

Lab-IX

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1 Aim

Write and execute an octave program to study of optical properties of Graphene.

2 Theory

3 Program

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% OpticalData
%
% Study of optical properties of Graphene.
% Author: Devansh Shukla I18PH021
% 9th March, 2022
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

graphics_toolkit gnuplot

% speed of light
c = 299792458; % m/s

% loading in the csv data
printf("Loading data/optical_data.csv ...\n")
format long g
d = dlmread("../data/optical_data.csv", ",");

% extracting the values of epsilon real and imag
eps_imag = d(:, 5);
eps_real = d(:, 10);
omega = d(:, 6);

% computing epsilon
eps = sqrt(eps_imag.**2 + eps_real.**2);

% computing various parameters
refractive_index = sqrt((eps + eps_real) ./ 2);
extension_kw = sqrt((eps - eps_real) ./ 2);
EELS = eps_imag ./ (eps .** 2);
reflectivity = ((sqrt(eps) - 1) ./ (sqrt(eps) + 1)) .^ 2;
absorption_alpha = sqrt(eps - eps_real) .* omega .* sqrt(2);
transmittance = 10 .^ (2 - absorption_alpha);
emx = transmittance - EELS;
wavelength = 2 * pi * c / omega;

printf("Plotting the parameters \n")
% Plotting the parameters
figure();
hold on
grid on
set(gcf, 'PaperSize', [6, 3]);
set(gca, 'XMinorTick', 'on', 'YMinorTick', 'on')
plot(omega, refractive_index, "linewidth", 2)
title("Refractive Index")
xlabel("Frequency")
ylabel("Refractive Index")
set(gcf, 'renderer', 'painters');
print -dpng refractive_index.png;
hold off

figure();
hold on
grid on
set(gcf, 'PaperSize', [6, 3]);
set(gca, 'XMinorTick', 'on', 'YMinorTick', 'on')
plot(omega, reflectivity, "linewidth", 2)
title("Reflectivity")
xlabel("Frequency")
ylabel("Reflectivity")
set(gcf, 'renderer', 'painters');
print -dpng reflectivity.png;
hold off

figure();
hold on
grid on
set(gcf, 'PaperSize', [6, 3]);
set(gca, 'XMinorTick', 'on', 'YMinorTick', 'on')
plot(omega, transmittance, "linewidth", 2)
title("Transmittance")
```

```

xlabel("Frequency")
ylabel("Transmittance")
set(gcf, 'renderer', 'painters');
print -dpng transmittance.png;
hold off

figure();
hold on
grid on
set(gcf, 'PaperSize', [6, 3]);
set(gca, 'XMinorTick', 'on', 'YMinorTick', 'on')
plot(omega, EELS, "linewidth", 2)
xlabel("Frequency")
ylabel("Energy loss spectrum")
title("Energy loss spectrum L(w)")
set(gcf, 'renderer', 'painters');
print -dpng eels.png;
hold off

figure();
hold on
grid on
set(gcf, 'PaperSize', [6, 3]);
set(gca, 'XMinorTick', 'on', 'YMinorTick', 'on')
plot(omega, absorption_alpha, "linewidth", 2)
xlabel("Frequency")
ylabel("Absorption coeff")
title("Absorption coeff")
set(gcf, 'renderer', 'painters');
print -dpng absorption_alpha.png;
hold off

figure();
hold on
grid on
set(gcf, 'PaperSize', [6, 3]);
set(gca, 'XMinorTick', 'on', 'YMinorTick', 'on')
plot(omega, extension_kw, "linewidth", 2)
xlabel("Frequency")
ylabel("Extension kw")
title("Extension kw")
set(gcf, 'renderer', 'painters');
print -dpng extension_kw.png;
hold off

