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Determined characteristics of Lovejoy cemetery tail using Photometry method

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ABSTRACT

Comets are remnants of the early solar system. They have undergone little alteration since their formation, and their nuclei are thought to preserve physical and chemical information about the early solar nebula. When a comet approaches the Sun, the ices contained in the nucleus sublimate, and complex molecules are released into the coma. These molecules, the parent species, can be observed in the infrared and radio domains .Comets images that recorded, by CCD camera a lot of information about the molecular interaction that carried out inside the comet due to the after of the sun and the atmosphere. The differences of photonic intensity can give us a curve which appears from any line of this image. While the equations can get upon special relation for temperature distribution, Velocity distribution, Distribution of density and density number distribution which give number of particles per unit volume. The interaction between cemetery tail ions and solar wind can be understood by means of spatial distribution of new-generated ions from the comet nucleus with the homogenous flow of the solar wind plasma. This research also provides the final equations for the image of the comet (Lovejoy) using the Matlab. We have fitted a function to the 1-D intensity distribution through the major axis that passing the centers of the nucleus of comet .this intensity distribution is really related to the number .of photon that reflected from the sun this equation leads us to predict the temperature and density distribution from the observed comet by optical telescope.

INTRODUCTION

As known that the comets are approaching approaches of our sun from two regions, Kuiper belt and Oort cloud. Comets travel close to the Sun besides the Sun's heat begins to vaporize the ices and causes them to form a fuzzy (Birmann,1951), luminous area of vaporized gas around the nucleus of the comet known as a coma. Outside the coma is a layer of hydrogen gas called a hydrogen halo which extends up to 1010 meters in diameter (Elinor,2002). The solar wind then blows these gases and dust particles away from the direction of the Sun causing two tails to form. These tails always point away from the Sun as the comet travels around it (Kenneth,2013).

One tail is called the ion tail and is made up of gases which have been broken apart into charged molecules and ions by the radiation from the Sun. Since the most common ion, CO+ scatters the blue light better than red light, to observers; this ion tail often appears blue. The other tail is called a dust tail and normally appears white (Elinor,2002).

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Mathematical model of light intensity:

The Comet Lovejoy is showed in fig. (1),

Fig. 1: Lovejoy comet the solar wind heated up the nucleus to produces a lot of dust and gases, the solar wind push the dust and gases far away from the core(Fermilabs,2014).

One line of this comet signifies along major axis of it, as shown in fig.(2). Where the equation of this line is:

$$y=0.3x+204 \quad v \tag{1}$$

Then, photonic curve will appear as shown in fig.(3) and increase at the centre of the nucleus to reach maximum value above the centre, but the photonic value decreases to the end of the tail.

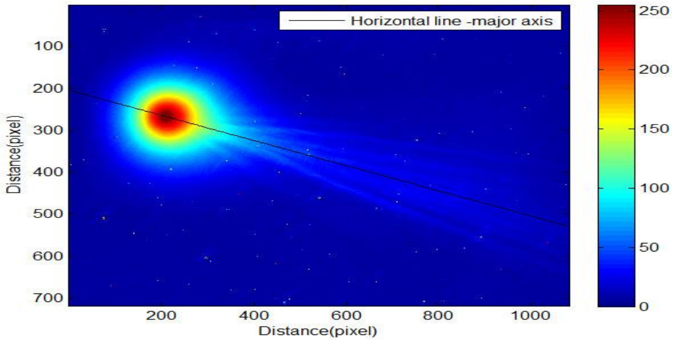

Fig. 2: Black line along major axis of the comet for finding light intensity of photonic curve .

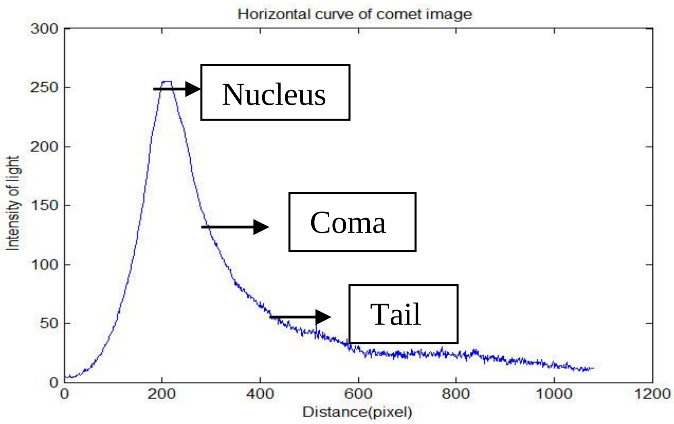

Fig. 3: Curve of photonic curve along line of major axis where maximum value at centre nucleus is 255.

