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Determination of the Time-Dependent Velocity for Charged Particle via Cosine Electrostatic Function

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บทคัดย่อ

งานวิจัยนี้ คณะผู้จัดทำได้ศึกษาประจุไฟฟ้าที่เคลื่อนที่อยู่ภายใต้สนามไฟฟ้า โดยทางคณะผู้จัดทำได้สร้างแบบจำลองฟังก์ชันทางคณิตศาสตร์ของสนามไฟฟ้าขึ้นมา 4 ชนิด โดยใช้กฎข้อที่สองของนิวตันในการคำนวณหาความเร็วประจุไฟฟ้าที่เคลื่อนที่อยู่ภายใต้สนามไฟฟ้าทั้ง 4 ชนิด ได้ผลลัพธ์เป็นกราฟออกมาสมการละ 4 ลักษณะ โดยพบว่า หากสนามไฟฟ้าอยู่ในรูปฟังก์ชันตรีโกณมิติชนิดโคไซน์กำลังคี่ จะทำให้ความเร็วในการสั่นของคลื่นไฟฟ้าประพฤติตัวเหมือนกราฟการหน่วง ในขณะเดียวกัน หากสนามไฟฟ้าอยู่ในรูปฟังก์ชันตรีโกณมิติชนิดโคไซน์กำลังคู่ จะทำให้ความเร็วในการสั่นของคลื่นไฟฟ้าประพฤติตัวเหมือนกราฟเอกซ์โพเนนเชียล

คำสำคัญ: สนามไฟฟ้าที่ขึ้นอยู่กับเวลา, สนามไฟฟ้าที่เป็นฟังก์ชันของเวลา, ประจุไฟฟ้าที่ขึ้นอยู่กับเวลา, ประจุไฟฟ้าที่เป็นฟังก์ชันของเวลา, กลุ่มคลื่นไฟฟ้า

Abstract

In this research, we develop the electric charge velocity modelswhich motion under the electrostatic field.The model of the time-dependent electrostatic field in 4 types, were created by the second law of Newton for evaluation of the electrical charge velocity that, moving under 4 electrostatic fields. The result shows that the formula of the electrostatic degree is an odd number, the electrical wave velocity behaves itself as underdamped. Whilethe formula of the electrostatic degree is an even number, the electrical wave velocity behaves itself as exponential.

Keywords: Time-dependent electrostatic field, Time-dependent electrical velocity, wave group

Introduction

The electrostatic field exists between particles, those have different electrical charges in each other's vicinity. In the macroscopic, the earth also creates the field with the circle direction. So this force acts on electricity in the electrical field. KanokpolN. ,(2018) et. al. studied calculation of velocity and acceleration for electron bound electricity time dependent type exponential sine by using based on the second law of Newton. The result gives that the electrical velocity, acceleration are direct varies on the parameter. Noureddine Z., et. al. (2014) study the demonstrate the great potential of dielectric barrier discharge based electrical precipitators (DBD-ESPs) energized by a low frequency AC high voltage. That's for the sub-micrometer particles collection. Thus, it gives us know that, the particle time-averaged velocity is direct varies on the frequency. The time-resolved velocity of particle increases during both the positive and negative discharges. Ploywarin C., et.al. (2018) evaluation of the displacement and the velocity of eletrical charge motion in the electricity by using integration by part technique. The result show that the velocity and the displacement are direct vary on the parameter, but if the velocity and the electric charge are higher, the time-function is lower.

The main target of this paper is to analyze the affect of the electrostatic field in cosine function, in the first, second, third, and forth degree. We use direct integration (by integration by part technique) and Mathematica for solving the solution and find the result. The result show that the electrical velocity is directly varies on the initial electrical field and the initial electrical charge, but inverse with the damping coefficient and the frequency. The velocity wave has vibrating behavior likes underdamped form when the degree of electrical field form is the odd number, and likes exponential function form when the degree of electrical field form is the even number.

