Negative Mass and Negative Refractive Index in Atom Nuclei

Nuclear Wave Equation

Gravitational and Inertial Control

Part 4

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The present study is divided into six parts – Index of Part-4

In This Paper

Following the analysis made in Part-3, the second external force is evaluated in this study.

The **nuclear response to external forces** is analyzed with the aim to observe any **changes in the nuclear mass** and study the **behavior of the refractive index** under such changes.

The analysis will be performed in the time domain as well as in the frequency domain by means of the Fast Fourier Transform (FFT) method. The external forces applied to the nucleus were classified into three types:

- **The force originated by a polarized transverse electromagnetic wave (TEM)** *(see Part-3)*
- **The force originated by a polarized TEM plus a static electric field**
- **The force originated by a signal plus a static electric field** *(see Part-5)*

Abstract

Some efforts have been made to prove negative mass behavior through some experiments performed in mechanics [1], and other disciplines [9], as well as some theories in electrostatics [2,3,4,5,6,7,8], but I haven't found research about similar effects in atomic level, where the most elementary mass given by the atomic nucleus is to be found.

- Is the second Newton's law still valid with negative mass?
- What could happen if we make the atom behave in a negative mass regime?
- Is the negative refractive index related to negative mass?
- Are we able to control the magnitude of mass?
- Are we able to control the sign of mass?

The answers to these questions are given through this series of papers, with results that are coincident with experimental data, except for the negative mass regime. Experiments must be done to confirm or invalidate the theory developed in these articles. Needless to say, if

experiments validate this theory, then a significant change in mankind is going to happen. In that case, I strongly ask scientists to cooperate by making use of the derived technologies for good and refrain from doing it for evil.

Introduction

The theory presented in these papers, as described in Part-1, is based on three fundamental aspects that have proved to be extremely effective to describe physical phenomena and predicting results that agree with experimental data [10, 11, 12]:

- **Spinning Ring Model of Elementary Particles (toroidal ring of continuous charge)**
- **New Atomic Model**
- **The Universal Electrodynamic Force**

Based on the new atomic model, a shell arrangement of the nuclear particles has been assumed in Part 1, as shown in Fig. 1.

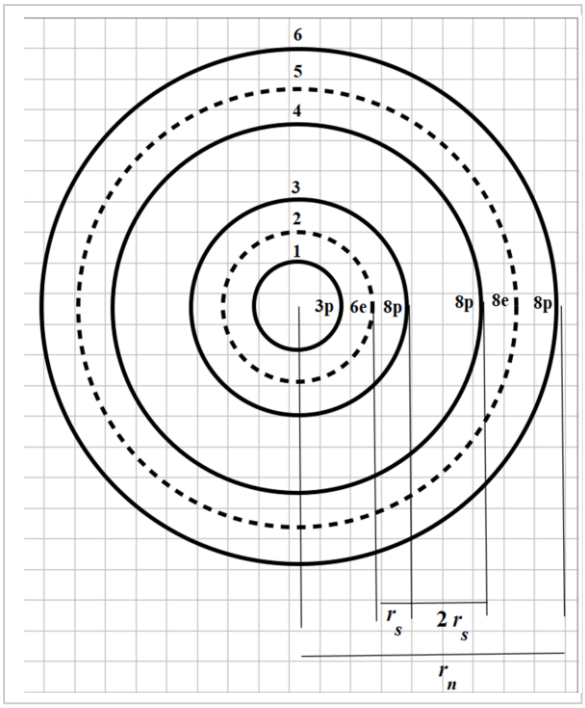


Figure 1
Assumed shell arrangement for Aluminum atomic nucleus

This sandwich configuration keeps the particles very tightly bound together. Note that at three shells in from the outermost shell, there are always two proton shells in a row for the larger nuclides.

This weak binding allows the outermost sandwich of shells to have liquid-like properties and forms the proper justification for a Liquid Drop Model of the nucleus.

As we already know, the torus ring model of the particles has an associated electric field as well as a magnetic field. However, due to the very tight packing configuration of the particles, we may safely assume that the distance among shells is extremely tiny and that the predominant force in the nucleus is of electrostatic origin, while the weaker magnetic forces will add some contribution to the equilibrium distance between each shell.

As demonstrated in Part 1, mass is an intrinsic property of the atomic nucleus. Under natural circumstances, it has a constant universal magnitude and is always positive. However, with some proper external agents, **we might be able to manipulate the intrinsic mass by changing its magnitude and sign**.

II. Nuclear Response to Force Caused by a Polarized Transverse Electromagnetic Wave (TEM) plus a Static Electric Field

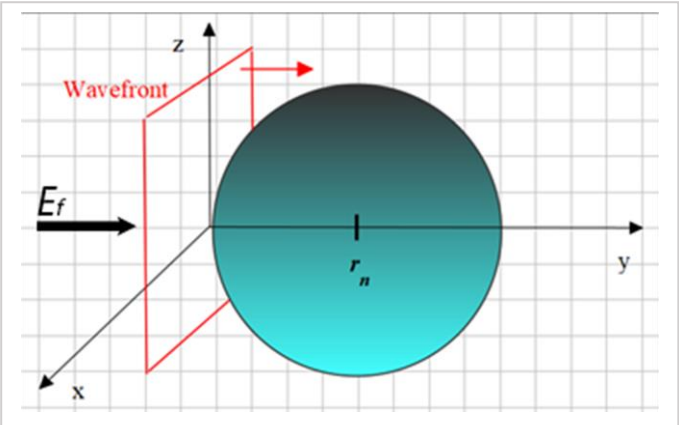


Figure 2
External wavefront and static electric field acting on the nucleus

Assume that a plane wave of amplitude E_m, frequency ω, and propagation velocity c in the y-direction strikes the outer shell of the "nuclear sphere".

Assume also that we add a static electric field that is parallel to the y-z plane in the y-direction. The components of the fields in cartesian coordinates are: $\vec{E}_f = 0\hat{\imath} + E_f\hat{\jmath} + 0\hat{k}$, and in spherical coordinates we have,

$$\vec{E}_f = E_f \sin(\theta)\sin(\phi)\hat{r} + E_f \sin(\phi)\cos(\theta)\hat{\theta} + E_f \cos(\phi)\hat{\phi}$$

As the static electric field is parallel to the y-z plane, and pointing in the y direction, $\emptyset = \frac{\pi}{2}$ and $\theta = \frac{\pi}{2}$. Then, the expression of the electric field is

$$\vec{E}_f = E_f\hat{r} \qquad \text{(a)}$$

As this static field is added to the wave, the composed electric field E "seen" by the nucleus will have a constant value given by E_f plus the component of the oscillating electric field corresponding to the wave.

We disregard some minor scattering caused by the few outer electrons in the atom, which are located at a very long distance from the nucleus. The incident wave energy may be totally absorbed, partially absorbed, or not absorbed at all by the nuclear shells.

The momentum density of any wave in vacuum is given by: $\frac{dp}{dV} = \frac{EB}{\mu_0 c^2}$. By replacing $B = \frac{E}{c}$, we get $\frac{dp}{dV} = \frac{E^2}{\mu_0 c c^2}$, which, by replacing c^2gives $\frac{dp}{dV} = \frac{\mu_0 \varepsilon_0 E^2}{\mu_0 c}$, so that the momentum density in function of only one of the EM fields is: $\frac{dp}{dV} = \frac{\varepsilon_0 E^2}{c}\left[\frac{Ns}{m^3}\right]$. Recall that we can write the force as the change in momentum, i.e., $F = \frac{dp}{dt}$, so we can write the momentum density as the force exerted by the wave on the nucleus volume: $\frac{dp}{dV} \cdot \frac{dt}{dt} = \frac{\varepsilon_0 E^2}{c}$, which gives us

$$Fdt = \frac{\varepsilon_0 E^2}{c} dV \qquad (1)$$

Where:

dt: time needed by the wave to travel with velocity c (or v) across the nucleus diameter ($2\,r_n$) from $t = 0$ to $t = \frac{2r_n}{c}$ (or $t = 2\frac{r_n}{v}$). Calculations will be made for a wave velocity of c and v in the nucleus.
dV: the volume element for the spherical nucleus ($r^2 \sin(\theta)\, dr d\theta d\emptyset$).

Note that the force given by (1) is calculated in vacuum and contains the vacuum permittivity ε_0. We ignore the value of the nuclear permittivity of Aluminum. Therefore, the same permittivity will be used for further calculations to be consistent with the Coulomb Force and the Universal Force used in the study.

The polarized wave acting on the nucleus is given by Eq. (21) and (22) in Part-2, whose magnitude is repeated here:

$$E(r,t) = E_m \cos(Kr - \omega t) \qquad (2)$$

The total external field acting on the nucleus is given by

$$E = E_f + E_m cos(Kr - \omega t) \quad (2a)$$

We assume that the outer shell of the "nuclear sphere" is reached by a plane wavefront traveling in the $+y$-direction with velocity c at $t = 0$. That is, the origin of coordinates is taken at the incident edge of the nucleus, which means the nucleus center is shifted $(r - r_n)$.

To calculate the exerted force on the atomic nucleus, we need to integrate the total field given by Eq. (1). Considering that the force is constant on the time interval, the force integrated on the nucleus volume is:

$$F \int_0^t d\,t = \int_0^{2\pi} \int_0^{\pi} \int_0^{r_n} \frac{\varepsilon_0 E^2}{c} (r - r_n)^2 \, dr \, d\theta \, d\phi \qquad (3)$$

Defining the time interval for the force integral

How to determine the time interval for integration? Three possibilities have been chosen that might give us a kind of “average force” (though is not an average) on the nuclear volume:

1. **The wave’s travel time through the nucleus for wave velocity v_w, that is $t = 2\frac{r_n}{v_w}$** *(absorption)*
2. **The wave’s travel time through the nucleus for wave velocity c, that is $t = 2\frac{r_n}{c}$** *(transmission)*
3. **The wave period, that is $t = T = \frac{2\pi}{\omega}$ (***absorption/ transmission, depends on wave vector’s choice***)**

1. Integrating the force caused by the electric field and the wave, for nuclear travel time, with wave velocity “v_w”

Replacing the wave Eq. (2) into the integral (3), and setting the time interval for this case,

$$F \int_0^{\frac{2r_n}{v_w}} d\,t = \frac{\varepsilon_0}{c} \int_0^{2\pi} \int_0^{\pi} \int_0^{r_n} \left(E_f + E_m cos(Kr - \omega t)\right)^2 (r - r_n)^2 \sin(\theta) \, d\,r \, d\,\theta d\emptyset$$

After integrating and doing some algebra, we get the expression of the wave force on the nucleus for this case:

$$F_{ext} = \frac{2\pi\varepsilon_0 v_w}{3c\,K^3 r_n} \cdot \left(-\frac{3E_m^2 \sin(2Kr_n - 2\omega t)}{8} - 12E_f E_m \sin(Kr_n - \omega t) + \frac{3E_m^2\left(K^2 r_n^2 - \frac{1}{2}\right)\sin(2\omega t)}{4} + \frac{3E_m^2 r_n K \cos(2\omega t)}{4} + \right.$$

$$\left. 6E_f E_m (K^2 r_n^2 - 2)\sin(\omega t) + r_n \left(12E_f E_m \cos(\omega t) + K^2 r_n^2 \left(E_f^2 + \frac{E_m^2}{2}\right)\right) K \right) \qquad (4)$$

2. *Integrating the force caused by the electric field and the wave, for nuclear travel time, with wave velocity "c"*

Replacing the wave Eq. (2) into the integral (3), and setting the time interval for this case,

$$F\int_0^{\frac{2r_n}{c}} d\,t = \frac{\varepsilon_0}{c}\int_0^{2\pi}\int_0^{\pi}\int_0^{r_n}\left(E_f + E_m cos(Kr-\omega t)\right)^2 (r-r_n)^2 \sin(\theta)\, d\,r\, d\,\theta d\emptyset$$

After integrating and doing some algebra, we get the expression of the wave force on the nucleus for this case:

$$F_{ext} = \frac{\pi\varepsilon_0}{6K^3 r_n}\cdot\left(4E_f^2K^3r_n^3 + 2E_m^2K^3r_n^3 + 6E_m^2K^2\sin(\omega t)\cos(\omega t)\,r_n^2 + 24E_fE_mr_n^2\sin(\omega t)\,K^2 + 6E_m^2K\sin^2(r_nK-\omega t)\,r_n + 6E_m^2K\cos^2(r_nK-\omega t)\,r_n - 6E_m^2K\sin^2(\omega t)\,r_n - 6E_m^2\sin^2(r_nK-\omega t)\,\omega t - 6E_m^2\cos^2(r_nK-\omega t)\,\omega t + 6E_m^2\sin^2(\omega t)\,\omega t + 6E_m^2\cos^2(\omega t)\,\omega t + 48E_fE_mK\cos(\omega t)\,r_n - 3E_m^2r_nK - 3E_m^2\sin(r_nK-\omega t)\cos(r_nK-\omega t) - 3E_m^2\sin(\omega t)\cos(\omega t) - 48E_fE_m\sin(r_nK-\omega t) - 48E_fE_m\sin(\omega t)\right) \quad (5)$$

3. *Integrating the force caused by the electric field and the wave, for a wave period*

Replacing the wave Eq. (2) into the integral (3), and setting the time interval for this case,

$$F\int_0^{\frac{2\pi}{\omega}} d\,t = \frac{\varepsilon_0}{c}\int_0^{2\pi}\int_0^{\pi}\int_0^{r_n}\left(E_f + E_m cos(Kr-\omega t)\right)^2 (r-r_n)^2 \sin(\theta)\, d\,r\, d\,\theta d\emptyset$$

After integrating and doing some algebra, we get the expression of the wave force on the nucleus for this case:

$$F_{ext} = \frac{2\varepsilon_0\omega}{3c\,K^3}\cdot\left(-\frac{3E_m^2\sin(2Kr_n-2\omega t)}{8} - 12E_fE_m\sin(Kr_n-\omega t) + \frac{3\left(K^2r_n^2-\frac{1}{2}\right)E_m^2\sin(2\omega t)}{4} + \frac{3E_m^2r_nK\cos(2\omega t)}{4} + 6E_fE_m(K^2r_n^2-2)\sin(\omega t) + r_n\left(12E_fE_m\cos(\omega t) + K^2r_n^2\left(E_f^2 + \frac{E_m^2}{2}\right)\right)K\right) \quad (6)$$

Now that we have the three versions of the external force exerted on the nucleus by a polarized TEM plus a static electric field, it's time to evaluate the nuclear response related to mass and refractive index behaviors.

II.a Nuclear Mass Analysis due to Force caused by Static Field plus Wave (4) – Partial or Total Energy Absorption

The intrinsic net force in the nucleus was already defined with Eq. (23) in Part-1. Now we have the action of an external force acting on the nucleus that will interact with the internal force. By applying Newton's second law, we have

$$\sum F = m_n\cdot a_{ep} = F_{net} + F_{ext} \qquad => \qquad m_n\cdot a_{ep} = F_{net} + F_{ext}$$

$$m_n = \frac{1}{a_{ep}}\cdot(F_{net} + F_{ext}) \qquad (7)$$

By replacing the forces in (7), we obtain the expression of the nuclear mass for this case:

$$m_n = \frac{1}{a_{ep}(t)} \cdot \left(- \frac{3.410^{12} \cdot q^2 \left(1 - \frac{v_{ep}^2(t)}{c^2} + \frac{v_{ep}^2(t) r_{ep}(t) a_{ep}(t)}{c^4} + \frac{v_{ep}^4(t)}{c^4} + \frac{2 r_{ep}(t) a_{ep}(t)}{c^2} \right)}{r_{ep}^2(t)} + \frac{2.0510^{13} \cdot q^2}{r_n^2} + \frac{2\pi \varepsilon_0 v_w}{3c\, K^3 r_n} \cdot \right.$$

$$\left(- \frac{3E_m^2 \sin(2Kr_n - 2\omega t)}{8} - 12 E_f E_m \sin(Kr_n - \omega t) + \frac{3E_m^2 \left(K^2 r_n^2 - \frac{1}{2} \right) \sin(2\omega t)}{4} + \frac{3E_m^2 r_n K \cos(2\omega t)}{4} + \right.$$

$$\left. \left. 6E_f E_m (K^2 r_n^2 - 2) \sin(\omega t) + r_n \left(12 E_f E_m \cos(\omega t) + K^2 r_n^2 \left(E_f^2 + \frac{E_m^2}{2} \right) \right) K \right) \right) \qquad (8)$$

Recall that:

$r_{ep}(t) = \left(0.37 r_n + A_e \cos(\omega_e t) - A_p \cos\left(\omega_p t\right)\right)$

$v_{ep}(t) = \left(-A_e \omega_e \sin(\omega_e t) + A_p \sin\left(\omega_p t\right) \omega_p\right)$

$a_{ep}(t) = \left(-A_e \omega_e^2 \cos(\omega_e t) + A_p \omega_p^2 \cos\left(\omega_p t\right)\right)$

Some graphs as examples are shown below to have a perception of what could be done to modify the nuclear mass magnitude and sign.

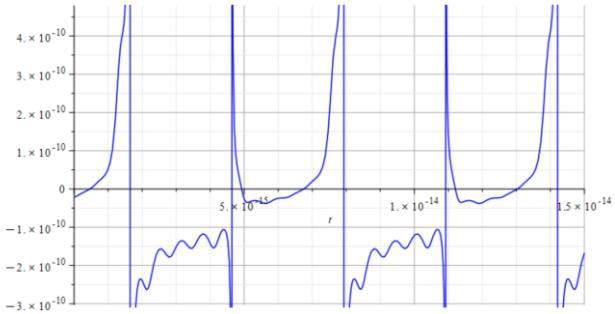
The main parameters used for the net force are:

$r_n = 3.5\ 10^{-15}\ [m]; \quad A_e = 2\ 10^{-16}\ [m]; \quad A_p = 10^{-3} A_e\ [m]; \quad N_0 = 378; \quad N_s = 312$

$\omega_e = 10^{15}\ [\frac{1}{s}]; \qquad \omega_p = 10^{16}\ [\frac{1}{s}]$

While for the wave: $v_w = v_{ep}(t); \qquad K = \frac{\omega}{v_{ep}(t)}$

Time Analysis of the Nuclear Mass

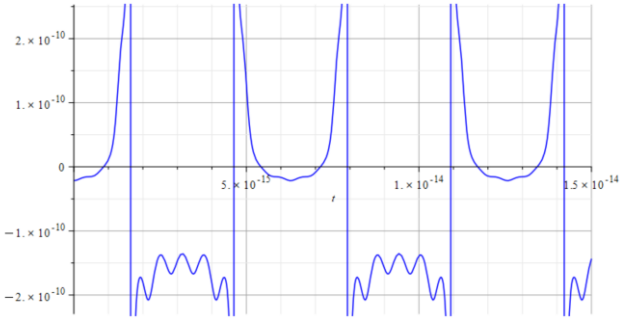


$+E_f$

Mass vs. time for the following parameters:

$\omega = 10^{12}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = 10^{26}\ [\frac{V}{m}]$

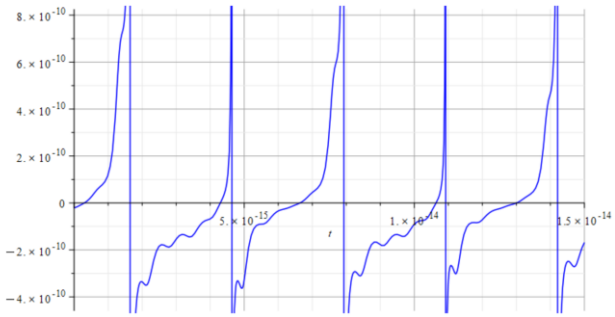
Figure 3



$-E_f$

Mass vs. time for the following parameters:

$\omega = 10^{12}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = -10^{26}\ [\frac{V}{m}]$

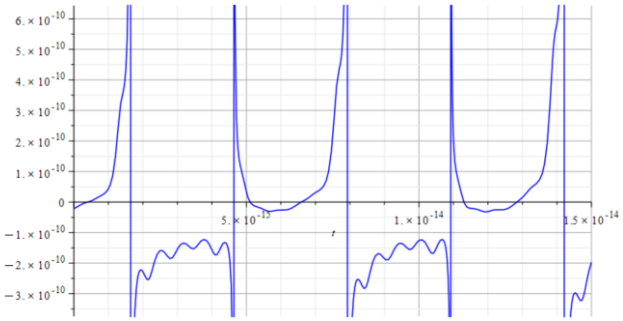


$+E_f$

Mass vs. time for the following parameters:

$\omega = 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = 2.5\ 10^{26}\ [\frac{V}{m}]$

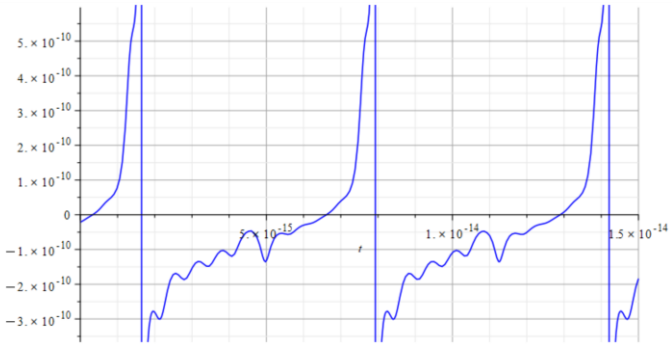
Figure 4



$-E_f$

Mass vs. time for the following parameters:

$\omega = 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = -2.5\ 10^{26}\ [\frac{V}{m}]$



$+E_f$

Mass vs. time for the following parameters:

$\omega = 10^{17}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = \pm 2.5\ 10^{5}\ [\frac{V}{m}]$

Figure 5

$-E_f$

Same result for both polarities

From the period of the mass plot, we determine that the oscillation frequency is approximately:

$f = 1.6\ 10^{14}\ [Hz]$

Frequency Analysis of the Nuclear Mass with FFT

Total number of samples $N = 2^{15}$, sampling frequency $f_s = 2^3\, f_w$ (wave frequency), which gives a frequency resolution $\Delta f = \frac{f_s}{N}\,[Hz]$ and a total acquisition time of T =\frac{N}{f_s}[s]. The frequency at the *i*-sample number on the plot is determined by $f = \frac{N_{(i)}}{T}\ [Hz]$.