It has been found the mathematical equation which is identical with the curve in above figure as following:

The equations f_1 and f_2 andf_T in fig.(5) are :

$$f_1(x) = 1.1\exp\left(-6.8587\left(1-\frac{37.5074}{x+37.5074}\right)^2\right) \tag{2}$$

$$f_2(x) = 1\exp\left(-25.5102\left(1-\frac{23.6714}{x+23.6714}\right)^2\right) \quad (3)$$

$$f_T(x) = f_1(x) + f_2(x) \quad (4)$$

where (x) is a variable between -20.7 to 90 by Δx = 0.1, when x-axis as shown in fig.(2) changes from 0 to 1000 pixels.

The function $f_T(x)$ must be identical with original curve. The $f_T(x)$ needs to normalize making maximum point of total function $f_T(x)$ (red curve) in fig.(5) and equal to 262 because the maximum value of original curve of comet (blue curve) is equal to 255, therefore, if we want painting the final function in Matlab must write as in the following equation :

$$f(x) = 4 + 258\left(\frac{f_T(x)}{\max f_T(x)}\right) \quad (5)$$

Maximum value of $\frac{f_T(x)}{\max f_T(x)}$ =1 , Therefore $f(x) = 262$, and the value (4) in eq.(5) represents background of the comet image.

1. Temperature distribution of comet Lovejoy:

It can be estimated the temperature using Total function in equation (5) has a maximum value, should be normalized by dividing it upon this value to produce final equation, As follows

$$f_{final}(x) = \frac{f_T(x)}{MAXf_T(x)} \quad (6)$$

Where maximum of f_{final} (x) = ff (x)=1.

If we supposed that the final equation as a function for intensity of photons, where intensity of photons is changing with each step of final change, therefore;

$$N = N_\circ f_f(x) \quad (7)$$

The Plank's relation which it between number of photons and temperature for gases represents the radiant photons at specified temperatures in volume V. This relation is as follows (Alan,2000):

$$N = (2 \times 10^7\ K^{-3} m^{-3})VT^3 \quad (8)$$

where: N is a number of photons which releases from volume V at temperature T.

$$N^\circ = (2 \times 10^7\ K^{-3} m^{-3})VT_\circ^3 \quad (9)$$

where N° is a maximum number of photons which releases from volume V at maximum temperature To.

Put eq.(8) and eq.(9) in eq.(7) to produce

$$T^3 = T_\circ^3 f_f(x) \quad (10)$$

Equation (10) gives us the temperature along final function, Meaning, it gives us temperature's distribution along with the comet, beginning from the coma to end of the tail.

2-Velocity distribution of comet Lovejoy:

Velocity of particles which surrounding the nucleus and in the comet's tail is thermal velocity measured by the following relation.

$$v^2 = \frac{3kT}{m} \quad (11)$$

Where v is velocity of particles at temperature T, and m is constant mass of, m=23.3mp (Wilkening,1982), where mp = mass of proton =1.6726$\times 10^{-27}$ kg

K=Boltzmann constant=1.38 $\times 10^{-23}\ m^2 kg\ s^{-2}\ k^{-1}$

Eq.(10) and eq.(11) produce general equation of velocity's distribution.

$$v^2 = \frac{3K}{23.3\,m_p} T_\circ \times [f_f(x)]^{\frac{1}{3}} \quad (12)$$

3-Distribution of density:

The relation of density is,

$\mathcal{P} = \frac{m}{v}$ Where $\mathcal{P}$ (density kg/m3), m is the mass (kg), and V is a volume (m3).

If the gas of comet contains (N) particles , and average mass of particle is equal to 23.3 mp [9] , where mp is proton mass , mp=1.6726$\times 10^{-27}$ kg.

$$\mathcal{P} = \frac{N(23.3m_p)}{v} = \frac{N}{v}(23.3mp) \quad (13)$$

The ratio (N/V) means a number of particles per unit volume, (particle/m3),

In general information of comets, the number of the received photons must be equivalent with number of atoms which radiates these photons (Michael,2015).