Material and Methods

Evaluation of velocity for particle moves in external electric force in cosine. In this case, the time-dependent force being given by

$F = F_e(\mathrm{t})$(electric force) implies that it is an explicit function of time; hence Newton's law maybe written as

$$F_e(t) = ma = m\frac{dv}{dt},$$

$$\frac{q\,E(t)}{m} = \frac{dv}{dt} \qquad (1)$$

Let us assume that at t=0, the initial velocity as v_0, and at the time as t, the velocity as v. Thus, from equation (1),

$$\int_{v_0}^{v} dv = \int_{0}^{t} \frac{q\,E(\mathrm{t})}{m}\,dt,$$

which in integration yields,

$$v(\mathrm{t}) = \int_{0}^{t} \frac{q\,E(\mathrm{t})}{m}\,dt + v_0 \qquad (2)$$

Experiments computation were designed which while related the fields of mechanics and electromagnetic. Newton's second law of motion and the mathematics of first order differential equation were studied by integrating one part at a time using basic calculus, trigonometric and exponential function. We are interested in the motion of particle charge q initially at rest when it interacts with the incoming electromagnetic wave of electric field intensity E, given by

$$E_1 = \varepsilon_0 e^{-\eta t}\cos(\omega \mathrm{t}), \qquad (3)$$

$$E_2 = \varepsilon_0 e^{-\eta t}\cos^2(\omega \mathrm{t}), \qquad (4)$$

$$E_3 = \varepsilon_0 e^{-\eta t}\cos^3(\omega \mathrm{t}), \qquad (5)$$

$$E_4 = \varepsilon_0 e^{-\eta t}\cos^4(\omega \mathrm{t}), \qquad (6)$$

where ω is the oscillation frequency, η is damping coefficient, and ε_0 is the initial electromagnetic. Substitute equation (3) into equation (2). The initial condition that at t=0, the initial velocity is v_0 and at the time as t, the velocity is $v_1(\mathrm{t})$, we get by direct intregration

$$v_1(\mathrm{t}) = \frac{q\,\varepsilon_0}{m}\int_0^t e^{-\eta t}\cos(\omega\,\mathrm{t})\,\mathrm{dt} + \mathrm{v}_0\,,$$

$$v_1(\mathrm{t}) = \left(\frac{\eta - \eta e^{-\eta t}\cos(\omega\,\mathrm{t}) + \omega e^{-\eta t}\sin(\omega\,\mathrm{t})}{\eta^2+\omega^2}\right)\frac{q\,\varepsilon_0}{m} + \mathrm{v}_0 \qquad (7)$$

Substitute electromagnetic $E_2(\mathrm{t})$ of equation (4) into equation (2), the first integration of equation (2) can be performed to obtain; $v_2(\mathrm{t})$; that is assumed that $v(0) = v_0$ at $t = t_0$,

$$v_2(\mathrm{t}) = \frac{q\,\varepsilon_0}{m}\int_0^t e^{-\eta t}\cos^2(\omega\,\mathrm{t})\,\mathrm{dt} + \mathrm{v}_0$$

$$v_2(\mathrm{t}) = \frac{q\,\varepsilon_0}{2m}\left[\int_0^t e^{-\eta t}dt + \int_0^t e^{-\eta t}\cos(2\omega\,\mathrm{t})\,\mathrm{dt}\right] + \mathrm{v}_0$$

$$v_2(\mathrm{t}) = \frac{q\,\varepsilon_0}{2m}\left[\frac{(1-e^{-\eta t})}{\eta} + \frac{(\eta - \eta e^{-\eta t}\cos(2\omega\,\mathrm{t}) + 2\omega e^{-\eta t}\sin(2\omega\,\mathrm{t}))}{\eta^2+4\omega^2}\right] + \mathrm{v}_0 \qquad (8)$$

In equation (2), we may substitute electromagnetic $E_3(\mathrm{t})$ of equation (5) and the limits $v(0) = \mathrm{v}_0$ when t=0 and $v = v$ when t=t. After integrated, we get the following result:

$$v_3(\mathrm{t}) = \frac{q\,\varepsilon_0}{m}\int_0^t e^{-\eta t}\cos^3(\omega\,\mathrm{t})\,\mathrm{dt} + \mathrm{v}_0$$

$$v_3(\mathrm{t}) = \frac{q\,\varepsilon_0}{m}\left[\frac{3}{4}\left(\frac{(\eta - \eta e^{-\eta t}\cos(\omega\,\mathrm{t}) + \omega e^{-\eta t}\sin(\omega\,\mathrm{t}))}{\eta^2+\omega^2}\right)\right.$$

$$\left. + \frac{1}{4}\left(\frac{(\eta - \eta e^{-\eta t}\cos(\omega\,\mathrm{t}) + \omega e^{-\eta t}\sin(\omega\,\mathrm{t}))}{\eta^2+\omega^2}\right)\right] + \mathrm{v}_0 \qquad (9)$$