For $+E_f$

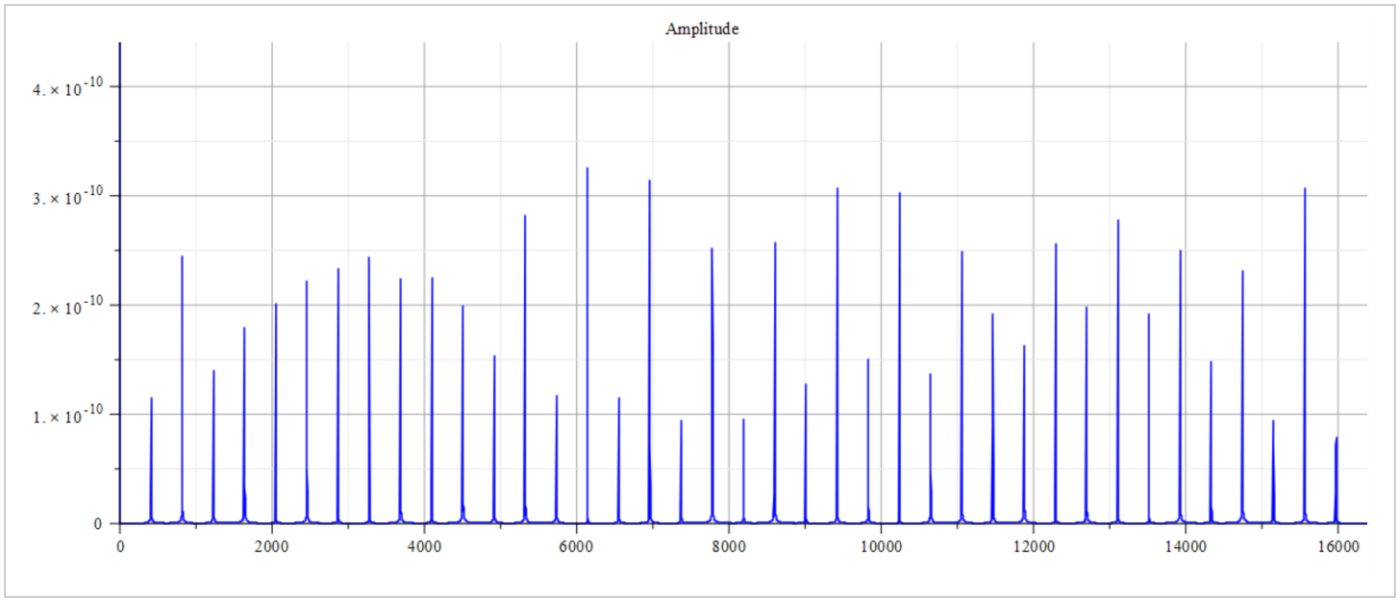


Figure 6

Frequency spectrum for the following parameters: $\omega = 10^{12}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = 10^{26}\ [\frac{V}{m}]$

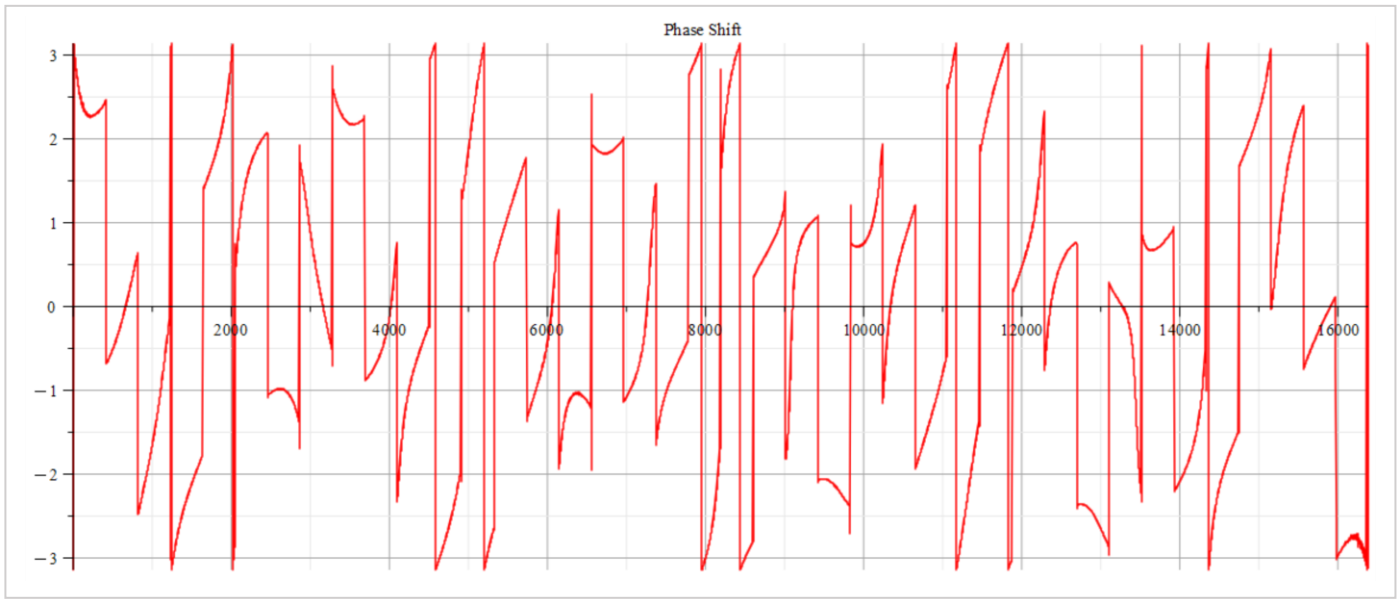


Figure 7

Phase shift for for the following parameters: $\omega = 10^{12}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = 10^{26}\ [\frac{V}{m}]$

For $-E_f$

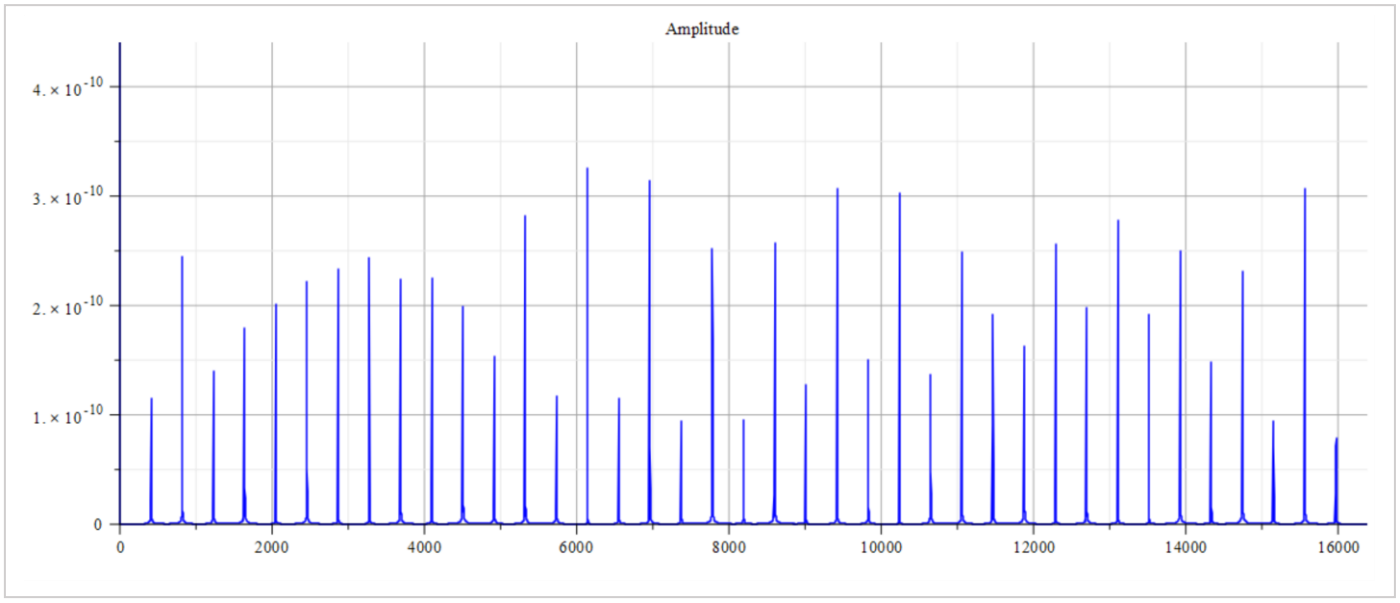


Figure 8

Frequency spectrum for the following parameters: $\omega = 10^{12}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = -10^{26}\ [\frac{V}{m}]$

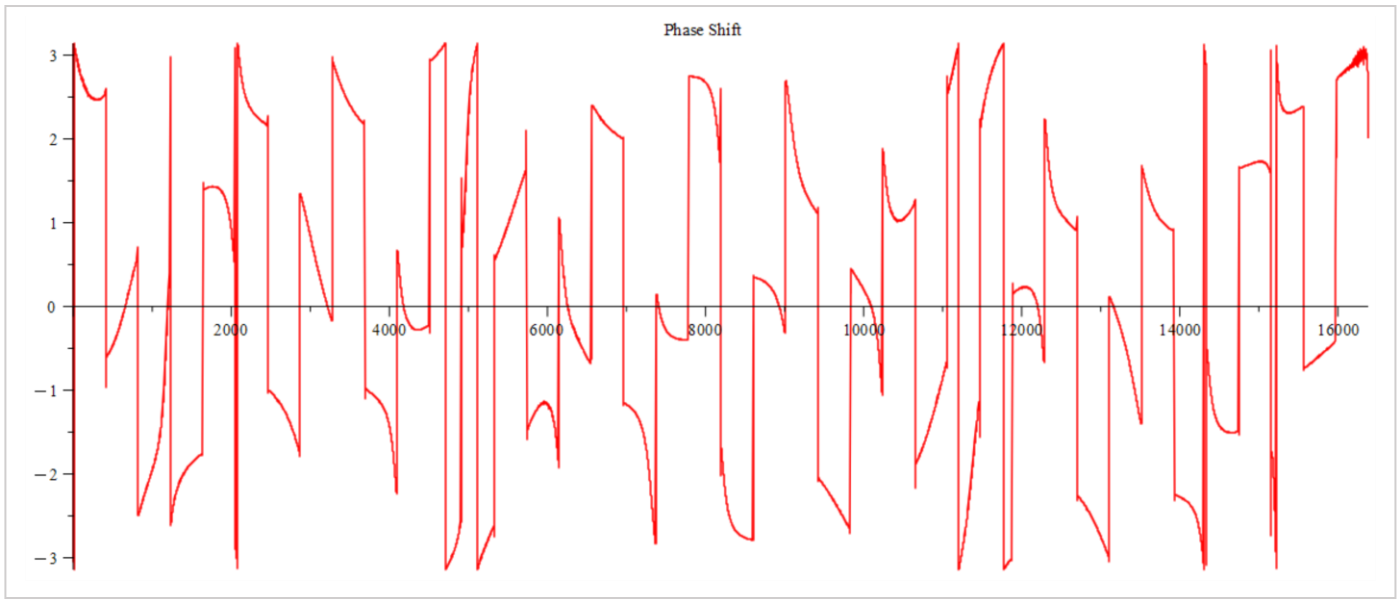


Figure 9

Phase shift for the following parameters: $\omega = 10^{12}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = -10^{26}\ [\frac{V}{m}]$

For $+E_f$

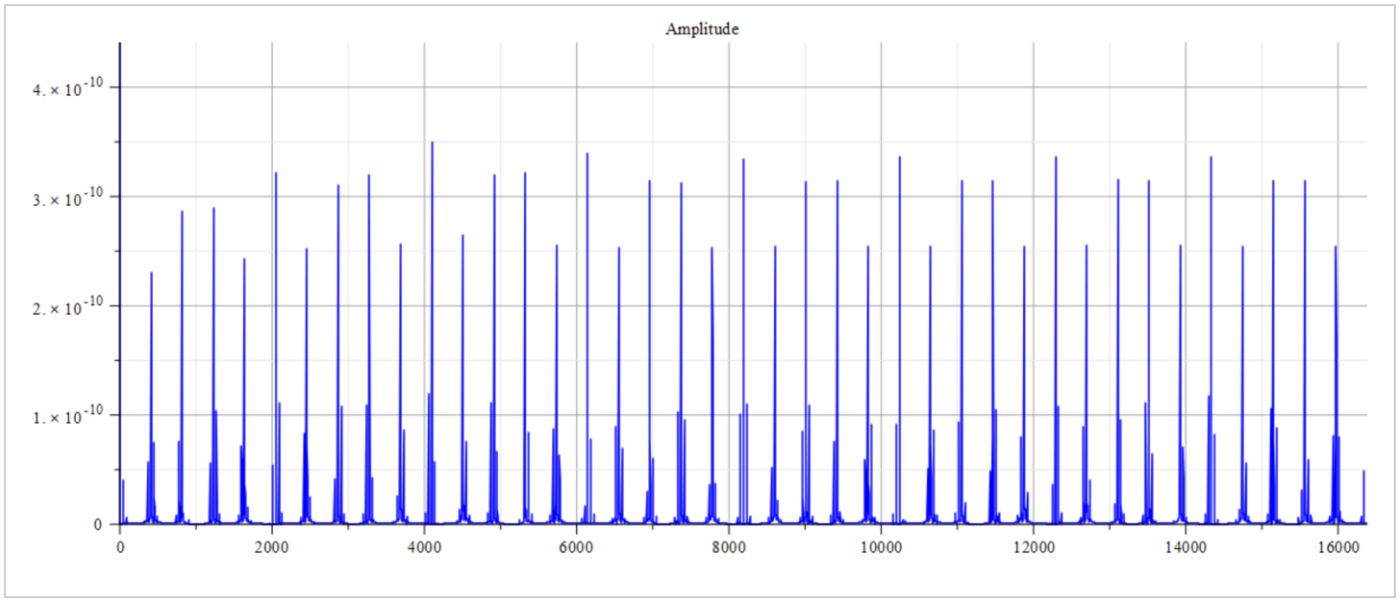


Figure 10

Frequency spectrum for the following parameters: $\omega = 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = 2.5\ 10^{26}\ [\frac{V}{m}]$

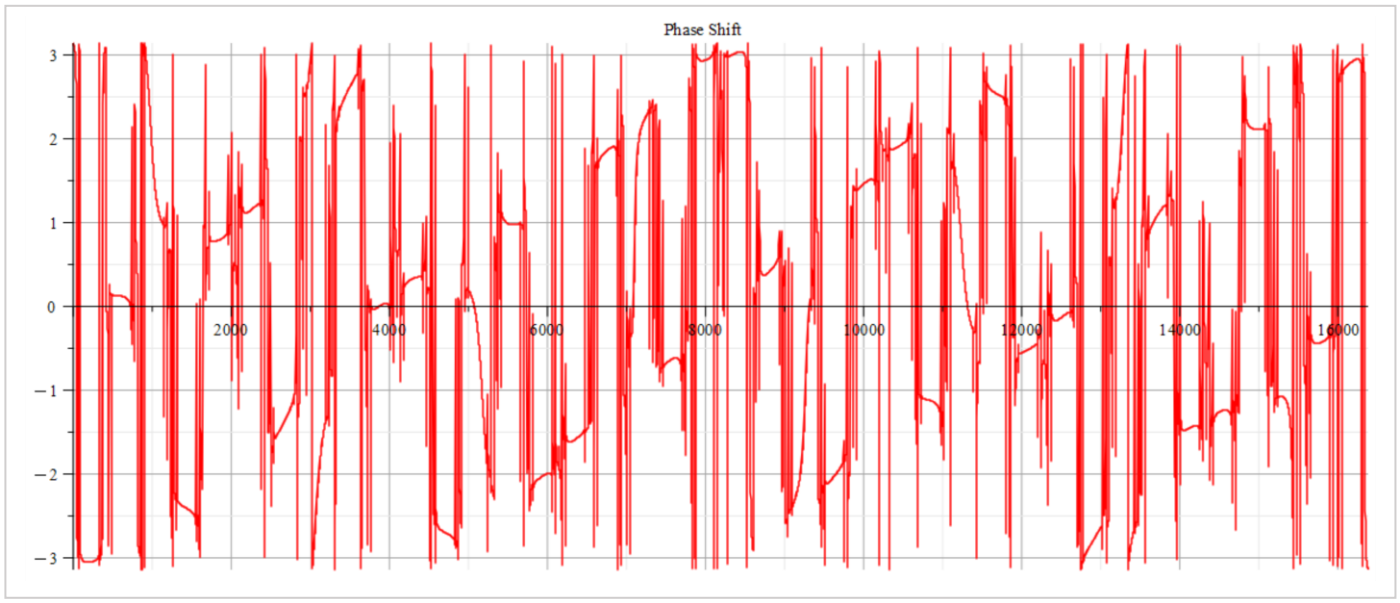


Figure 11

Phase shift for the following parameters: $\omega = 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = 2.5\ 10^{26}\ [\frac{V}{m}]$

For $-E_f$

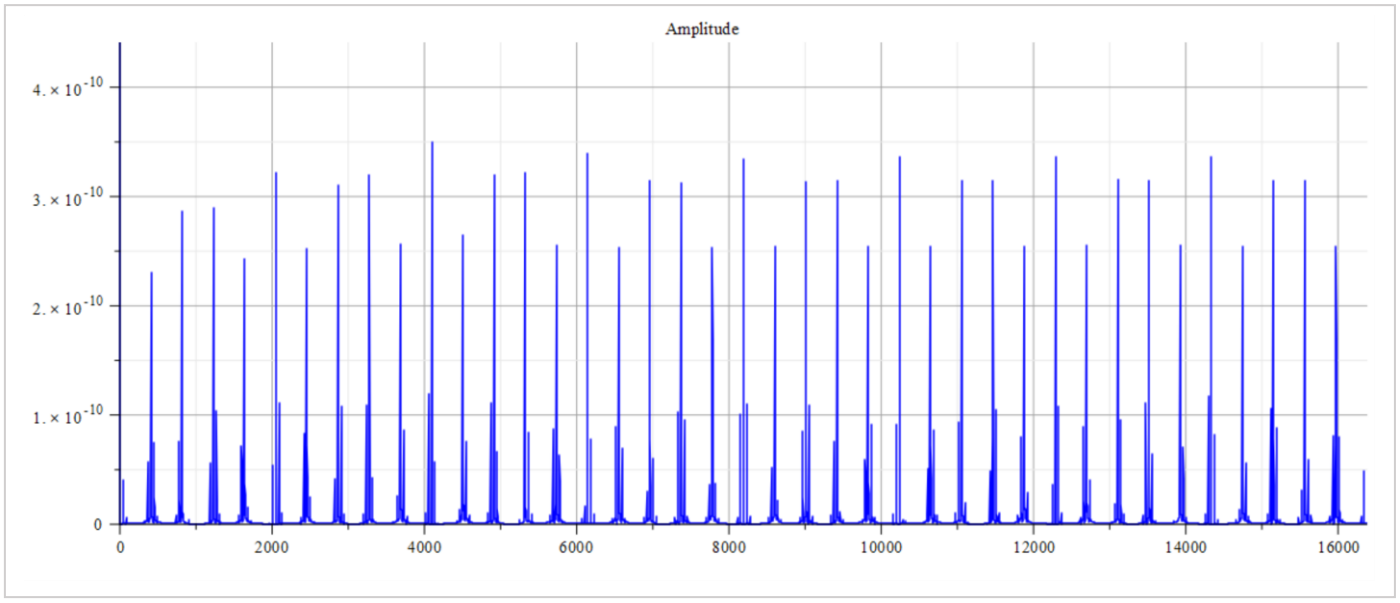


Figure 12

Frequency spectrum for the following parameters: $\omega = 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = -2.5\ 10^{26}\ [\frac{V}{m}]$

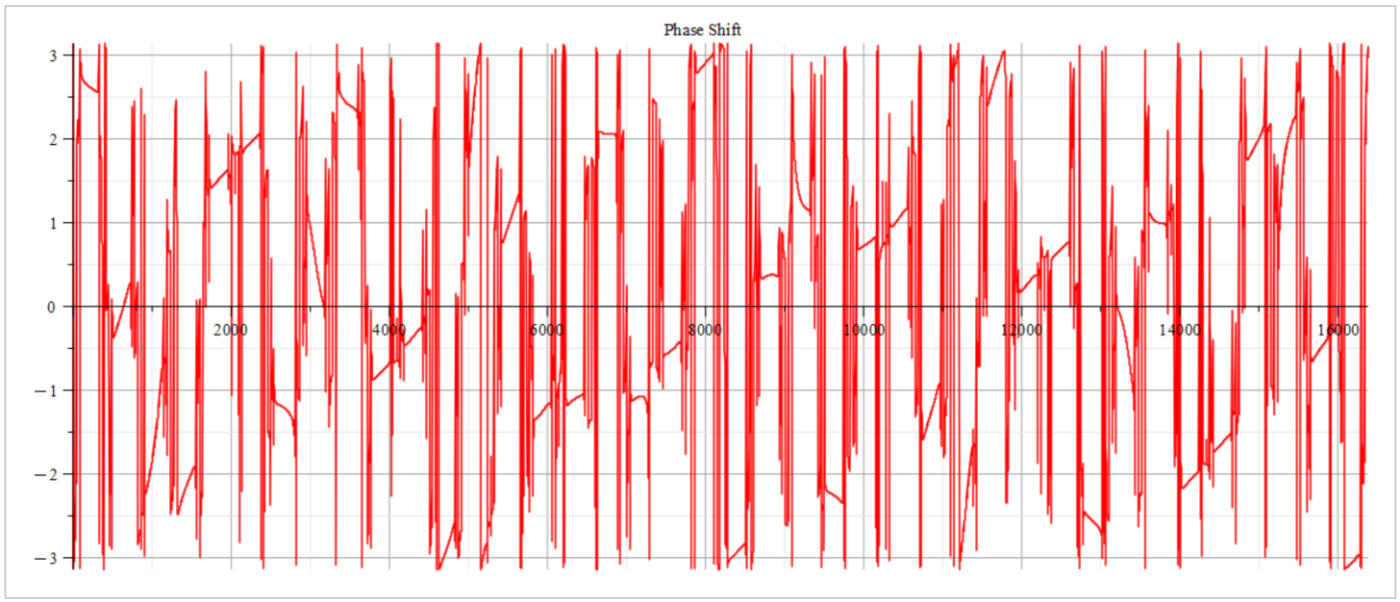


Figure 13

Phase shift for the following parameters: $\omega = 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = -2.5\ 10^{26}\ [\frac{V}{m}]$

For + E_f

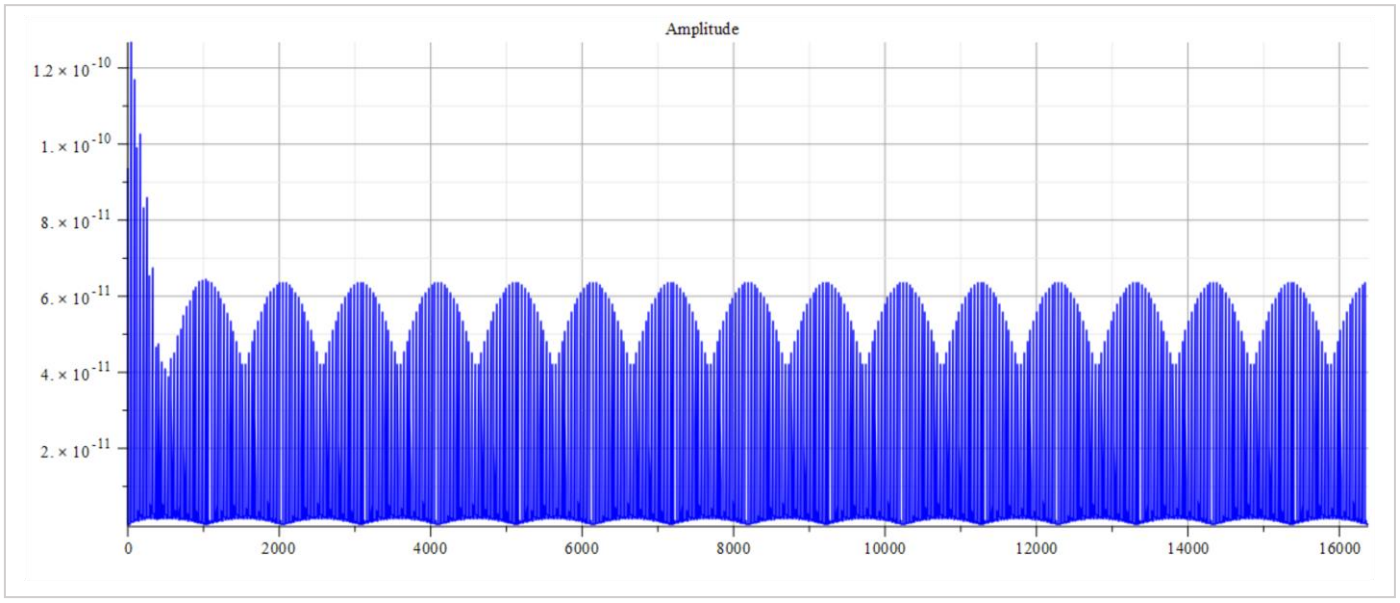


Figure 14

Frequency spectrum for the following parameters: $\omega = 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = 2.5\ 10^{26}\ [\frac{V}{m}]$

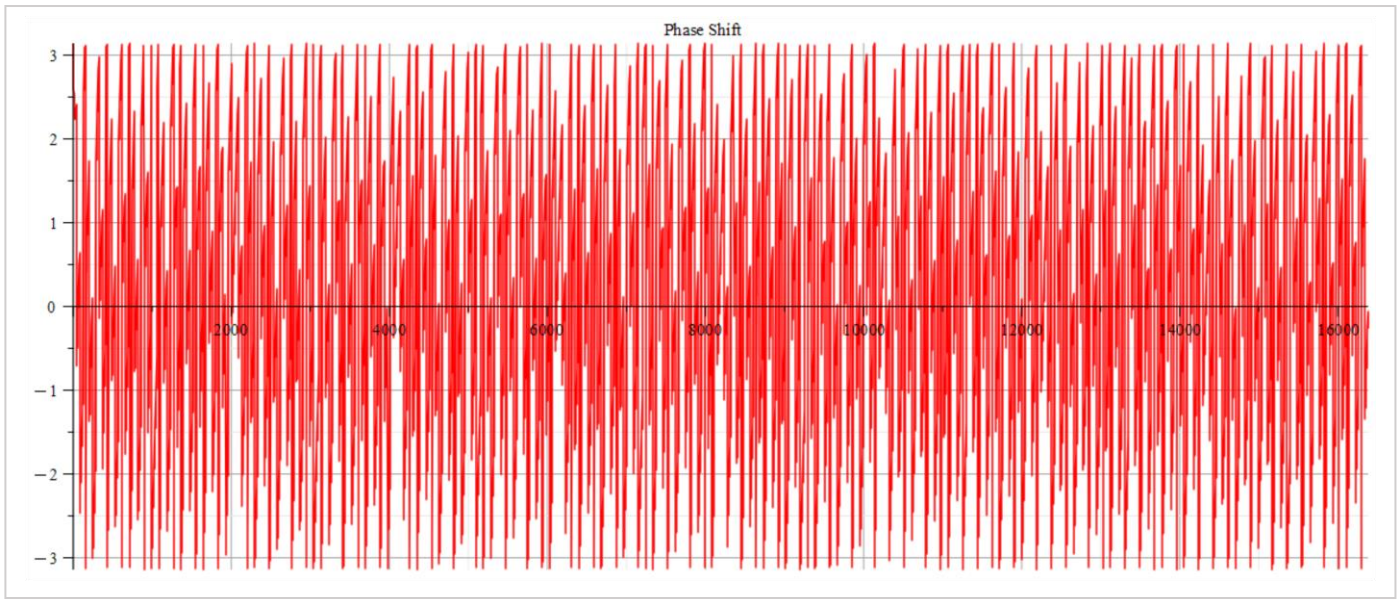


Figure 15

Phase shift for the following parameters: $\omega = 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = 2.5\ 10^{26}\ [\frac{V}{m}]$

For - E_f

The graphs are very similar for $+\boldsymbol{E_f}$**.** The frequency spectrum always shows the same main frequency and harmonics. However, there are some changes in amplitudes, and in the phase behavior.