From eq.(8) we have ,

$$N = (2 \times 10^7\ K^{-3} m^{-3})VT^3 \qquad \frac{N}{V} = (2 \times 10^7\ K^{-3})T^3 \tag{14}$$

Eq.(14) with eq.(13) produce

$\mathcal{P} = 2 \times 10^7 VT^3 \frac{23.3 m_p}{V} = 2 \times 10^7 \times 23.3\ T^3\ m_p$ (for same volume V)

With eq.(10) can get by the following equation:

$$\mathcal{P} = 4.66 \times 10^8 T_\circ^3 m_p\ f_f(x) \text{ kg.m-3} \tag{15}$$

4-Distribution of density number:

Unit of density number is a (particle /m3).

So, from eq.(14)

$\frac{N}{V} = (2 \times 10^7 K^{-3})T^3$, number of atoms per unit volume (particle/m3)

Distribution of temperature from eq. (10).

$T^3 = T_\circ^3\ f_f(x)$

So, general solution for find distribution of particles number at specific temperature is as in the following equation.

$$\frac{N}{V} = 2 \times 10^7 T_\circ^3 f_f(x) \tag{16}$$

5-Distribution of energy:

The thermal energy is known:

$$E = \frac{3}{2} KT \tag{17}$$

Eq.(17) with eq.(10) produces the following equation:

$$E = \frac{3}{2} KT_\circ \times [f_f(x)]^{\frac{1}{3}} \tag{18}$$

Eq.(18) is a general equation for distribution of thermal energy for any comet with deferent function $f_f(x)$ which has special property for each comet.

Applications:

The curve of fig.(3) represents light intensity of comet's image along the line which drawn from the head of coma to end the tail, where $f_f(x)$ in eq.(5) is identical over this curve as shown in fig.(4).

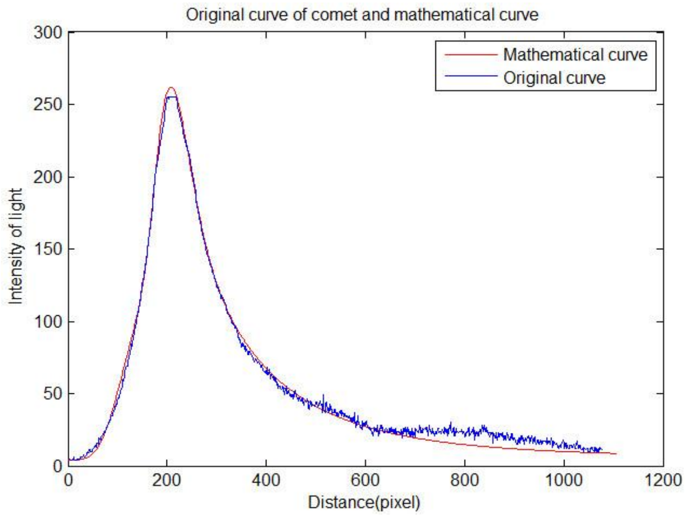

Fig. 4: Red curve (mathematical equation) is identical with blue curve of the comet.

There are cutting region at top blue curve in fig.(4) because the maximum of light intensity in CCD camera at 255 in gray scale value and there are abnormality in blue curve of comet in intensity of light at 700-1000 along x-axis may return to reason that the comet may release a large amount of gasses when it was in this region with its motion.

In fact the red curve (mathematical curve) which in above figure is consist from two equations as shown in fig.(5).

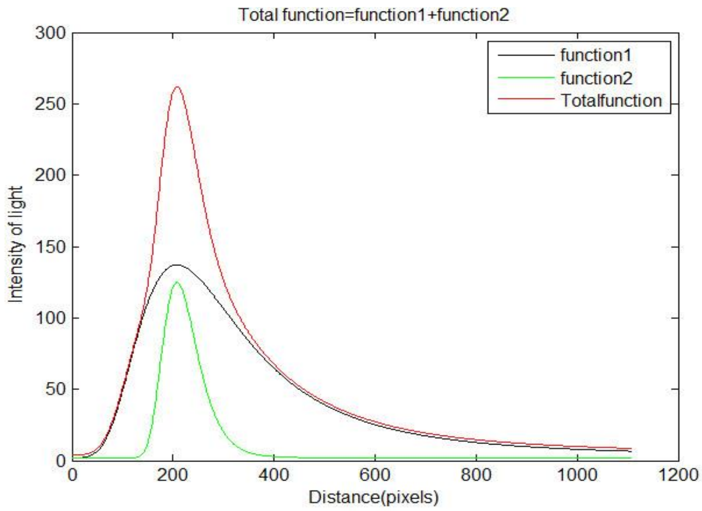

Fig. 5: Red curve which identical with original curve of comet is consist from two function ,black curve and green curve.