We also substitute electromagnetic $E_4(\mathrm{t})$ from equation (6) into equation (2) under the initial condition $v(0) = \mathrm{v}_0$ when t=0 and v=v, when t=t, we get the result of the integration

$$v_4(\mathrm{t}) = \frac{q\,\varepsilon_0}{m}\int_0^t e^{-\eta t}\cos^4(\omega\,\mathrm{t})\,\mathrm{dt} + \mathrm{v}_0$$

$$v_4(\mathrm{t}) = \frac{q\varepsilon_0}{m}\left[\frac{3}{8}\int_0^t e^{-\eta t}dt + \frac{1}{2}\int_0^t e^{-\eta t}\cos(2\omega \mathrm{t})dt + \frac{1}{8}\int_0^t e^{-\eta t}\cos(4\omega \mathrm{t})dt\right] + \mathrm{v}_0$$

$$v_4(\mathrm{t}) = \frac{q\varepsilon_0}{m}\left[\frac{3}{8}\int_0^t\left(\frac{1-e^{-\eta t}}{\eta}\right)dt + \frac{1}{2}\left(\frac{\eta - \eta e^{-\eta t}\cos(2\omega \mathrm{t}) + 2\omega e^{-\eta t}\sin(2\omega \mathrm{t})}{\eta^2 + 16\omega^2}\right)\right.$$

$$\left. + \frac{1}{8}\left(\frac{\eta - \eta e^{-\eta t}\cos(4\omega \mathrm{t}) + 4\omega e^{-\eta t}\sin(4\omega \mathrm{t})}{\eta^2 + 16\omega^2}\right)\right] + v_0 \qquad (10)$$

The Numerical Result

We can describe the numerical and the result ofthe time-dependent ofthe electrical charge velocity which is affected by cosine electrical field as time-dependent charge velocity as figure (1), figure (2), figure (3) and figure (4)

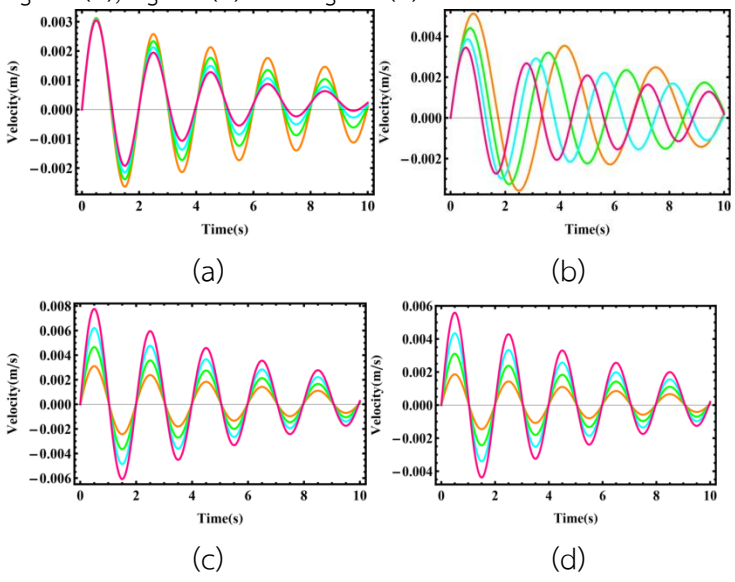


Figure 1 the time-dependent velocity of charge in cosine

(1a) represents the time-dependent velocity of charge depending on the damping coefficient (the orange line as $\eta = 0.10$ as, the green line as $\eta = 0.15$, the light blue line as $\eta = 0.20$, and thepink lineas $\eta = 0.25$).(1b) represents the time-dependent velocity of charge depending on frequency (the orange line as $f = 0.30\,\mathrm{Hz}$, the green lineas $f = 0.35\mathrm{Hz}$,

the light blue line as $f = 0.40\,\mathrm{Hz}$, and thepink line as $f = 0.45\,\mathrm{Hz}$), (1c) represents the time-dependent velocity of charge dependingon electric field (the orange line as $E_0 = 0.1\,N/C$, the green line as $E_0 = 0.15\,N/C$, the light blue line as $E_0 = 0.2\,N/C$, and the pink line as $E_0 = 0.25\,N/C$), (1d) represents the time-dependent velocity of charge dependingon the initial charged particle (the orange line as $q_0 = 0.003C$, the green line as $q_0 = 0.005C$, the light blue line is $q_0 = 0.007C$, and the pink line as $q_0 = 0.009C$)