From the Fourier frequency analysis, we see that the main frequency is: $f_0 = 1.6\ 10^{14}\ [Hz]$.

In general, the main frequency and harmonics are given by the following formula:

$f_n = f_0 + nf_0, \quad n = 0, 1, 2, 3..$

II.b Refractive Index Analysis due to Force caused by Static Field plus Wave (4) – Partial or Total Energy Absorption

When the nucleus is under the action of external forces, and if it doesn't break apart, then we can assume that a dynamic equilibrium state must exist. Under such circumstances, Newton's second law requires that the sum of forces be equal to zero, $\vec{F}_{net} + \vec{F}_{ext} = 0$, that is,

$$F_{net} = -F_{ext} \qquad (9)$$

Recall that the net nuclear force has already been written in terms of the index of refraction in Part-1, Eq. (23a):

$$\vec{F}_{net} = -\frac{378k\,q^2}{r_{ep}^2(t)}\left(1 - \frac{1}{n^2} + \frac{v_{ep}^2(t) r_{ep}(t) a_{ep}(t)}{n^2 c^2} + \frac{1}{n^4} + \frac{2 r_{ep}(t) a_{ep}(t)}{c^2}\right)\hat{r} + \frac{2279.035793k\,q^2\hat{r}}{r_n^2}$$

Now we can equate the forces according to Eq. (9), then solve for "n",

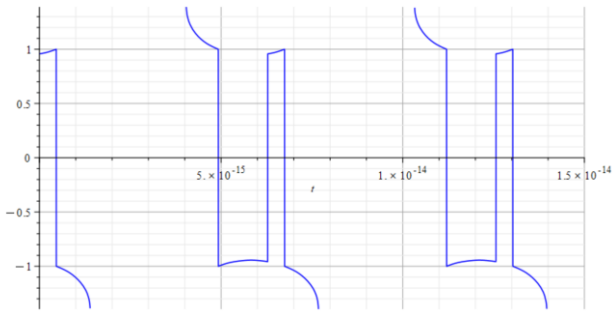
$$-\frac{3.410^{12}\cdot q^2\left(1-\frac{1}{n^2}+\frac{r_{ep}(t)a_{ep}(t)}{n^2c^2}+\frac{1}{n^4}+\frac{2r_{ep}(t)a_{ep}(t)}{c^2}\right)}{r_{ep}^2(t)} + \frac{2.0510^{13}\cdot q^2}{r_n^2} = -\frac{2\pi\varepsilon_0 v_w}{3c\,K^3 r_n}\cdot\left(-\frac{3E_m^2\sin(2Kr_n-2\omega t)}{8} - 12E_fE_m\sin(Kr_n-\omega t) + \frac{3E_m^2\left(K^2r_n^2-\frac{1}{2}\right)\sin(2\omega t)}{4} + \frac{3E_m^2 r_n K\cos(2\omega t)}{4} + 6E_fE_m(K^2r_n^2-2)\sin(\omega t) + r_n\left(12E_fE_m\cos(\omega t) + K^2r_n^2\left(E_f^2+\frac{E_m^2}{2}\right)\right)K\right) \qquad (10)$$

The refractive index "n" is a somewhat long-expression which is nonsense to copy here. Some plots as examples are shown below, where the main used parameters are:

$r_n = 3.5\ 10^{-15}\ [m]$; $A_e = 2\ 10^{-16}\ [m]$; $A_p = 10^{-3}A_e\ [m]$; $N_0 = 378$; $N_s = 312$

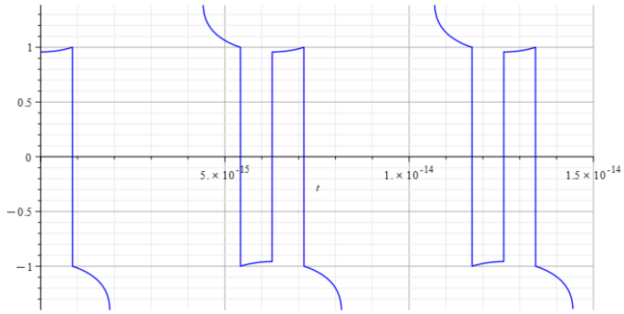
$\omega_e = 10^{15}\ [\frac{1}{s}]$; $\omega_p = 10^{16}\ [\frac{1}{s}]$

While for the wave: $v_w = v_{ep}(t)$; $K = \frac{\omega}{v_{ep}(t)}$



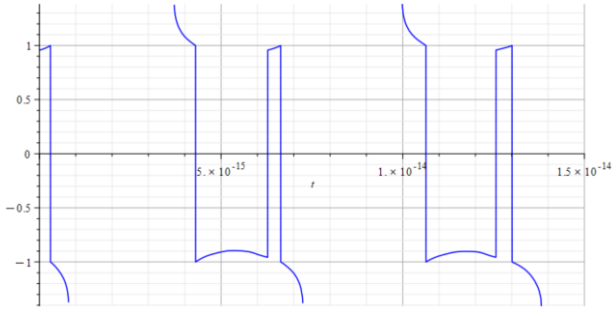
$+\boldsymbol{E_f}$

Refractive Index vs. time for the following parameters: $\omega = 10^{12}\ [\frac{1}{s}]$ $E_m = 10^{26}\ [\frac{V}{m}]$ $E_f = 10^{26}\ [\frac{V}{m}]$



$-\boldsymbol{E_f}$

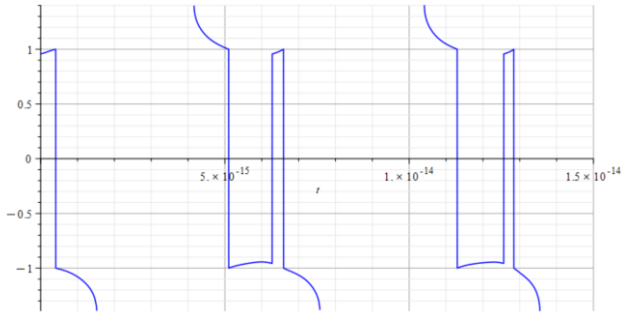
Figure 16 *Refractive Index vs. time for the following parameters:* $\omega = 10^{12}\ [\frac{1}{s}]$ $E_m = 10^{26}\ [\frac{V}{m}]$ $E_f = -10^{26}\ [\frac{V}{m}]$



$+\boldsymbol{E_f}$

Refractive Index vs. time for the following parameters: ***Figure 17***

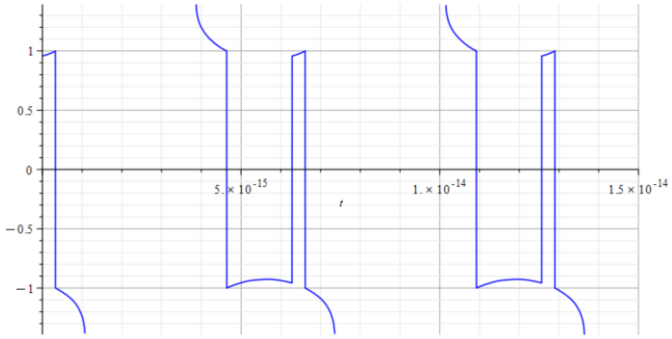
$\omega = 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = 2.5\ 10^{26}\ [\frac{V}{m}]$



$-\boldsymbol{E_f}$

Refractive Index vs. time for the following parameters:

$\omega = 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = -2.5\ 10^{26}\ [\frac{V}{m}]$



$+\boldsymbol{E_f}$

Refractive Index vs. time for the following parameters: ***Figure 18***

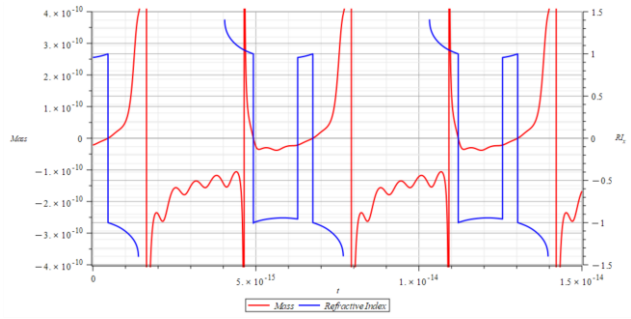
$\omega = 10^{17}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = \pm 2.5\ 10^{26}\ [\frac{V}{m}]$

$-\boldsymbol{E_f}$

Same result for both polarities

II.c Comparison of Mass with Refractive Index Behavior due to Force caused by Static Field plus Wave (4) – Partial or Total Energy Absorption

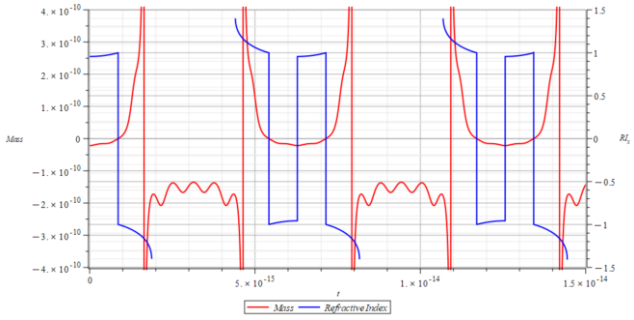
To analyze the changes in the refractive index "n" with respect to changes in nuclear mass, overlaid graphs of both quantities are shown below, which uncover interesting results.



$+E_f$

Mass & Refractive Index vs. time for the following parameters:

$\omega = 10^{12}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = 10^{26}\ [\frac{V}{m}]$



$-E_f$

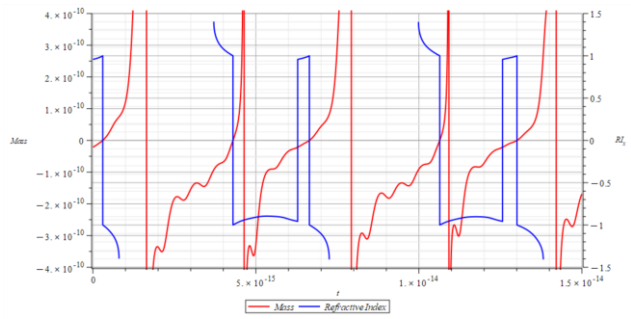
Mass & Refractive Index vs. time for the following parameters.:

$\omega = 10^{12}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = -10^{26}\ [\frac{V}{m}]$

Figure 19

The Refractive Index oscillates, and the period switches between n=±1 at the crossing point of m=0, as well at some point with mass plot slope =0. It seems that the refractive index depends on the derivative of the mass, by changing the sign at both m=0 points, that is,

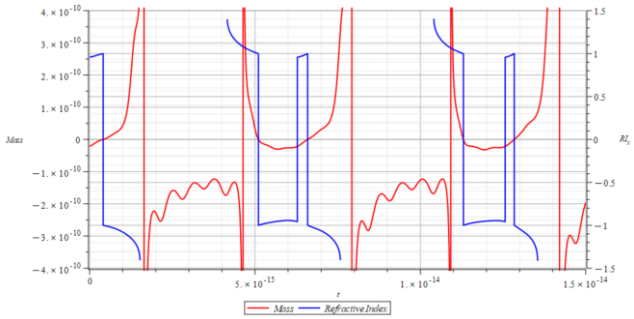
$$n \propto \pm\frac{dm}{dt}$$



$+E_f$

Mass & Refractive Index vs. time for the following parameters:

$\omega = 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = 2.5\ 10^{26}\ [\frac{V}{m}]$



$-E_f$

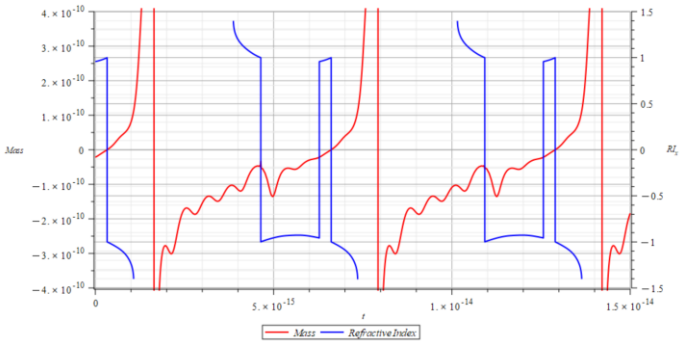
Mass & Refractive Index vs. time for the following parameters.:

$\omega = 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = -2.5\ 10^{26}\ [\frac{V}{m}]$

Figure 20

The Refractive Index oscillates, and the period switches between n=±1 at the crossing point of m=0. It seems that the refractive index depends on the derivative of the mass, by changing the sign at both m=0 points.

$$n \propto \pm\frac{dm}{dt}$$



$+\boldsymbol{E_f}$ $\quad\quad\quad

III.a Nuclear Mass Analysis due to Force caused by Static Field plus Wave (5) – Total Energy Transmission

The intrinsic net force in the nucleus was already defined with Eq. (23) in Part-1. Now we have the action of an external force acting on the nucleus that will interact with the internal force. By applying Newton's second law, we have

$$\sum F = m_n \cdot a_{ep} = F_{net} + F_{ext} \qquad => \qquad m_n \cdot a_{ep} = F_{net} + F_{ext}$$

$$m_n = \frac{1}{a_{ep}} \cdot (F_{net} + F_{ext}) \qquad (11)$$

By replacing the forces in (11), we obtain the expression of the nuclear mass for this case:

$$m_n = \frac{1}{a_{ep}(t)} \cdot \left(- \frac{3.410^{12} \cdot q^2 \left(1 - \frac{v_{ep}^2(t)}{c^2} + \frac{v_{ep}^2(t) r_{ep}(t) a_{ep}(t)}{c^4} + \frac{v_{ep}^4(t)}{c^4} + \frac{2 r_{ep}(t) a_{ep}(t)}{c^2} \right)}{r_{ep}^2(t)} + \frac{2.0510^{13} \cdot q^2}{r_n^2} + \frac{\pi \varepsilon_0}{6K^3 r_n} \cdot \right.$$

$$\left. \begin{aligned} &\left(4E_f^2 K^3 r_n^3 + 2E_m^2 K^3 r_n^3 + 6E_m^2 K^2 \sin(\omega t)\cos(\omega t)\, r_n^2 + 24 E_f E_m r_n^2 \sin(\omega t)\, K^2 + 6E_m^2 K \sin^2(r_n K - \omega t)\, r_n + 6E_m^2 K \cos^2(r_n K - \omega t)\, r_n - 6E_m^2 K \sin^2(\omega t)\, r_n - 6E_m^2 \sin^2(r_n K - \omega t)\, \omega t - 6E_m^2 \cos^2(r_n K - \omega t)\, \omega t + 6E_m^2 \sin^2(\omega t)\, \omega t + 6E_m^2 \cos^2(\omega t)\, \omega t + 48 E_f E_m K \cos(\omega t)\, r_n - 3E_m^2 r_n K - 3E_m^2 \sin(r_n K - \omega t)\cos(r_n K - \omega t) - 3E_m^2 \sin(\omega t)\cos(\omega t) - 48 E_f E_m \sin(r_n K - \omega t) - 48 E_f E_m \sin(\omega t)\right) \end{aligned} \right) \qquad (12)$$

Recall that:

$$r_{ep}(t) = \left(0.37 r_n + A_e \cos(\omega_e t) - A_p \cos(\omega_p t)\right)$$

$$v_{ep}(t) = \left(-A_e \omega_e \sin(\omega_e t) + A_p \sin(\omega_p t)\, \omega_p\right)$$

$$a_{ep}(t) = \left(-A_e \omega_e^2 \cos(\omega_e t) + A_p \omega_p^2 \cos(\omega_p t)\right)$$

Some graphs as examples are shown below to have a perception of what could be done to modify the nuclear mass magnitude and sign.

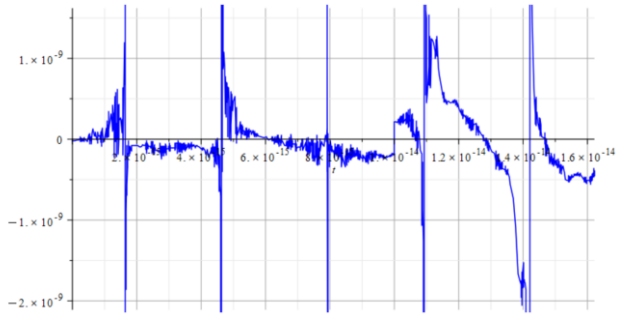
The main parameters used for the net force are:

$r_n = 3.5\ 10^{-15}\ [m]; \quad A_e = 2\ 10^{-16}\ [m]; \quad A_p = 10^{-3} A_e\ [m]; \quad N_0 = 378; \quad N_s = 312$

$\omega_e = 10^{15}\ [\frac{1}{s}]; \qquad \omega_p = 10^{16}\ [\frac{1}{s}]$

While for the wave: $K = \frac{\omega}{c}$

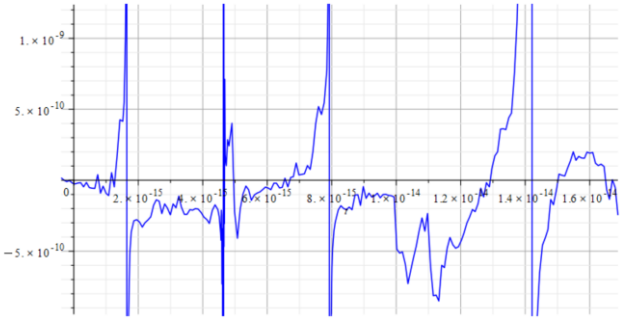
Time Analysis of the Nuclear Mass



$+E_f$

Mass vs. time for the following parameters:

$\omega = 1.6\ 10^{15}\ [\frac{1}{s}]\quad E_m = 10^{17}\ [\frac{V}{m}]\quad E_f = 10^{18}\ [\frac{V}{m}]$

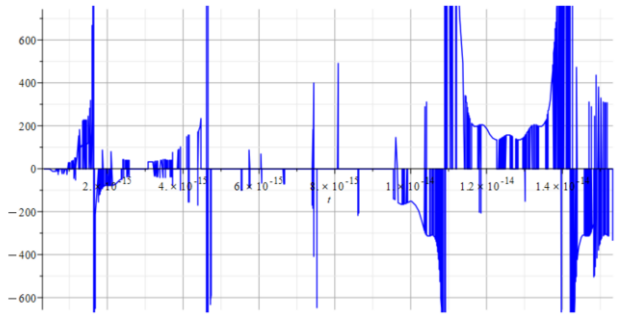


$-E_f$

Mass vs. time for the following parameters:

$\omega = 1.6\ 10^{15}\ [\frac{1}{s}]\quad E_m = 10^{17}\ [\frac{V}{m}]\quad E_f = -10^{18}\ [\frac{V}{m}]$

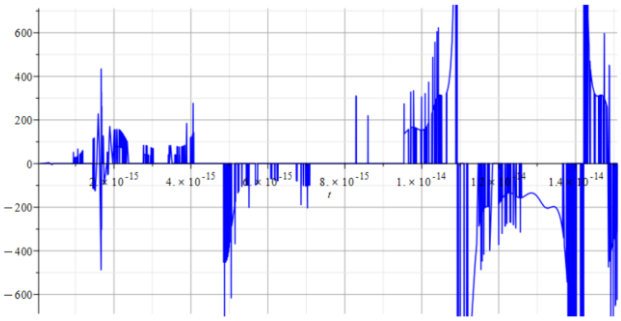
Figure 22



$+E_f$

Mass vs. time for the following parameters:

$\omega = 10^{8}\ [\frac{1}{s}]\quad E_m = 10^{15}\ [\frac{V}{m}]\quad E_f = 10^{17}\ [\frac{V}{m}]$

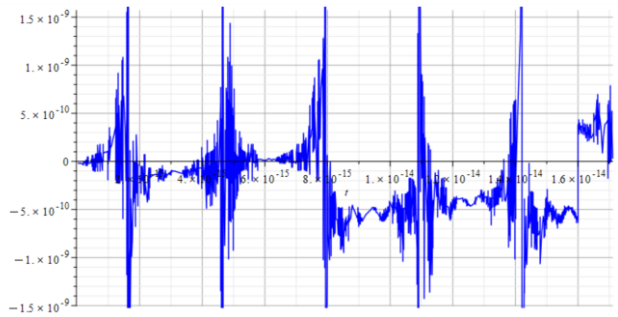


$-E_f$

Mass vs. time for the following parameters:

$\omega = 10^{8}\ [\frac{1}{s}]\quad E_m = 10^{15}\ [\frac{V}{m}]\quad E_f = -10^{17}\ [\frac{V}{m}]$

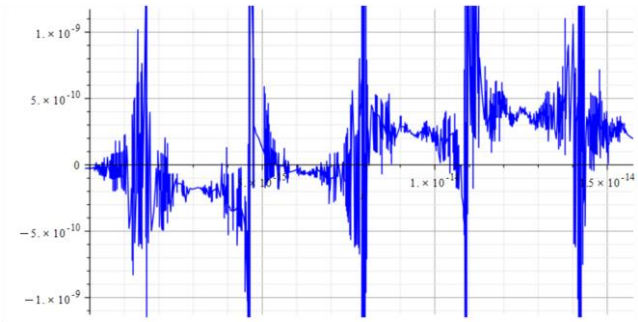
Figure 23



$+E_f$

Mass vs. time for the following parameters:

$\omega = 10^{15}\ [\frac{1}{s}]\quad E_m = 7\ 10^{16}\ [\frac{V}{m}]\quad E_f = 8\ 10^{17}\ [\frac{V}{m}]$



$-E_f$

Mass vs. time for the following parameters:

$\omega = 10^{15}\ [\frac{1}{s}]\quad E_m = 7\ 10^{16}\ [\frac{V}{m}]\quad E_f = -8\ 10^{17}\ [\frac{V}{m}]$

Figure 24

From the period of the mass plot, we determine that the oscillation frequency is approximately:

$f = 1.6\ 10^{14}\ [Hz]$

Frequency Analysis of the Nuclear Mass with FFT

Total number of samples $N = 2^{13}$, sampling frequency $f_s = 2^3 f_p$ (proton frequency), which gives a frequency resolution $\Delta f = \frac{f_s}{N} = 1.55\ 10^{12}[Hz]$ and a total acquisition time of $T = \frac{N}{f_s} = 6.43\ 10^{-13}[s]$.

The frequency at the *i*-sample number on the plot is determined by $f = \frac{N_{(i)}}{T}\ [Hz]$.