The final function $f_f(x)$ from eq.(5) and its both two equations with original curve of comet shown as fig.(6).

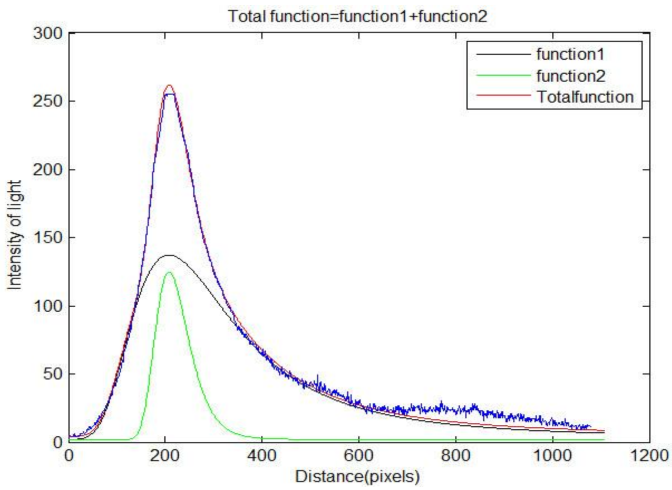

Fig. 6: Final function (red curve) is identical with original curve of comet (blue curve).

The gas of comet Lovejoy which surrounds comet's nucleus reaching to 5000 K^o at nearest point with the sun (Salman, 2014). It is maximum temperature, therefore it can be paint drawn eq (10) , as shown in fig.(7)

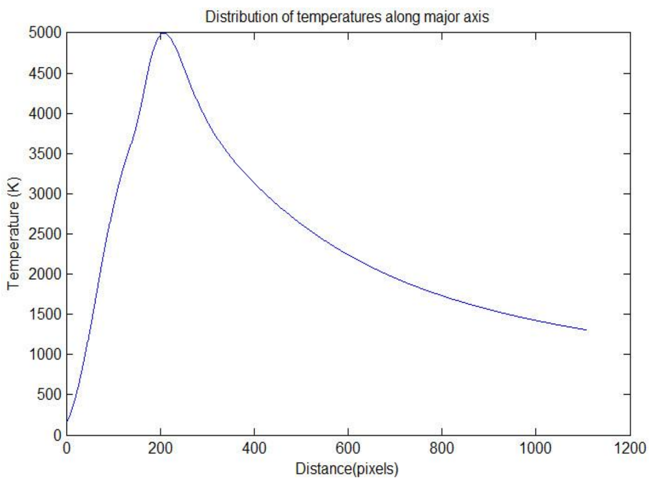

Fig. 7: Shows a Temperature distribution along comet Lovejoy with maximum temperature equal 5000k at nucleus's center, versus x-axis line.

Velocity of gas's particles of comet from eq.(12) can be seen in fig.(8).

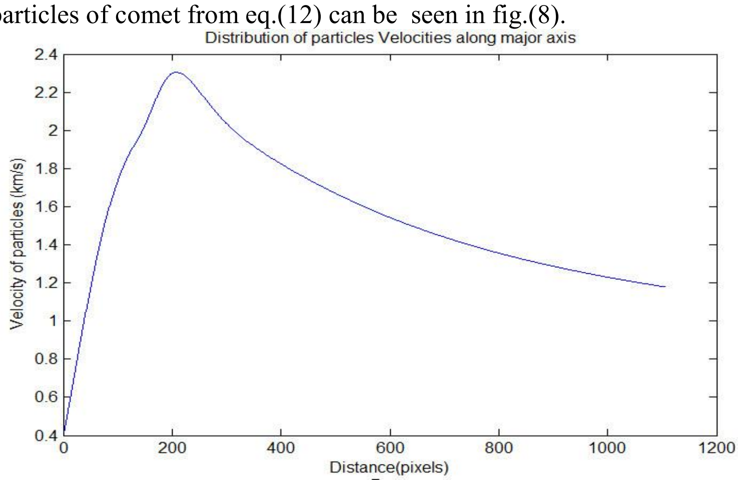

Fig. 8: displays a distribution of particles velocities along x-axis of comet Lovejoy. It appears the maximum of velocity as 2.3047 km/s.