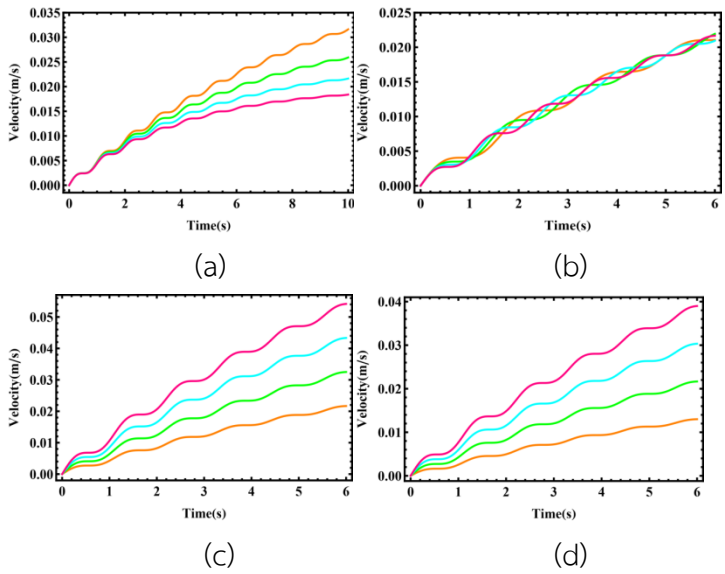


Figure 2 the time-dependent velocity of charge in the second degree of cosine

(2a) represents the time-dependent velocity of charge dependingon the damping coefficient (the orange line as $\eta = 0.1$as, the green line as $\eta = 0.15$, the light blue line as $\eta = 0.2$, and the pink lineas $\eta = 0.25$).(2b) represents the time-dependent velocity of charge dependingon frequency (the orange line as $f = 0.3\,\mathrm{Hz}$, the green lineas $f = 0.35\mathrm{Hz}$, the light blue line as $f = 0.4\,\mathrm{Hz}$, and the pink line as $f = 0.45\,\mathrm{Hz}$), (2c) represents the time-dependent velocity of charge dependingon electric field (the orange line as $E_0 = 0.1N/C$, the green line as $E_0 = 0.15\,N/C$, the light blue line as $E_0 = 0.20\,N/C$, and the pink line as $E_0 = 0.25\,N/C$), (2d) represents the

time-dependent velocity of charge dependingon the initial charged particle (the orange line as $q_0 = 0.003C$, the green line as $q_0 = 0.005C$, the light blue line is $q_0 = 0.007C$, and the pink line as $q_0 = 0.009C$)