For $+E_f$

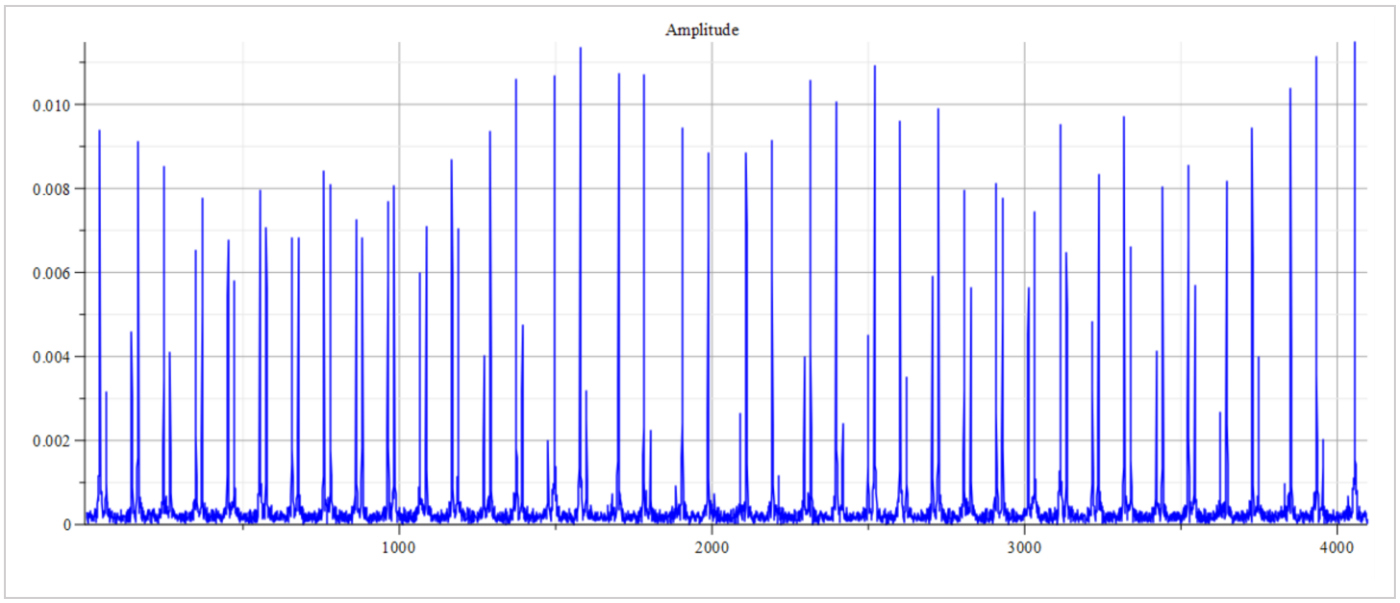


Figure 25

Frequency spectrum for the following parameters: $\omega = 1.6\ 10^{15}\ [\frac{1}{s}]\ \ E_m = 10^{17}\ [\frac{V}{m}]\ \ E_f = 10^{18}\ [\frac{V}{m}]$

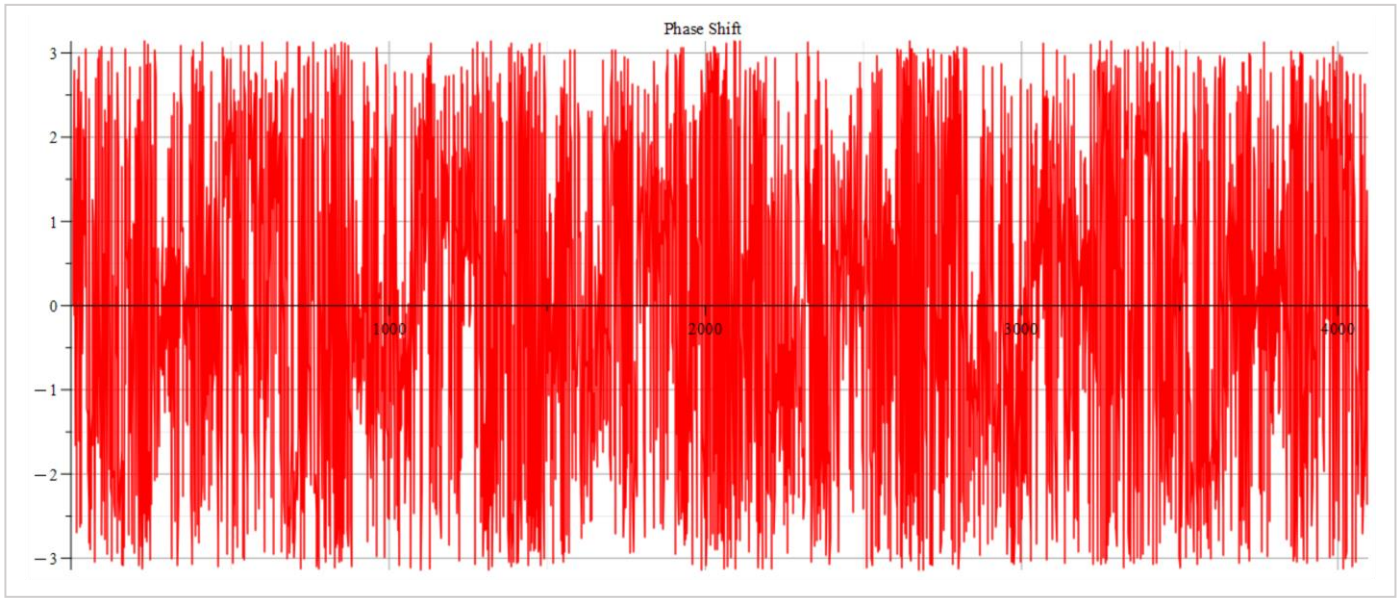


Figure 26

Phase shift for the following parameters: $\omega = 1.6\ 10^{15}\ [\frac{1}{s}]\ \ E_m = 10^{17}\ [\frac{V}{m}]\ \ E_f = 10^{18}\ [\frac{V}{m}]$

For $-E_f$

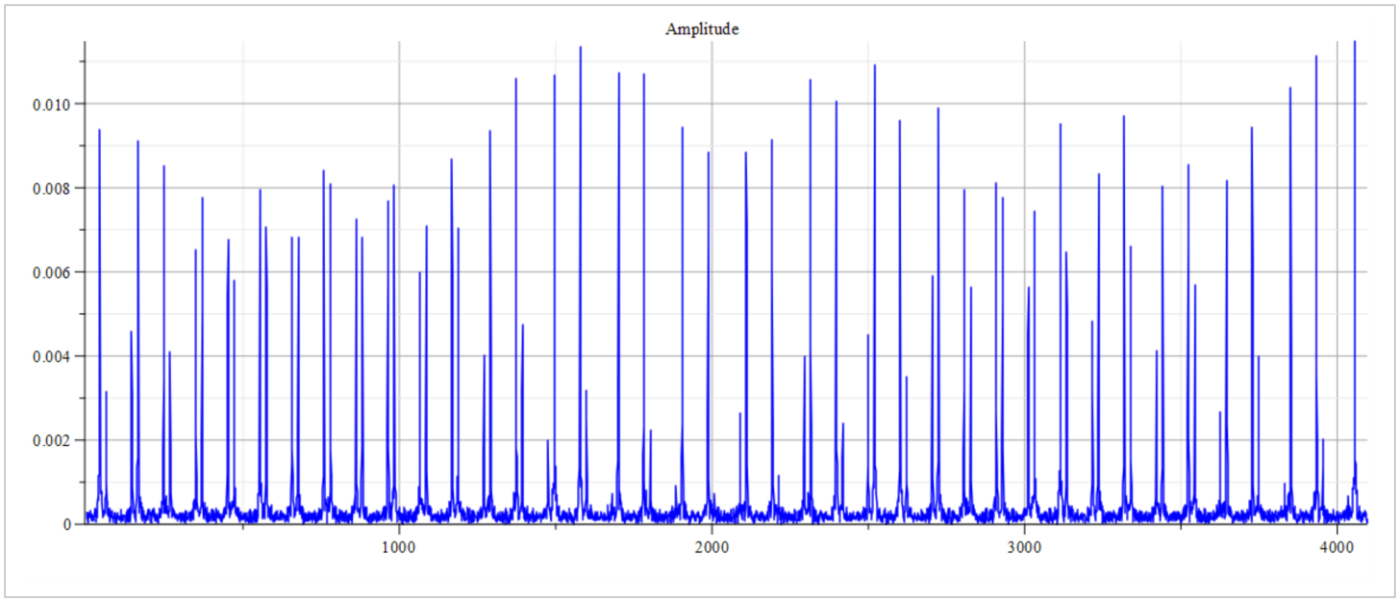


Figure 27

Frequency spectrum for the following parameters: $\omega = 1.6\ 10^{15}\ [\frac{1}{s}]\ \ E_m = 10^{17}\ [\frac{V}{m}]\ \ E_f = -10^{18}\ [\frac{V}{m}]$

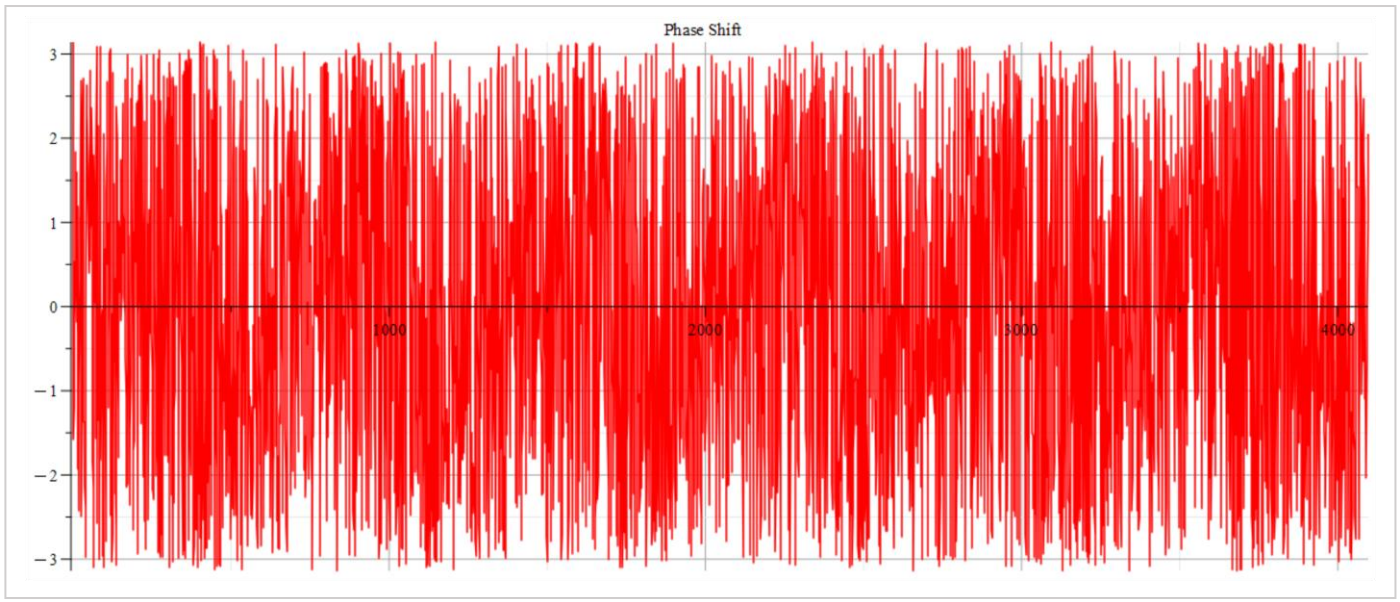


Figure 28

Phase shift for the following parameters: $\omega = 1.6\ 10^{15}\ [\frac{1}{s}]\ \ E_m = 10^{17}\ [\frac{V}{m}]\ \ E_f = -10^{18}\ [\frac{V}{m}]$

The frequency spectrum plots are the same. There are some differences in the phase behavior.

From the Fourier frequency analysis, we see that the main frequency is: $f_0 = 1.6\ *\ 2\ 10^{14}\ [Hz]$.

In general, the main frequency and harmonics is given by the following formula:

$f_n = f_0 + nf_0, \quad n = 0, 1, 2, 3..$

The frequency measured between the first peaks of the double-peak sequence is given by

$f_n = 6.52\ 10^{13} + n\ (f_n - f_{n-1})$, while the frequency measured between the second peaks of the double-peak sequence is given by $f_n = 9.63\ 10^{13} + n\ (f_n - f_{n-1})$.

The frequency gap between peaks on each pair is $f_{pp} = 1.6\ *2\ 10^{13}\ [Hz]$.

For $+E_f$

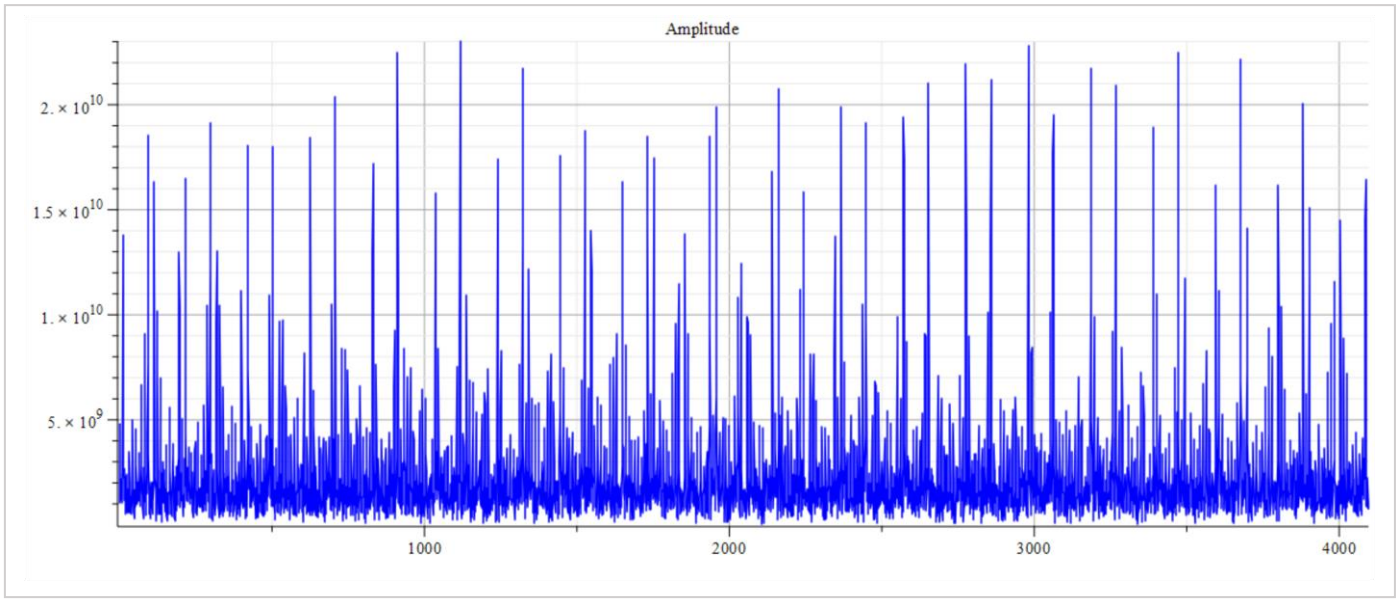


Figure 29

Frequency spectrum for the following parameters: $\omega = 10^8\ [\frac{1}{s}]\ \ E_m = 10^{15}\ [\frac{V}{m}]\ \ E_f = 10^{17}\ [\frac{V}{m}]$

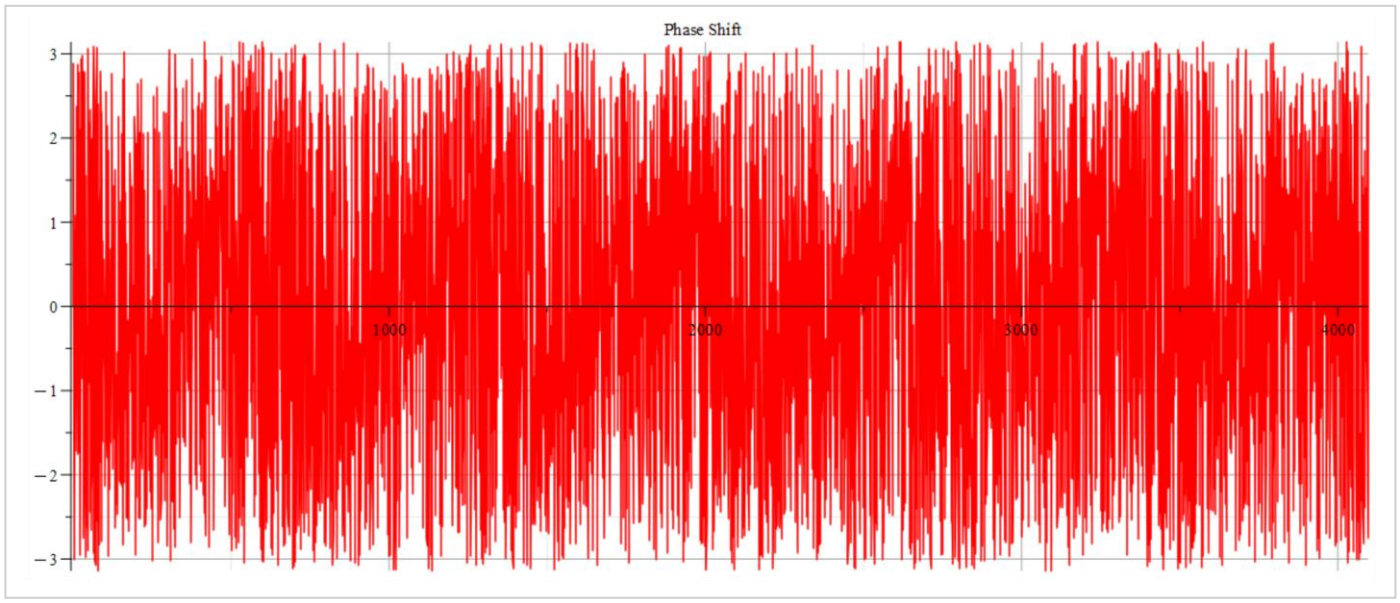


Figure 30

Phase shift for the following parameters: $\omega = 10^8\ [\frac{1}{s}]\ \ E_m = 10^{15}\ [\frac{V}{m}]\ \ E_f = 10^{17}\ [\frac{V}{m}]$

For $-E_f$

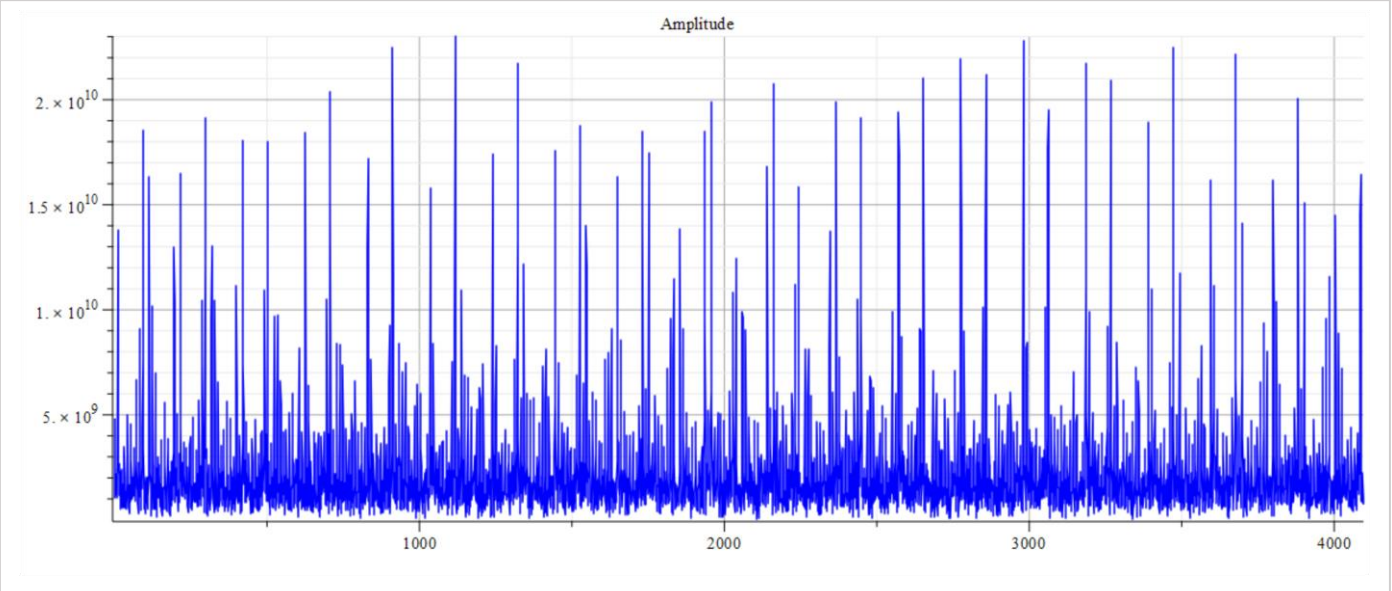


Figure 31

Frequency spectrum for the following parameters: $\omega = 10^8\ [\frac{1}{s}]\ \ E_m = 10^{15}\ [\frac{V}{m}]\ \ E_f = -10^{17}\ [\frac{V}{m}]$

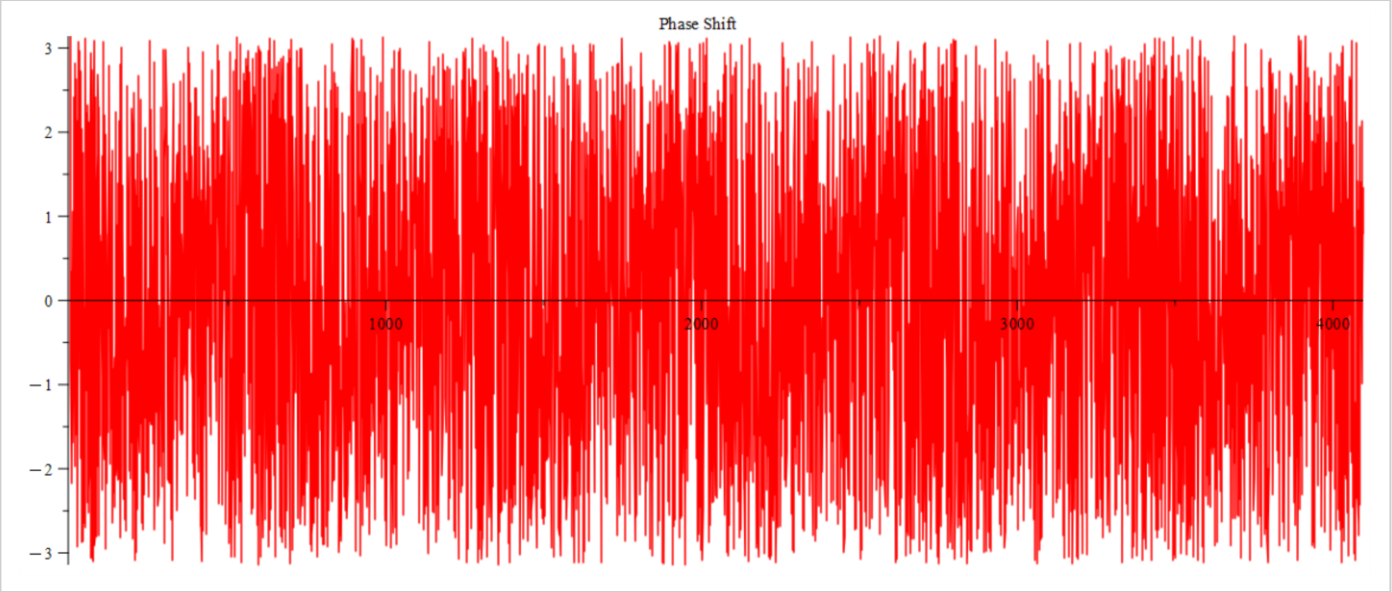


Figure 32

Phase shift for the following parameters: $\omega = 10^8\ [\frac{1}{s}]\ \ E_m = 10^{15}\ [\frac{V}{m}]\ \ E_f = -10^{17}\ [\frac{V}{m}]$

The frequency spectrum plots are the same. There are some differences in the phase behavior.

The spectrum contains many frequencies. However, we see that the main frequency is: $f_0 = 1.7\ 10^{13}\ [\mathrm{Hz}]$.

There is a visible repetition pattern of mirrored three peaks and double peaks.