Eq.(15) is a general equation of density's distribution representing in fig.(5), for comet Lovejoy.

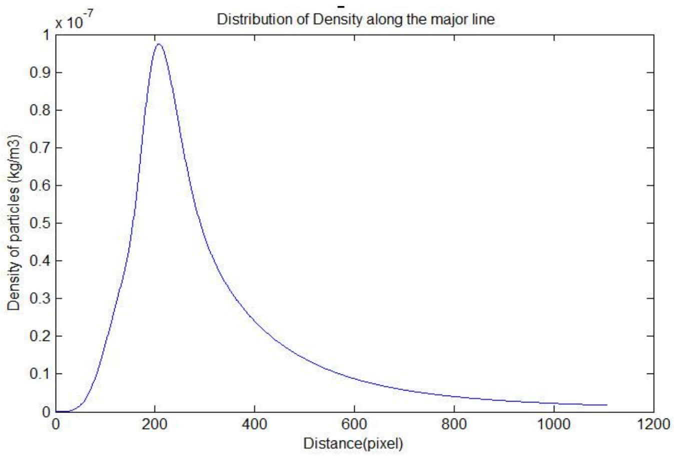

Fig. 5: shows the density in comet Lovejoy along major , where the density at nucleus center is 9.7429$\times 10^{-8}$ kg/m3, in its maximum value.

Density's number of comet Lovejoy from eq. (16) is as shown in fig. (6).

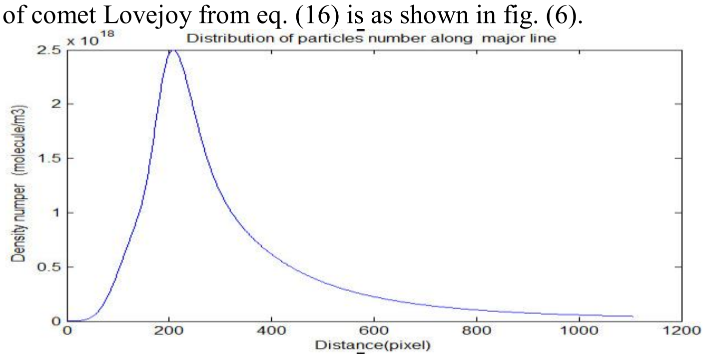

Fig. 6: shows density distribution number of the particles in comet Lovejoy along x-axis, major axis, where the maximum value was 2. 5*1018 particle/m3.

Standard measurement for intensity number was 1018-1020 molecule/m3 (Michael,2015). This value of comet Lovejoy was equal to 2.5 $\times$1018 molecule/m3 as shown in fig (6). They are good approximate results with standard measurements. The thermal energy of the particles in any region also can be represented in special figure from eq.(18) as shown in fig.(7)

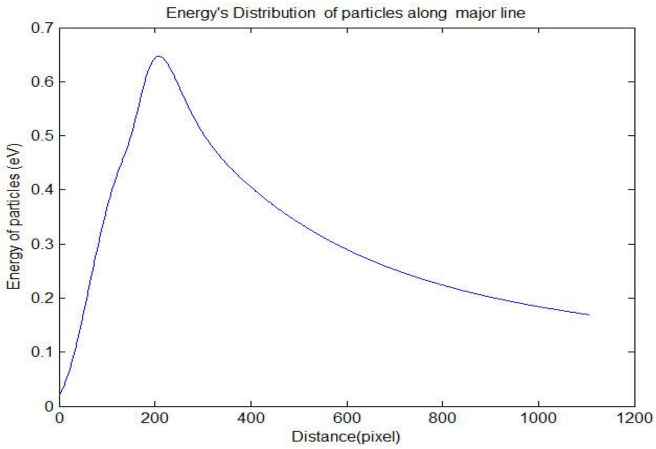

Fig. 7: Energy function of gas's particles along major axis of comet Lovejoy in (eV) where maximum value of energy was 0.6469 eV.