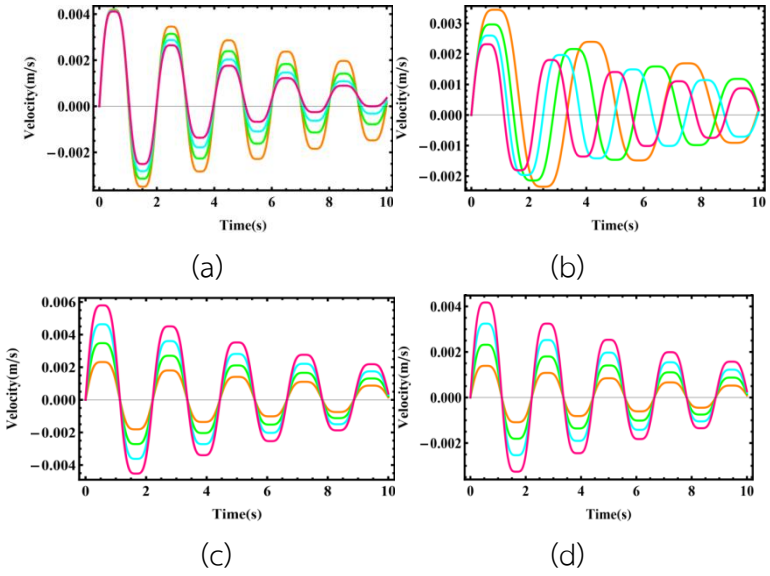


Figure 3 the time-dependent velocity of charge inthe third degree of cosine

(3a) represents the time-dependent velocity of charge dependingon the damping coefficient (the orange line as $\eta = 0.10$ as, the green line as $\eta = 0.15$, the light blue line as $\eta = 0.20$, and the pink lineas $\eta = 0.25$).(3b) represents the time-dependent velocity of charge dependingon frequency (the orange line as $f = 0.3\text{Hz}$, the green lineas $f = 0.35\text{Hz}$, the light blue line as $f = 0.4\text{Hz}$, and the pink line as $f = 0.45\text{Hz}$), (3c) represents the time-dependent velocity of charge dependingon electric field (the orange line as $E_0 = 0.1N/C$, the green line as $E_0 = 0.15N/C$, the light blue line as $E_0 = 0.2N/C$, and the pink line as $E_0 = 0.25N/C$), (3d) represents the time-dependent velocity of charge dependingon the initial charged particle (the orange line as $q_0 = 0.003C$, the green line as $q_0 = 0.005C$, the light blue line is $q_0 = 0.007C$, and the pink line as $q_0 = 0.009C$)

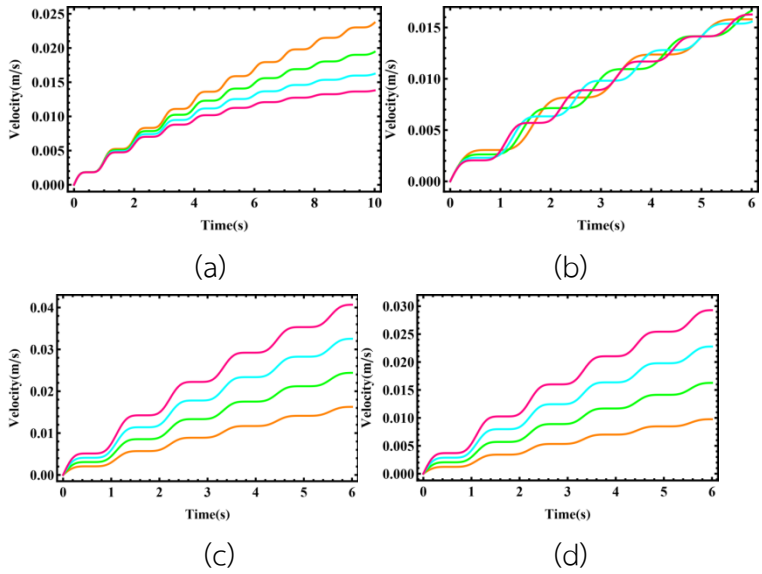


Figure 4 the time-dependent velocity of charge in the fourth degree of cosine

(4a) represents the time-dependent velocity of charge dependingon the damping coefficient (the orange line as $\eta = 0.1$as, the green line as $\eta = 0.15$, the light blue line as $\eta = 0.2$, and the pink lineas $\eta = 0.25$).(4b) represents the time-dependent velocity of charge dependingon frequency (the orange line as $f = 0.3\,\mathrm{Hz}$, the green lineas $f = 0.35\,\mathrm{Hz}$, the light blue line as $f = 0.4\,\mathrm{Hz}$, and the pink line as $f = 0.45\,\mathrm{Hz}$), (4c) represents the time-dependent velocity of charge dependingon electric field (the orange line as $E_0 = 0.1\,N/C$, the green line as $E_0 = 0.15\,N/C$, the light blue line as $E_0 = 0.2\,N/C$, and the pink line as $E_0 = 0.25\,N/C$), (4d) represents the time-dependent velocity of charge dependingon the initial charged particle (the orange line as $q_0 = 0.003C$, the green line as $q_0 = 0.005C$, the light blue line is $q_0 = 0.007C$, and the pink line as $q_0 = 0.009C$)