For + E_f

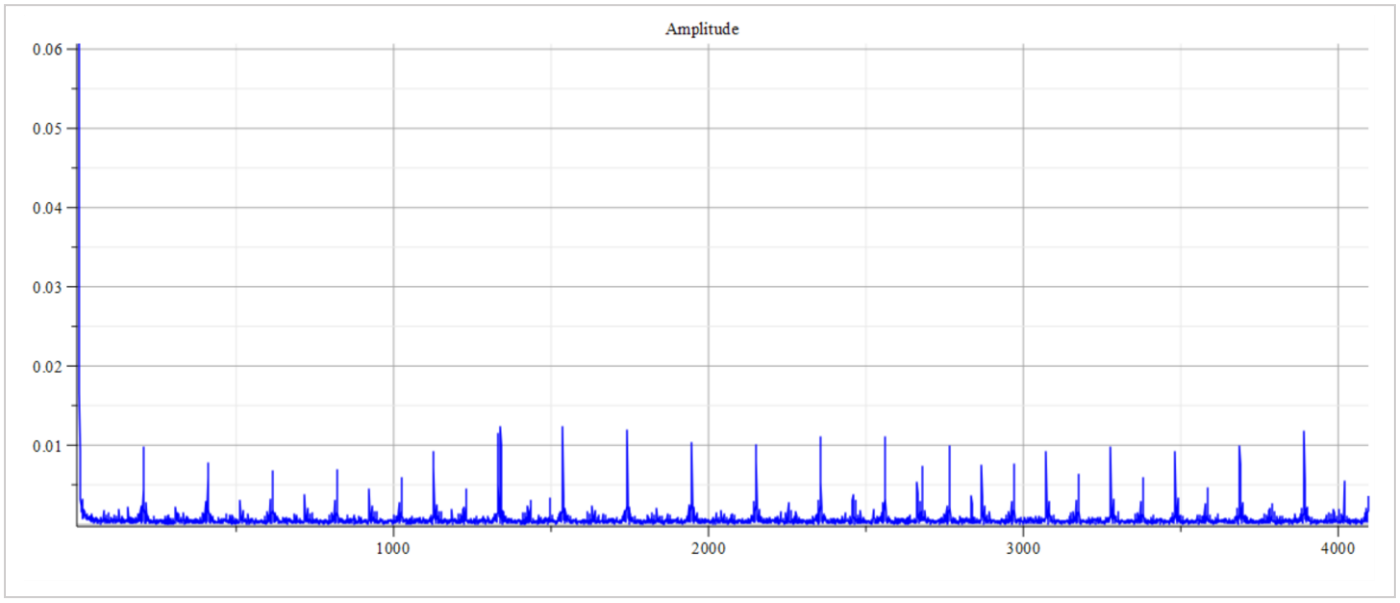


Figure 33

Frequency spectrum for the following parameters: $\omega = 10^{15}\ [\frac{1}{s}]\ \ E_m = 7\ 10^{16}\ [\frac{V}{m}]\ \ E_f = 8\ 10^{17}\ [\frac{V}{m}]$

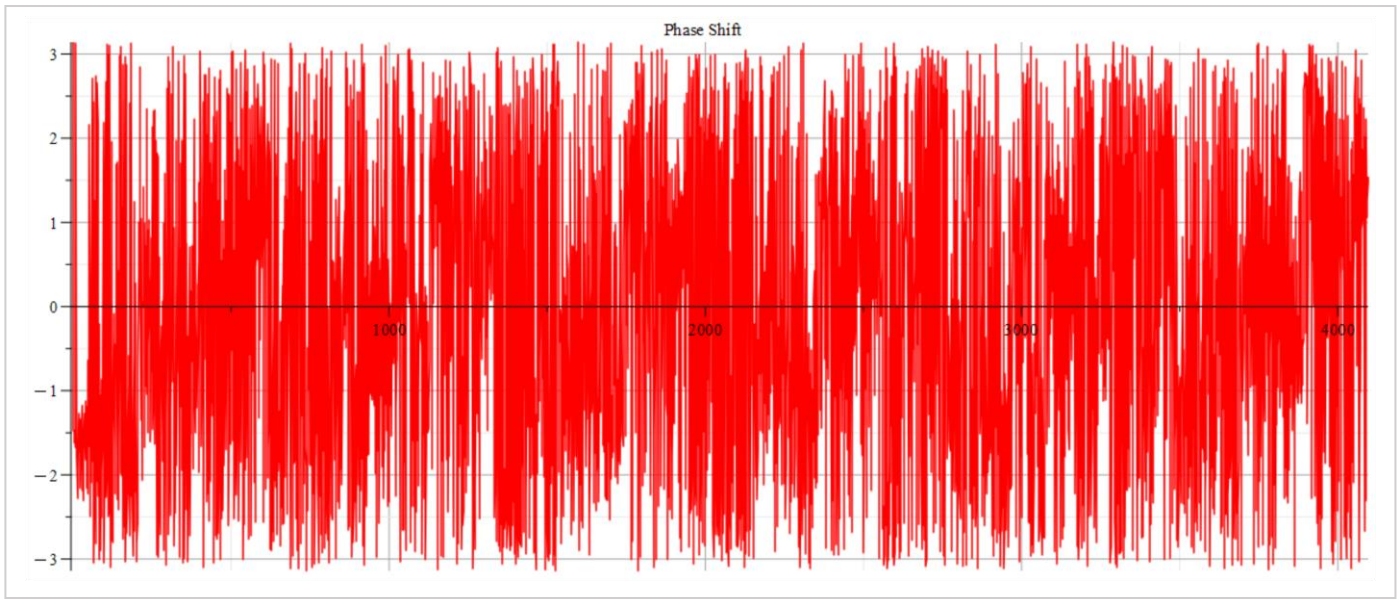


Figure 34

Phase shift for the following parameters: $\omega = 10^{15}\ [\frac{1}{s}]\ \ E_m = 7\ 10^{16}\ [\frac{V}{m}]\ \ E_f = 8\ 10^{17}\ [\frac{V}{m}]$

For - E_f

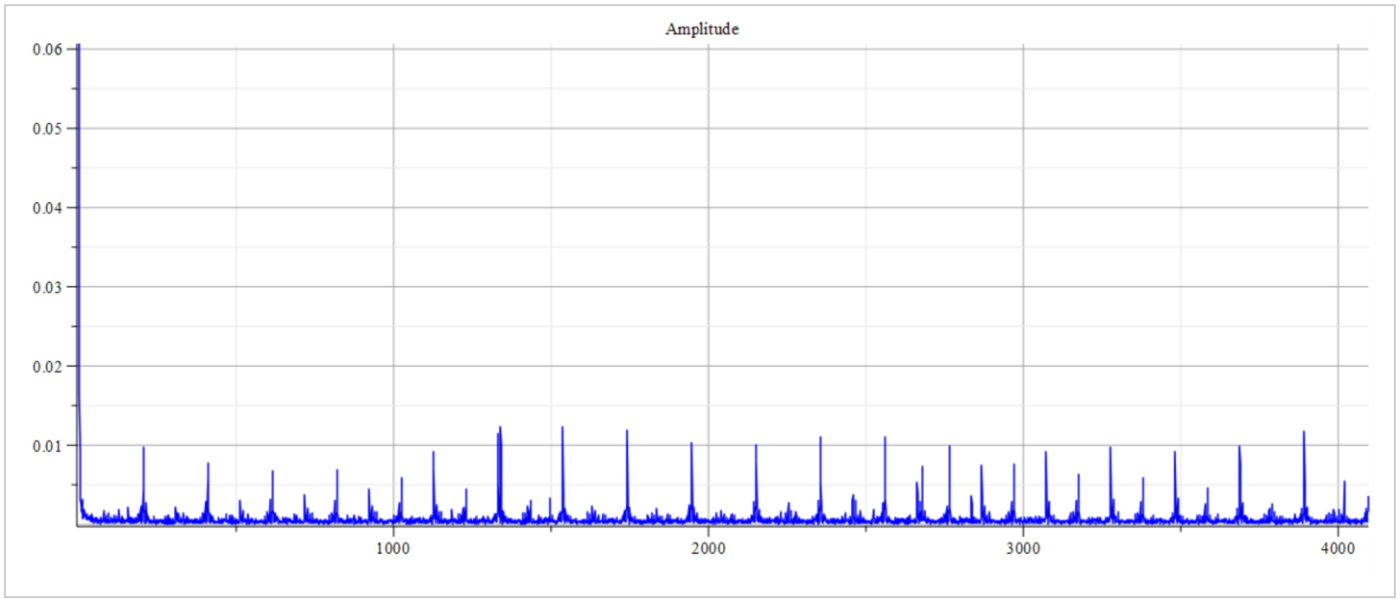


Figure 35

Frequency spectrum for the following parameters: $\omega = 10^{15}\ [\frac{1}{s}]\ \ E_m = 7\ 10^{16}\ [\frac{V}{m}]\ \ E_f = -8\ 10^{17}\ [\frac{V}{m}]$

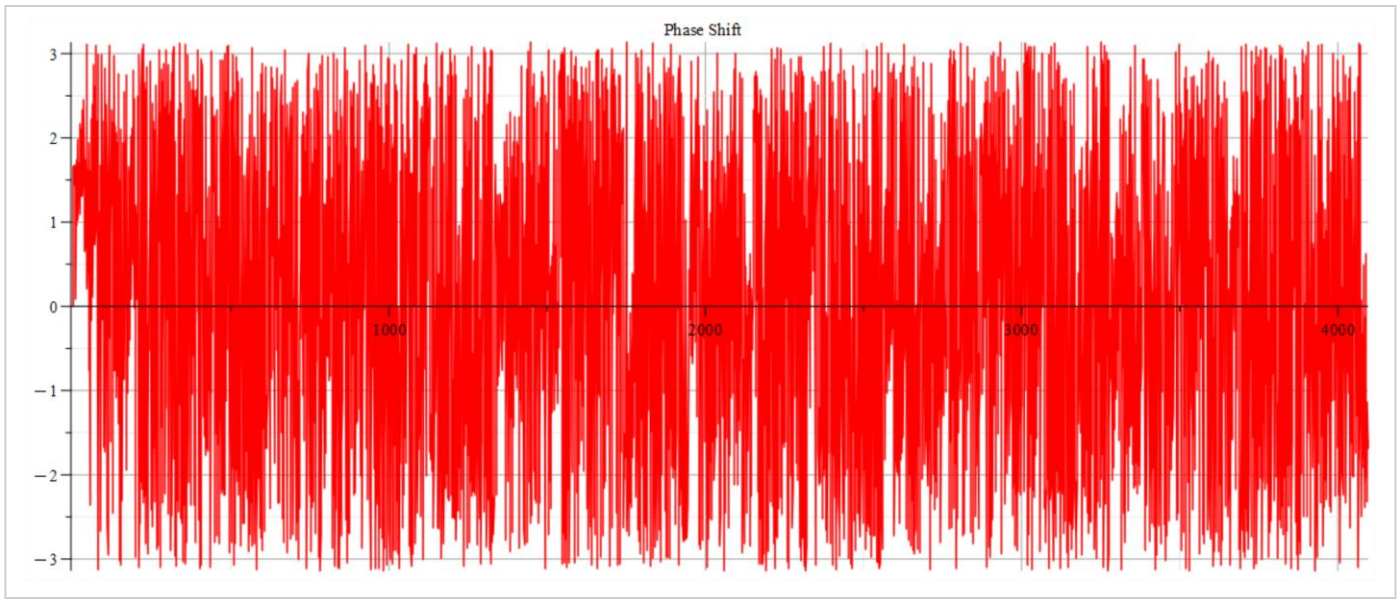


Figure 36

Phase shift for the following parameters: $\omega = 10^{15}\ [\frac{1}{s}]\ \ E_m = 7\ 10^{16}\ [\frac{V}{m}]\ \ E_f = -8\ 10^{17}\ [\frac{V}{m}]$

The frequency spectrum plots are the same. There are some differences in the phase behavior.

From the Fourier frequency analysis, we see that the main frequency is:

$f_0 = 1.6\ *\ 2\ 10^{14}\ [Hz]$

In general, the main frequency and harmonics are given by the following formula:

$f_n = f_0 + nf_0, \quad n = 0, 1, 2, 3..$

III.b Refractive Index Analysis due to Force caused by Static Field plus Wave (5) – Total Energy Transmission

When the nucleus is under the action of external forces, and if it doesn't break apart, then we can assume that a dynamic equilibrium state must exist. Under such circumstances, Newton's second law requires that the sum of forces be equal to zero, $\vec{F}_{net} + \vec{F}_{ext} = 0$, that is,

$$F_{net} = -F_{ext} \qquad (13)$$

Recall that the net nuclear force has already been written in terms of the index of refraction in Part-1, Eq. (23a):

$$\vec{F}_{net} = -\frac{378k\,q^2}{r_{ep}^2(t)}\left(1 - \frac{1}{n^2} + \frac{v_{ep}^2(t) r_{ep}(t) a_{ep}(t)}{n^2 c^2} + \frac{1}{n^4} + \frac{2 r_{ep}(t) a_{ep}(t)}{c^2}\right)\hat{r} + \frac{2279.035793k\,q^2\hat{r}}{r_n^2}$$

Now we can equate the forces according to Eq. (13), then solve for "n",

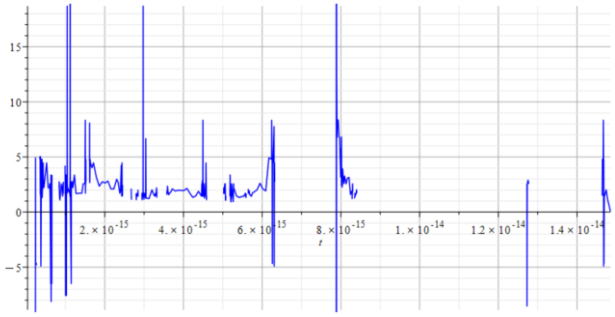
$$-\frac{3.410^{12}\cdot q^2\left(1-\frac{1}{n^2}+\frac{r_{ep}(t)a_{ep}(t)}{n^2c^2}+\frac{1}{n^4}+\frac{2r_{ep}(t)a_{ep}(t)}{c^2}\right)}{r_{ep}^2(t)} + \frac{2.0510^{13}\cdot q^2}{r_n^2} = -\frac{\pi\varepsilon_0 E_m^2}{6K^3 r_n}\cdot(2K^3 r_n^3 + 6K^2\cos(\omega t)\sin(\omega t)\,r_n^2 + 6K\cos^2(r_nK-\omega t)\,r_n + 6K\sin^2(r_nK-\omega t)\,r_n - 6K\sin^2(\omega t)\,r_n - 6\cos^2(r_nK-\omega t)\,\omega t - 6\sin^2(r_nK-\omega t)\,\omega t + 6\cos^2(\omega t)\,\omega t + 6\sin^2(\omega t)\,\omega t - 3r_nK - 3\cos(r_nK-\omega t)\sin(r_nK-\omega t) - 3\cos(\omega t)\sin(\omega t))$$

The refractive index "n" is a somewhat long-expression which is nonsense to copy here. Some plots as examples are shown below, where the main used parameters are:

$r_n = 3.5\ 10^{-15}\ [m]$; $A_e = 2\ 10^{-16}\ [m]$; $A_p = 10^{-3}A_e\ [m]$; $N_0 = 378$; $N_s = 312$

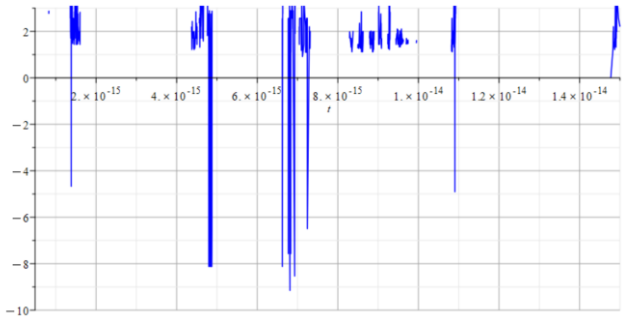
$\omega_e = 10^{15}\ [\frac{1}{s}]$; $\omega_p = 10^{16}\ [\frac{1}{s}]$

While for the wave: $K = \frac{\omega}{c}$



$+\boldsymbol{E_f}$

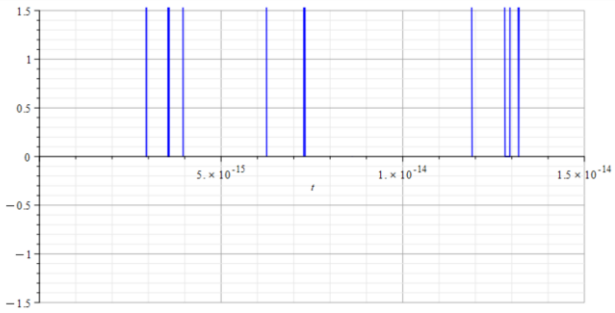
Refractive Index vs. time for the following parameters: $\omega = 1.6\ 10^{15}\ [\frac{1}{s}]$ $E_m = 10^{17}\ [\frac{V}{m}]$ $E_f = 10^{18}\ [\frac{V}{m}]$



$-\boldsymbol{E_f}$

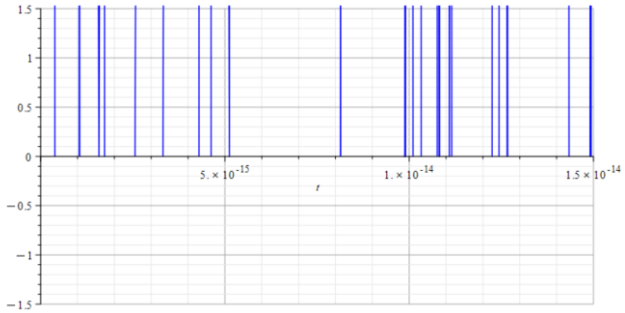
Refractive Index vs. time for the following parameters: $\omega = 1.6\ 10^{15}\ [\frac{1}{s}]$ $E_m = 10^{17}\ [\frac{V}{m}]$ $E_f = -10^{18}\ [\frac{V}{m}]$

Figure 37



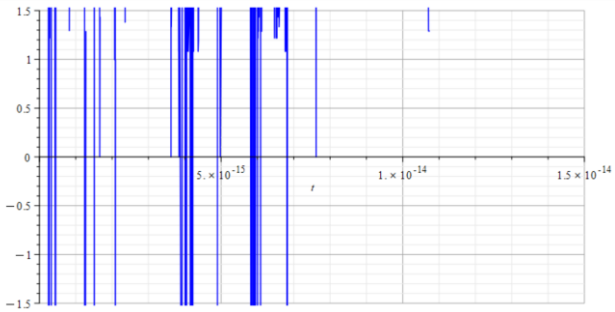
$+\boldsymbol{E_f}$

Refractive Index vs. time for the following parameters: $\omega = 10^8\ [\frac{1}{s}]\ \ E_m = 10^{15}\ [\frac{V}{m}]\ \ E_f = 10^{17}\ [\frac{V}{m}]$



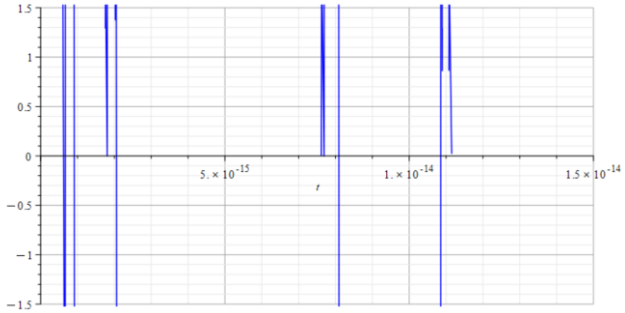
$-\boldsymbol{E_f}$

Figure 38 *Refractive Index vs. time for the following parameters:* $\omega = 10^8\ [\frac{1}{s}]\ \ E_m = 10^{15}\ [\frac{V}{m}]\ \ E_f = -10^{17}\ [\frac{V}{m}]$



$+\boldsymbol{E_f}$

Refractive Index vs. time for the following parameters: $\omega = 10^{15}\ [\frac{1}{s}]\ \ E_m = 7\ 10^{16}\ [\frac{V}{m}]\ \ E_f = 8\ 10^{17}\ [\frac{V}{m}]$



$-\boldsymbol{E_f}$

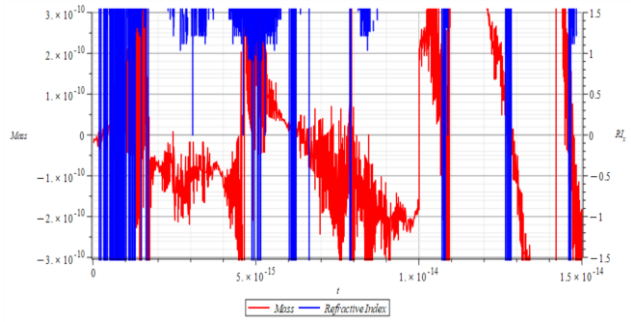
Figure 39 *Refractive Index vs. time for the following parameters:* $\omega = 10^{15}\ [\frac{1}{s}]\ \ E_m = 7\ 10^{16}\ [\frac{V}{m}]\ \ E_f = -8\ 10^{17}\ [\frac{V}{m}]$

The refractive index derived from the integration that gave force (5) shows bizarre values and might not be considered as valid in this case. It is also possible that the graph engine threw such unreal values at asymptotic points due to the extreme oscillatory behavior of the mass in these cases.

III.c Comparison of Mass with Refractive Index Behavior due to Force caused by Static Field plus Wave (5) – Total Energy Transmission

To analyze the changes in the refractive index "n" with respect to changes in nuclear mass, overlaid graphs of both quantities are shown below, which uncover interesting results.

While for the wave: $K = \frac{\omega}{c}$

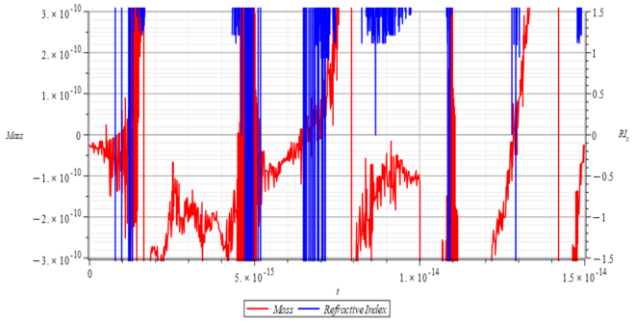


$+E_f$

Figure 40

Mass & Refractive Index vs. time for the following parameters:

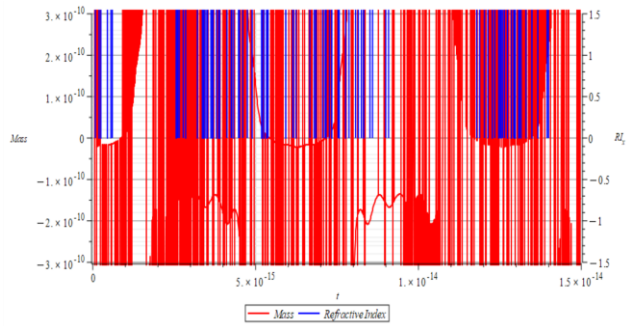
$\omega = 1.6\ 10^{15}\ [\frac{1}{s}]\ \ E_m = 10^{17}\ [\frac{V}{m}]\ \ E_f = 10^{18}\ [\frac{V}{m}]$



$-E_f$

Mass & Refractive Index vs. time for the following parameters:

$\omega = 1.6\ 10^{15}\ [\frac{1}{s}]\ \ E_m = 10^{17}\ [\frac{V}{m}]\ \ E_f = -10^{18}\ [\frac{V}{m}]$

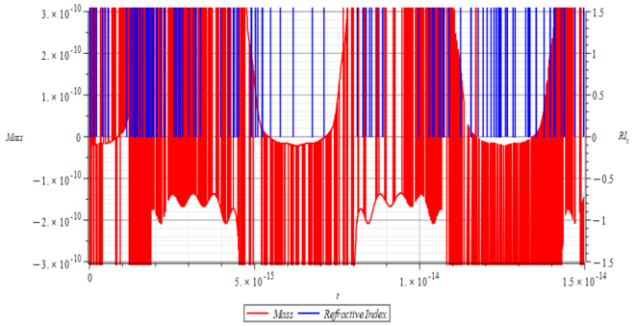


$+E_f$

Figure 41

Mass & Refractive Index vs. time for the following parameters:

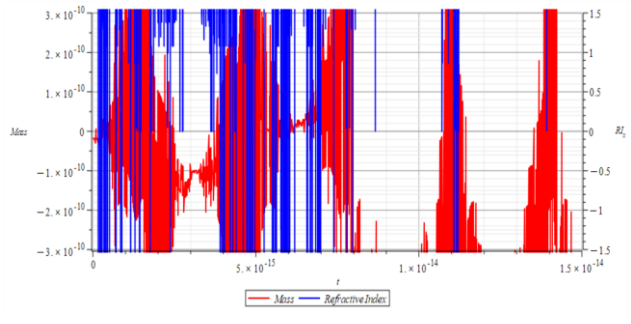
$\omega = 10^{8}\ [\frac{1}{s}]\ \ E_m = 10^{15}\ [\frac{V}{m}]\ \ E_f = 10^{17}\ [\frac{V}{m}]$



$-E_f$

Mass & Refractive Index vs. time for the following parameters:

$\omega = 10^{8}\ [\frac{1}{s}]\ \ E_m = 10^{15}\ [\frac{V}{m}]\ \ E_f = -10^{17}\ [\frac{V}{m}]$

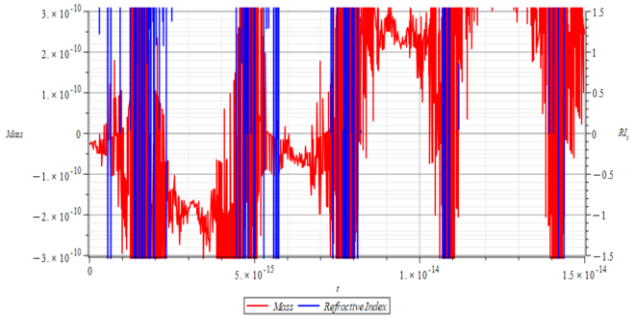


$+E_f$

Figure 42

Mass & Refractive Index vs. time for the following parameters:

$\omega = 10^{15}\ [\frac{1}{s}]\ \ E_m = 7\ 10^{16}\ [\frac{V}{m}]\ \ E_f = 8\ 10^{17}\ [\frac{V}{m}]$



$-E_f$

Mass & Refractive Index vs. time for the following parameters:

$\omega = 10^{15}\ [\frac{1}{s}]\ \ E_m = 7\ 10^{16}\ [\frac{V}{m}]\ \ E_f = -8\ 10^{17}\ [\frac{V}{m}]$

As stated in the previous paragraph, it is impossible to make any comparison between mass and refractive index in these cases, because the high-frequency oscillations of the mass yield very

sharp changes in the refractive index. As a result, it is highly probable that the graph engine can't follow such changes the right way.

