List of Figures

Figure 1.1 Displays allotropes of Carbon a) Graphite b) Diamond c) Carbonnanotubes d)
Buckyball- Fullerene 4
Figure 1.2 2D Graphene sheet composed of hexagonal rings compactly placed nextto each
other. Black small balls represent carbon atoms. 7
Figure 1.3 The arrangement of electrons and their relative spin in elemental carbon (left) and in
graphene (right) shows the s and two of the p orbitals of the second shell interact covalently to form
three sp2 hybrid orbitals. Bottom figure displays the sp ² hybridization model [1]7
Figure 1.4 A direct lattice of SLG sheet (green) with carbon atoms in blue. The Bravias lattice
consists of two atoms per unit cell A,B (Yellow). This unit cell i.e. the primitive cell is a parallelogram
(dashed blue lines) with primitive vectors a_1 and a_2 and interstitial distance between two carbon
atoms A and B being $a = 1.42$ Å (redrawn with reference to the concept from [1])
<i>Figure 1.5</i> Hexagonal Brillioun zone - the reciprocal lattice of Graphene sheet with vectors b_1 and
<i>b</i> ₂ . <i>The Brillouin zone is cornered at</i> K <i>points famously known as Dirac points.</i> 9
Figure 1.6 Dirac Cone with Dirac point (E_f) at the centre depicting the linear dispersion relation of
Graphene and x,y,z representing three axis of the cone
Figure 1.7 Tight Binding band structure of Graphene depicting linear behaviour at K points [3] 10
Figure 1.8 Displays a) position of carbon atoms in Bilayer graphene b) Band Structure of Bilayer
<i>Graphene</i> [11]
<i>Figure 1.9</i> 3D Band structure of Gapped graphene. Moving from front to back the value of Δ (gap)
decreases, changing the shape of band structure from parabola to linear
<i>Figure 1.10</i> Alternate layers of graphene (green) and SiO_2 (yellow) with a period of width L,
resembling the quantum well (below) structure
Figure 1.11 Infinite series of Feynman diagrams corresponding to the RPA for $\chi nn(q, \omega)$ [32] 25
<i>Figure 2.1 Plot of</i> $S(x,y)$ <i>At</i> $x=1$ <i>. Solid curve A for doped graphene and dotted curve B for undoped</i>
graphene
Figure 2.2 Plot of $S(x)$ vs x : Solid curve A for doped graphene and dotted curve B for undoped
graphene
Figure 2.3 Static dimensionless long wavelength limit regularised analytical structure factor,
SARx vs x, sans LFC, plotted in the curves A, B, C & D, for dimensionless coupling constants
$\alpha = 1, 2, 3 \& 4, respectively. $
Figure 2.4 Static dimensionless regularised structure factor, SRx vs x, with LFC, plotted in the curves
A, B, C & D, for dimensionless coupling constants $\alpha = 1, 2, 3 \& 4$, respectively
Figure 2.5 Static dimensionless regularised structure factor, SRx vs x, sans LFC, plotted in the
curves A, B, C & D, for dimensionless coupling constants $\alpha = 1, 2, 3, \& 4$, respectively
Figure 2.6 Magnetic static dimensionless regularised structure factor, SRxvs x, with LFC, plotted in
the curves A, B, C & D, for dimensionless coupling constants $\alpha = 1, 2, 3 \& 4$, respectively