Discussion

From fig (1) represents the time- dependent electric charge velocity, from fig (1 a) represents the time- dependent electric charge velocity that dependingon the damping coefficient (η). The orange line as $\eta = 0.1$as, the green lineas $\eta = 0.15$, the light blue line as $\eta = 0.2$, and the pink lineas $\eta = 0.25$. If the damping coefficient is higher, the velocity of

electric charge decreases. From fig (1b) represents the time-dependent electric charge velocity that dependingon frequency, f. The orange line as $f=0.3\text{Hz}$, the green lineas $f=0.35\text{Hz}$, the light blue line as $f=0.4\text{Hz}$, and the pink line as $f=0.45\text{Hz}$. When the frequency is higher, the amplitude of velocity is lower. But the vibrating of velocity amplitude is higher. From fig (1c) represents the time-dependent electric charge velocity that dependingon the initial electric field, E_0. The orange line as $E_0=0.1N/C$, the green line as $E_0=0.15\,N/C$, the light blue line as $E_0=0.2\,N/C$, and the pink line as $E_0=0.25\,N/C$. When the initial electric field is higher, the amplitude of the velocity and the velocity of electric charge are higher. And the velocity wave has more underdamped vibrating behavior. From fig (1d) represents the time-dependent electric charge velocity that dependingon the initial charged particle, q_0. The orange line as $q_0=0.003C$, the green line as $q_0=0.005C$, the light blue line is $q_0=0.007C$, and the pink line as $q_0=0.009C$.When the initial charged particle is higher, the amplitude of velocity is higher. From fig (2) represents the time-dependent electric charge velocity, from fig (2a) represents the time-dependent electric charge velocity that dependingon the damping coefficient (η). The orange line as $\eta=0.1$as, the green lineas $\eta=0.15$, the light blue line as $\eta=0.2$, and the pink lineas $\eta=0.25$. When the damping coefficient is higher, the velocity of electric charge is lower. The vibrating behavior of electric charge likes exponential function form. From fig (2b) represents the time-dependent electric charge velocity that dependingon frequency f. When the frequency is higher, the amplitude and wavelength of velocity are lower. But the vibrating times of velocity amplitude is higher. From fig (2c) represents the time-dependent electric charge velocity that dependingon the initial electric field, E_0. When the initial electric field is higher, the velocity of electric charge is higher. And that makes the velocity wave has vibrating behavior more exponential function form. From fig (2d) represents the time-dependent electric charge velocity that dependingon the initial charged particle, q_0. When the initial

charged particle is higher, the electric velocity is higher. The velocity wave has vibrating behavior exponential function form.

From fig (3) represents the time-dependent electric charge velocity, the electric charge has a long time vibration. From fig (3a) represents the time-dependent electric charge velocity that dependingon the damping coefficient (η). When the damping coefficient is higher, the velocity of electric charge is lower. From fig (3b) represents the time-dependent electric charge velocity that dependingon frequency, f. When the frequency is higher, the amplitude of velocity is lower. But the vibrating of velocity amplitude is higher. From fig (3c) represents the time-dependent electric charge velocity that dependingon the initial electric field, E_0. When the initial electric field is higher, the amplitude of the velocity and the velocity of electric charge are higher. And the velocity wave has more underdamped vibrating behavior. From fig (3d) represents the time-dependent electric charge velocity that dependingon the initial charged particle, q_0. When the initial charged particle is higher, the amplitude of velocity is higher. From fig (4) represents the time-dependent electric charge velocity, from fig (4a) represents the time-dependent electric charge velocity that dependingonthe damping coefficient (η). When the damping coefficient is higher, the velocity of electric charge is lower. The vibrating behavior of electric charge likes exponential function form. From fig (4b) represents the time-dependent electric charge velocity that dependingon frequency, f. When the frequency is higher, the amplitude and wavelength of velocity are lower. But the vibrating times of velocity amplitude is higher. From fig (4c) represents the time-dependent electric charge velocity that dependingon the initial electric field, E_0. When the initial electric field is higher, the velocity of electric charge is higher. And that makes the velocity wave has vibrating behavior more exponential function form. From fig (4d) represents the time-dependent electric charge velocity that dependingon the initial charged particle, q_0. When the initial charged particle is higher, the electric velocity is higher. The velocity wave has vibrating behavior exponential function form. Also the electric field in the first degree form and the third degree form can apply for the stellar flaring emission

prediction. And the electric field in the second and forth degree form can apply for studying and predict the maps overview, that shows the distances of the all different star in the universe.

Conclusion

From the result, the figures show that the electrical velocity depends on the damping coefficient, the frequency, the initial electric field, the initial electrical charge. So it directly varies on the initial electrical field and the initial electrical charge, but inverse with the damping coefficient and the frequency. The velocity wave has vibrating behavior likes underdamped form when the degree of electrical field form is the odd number, and likes exponential function form when the degree of electrical field form is the even number.

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