The representation of all previous functions shown in above figures signified in one figure to illustrate differences in each function as shown in fig.(8)

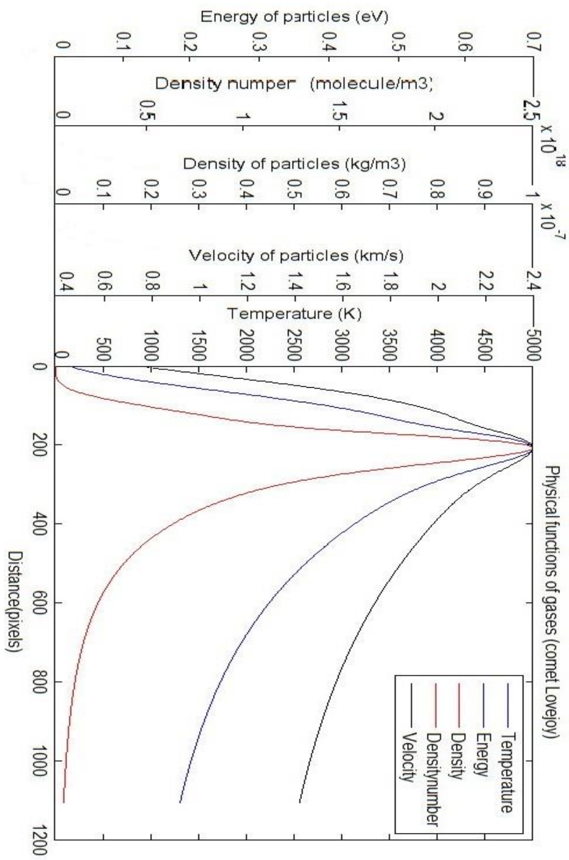

Fig. 8: Physical function of gases (comet Lovejoy) versus distance in pixel.

Results:

Fitting function to the intensity distribution of comet will split into two functions the first is for particles having low energy and other for particles having high energy .

Solar wind has a specific energy, by interaction solar wind with these particles which produces a different effect and energies on the particles.

All particles which surround nucleus will changes their sigma in Gaussian function, but this change increases whenever particles energy in decreases. Therefore, it should be noted that the particles which have a high energy their sigma is law value, and the particles which have a low energy their sigma is high value.

So, the description intensity curve of any comet can not be measured by constant sigma in Gaussian function, because an effect of the solar wind at different energies certainly changes their sigma at different energies of particles, therefore the sigma is not constant in description the gases around the comet.

In known one of physical characteristics of the comets is the constant 1km/s “for the particles which around the nucleus”. It is velocity of particles near the nucleus. It is true for one value of energy, but in fact it is not true for taking more one of energy values, for example, distribution of temperature which produces from its velocities distribution.

The velocity 1 km/s from standard references means average of particles velocity. This value appeared in the measurements because if we compute the velocity of comet's particles can be computed at middle the visible spectrum.

The value 1km/s appeared in this work approximates the average velocity. As shown in Fig.(4) where the average velocity 1.1 km/s exactly such as expected and such as observed. It applies with the standard measurements.

Conclusions:

Some important interesting points have been concluding in the followings.

1- There are three regions that divided the image of the comet Lovejoy, then regions are clearly visible and identified, they are related to the tail, coma and nucleus.

2- The temperature distribution of the comet Lovejoy is then governed by two functions $f_1(x)$ and $f_2(x)$ according to the position of the comet of the nucleus. It found that the temperature distribution is obey smooth positive exponential function starting from the beginning of the tail up to the center of the nucleus while it is sharply negative exponational function starting from the center of the nucleus to the end of the comet.

3- The density decreases as the distance increases. This is because of the effects of the magnetic pressure and the solar wind where both effects compete to govern the plasma particles.

4- In this study we find the relationship between temperature and distance. This increase in temperature is expected to be due to an increase in energy particles from the comet nucleus where the plasma ions near the nucleus added a mass to the cometary tail leading to the molecular weight of the tail structure. There is a significant change during solar wind interaction with the comet nucleus as shown in Figure (7).

Future Work:

1- Understanding the study of the distribution of pressure and temperature electron and the proton individually. Such a study could be more important in the process of interaction between ions in space.

2-Include the study momentum and dynamic motion of comet in the solar system. Adding the results of such study to those of the present research can give a full picture about comet motion in the solar system.

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