Figure 2.7 Spin symmetric dimensionless regularised pair correlation function, gkFr vs kFr,
with LFC, in the curves A, B, C & D, for dimensionless coupling constants $\alpha =$
1, 2, 3 & 4, <i>respectively</i>
Figure 2.8 Spin symmetric dimensionless regularised pair correlation function, gkFr vs kFr,
sans LFC, in the curves A, B, C & D, for dimensionless coupling constants $\alpha =$
1, 2, 3 & 4, <i>respectively</i>
<i>Figure 2.9</i> Parallel spin dimensionless regularised pair correlation function, $g\uparrow\uparrow kFr$ vs kFr,
with LFC, in the curves A, B, C & D, for dimensionless coupling constants $\alpha =$
1, 2, 3 & 4, <i>respectively</i>
<i>Figure 2.10</i> Parallel spin dimensionless regularised pair correlation function, $g\uparrow\uparrow kFr$ vs kFr,
sans LFC, in the curves A, B, C & D, for dimensionless coupling constants $\alpha =$
1, 2, 3 & 4, <i>respectively</i>
<i>Figure 2.11</i> Anti parallel spin dimensionless regularised pair correlation function, $g\uparrow\downarrow kFr$ vs kFr ,
with LFC, in the curves A, B, C & D, for dimensionless coupling constants $\alpha =$
1, 2, 3 & 4, respectively
Figure 2.12 Anti parallel spin dimensionless regularised pair correlation function, $g\uparrow\downarrow kFr$ vs kFr ,
sans LFC, in the curves A, B, C & D, for dimensionless coupling constants $\alpha =$
1, 2, 3 & 4, <i>respectively</i>

Figure 2.13 Normalized screened self energy, $Esl(k)/e2kf$ is plotted against normalized wave
vector k/kf . Solid Curve displays Self energy of graphene while dashed curve is for 2DEG, without
LFC
Figure 2.14 Normalized screened self energy, Esl/e2kf as a function of k/kf without LFC (solid
line curve) with LFC (dashed line curve)
<i>Figure 2.15 Screened self energy for BLG</i> $Esl(k)/e2kf$ versus <i>x Curve-A is for</i> $n = 10^{14} cm^{-2}$ <i>while</i>
Curve-B is for $n = 5 \times 10^{13} cm^{-2}$
Figure 2.16 Density of screening charge plotted against kfr for $n = 4.77 \times 10^{14} \text{ cm}^{-2}$ at $\alpha = 2$
(<i>Curve-A</i>) and for $\alpha = 4$ (<i>curve-B</i>)
Figure 2.17 Density of screening charge $\operatorname{IS}(1)/\operatorname{ZeRIZ}$ pionea against RI for SLG for $\alpha = 4$ at $n = 8.04 \times 10^{14} \text{ cm}^{-2}$ (curve-B) and $n = 4.77 \times 10^{14} \text{ cm}^{-2}$ (curve-A)
Figure 2.18 Density of screening charge $ns(r)/Zekf2$ with LFC (dashed line) and without LFC
(solid line) for $\alpha = 4$ at $n = 8.04 \times 10^{14} \text{ cm}^{-2}$
Figure 2.19 Density of screening charge $ns(r)/Zekf2$ versus kfr for BLG Curve-A is for $n =$
$10^{14} cm^{-2}$ while Curve-B is for $n = 5 \times 10^{13} cm^{-2}$
Figure 2.20 Screened potential VSCRr $\rightarrow kfr$; with LFC(dashed line), without LFC (solid line)89
Figure 2.21 Screened Potential VSCRr versus kfr for BLG for $n = 10^{14} cm^{-2}$
<i>Figure 2.22 Pair distribution function</i> $g(r, z) \rightarrow z$ <i>for</i> $\alpha = 1$ solid line, $\alpha = 2$ dotted line and $\alpha = 2$
3(dashed line)