figure();
hold on
grid on
set(gcf, 'PaperSize', [6, 3]);
set(gca, 'XMinorTick', 'on', 'YMinorTick', 'on')
plot(omega, emx, "linewidth", 2)
xlabel("Frequency")
ylabel("Optical conductivity")
title("Optical conductivity")
set(gcf, 'renderer', 'painters');
print -dpng optical_conductivity.png;
hold off

figure();
hold on
grid on
set(gcf, 'PaperSize', [6, 3]);
set(gca, 'XMinorTick', 'on', 'YMinorTick', 'on')
plot(omega, eps_imag, "linewidth", 2)
xlabel("Frequency")
ylabel("Imag(epsilon)")
title("Imag part of complex dielectric function")
set(gcf, 'renderer', 'painters');
print -dpng imag_eps.png;
hold off

```

4 Results

4.1 Terminal output

```
(escape) devansh@ds:~/GitHub/Vault/OctaveLab/Programs/outputs$ octave ../OpticalData.m
Loading data/optical_data.csv ...
Plotting the parameters
```

4.2 Plots

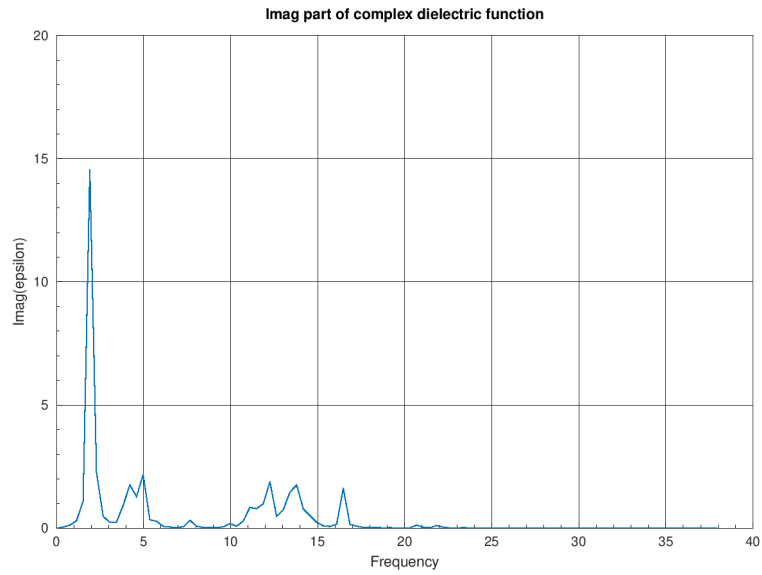


Figure 1: $\text{Imag}(\epsilon)$

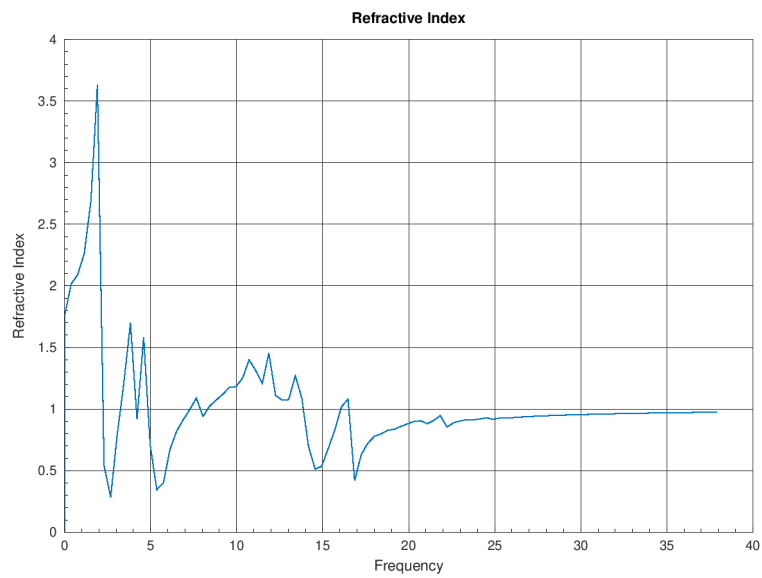


Figure 2: Refractive index $n(\omega)$