IV.a Nuclear Mass Analysis due to Force caused by Static Field plus Wave (6) – Energy Absorption/Transmission

The intrinsic net force in the nucleus was already defined with Eq. (23) in Part-1. Now we have the action of an external force acting on the nucleus that will interact with the internal force. By applying Newton's second law, we have

$$\sum F = m_n \cdot a_{ep} = F_{net} + F_{ext} \qquad => \qquad m_n \cdot a_{ep} = F_{net} + F_{ext}$$

$$m_n = \frac{1}{a_{ep}} \cdot (F_{net} + F_{ext}) \qquad (14)$$

By replacing the forces in (14), we obtain the expression of the nuclear mass for this case:

$$m_n = \frac{1}{a_{ep}(t)} \cdot \left(-\frac{3.410^{12} \cdot q^2 \left(1 - \frac{v_{ep}^2(t)}{c^2} + \frac{v_{ep}^2(t) r_{ep}(t) a_{ep}(t)}{c^4} + \frac{v_{ep}^4(t)}{c^4} + \frac{2 r_{ep}(t) a_{ep}(t)}{c^2}\right)}{r_{ep}^2(t)} + \frac{2.0510^{13} \cdot q^2}{r_n^2} + \frac{2\varepsilon_0 \omega}{3c\,K^3} \cdot \right.$$

$$\left(-\frac{3E_m^2 \sin(2Kr_n - 2\omega t)}{8} - 12E_f E_m \sin(Kr_n - \omega t) + \frac{3\left(K^2 r_n^2 - \frac{1}{2}\right) E_m^2 \sin(2\omega t)}{4} + \frac{3E_m^2 r_n K \cos(2\omega t)}{4} + \right.$$

$$\left. \left. 6E_f E_m (K^2 r_n^2 - 2) \sin(\omega t) + r_n \left(12E_f E_m \cos(\omega t) + K^2 r_n^2 \left(E_f^2 + \frac{E_m^2}{2} \right) \right) K \right) \right) \qquad (15)$$

Recall that:

$$r_{ep}(t) = \left(0.37 r_n + A_e \cos(\omega_e t) - A_p \cos(\omega_p t)\right)$$

$$v_{ep}(t) = \left(-A_e \omega_e \sin(\omega_e t) + A_p \sin(\omega_p t)\, \omega_p\right)$$

$$a_{ep}(t) = \left(-A_e \omega_e^2 \cos(\omega_e t) + A_p \omega_p^2 \cos(\omega_p t)\right)$$

Some graphs as examples are shown below to have a perception of what could be done to modify the nuclear mass magnitude and sign.

The main parameters used for the net force are:

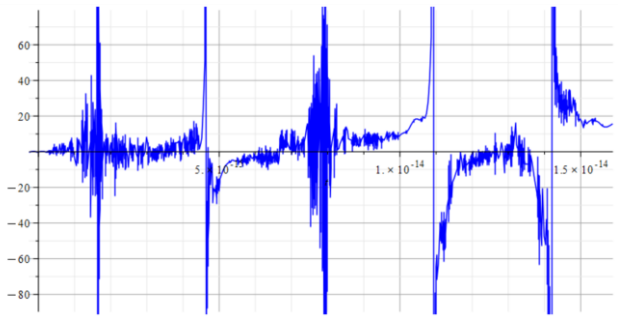
$r_n = 3.5\ 10^{-15}\ [m]; \quad A_e = 2\ 10^{-16}\ [m]; \quad A_p = 10^{-3} A_e\ [m]; \quad N_0 = 378; \quad N_s = 312$

$\omega_e = 10^{15}\ [\frac{1}{s}]; \qquad \omega_p = 10^{16}\ [\frac{1}{s}]$

While for the wave: $K = \frac{\omega}{c}$ and $K = \frac{\omega}{v_{ep}(t)}$

Time Analysis of the Nuclear Mass for Wave Velocity "c" and "$v_{ep}(t)$" and electric field polarity ± E_f

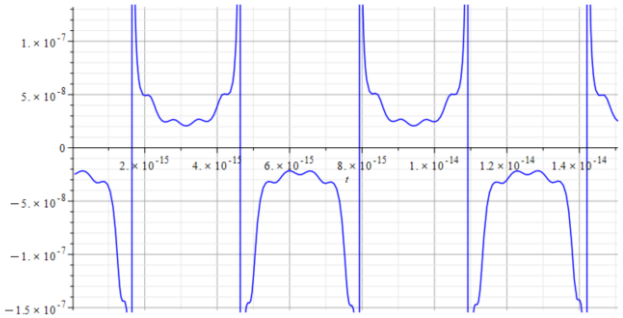
For + E_f



$$\mathbf{K} = \frac{\boldsymbol{\omega}}{\mathbf{c}}$$

Mass vs. time for the following parameters:

$\omega = 6\ 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = 3\ 10^{27}\ [\frac{V}{m}]$



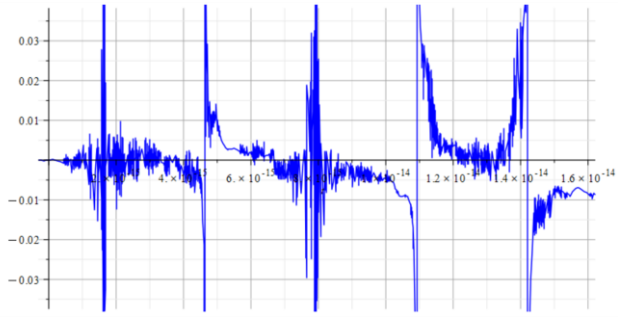
$$\mathbf{K} = \frac{\boldsymbol{\omega}}{\mathbf{v_{ep}(t)}}$$

Mass vs. time for the following parameters:

$\omega = 6\ 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = 3\ 10^{27}\ [\frac{V}{m}]$

Figure 43

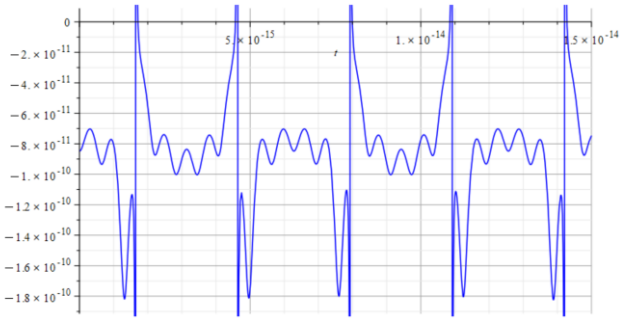
For - E_f



$$\boldsymbol{K} = \frac{\boldsymbol{\omega}}{\boldsymbol{c}}$$

Mass vs. time for the following parameters:

$\omega = 6\ 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{24}\ [\frac{V}{m}]\ \ E_f = -1.5\ 10^{26}\ [\frac{V}{m}]$



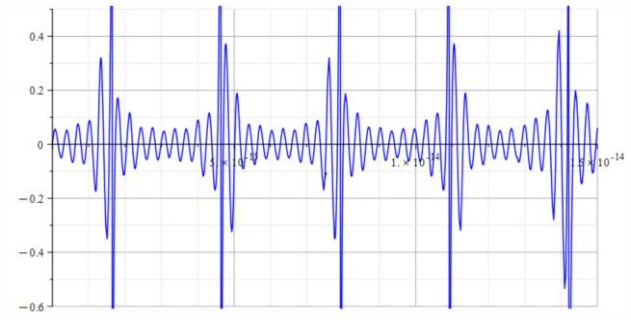
$$\boldsymbol{K} = \frac{\boldsymbol{\omega}}{\boldsymbol{v_{ep}(t)}}$$

Mass vs. time for the following parameters:

$\omega = 6\ 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{24}\ [\frac{V}{m}]\ \ E_f = -1.5\ 10^{26}\ [\frac{V}{m}]$

Figure 44

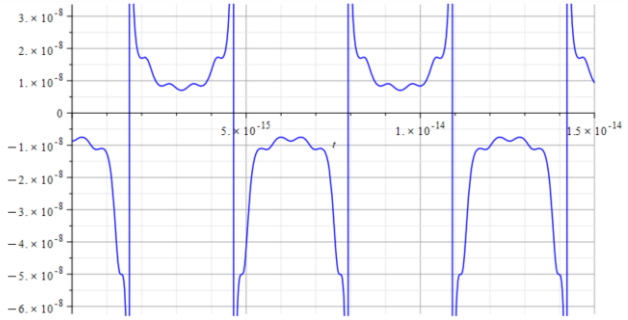
For + E_f



$$K = \frac{\omega}{c}$$

Mass vs. time for the following parameters:

$\omega = 2\ 10^{16}\ [\frac{1}{s}]\ \ E_m = 8\ 10^{25}\ [\frac{V}{m}]\ \ E_f = 3\ 10^{26}\ [\frac{V}{m}]$



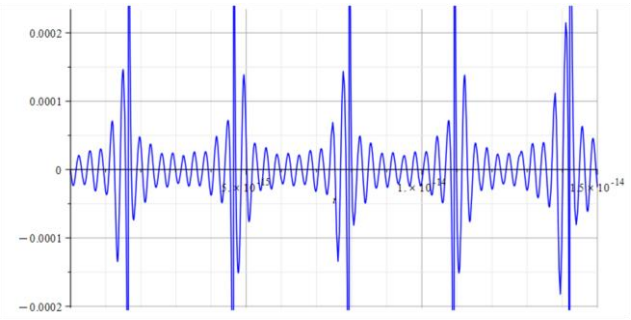
$$K = \frac{\omega}{v_{ep}(t)}$$

Mass vs. time for the following parameters:

$\omega = 2\ 10^{16}\ [\frac{1}{s}]\ \ E_m = 8\ 10^{25}\ [\frac{V}{m}]\ \ E_f = 3\ 10^{26}\ [\frac{V}{m}]$

Figure 45

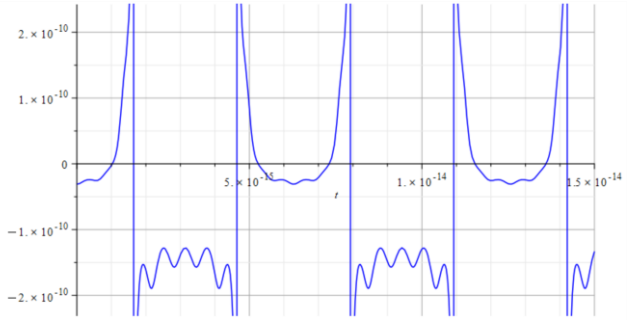
For - E_f



$$K = \frac{\omega}{c}$$

Mass vs. time for the following parameters:

$\omega = 2\ 10^{16}\ [\frac{1}{s}]\ \ E_m = 10^{24}\ [\frac{V}{m}]\ \ E_f = -10^{25}\ [\frac{V}{m}]$



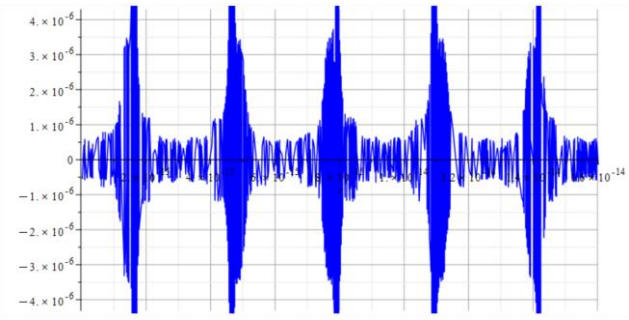
$$K = \frac{\omega}{v_{ep}(t)}$$

Mass vs. time for the following parameters:

$\omega = 2\ 10^{16}\ [\frac{1}{s}]\ \ E_m = 10^{24}\ [\frac{V}{m}]\ \ E_f = -10^{25}\ [\frac{V}{m}]$

Figure 46

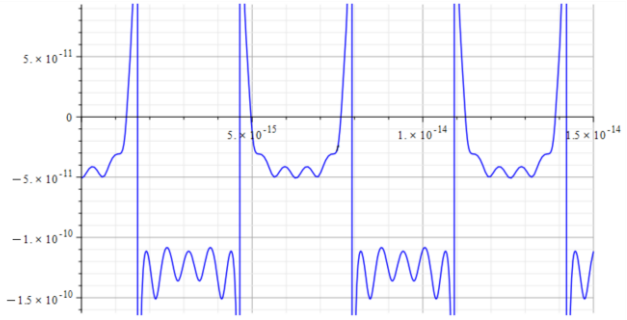
For + E_f



$$K = \frac{\omega}{c}$$

Mass vs. time for the following parameters:

$\omega = 10^{18}\ [\frac{1}{s}]\ \ E_m = 10^{23}\ [\frac{V}{m}]\ \ E_f = 2.5\ 10^{24}\ [\frac{V}{m}]$



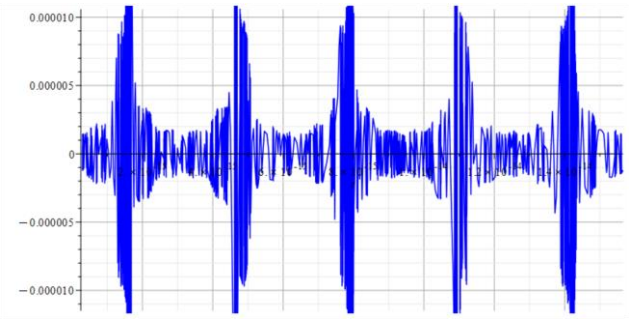
$$K = \frac{\omega}{v_{ep}(t)}$$

Mass vs. time for the following parameters:

$\omega = 10^{18}\ [\frac{1}{s}]\ \ E_m = 10^{23}\ [\frac{V}{m}]\ \ E_f = 2.5\ 10^{24}\ [\frac{V}{m}]$

Figure 47

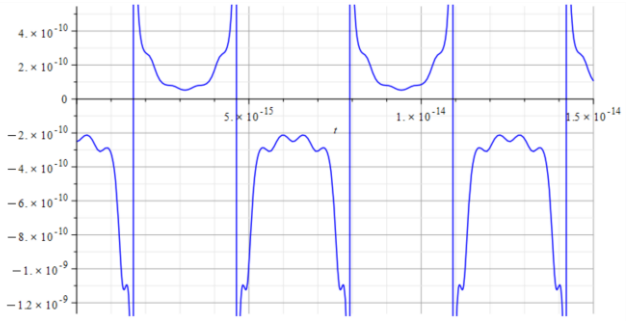
For - E_f



$$K = \frac{\omega}{c}$$

Mass vs. time for the following parameters:

$\omega = 10^{18}\ [\frac{1}{s}]\ \ E_m = 10^{23}\ [\frac{V}{m}]\ \ E_f = -7\ 10^{24}\ [\frac{V}{m}]$



$$K = \frac{\omega}{v_{ep}(t)}$$

Mass vs. time for the following parameters:

$\omega = 10^{18}\ [\frac{1}{s}]\ \ E_m = 10^{23}\ [\frac{V}{m}]\ \ E_f = -7\ 10^{24}\ [\frac{V}{m}]$

Figure 48

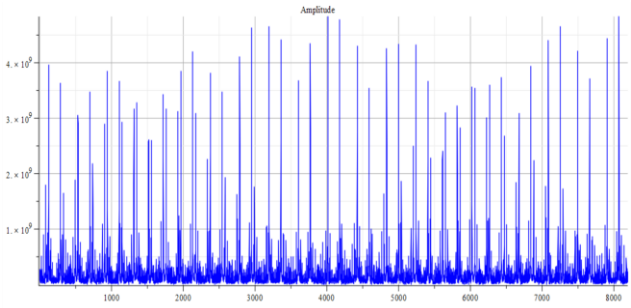
From the period of the mass plot, we determine that the oscillation frequency is approximately:

$f = 1.6\ 10^{14}\ [Hz]$

Frequency Analysis of the Nuclear Mass with FFT for Wave Velocity "c" and Electric field Polarity ± E_f

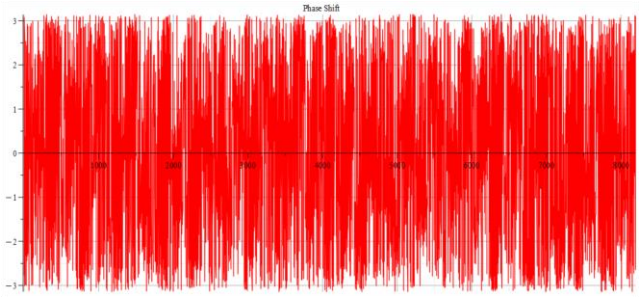
Total number of samples $N = 2^{14}\ or\ 2^{15}$, sampling frequency $f_s \geq 2^3 f_w$ (wave frequency), which gives a frequency resolution $\Delta f = \frac{f_s}{N}[Hz]$ and a total acquisition time of $T = \frac{N}{f_s}[s]$. The frequency at the *i*-sample number on the plot is determined by $f = \frac{N_{(i)}}{T}\ [Hz]$.

For +E_f



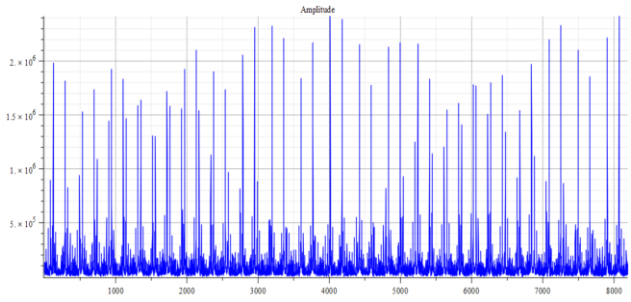
Frequency spectrum for the following parameters:
$\omega = 6\ 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ \ E_f = 3\ 10^{27}\ [\frac{V}{m}]$

Figure 49
$\boldsymbol{K = \frac{\omega}{c}}$



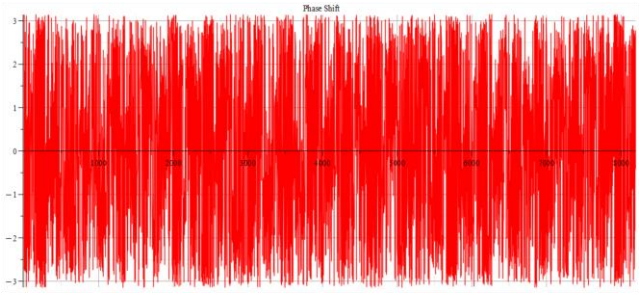
Phase shift for the same parameters

For -E_f



Frequency spectrum for the following parameters:
$\omega = 6\ 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{24}\ [\frac{V}{m}]\ \ \ E_f = -1.5\ 10^{26}\ [\frac{V}{m}]$

Figure 50
$\boldsymbol{K = \frac{\omega}{c}}$



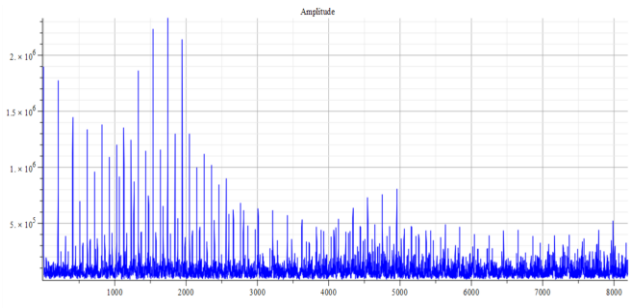
Phase shift for the same parameters

Both frequency spectrum plots are very similar, but phase behavior differs. The spectrum contains many frequencies, being the main measured at the small amplitudes near the origin to be: $f_0 = 2.33\ 10^{12}\ [Hz]$. In general, the main frequency and harmonics are given by the following formula: $f_n = f_0 + nf_0,\ \ n = 0, 1, 2, 3\ldots$, and for this case,

$f_n = 2.33\ 10^{12} + n\ 7\ 10^{12}\ [Hz]$.

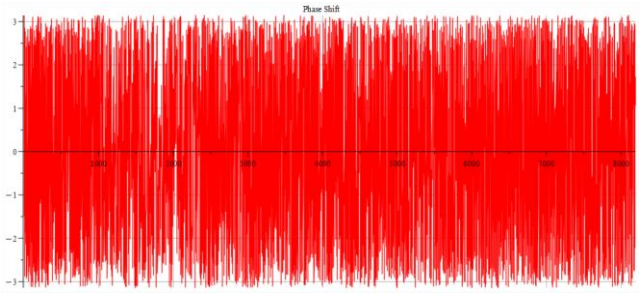
There is a visible repetition pattern of high amplitude mirrored double peaks which repeat periodically. However, it's somewhat difficult to determine the repetition frequency.

For $+E_f$



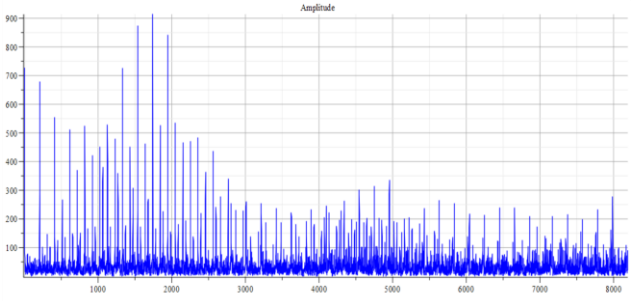
Frequency spectrum for the following parameters:
$\omega = 2\ 10^{16}\ [\frac{1}{s}]\ \ E_m = 8\ 10^{25}\ [\frac{V}{m}]\ \ \ E_f = 3\ 10^{26}\ [\frac{V}{m}]$

Figure 51
$\boldsymbol{K = \frac{\omega}{c}}$



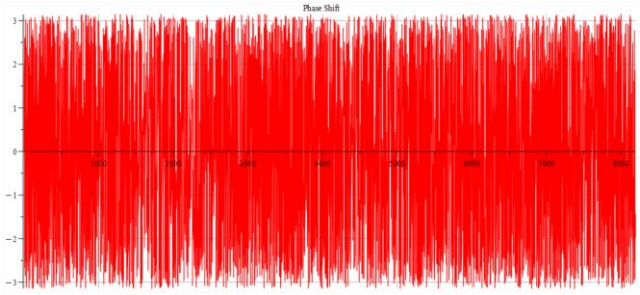
Phase shift for the same parameters

For $-E_f$



Frequency spectrum for the following parameters:
$\omega = 2\ 10^{16}\ [\frac{1}{s}]\ \ E_m = 10^{24}\ [\frac{V}{m}]\ \ \ E_f = -10^{25}\ [\frac{V}{m}]$

Figure 52
$\boldsymbol{K = \frac{\omega}{c}}$

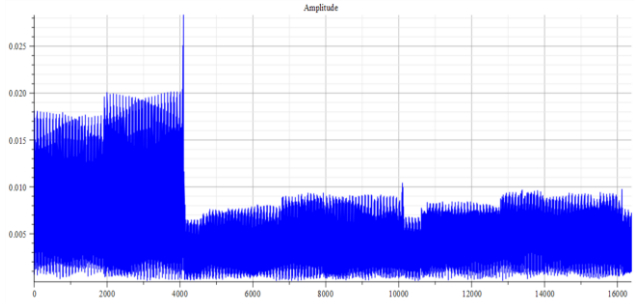


Phase shift for the same parameters

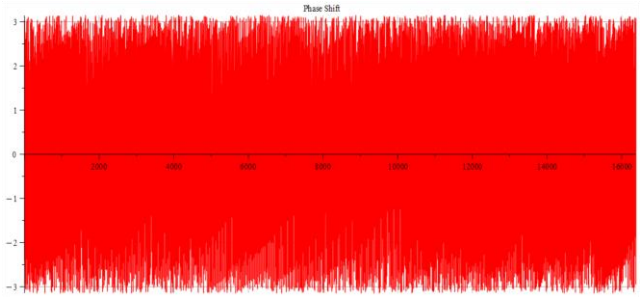
Both frequency spectrum plots are very similar, but phase behavior differs. The spectrum contains many frequencies, but by measuring the high amplitude peaks we get the main frequency to be: $f_0 = 2\ *\ 1.6\ 10^{14}\ [\mathrm{Hz}]$. In general, the main frequency and harmonics are given by the following formula: $f_n = f_0 + \mathrm{n} f_0,\ \ \mathrm{n} = 0,\ 1,\ 2,\ 3$ ..., and for this case,

$f_n = 2\ *1.6\ 10^{14} + n\ 2\ *\ 1.6\ 10^{14}\ [Hz]$.