<i>Figure 3.1</i> Static (above) and dynamic (below) polarization function of gapped graphene [11] 111 <i>Figure 3.2</i> Dynamic Structure Factor $S(x, y) \rightarrow y$ for $x=0.5$ and gap $b = \Delta \varepsilon f = 0.5$ for $\alpha =$
Figure 5.2 Dynamic Structure Factor $S(x, y) \rightarrow y$ for $x=0.5$ and gap $b = \Delta \varepsilon f = 0.5$ for $a = 1.0, 4.0$
Figure 3.3 Static Structure Factor $S(x) \rightarrow x$ for $\alpha = 2.0$. Solid line (unregularized) Dashed line
(regularized)
Figure 3.4 Static Structure Factor $S(x) \rightarrow x$ for $\alpha = 4.0$. Solid line (unregularized) Dashed line
(regularized)
Figure 3.5 Energy Loss dw/dt (in units of 2Z2e2Ef2/kħ2vf) as a function of Hkf. Solid lines
$(Thick \rightarrow \Delta \epsilon f = 1.5; Thin \rightarrow \Delta \epsilon f = 0.5) \alpha = 3; Dotted(\Delta \epsilon f = 1.5) and Dashed lines (\Delta \epsilon f = 0.5)$
for $\alpha = 1$ dotted for the velocity to fermi velocity ratio $vvf = 1.0$
Figure 3.6 Energy Loss dw/dt (in units of $2Z2e2Ef2/\epsilon0\hbar2vf\pi$) as a function of Hkf. Solid lines (Thick $\Delta Acf = 1.5$) Think $\Delta Acf = 0.5$) $\alpha = 2 + Detted(Acf = 1.5)$ and Decked lines (Acf = 0.5)
(<i>Thick</i> $\rightarrow \Delta \epsilon f = 1.5$; Thin $\rightarrow \Delta \epsilon f = 0.5$) $\alpha = 3$; <i>Dotted</i> ($\Delta \epsilon f = 1.5$) and <i>Dashed lines</i> ($\Delta \epsilon f = 0.5$) for $\alpha = 1$ dotted for the velocity to fermi velocity ratio $vvf = 1.0$
Figure 3.7 Energy Loss dw/dt (in units of $2Z2e2Ef2\epsilon0\hbar2vf\pi$) as a function of Hkf. Solid lines
$vvf = 1.0$; Dotted $vvf = 2.0$; Dashed $vvf = 3.0$; $\Delta \epsilon f = 0.5$ and $\alpha = 3$
Figure 3.8 Numerical results for energy loss dWdt \rightarrow Hkf obtained using eq. 3.34, using full
polarization of gapped graphene, for different values of Gap $\Delta \varepsilon f = b$. Inset shows dWdt \rightarrow Hkf for
$\Delta \varepsilon f = 1.5$. The dWdt has been obtained in the units of $2Z2e2Ef2\varepsilon 0\hbar 2vf\pi$
<i>Figure 3.9</i> Energy Loss dw/dt (in units of $2Z2e2Ef2\epsilon0\hbar2vf\pi$) as a function of vvf plotted using eq.
(3.59), for various values of $b = 0.1, 0.5, 1.0, 1.5$ and $\alpha = 1$
Figure 3.10 Energy Loss dw/dt (in units of $2Z2e2Ef2\epsilon0\hbar2vf\pi$) as a function of vvf plotted using
eq. (3.59), for various values of $b = 0.1, 0.5, 1.0, 1.5$ and $\alpha = 3$
$rkf = R \text{ using } eq. 3.61$, for velocity $vvf = 2.0 = u$; $n = 7.9524 \times 10^{12} \text{ cm}^{-2}$ and $\alpha = 1.0$
Figure 3.12 Induced charge density $ngrn$ in the units of $Z\pi$ Plotted against particle position
$rkf = R \text{ using } eq. 3.61, \text{ for velocity } vvf = 1.0 = u; n = 7.9524 \times 10^{12} \text{ cm}^{-2} \text{ and } \alpha = 1.0125$
Figure 3.13 Induced charge density ngrn in the units of $Z\pi$ Plotted against particle position
$rkf = R \text{ using } eq. (3.64), \text{ for velocity } u = 4.0; n = 7.9524 \times 10^{14} cm^{-2} \text{ and } \alpha = 3.0127$
Figure 3.14 Induced charge density ngrn in the units of $Z\pi$ Plotted against particle position