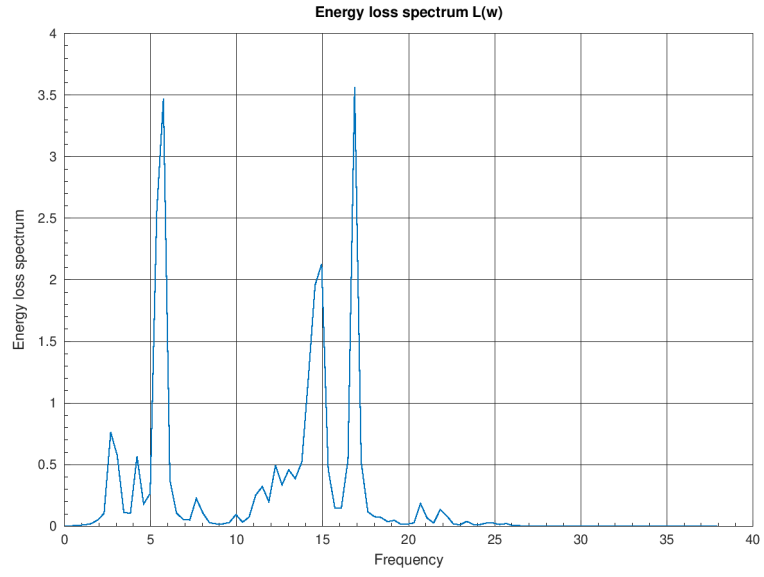


Figure 3: Energy loss spectrum $L(\omega)$

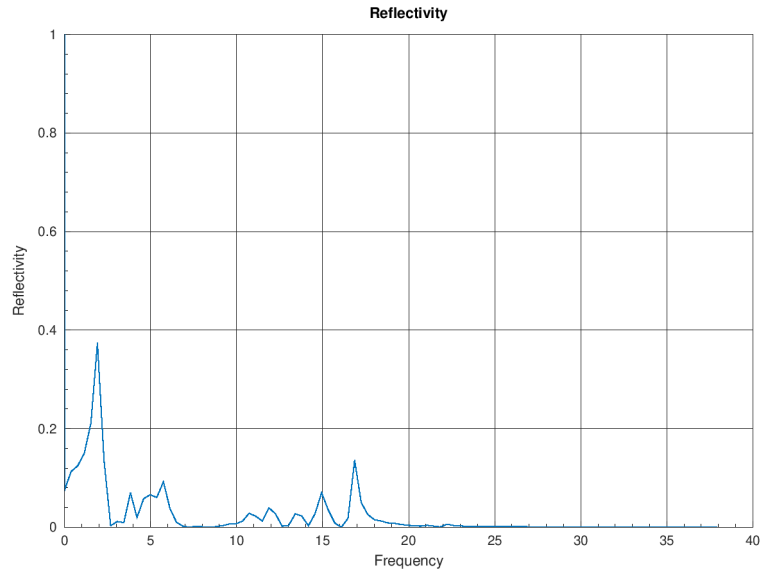


Figure 4: Reflectivity $R(\omega)$

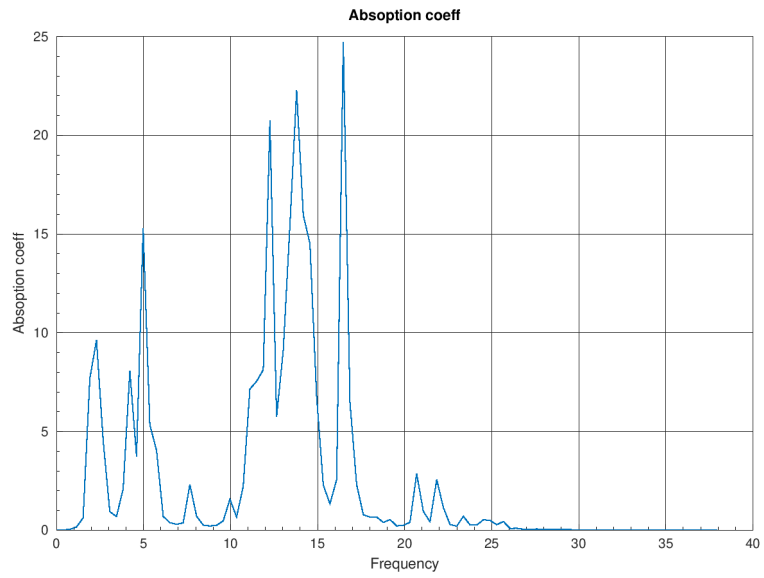


Figure 5: Absorption coefficient $\alpha(\omega)$

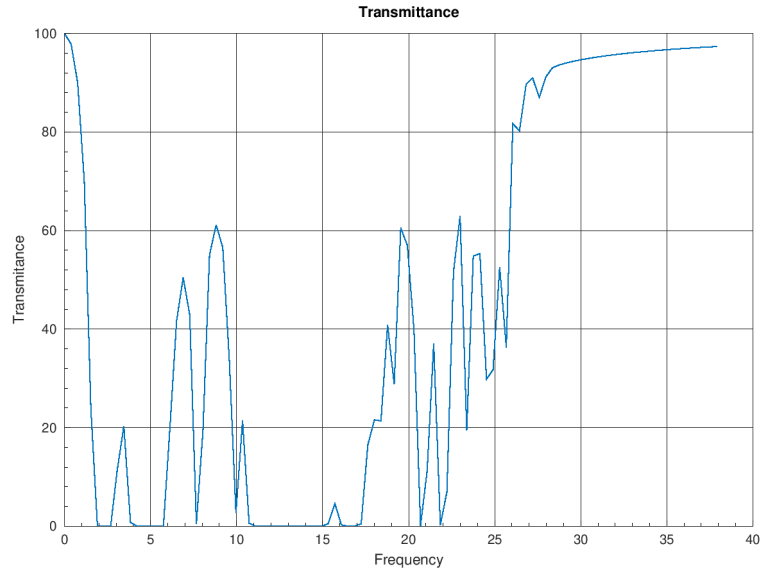


Figure 6: Transmittance

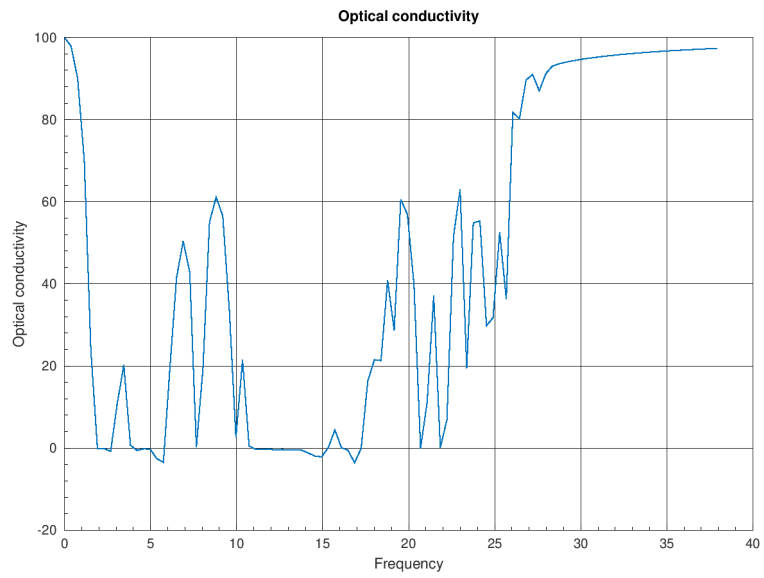


Figure 7: Optical conductivity

5 Remarks

The programs can be used to study of optical properties of graphene defining the required parameters.