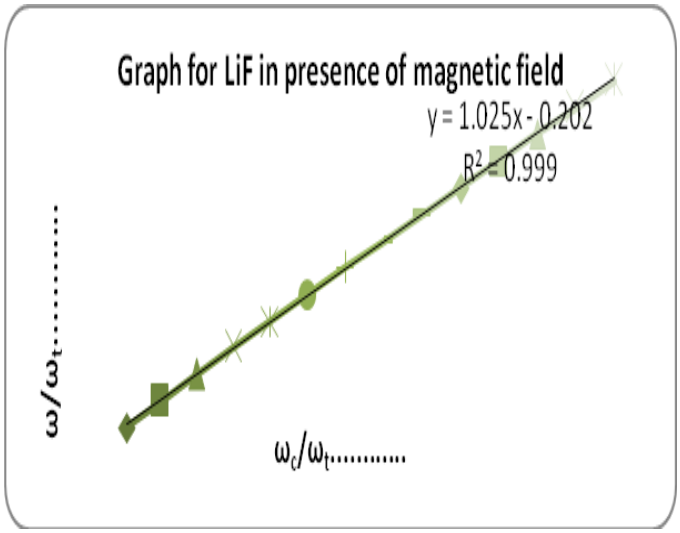

Fig.9

Above fig.9 shows the variation ofω_c/ω_t versus ω/ω_t for constant value of$\omega_p/\omega_t$for LiF. It is also seen from above fig. that the value of lattice vibration frequency ratio increases gradually with increasing the value of cyclotron frequency ratio. Moreover it is seen that the graph is smooth and linear for the condensed material LiF.

Table For Carbon

ω_c/ω_t	ω/ω_t
1.0	*2.553237*
1.5	*2.877976*
2.0	*3.228403*
2.5	*3.60123*
3.0	*3.993147*
3.5	*4.401091*
4.0	*4.822372*
4.5	*5.25471*
5.0	*5.696214*
5.5	*6.145332*
6.0	*6.600803*
6.5	*7.061598*
7.0	*7.526882*
7.5	*7.995972*

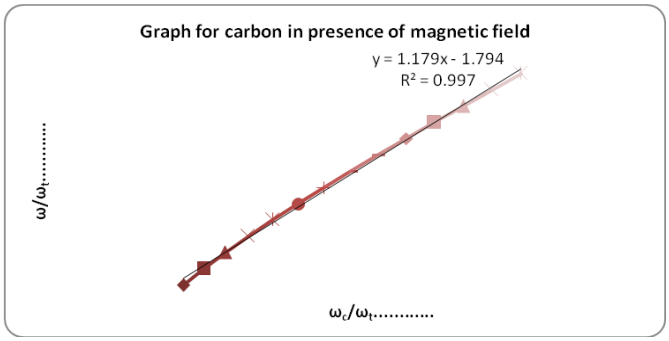

Fig.10

Above fig.10 shows the variation ofω_c/ω_t versus ω/ω_t for constant value of$\omega_p/\omega_t$for Carbon. It is seen from above fig. that the value of lattice vibration frequency ratio increases gradually with increasing the value of cyclotron frequency ratio. It is also seen that the graph is smooth and nearly linear for the condensed material Carbon.

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BIOGRAPHIES

Currently teaching as an Associate Professor (Physics) in the department of Applied Sciences and Humanities, S R IMT (Dr.APJ Abdul Kalam Technical University, Lucknow), having approximately 9 years of experience.