$rkf = R \text{ using } eq. (3.64), \text{ for velocity } u = 4.0; n = 7.9524 \times 10^{14} \text{ cm}^{-2} \text{ and } \alpha = 1.0 \dots 128$
Figure 3.15 Induced charge density ngrn in the units of $Z\pi$ Plotted against particle position
$rkf = R$ using eq. (3.64), for velocity $u = 2.0$; $n = 7.9524 \times 10^{14} cm^{-2}$ and $\alpha = 1.0$
<i>rigure 5.10 Induced charge density ngrit in the units of 2n Pioned against particle position</i> $rkf = R \text{ using eq. (3.64), for velocity } u = 2.0; n = 7.9524 \times 10^{12} \text{ cm}^{-2}$ and $\alpha = 1.0$
Figure 3.17 Induced charge density $ngrn$ in the units of $Z\pi$ Plotted against particle position
$rkf = R \text{ using } eq. (3.51), \text{ for velocity } u = 1,0 4.0; n = 7.9524 \times 10^{12} \text{ cm}^{-2} \text{ and } \alpha = 1.0 \text{ for gap}$
values b=0.5 and 1.5
Figure 4.1Plasmon-Phonon coupled modes for $n = 10^{12} \text{ cm}^{-2}2$ and $d = 400\text{\AA}$

	1^{12} cm ⁻² while dotted line corresponds to $n = 10^{14}$ cm ⁻² for $d = 400$ Å. Inset curves are upto $< 0.2kf$
•	gure 4.3 Plasmon-Phonon coupled modes obtained using full polarization for
	= 400Å, 10^{12} cm ⁻² dashed curve 10^{14} cm ⁻² solid curve. Inset shows coupled modes $q < 0$
u	= 400Å, 10 cm uusheu curve 10 cm soliu curve. Insel shows coupled modes q < 0
 E:	$f_{a} = 4.4$ Discuss Discuss sounds for $d = 0.00$ Å (for $d = 0.00$ Å (for $d = 4.00$ Å (solid)
	gure 4.4 Plasmon-Phonon coupled modes for $d = 800\text{\AA}$ (dashed curve) and $d = 400\text{\AA}$ (solid
	<i>rve)</i> for $n = 10^{12} cm^{-2}$. Inset curves are upto $q < 0.2 kf$
	gure 4.5 Numerical results for Plasmon-Phonon coupled modes, dashed curve corresponds to
<i>d</i> :	= 400Å while solid line corresponds to $d = 800$ Å for = $10^{12} cm^{-2}$. Inset curves are upto $q <$
0.5	5kf
Fi	gure 4.6 Plasmon-Phonon coupling mode for weak coupling. Dashed curves displays ω + and
тc	odes. Uncoupled modes are shown by ω_{LO} , ω_{TO} (Dotted curves), while solid curve displays
pla	asmon mode ωq without plasmon-phonon coupling
Fi	gure 4.7 Coupling mode interaction strength ($R \pm R0$) vs. n for GBS for $d = 800$ Å
Fi	gure 4.8 Coupling mode interaction strength ($R \pm R0$) vs. n for GBS for $d = 400$ Å.
	gure 4.9 Damping in low frequency regime for GBS for different values of n
	gure 4.10 Density Plots of energy loss function of GBS plotted for $n=10^{12}$ cm ⁻² and $d=400$ Å for
-	wer (Cos $(q_z d) = -1$) and upper boundaries (Cos $(q_z d) = 1$)
	gure 4.11 Density Plots of energy loss function of GBS plotted for $n=10^{14}$ cm ⁻² and $d=400$
-	gure 4.11 Density Photos of energy loss function of ODS phonear for $n=10^{-10}$ cm ⁻ and $u=400^{-10}$ and upper boundaries ($Cos(q_z d)=1$)
	gure 4.12 Density Plots of energy loss function of GBS plotted for $n=10^{14}$ cm ⁻² and $d=800$
	gure 4.12 Density Fions of energy loss function of GBS profiled for $n=10^{\circ}$ cm ⁻ and $a=800^{\circ}$ agstrom for lower (Cos($q_z d$)=-1) and upper boundaries (Cos($q_z d$)=1)