For $+E_f$



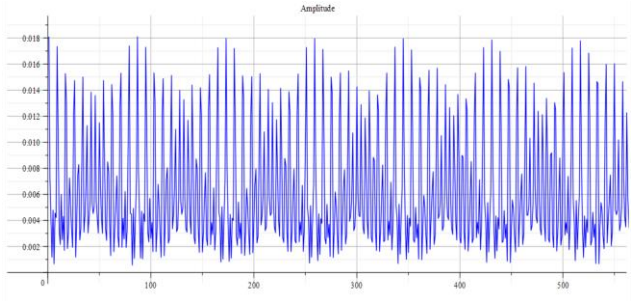
Frequency spectrum for the following parameters:
$\omega = 10^{18}\ [\frac{1}{s}]\ \ E_m = 10^{23}\ [\frac{V}{m}]\ \ \ E_f = 2.5\ 10^{24}\ [\frac{V}{m}]$



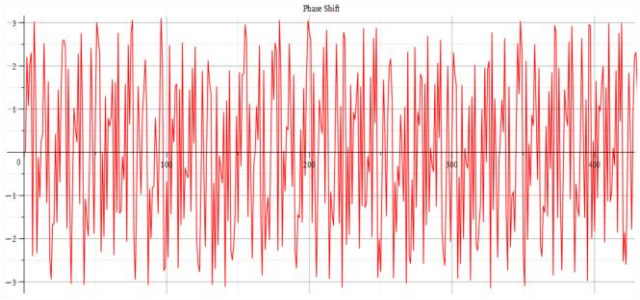
Phase shift for the same parameters

Figure 53
$\boldsymbol{K = \frac{\omega}{c}}$

For $+E_f$ (expanded)



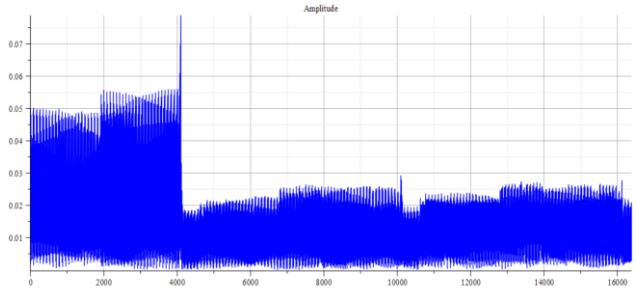
Frequency spectrum for the following parameters:
$\omega = 10^{18}\ [\frac{1}{s}]\ \ E_m = 10^{23}\ [\frac{V}{m}]\ \ \ E_f = 2.5\ 10^{24}\ [\frac{V}{m}]$



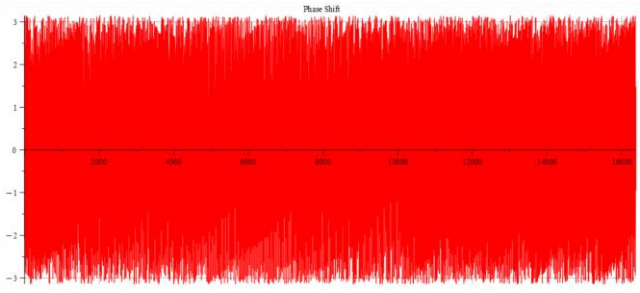
Phase shift for same parameters

Figure 54
$\boldsymbol{K = \frac{\omega}{c}}$

For $-E_f$



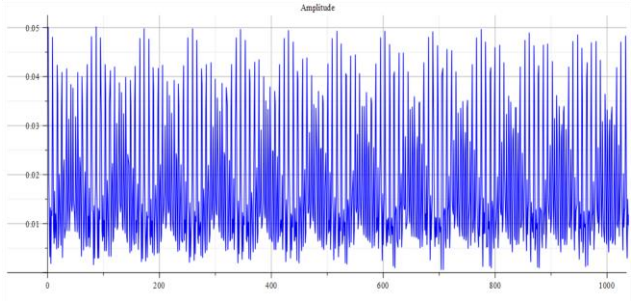
Frequency spectrum for the following parameters:
$\omega = 10^{18}\ [\frac{1}{s}]\ \ E_m = 10^{23}\ [\frac{V}{m}]\ \ \ E_f = -7\ 10^{24}\ [\frac{V}{m}]$



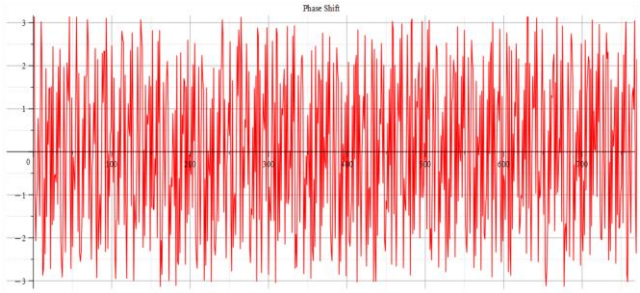
Phase shift for the same parameters

Figure 55
$\boldsymbol{K = \frac{\omega}{c}}$

For -E_f (expanded)



Frequency spectrum for the following parameters:
$\omega = 10^{18}\ [\frac{1}{s}]\quad E_m = 10^{23}\ [\frac{V}{m}]\quad E_f = -7\ 10^{24}\ [\frac{V}{m}]$



Phase shift for the same parameters

Figure 56
$\boldsymbol{K = \frac{\omega}{c}}$

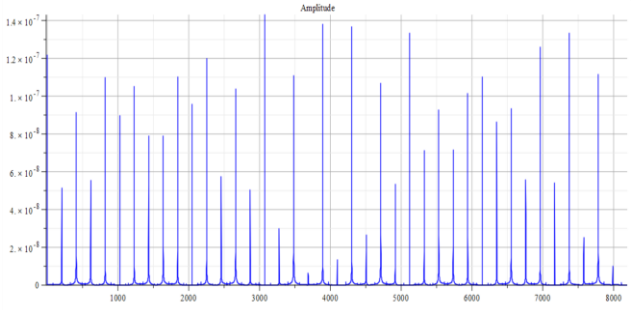
Both frequency spectrum plots are very similar, but phase behavior differs. The spectrum contains many frequencies, but by measuring the high amplitude peaks, we get the main frequency to be: $f_0 = 3.5\ 10^{14}\ [Hz]$. In general, the main frequency and harmonics are given by the following formula: $f_n = f_0 + nf_0,\quad n = 0, 1, 2, 3\ldots$, and for this case,

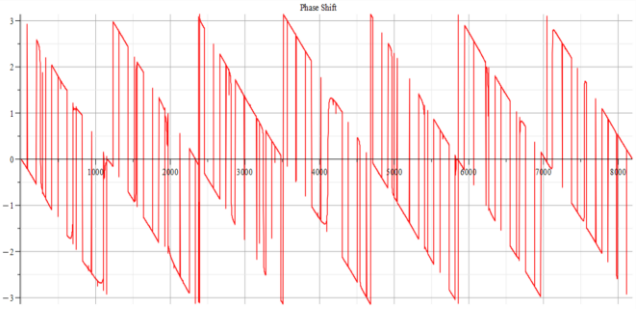
$f_n = 3.5\ 10^{14} + n\ 3.1\ 10^{14}\ [Hz]$.

Frequency Analysis of the Nuclear Mass with FFT for Wave Velocity "$v_{ep}(t)$" and Electric Field Polarity ± E_f

Total number of samples $N = 2^{14}\ or\ 2^{15}$, sampling frequency $f_s \geq 2^3 f_w$ (wave frequency), which gives a frequency resolution $\Delta f = \frac{f_s}{N}[Hz]$ and a total acquisition time of $T = \frac{N}{f_s}[s]$. The frequency at the *i*-sample number on the plot is determined by $f = \frac{N_{(i)}}{T}\ [Hz]$.

For +E_f



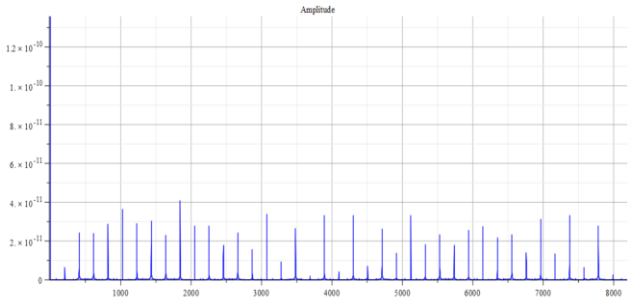


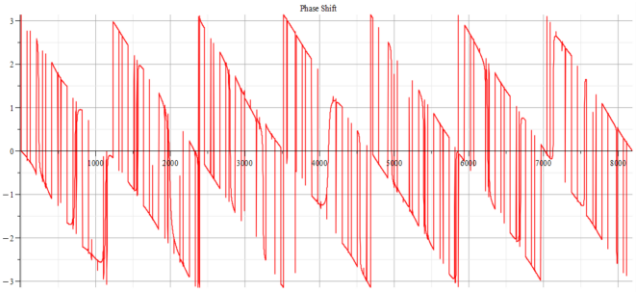
Frequency spectrum for the following parameters: $\omega = 6\ 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ \ E_f = 3\ 10^{27}\ [\frac{V}{m}]$

Figure 57 $\mathbf{K = \frac{\omega}{v_{ep}(t)}}$

Phase shift for the same parameters

For -E_f





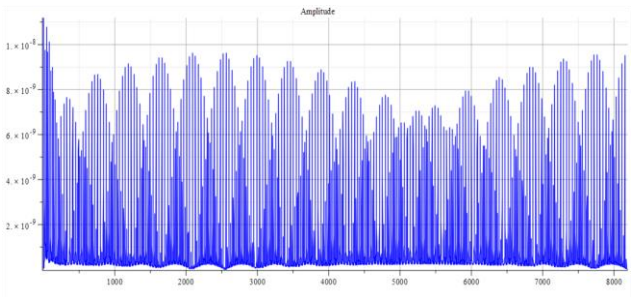
Frequency spectrum for the following parameters: $\omega = 6\ 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{24}\ [\frac{V}{m}]\ \ \ E_f = -1.5\ 10^{26}\ [\frac{V}{m}]$

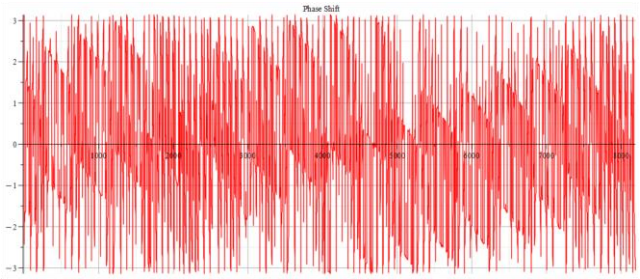
Figure 58 $\boldsymbol{K = \frac{\omega}{v_{ep}(t)}}$

Phase shift for the same parameters

We get the main frequency to be: $f_0 = 1.6\ 10^{14}\ [Hz]$. In general, the main frequency and harmonics are given by the following formula: $f_n = f_0 + nf_0,\ \ \ n = 0, 1, 2, 3..$

For +E_f



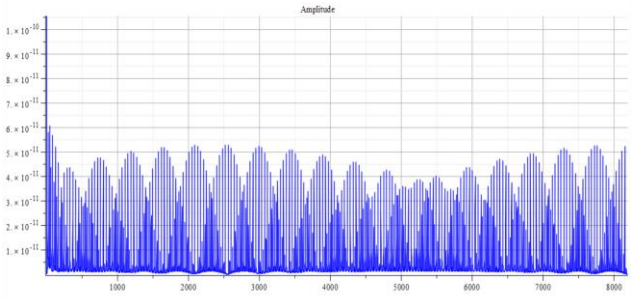


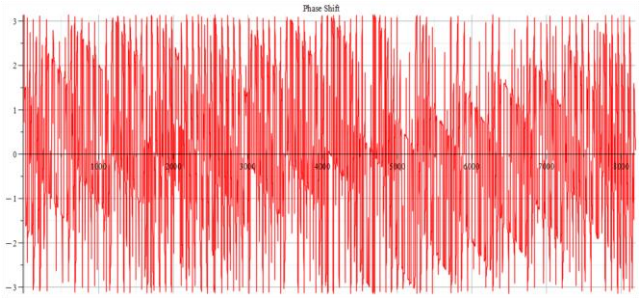
Frequency spectrum for the following parameters: $\omega = 2\ 10^{16}\ [\frac{1}{s}]\ \ E_m = 8\ 10^{25}\ [\frac{V}{m}]\ \ \ E_f = 3\ 10^{26}\ [\frac{V}{m}]$

Figure 59 $\boldsymbol{K = \frac{\omega}{v_{ep}(t)}}$

Phase shift for the same parameters

For -E_f





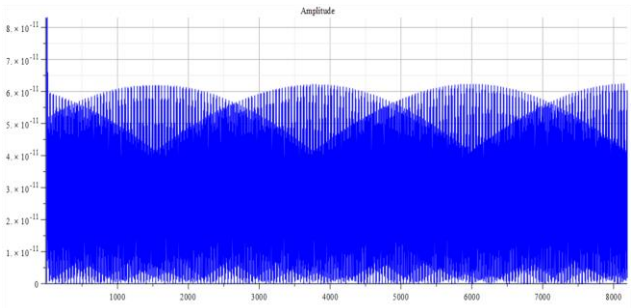
Frequency spectrum for the following parameters: $\omega = 2\ 10^{16}\ [\frac{1}{s}]\ \ E_m = 10^{24}\ [\frac{V}{m}]\ \ \ E_f = -10^{25}\ [\frac{V}{m}]$

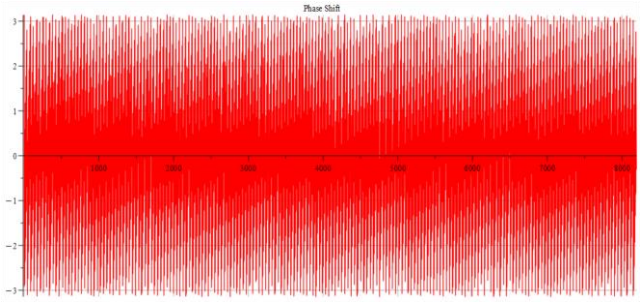
Figure 60 $\boldsymbol{K = \frac{\omega}{v_{ep}(t)}}$

Phase shift for the same parameters

We get the main frequency to be: $f_0 = 1.6\ 10^{14}\ [Hz]$. In general, the main frequency and harmonics are given by the following formula: $f_n = f_0 + nf_0, \ \ n = 0, 1, 2, 3..$

For +E_f



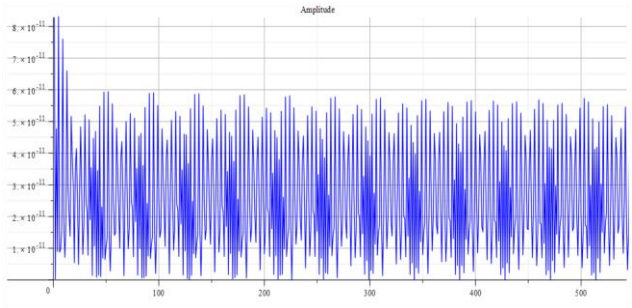


Frequency spectrum for the following parameters: $\omega = 10^{18}\ [\frac{1}{s}]\ \ E_m = 10^{23}\ [\frac{V}{m}]\ \ \ E_f = 2.5\ 10^{24}\ [\frac{V}{m}]$

Figure 61 $\boldsymbol{K = \frac{\omega}{v_{ep}(t)}}$

Phase shift for the same parameters

For $+E_f$ (expanded)



Frequency spectrum for the following parameters:
$\omega = 10^{18}\ [\frac{1}{s}]\ \ E_m = 10^{23}\ [\frac{V}{m}]\ \ \ E_f = 2.5\ 10^{24}\ [\frac{V}{m}]$

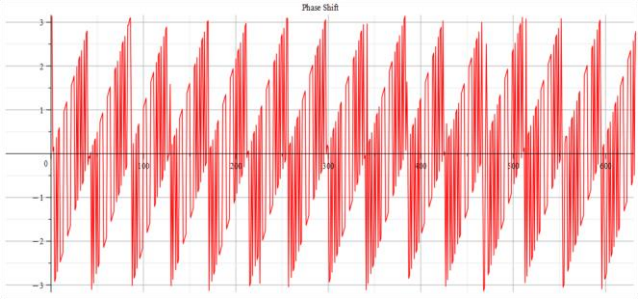
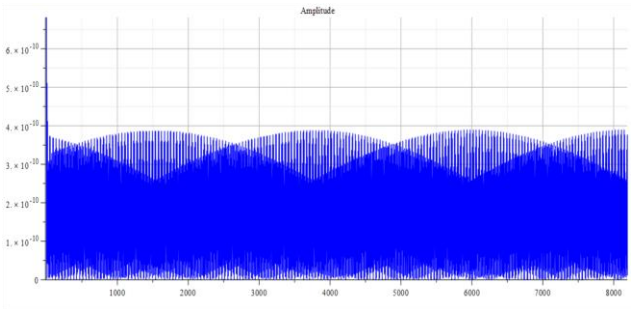


Figure 62
$\boldsymbol{K = \frac{\omega}{v_{ep}(t)}}$

Phase shift for the same parameters

For $-E_f$



Frequency spectrum for the following parameters:
$\omega = 10^{18}\ [\frac{1}{s}]\ \ E_m = 10^{23}\ [\frac{V}{m}]\ \ \ E_f = -7\ 10^{24}\ [\frac{V}{m}]$

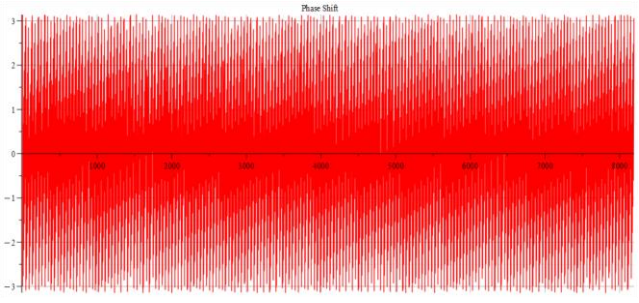


Figure 63
$\boldsymbol{K = \frac{\omega}{v_{ep}(t)}}$

Phase shift for the same parameters

Expanded graphs for $-E_f$ look like those for $+E_f$.

We get the main frequency to be: $f_0 = 3.8\ 10^{14}\ [Hz]$. In general, the main frequency and harmonics are given by the following formula: $f_n = f_0 + nf_0, \quad n = 0, 1, 2, 3\ldots$, and for this case,

$f_n = 3.8\ 10^{14} + n\ *\ 2\ *\ 1.6\ 10^{14}\ [Hz]$.

IV.b Refractive Index Analysis due to Wave Force (6) for Wave Velocity "c" and "$v_{ep}(t)$" and Electric Field Polarity ± E_f

When the nucleus is under the action of external forces, and if it doesn't break apart, then we can assume that a dynamic equilibrium state must exist. Under such circumstances, Newton's second law requires that the sum of forces be equal to zero, $\vec{F}_{net} + \vec{F}_{ext} = 0$, that is,

$$F_{net} = -F_{ext} \qquad (16)$$

Recall that the net nuclear force has already been written in terms of the index of refraction in Part-1, Eq. (23a):

$$\vec{F}_{net} = -\frac{378k\,q^2}{r_{ep}^2(t)}\left(1 - \frac{1}{n^2} + \frac{v_{ep}^2(t)r_{ep}(t)a_{ep}(t)}{n^2c^2} + \frac{1}{n^4} + \frac{2r_{ep}(t)a_{ep}(t)}{c^2}\right)\hat{r} + \frac{2279.035793k\,q^2\hat{r}}{r_n^2}$$

Now we can equate the forces according to Eq. (16), then solve for "n",

$$-\frac{3.410^{12}\cdot q^2\left(1-\frac{1}{n^2}+\frac{r_{ep}(t)a_{ep}(t)}{n^2c^2}+\frac{1}{n^4}+\frac{2r_{ep}(t)a_{ep}(t)}{c^2}\right)}{r_{ep}^2(t)} + \frac{2.0510^{13}\cdot q^2}{r_n^2} = -\frac{2\varepsilon_0\omega}{3c\,K^3}\cdot\left(-\frac{3E_m^2\sin(2Kr_n-2\omega t)}{8} - 12E_fE_m\sin(Kr_n-\omega t) + \frac{3\left(K^2r_n^2-\frac{1}{2}\right)E_m^2\sin(2\omega t)}{4} + \frac{3E_m^2r_nK\cos(2\omega t)}{4} + 6E_fE_m(K^2r_n^2-2)\sin(\omega t) + r_n\left(12E_fE_m\cos(\omega t) + K^2r_n^2\left(E_f^2+\frac{E_m^2}{2}\right)\right)K\right)$$

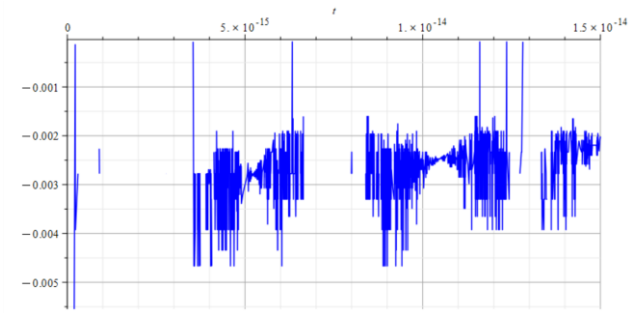
The refractive index "n" is a somewhat long-expression which is nonsense to copy here. Some plots as examples are shown below, where the main used parameters are:

$r_n = 3.5\,10^{-15}\,[m]$; $A_e = 2\,10^{-16}\,[m]$; $A_p = 10^{-3}A_e\,[m]$; $N_0 = 378$; $N_s = 312$

$\omega_e = 10^{15}\,[\frac{1}{s}]$; $\omega_p = 10^{16}\,[\frac{1}{s}]$

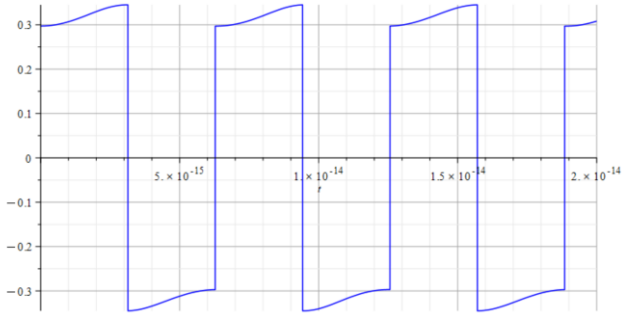
While for the wave: $K = \frac{\omega}{c}$ and $K = \frac{\omega}{v_{ep}(t)}$

For + E_f



$$K = \frac{\omega}{c}$$

Refractive Index vs. time for the following parameters: $\omega = 6\ 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = 3\ 10^{27}\ [\frac{V}{m}]$

