ABSTRACT

Using quantum hydrodynamic equations, propagation of electrostatic waves in a Single–Walled Carbon Nanotube (SWCNT) and Multi–Walled Carbon Nanotube (MWCNT) filled with plasma was studied and dispersion equations were calculated. By drawing these equations, it was found that in acoustic mode and for large $\Xi$ values, variations of mode in relation to $z$ is softer than Single–Walled Carbon Nanotubes (SWCNT) and Multi–Walled Carbon Nanotubes (MWCNT) with small $\Xi$ values. In optical mode, larger $\Xi$ values leads to lower absolute grade variation.

1. INTRODUCTION

Researches of Longmoir create a new field of physics called plasma. The term “Plasma” was firstly used by Longmoir in 1928 for a positive column in removing tube which has equal number of ions and electrons [1–11]. Plasma is a quasi–neutral gas containing charged and neutral particles which behave as a unit. The constituents of plasma imparted some force to each other even from far distances. This long range Coulomb force enables plasma to perform various possible moves. Behaving as a unit considers moves which not only are depend on local conditions but also on plasma state in far distance [12–19]. From physics point of view, collective excitations of electron gas or plasma which is performed by plasma frequency is known as Plasmon [20, 21]. In 1991, Igima from NEC Company, Japan, observed Single–Walled Carbon Nanotubes (SWCNT) and Multi–Walled Carbon Nanotubes (MWCNT) and then, these tubes have been considerably investigated [22, 23]. Single–Walled Carbon Nanotubes (SWCNT) and Multi–Walled Carbon Nanotubes (MWCNT) are new forms of pure Carbon including a hexagonal lattice of Carbon atoms which forms cylindrical tubes. Two major groups of Carbon nanotubes are single–walled and multi–walled nanotubes [24, 25]. Till now, numerous studies have been performed about collective excitations of electrons in Single–Walled Carbon Nanotubes (SWCNT) and Multi–Walled Carbon Nanotubes (MWCNT). Quantum hydrodynamic equations (QHD) are used in the current paper. Using linearizing the equations and ignoring the effects of non–linearity, the coupled dispersion equation in Single–Walled Carbon Nanotubes (SWCNT) and Multi–Walled Carbon Nanotubes (MWCNT) is found when two plasma fluids are subjected to magnetic field.

2. RESULTS AND DISCUSSION

Using Mathematica 10, dispersion relationship is drawn. Figure (1) shows a Single–Walled Carbon Nanotube

(SWCNT) with limited radius of $R=7R_a$. The acoustic mode for small $\Xi z$ (long $\lambda$) becomes asymptote to zero and linearly approaches to a constant asymptote for large $\Xi z$ (short $\lambda$).

In Figure (2), a Single–Walled Carbon Nanotube (SWCNT) with limited radius of $R=7R_a$ approaches to a common asymptote for various $\Xi$ values in large $\Xi z$ (short $\lambda$). However, in small $\Xi z$ (long $\lambda$), nanotube with constant radius approaches to a constant asymptote for various $\Xi$ values and behaves non–linearly.

Figure (3) shows a Multi–Walled Carbon Nanotube (MWCNT) with limited radius of $R=7R_a$. The acoustic mode for small $\Xi z$ (long $\lambda$) becomes asymptote to zero and linearly approaches to a constant asymptote for large $\Xi z$ (short $\lambda$).

In Figure (4), a Multi–Walled Carbon Nanotube (SWCNT) with limited radius of $R=7R_a$ approaches to a common asymptote for various $\Xi$ values in large $\Xi z$ (short $\lambda$). However, in small $\Xi z$ (long $\lambda$), nanotube with constant radius approaches to a constant asymptote for various $\Xi$ values and behaves non–linearly.

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**Figure 1:** Acoustic mode for Single–Walled Carbon Nanotube (SWCNT) with constant $R=7R_a$ in magnetic field for various $\Xi$ values.

**Figure 2:** Optical mode for Single–Walled Carbon Nanotube (SWCNT) with constant $R=7R_a$ in magnetic field for various $\Xi$ values.

**Figure 3:** Acoustic mode for Multi–Walled Carbon Nanotube (MWCNT) with constant $R=7R_a$ in magnetic field for various $\Xi$ values.