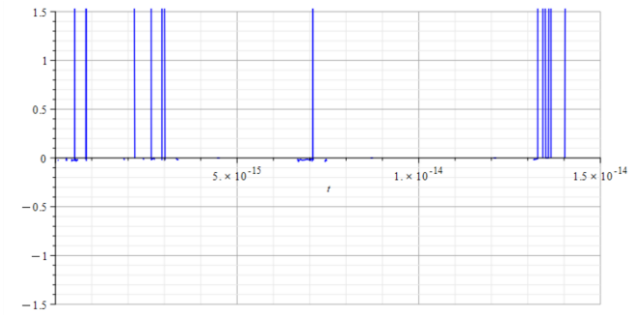


$$K = \frac{\omega}{v_{ep}(t)}$$

Refractive Index vs. time for the following parameters: $\omega = 6\ 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = 3\ 10^{27}\ [\frac{V}{m}]$

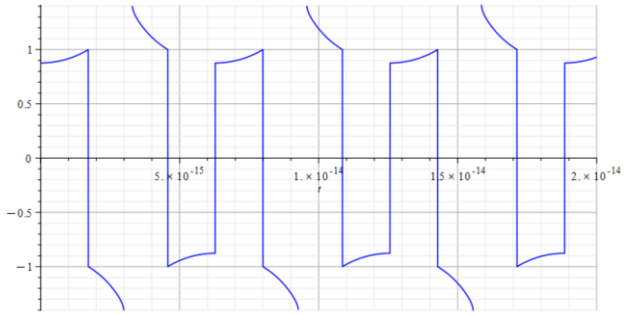
Figure 64

For - E_f



$$K = \frac{\omega}{c}$$

Refractive Index vs. time for the following parameters: $\omega = 6\ 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{24}\ [\frac{V}{m}]\ \ E_f = -1.5\ 10^{26}\ [\frac{V}{m}]$

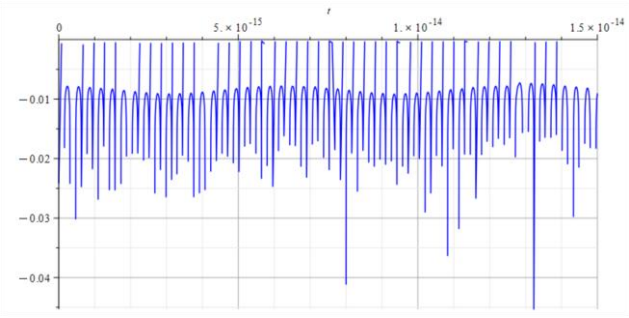


$$K = \frac{\omega}{v_{ep}(t)}$$

Refractive Index vs. time for the following parameters: $\omega = 6\ 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{24}\ [\frac{V}{m}]\ \ E_f = -1.5\ 10^{26}\ [\frac{V}{m}]$

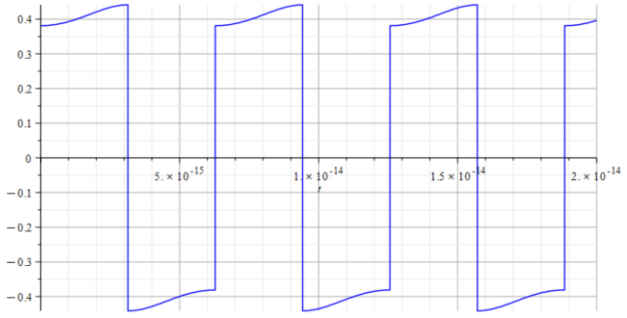
Figure 65

For + E_f



$$K = \frac{\omega}{c}$$

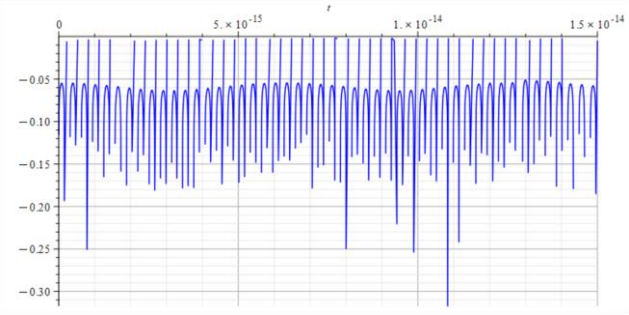
Refractive Index vs. time for the following parameters: $\omega = 2\ 10^{16}\ [\frac{1}{s}]\ \ E_m = 8\ 10^{25}\ [\frac{V}{m}]\ \ E_f = 3\ 10^{26}\ [\frac{V}{m}]$



$$K = \frac{\omega}{v_{ep}(t)}$$

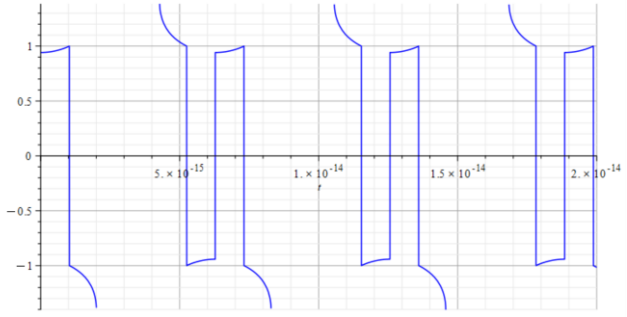
Figure 66 *Refractive Index vs. time for the following parameters:* $\omega = 2\ 10^{16}\ [\frac{1}{s}]\ \ E_m = 8\ 10^{25}\ [\frac{V}{m}]\ \ E_f = 3\ 10^{26}\ [\frac{V}{m}]$

For - E_f



$$K = \frac{\omega}{c}$$

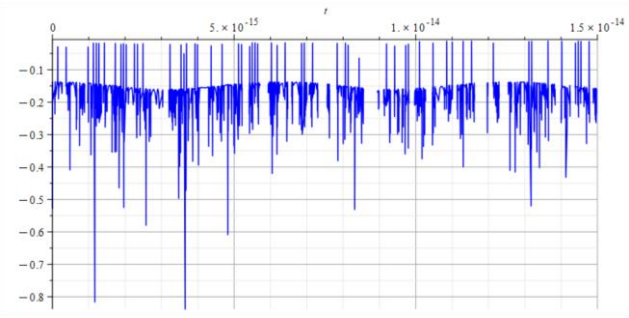
Refractive Index vs. time for the following parameters: $\omega = 2\ 10^{16}\ [\frac{1}{s}]\ \ E_m = 10^{24}\ [\frac{V}{m}]\ \ E_f = -10^{25}\ [\frac{V}{m}]$



$$K = \frac{\omega}{v_{ep}(t)}$$

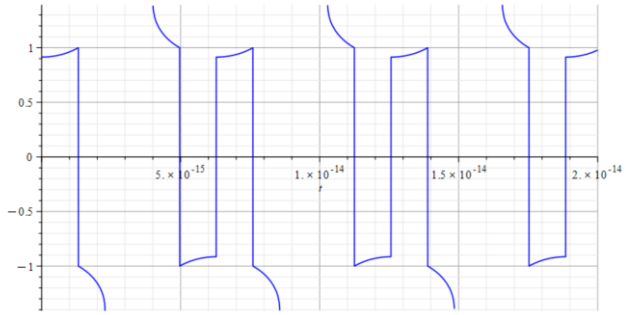
Figure 67 *Refractive Index vs. time for the following parameters:* $\omega = 2\ 10^{16}\ [\frac{1}{s}]\ \ E_m = 10^{24}\ [\frac{V}{m}]\ \ E_f = -10^{25}\ [\frac{V}{m}]$

For + E_f



$$K = \frac{\omega}{c}$$

Refractive Index vs. time for the following parameters:
$\omega = 10^{18}\ [\frac{1}{s}]\quad E_m = 10^{23}\ [\frac{V}{m}]\quad E_f = 2.5\ 10^{24}\ [\frac{V}{m}]$

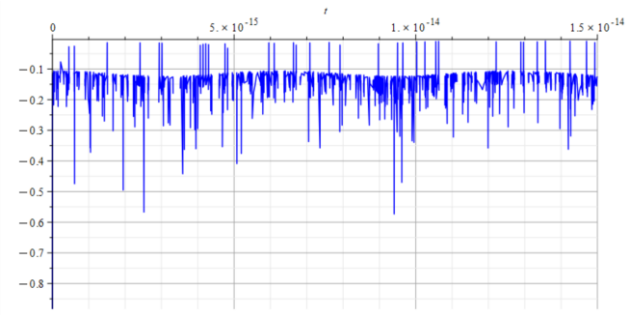


$$K = \frac{\omega}{v_{ep}(t)}$$

Refractive Index vs. time for the following parameters:
$\omega = 10^{18}\ [\frac{1}{s}]\quad E_m = 10^{23}\ [\frac{V}{m}]\quad E_f = 2.5\ 10^{24}\ [\frac{V}{m}]$

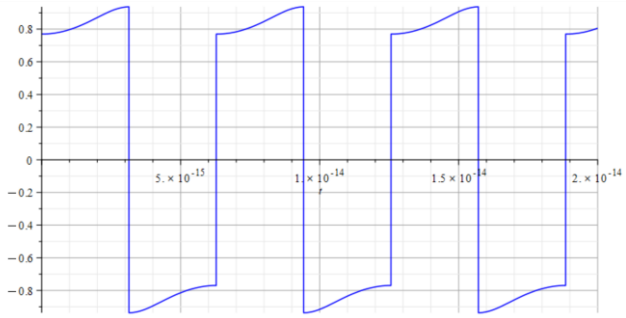
Figure 68

For - E_f



$$K = \frac{\omega}{c}$$

Refractive Index vs. time for the following parameters:
$\omega = 10^{18}\ [\frac{1}{s}]\quad E_m = 10^{23}\ [\frac{V}{m}]\quad E_f = -7\ 10^{24}\ [\frac{V}{m}]$



$$K = \frac{\omega}{v_{ep}(t)}$$

Refractive Index vs. time for the following parameters:
$\omega = 10^{18}\ [\frac{1}{s}]\quad E_m = 10^{23}\ [\frac{V}{m}]\quad E_f = -7\ 10^{24}\ [\frac{V}{m}]$

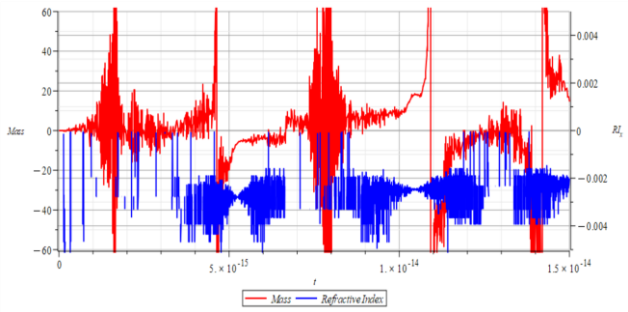
Figure 69

We observe that for wave velocity “c”, under the given conditions, the refractive index is negative in most of the cases.

IV.c Comparison of Mass with Refractive Index Behavior due to Force caused by Static Field plus Wave (6), for Wave Velocity "c" and "$v_{ep}(t)$" and ± E_f

To analyze the changes in the refractive index "n" with respect to changes in nuclear mass, overlaid graphs of both quantities are shown below, which uncover interesting results.

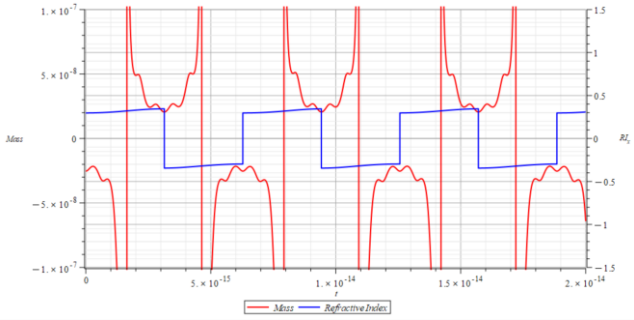
For + E_f



$$K = \frac{\omega}{c}$$

Mass & Refractive Index vs. time for parameters:
$\omega = 6\ 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = 3\ 10^{27}\ [\frac{V}{m}]$

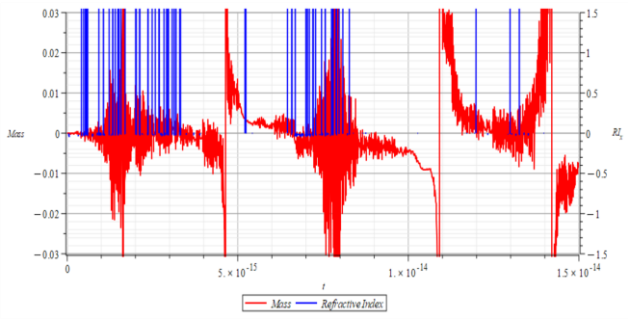
Figure 70



$$K = \frac{\omega}{v_{ep}(t)}$$

Mass & Refractive Index vs. time for parameters:
$\omega = 6\ 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{26}\ [\frac{V}{m}]\ \ E_f = 3\ 10^{27}\ [\frac{V}{m}]$

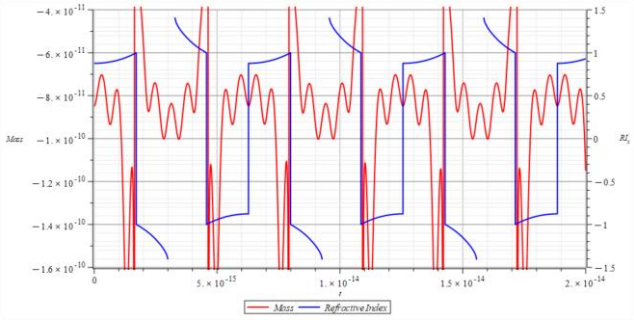
For - E_f



$$K = \frac{\omega}{c}$$

Mass & Refractive Index vs. time for parameters:
$\omega = 6\ 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{24}\ [\frac{V}{m}]\ \ E_f = -1.5\ 10^{26}\ [\frac{V}{m}]$

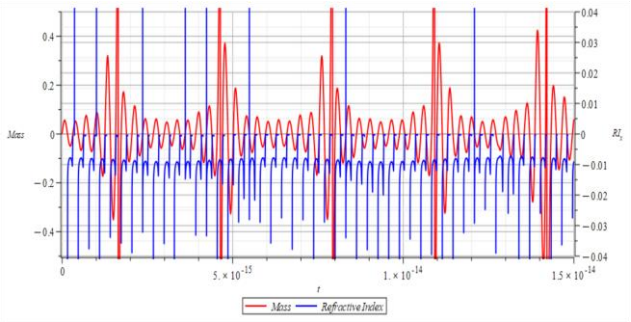
Figure 71



$$K = \frac{\omega}{v_{ep}(t)}$$

Mass & Refractive Index vs. time for parameters:
$\omega = 6\ 10^{14}\ [\frac{1}{s}]\ \ E_m = 10^{24}\ [\frac{V}{m}]\ \ E_f = -1.5\ 10^{26}\ [\frac{V}{m}]$

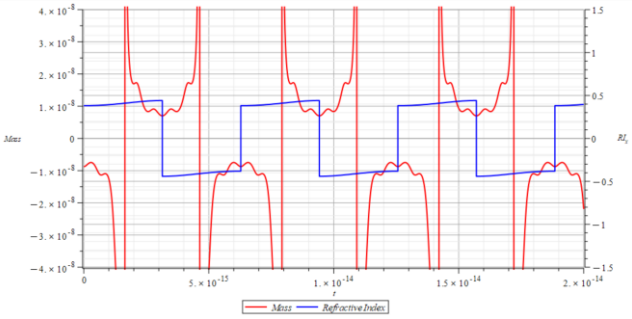
For + E_f



$$K = \frac{\omega}{c}$$

Mass & Refractive Index vs. time for parameters:
$\omega = 2\ 10^{16}\ [\frac{1}{s}]\ \ E_m = 8\ 10^{25}\ [\frac{V}{m}]\ \ E_f = 3\ 10^{26}\ [\frac{V}{m}]$

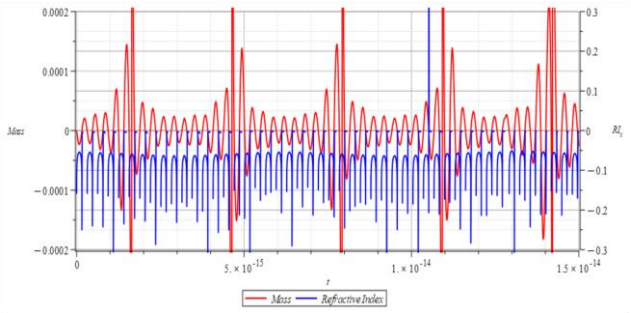
Figure 72



$$K = \frac{\omega}{v_{ep}(t)}$$

Mass & Refractive Index vs. time for parameters:
$\omega = 2\ 10^{16}\ [\frac{1}{s}]\ \ E_m = 8\ 10^{25}\ [\frac{V}{m}]\ \ E_f = 3\ 10^{26}\ [\frac{V}{m}]$

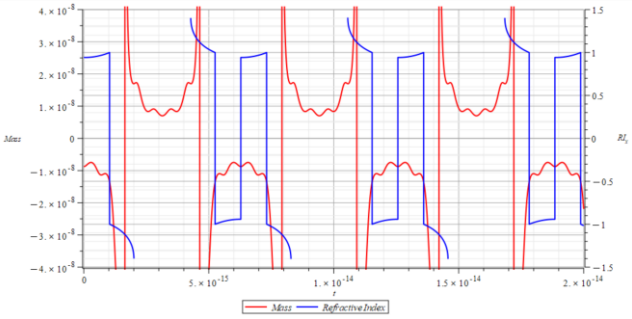
For - E_f



$$K = \frac{\omega}{c}$$

Mass & Refractive Index vs. time for parameters:
$\omega = 2\ 10^{16}\ [\frac{1}{s}]\ \ E_m = 10^{24}\ [\frac{V}{m}]\ \ E_f = -10^{25}\ [\frac{V}{m}]$

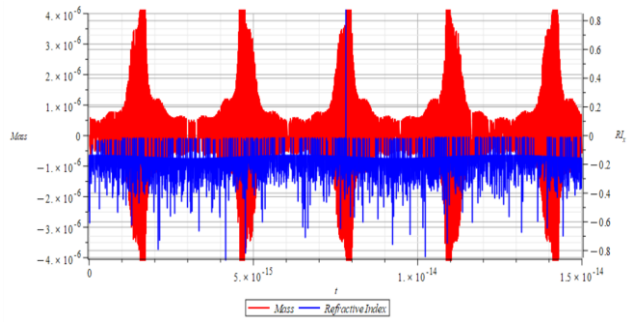
Figure 73



$$K = \frac{\omega}{v_{ep}(t)}$$

Mass & Refractive Index vs. time for parameters:
$\omega = 2\ 10^{16}\ [\frac{1}{s}]\ \ E_m = 10^{24}\ [\frac{V}{m}]\ \ E_f = -10^{25}\ [\frac{V}{m}]$

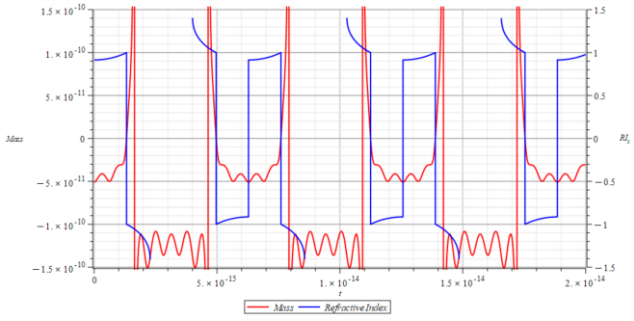
For + E_f



$$K = \frac{\omega}{c}$$

Mass & Refractive Index vs. time for parameters:

$\omega = 10^{18}\ [\frac{1}{s}]\ \ E_m = 10^{23}\ [\frac{V}{m}]\ \ E_f = 2.5\ 10^{24}\ [\frac{V}{m}]$



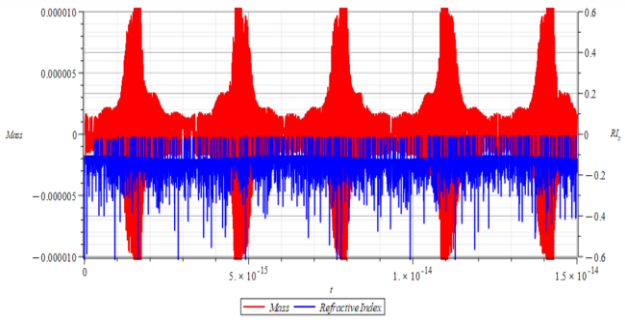
$$K = \frac{\omega}{v_{ep}(t)}$$

Mass & Refractive Index vs. time for parameters:

$\omega = 10^{18}\ [\frac{1}{s}]\ \ E_m = 10^{23}\ [\frac{V}{m}]\ \ E_f = 2.5\ 10^{24}\ [\frac{V}{m}]$

Figure 74

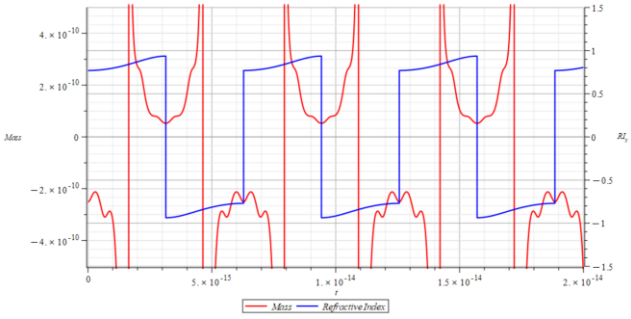
For - E_f



$$K = \frac{\omega}{c}$$

Mass & Refractive Index vs. time for parameters:

$\omega = 10^{18}\ [\frac{1}{s}]\ \ E_m = 10^{23}\ [\frac{V}{m}]\ \ E_f = -7\ 10^{24}\ [\frac{V}{m}]$



$$K = \frac{\omega}{v_{ep}(t)}$$

Mass & Refractive Index vs. time for parameters:

$\omega = 10^{18}\ [\frac{1}{s}]\ \ E_m = 10^{23}\ [\frac{V}{m}]\ \ E_f = -7\ 10^{24}\ [\frac{V}{m}]$

Figure 75

In Fig. 71 right, we observe that, also during a full negative mass regime, the refractive index changes with mass changes. The Refractive Index depends on the slope of the mass plot, that is, the rate of change of mass.

In general, though this is not the rule, for wave velocity “c”, it decreases with negative mass slope, and vice versa, until reaching the m=0 point, where abruptly switches between n=±1. It seems that the Refractive Index is proportional to the derivative of the mass, and the sign of the derivative changes when the mass sign changes, also at mass minima/maxima (slope = 0) as well as at indeterminate points (slope = ∞).

For wave velocity “$v_{ep}(t)$”, the Refractive Index oscillates and switches between n=±1 at m=0 and when the slope of the mass =0. It seems that the refractive index depends on the derivative of the mass.

$$n \propto \pm\frac{dm}{dt}$$

These are important results that tell us that the refractive index behavior is like a “beacon”, signaling the zones of the negative mass regime, as well as mass changes.

Conclusions

It has been demonstrated that the application of the Universal Electrodynamic Force to the new Atomic Model predicts important changes in nuclear mass when an external force caused by a TEM with an added Static Electric Field is acting on the atomic nucleus.

As we have demonstrated in previous papers, mass is an electrodynamic quantity and as such, it can be manipulated at will. It was demonstrated in this paper that one means to achieve mass changes is not only by striking the nucleus with a TEM but also by the addition of a static electric field.

It was clearly seen from the results, that the magnitude and the sign of the mass can be modified by changing the amplitude and/or frequency of the external wave, within a certain range, and by modifying the magnitude and sign of the static electric field.

The somewhat abrupt sign change of the refractive index values during mass sign change was also clearly demonstrated. There is clear evidence that the refractive index is proportional to the rate of change of the mass, i.e., to the derivative of mass with respect to time.

The refractive index can be used as an aid to search for the negative mass region of the nucleus, as well as in any piece of “macro” material. The refractive index is a “beacon” that signals the exact point of mass sign change and its range, and any mass changes in general.

Fourier's analysis shows in the phase shift graphs many swings of phase between ±π, which clearly indicate resonance states in the nucleus at those frequencies, as well interferences with the external agent.

In previous papers, we described that the main force that keeps the nuclear shell in a very tight packing structure in such a tiny space is the electrostatic force. This is really an enormous force. It means that we also need huge external electromagnetic fields to achieve some nuclear interaction, and this may represent a technical limitation in the present time.

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