Determination of some characteristics of comet's gases by photometry method for comet Hyakutake

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Abstract

The present paper focuses on the study of some characteristics of comets ions by photometry method which represent by CCD camera which it provide seeing these images in a graded light. From 0-255 when Zero (low a light intensity) and 255 (highlight intensity). These differences of photonic intensity can be giving us a curve which appear from any line of this image.
From these equations the focus is concentrating on determine the temperature distribution, velocity distribution, and intensity number distribution which is give number of particles per unit volume.
The results explained the interaction near the cometary nucleus which is mainly affected by the new ions added to the density of the solar wind, the average molecular weight increase and result in many unique characteristics of the cometary tail.

Key words
Processing image, comet's gases, comet Hyakutake.

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حساب بعض الخصائص للمذنب الغازي باستخدام طريقة قياس الفوتومترية لمذنب هايكوتك

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الخلاصة

في هذا البحث تم التحقق من صور المذنبات بواسطة كاميرا CCD التي توفر رؤية هذه الصور التدرج الضوئي من 0-255 عند صفر (منخفض الشدة) و 255 (الشدة العالية). هذه الاختلافات في شدة الضوء يمكن ان تعطي لنا منحنى الذي يظهر من اي خط في هذه الصورة.
من المعادلات يمكن الحصول على العلاقة الخاصة لتوزيع درجة الحرارة و توزيع السرعة وعدد توزيع الشدة التي تعطي عدد من الجزيئات لكل وحدة حجم.
وكانت النتائج جيدة حيث تظهر التفاعل بالقرب من نواة المذنب الذي يتأثر اساساً من ايونات جديدة تضاف الى كثافة الرياح الشمسية، فأن متوسط الزيادة الوزن الجزيئي ويؤدي في كثير من الخصائص الفيزياوية الفـريدة لذيل المذنبات.

Introduction

As known that the comets are approaching of our sun from two regions, kiuper belt and Oort cloud, comets travel close to the sun, the sun's heat begins to vaporize the ices and causes them to form a fuzzy [1], 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 10^{10} meters in diameter [2]. 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 [3]. 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 [2].

Comet's photonic function

Comet Hyakutake in Fig. 1, 31 January 1996 [4], in aphelion about 3410 AU, perihelion 0.2301987 AU, semi- major axis 400AU, and it has eccentricity 0.9998946 [5], and orbital period about 70,000 yr [5].

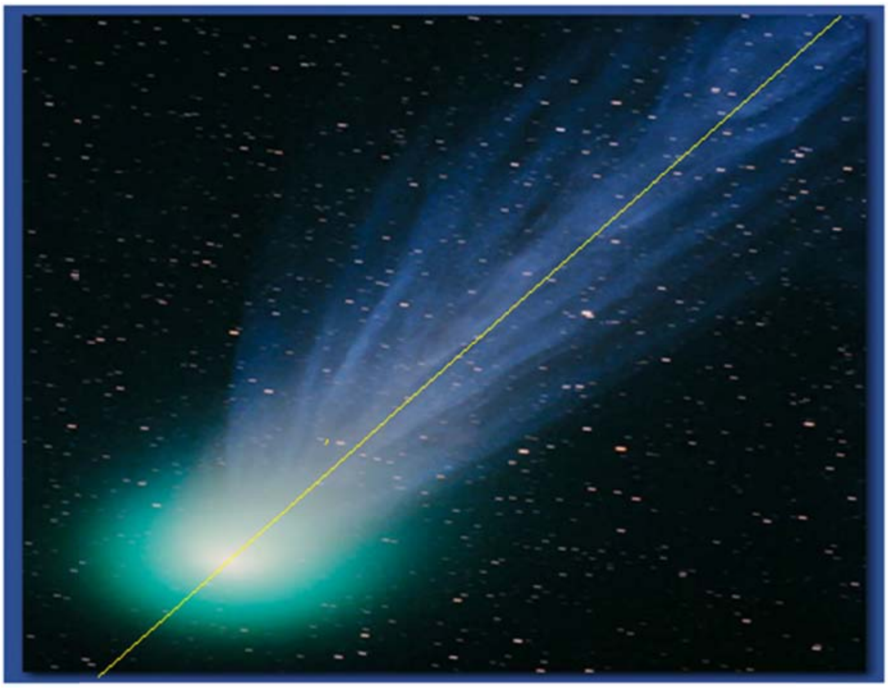

Fig. 1: Comet Haykutake is long period comet but it is also considered 'fresh', the solar wind heated up the nucleus to produces lot of dust and gases, the solar wind push the dust and gases far away the core [6].

When we take one line of this comet, along major axis of it, will appears photonic curve. The curve in Fig.2 shows an increase as approaching from center nucleus to reach maximum value above the center, and the photonic value decreases as the curve away to end tail.

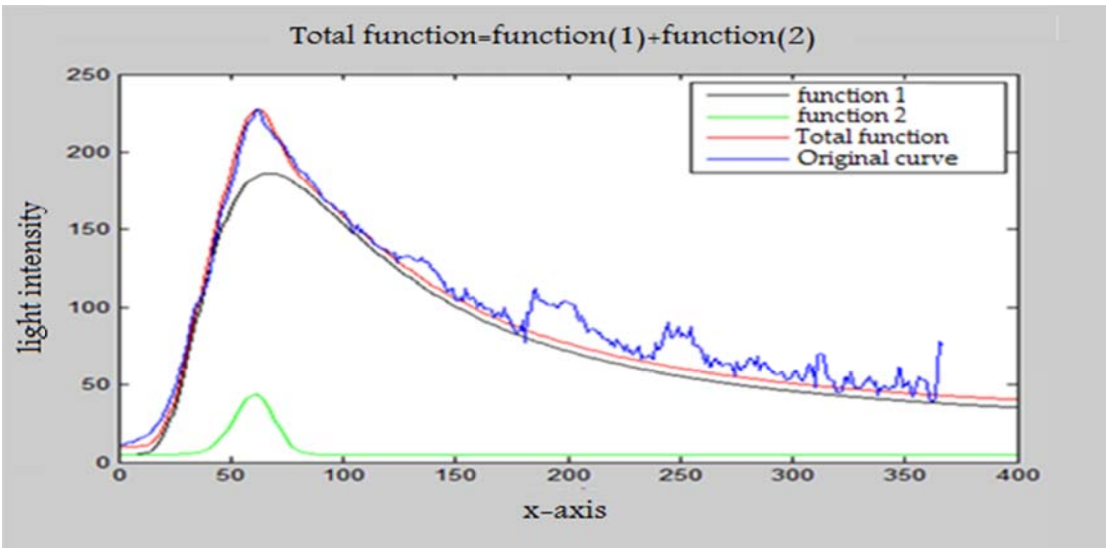

Fig. 2: The original curve of the comet (blue curve) and the total function(x) red curve.

where maximum total function here is 229, which represents maximum light intensity in one pixel on CCD camera.

Function(1), $f_1(j)$,is Gaussian equation but its δ_1 increases with the distance whenever get away from the nucleus center.

$$f_1(j) = 1.7exp\left(-\frac{(j+14).^2}{2\delta_1^2}\right) \qquad (1)$$

where (j) is a variable between -20 to 20 by Δj= 0.1, when x-axis in Fig. 2 changes from 0 to 400.

And δ_1 changes from value (-1.1) to (0.3035) by $\Delta\ \delta_1$=0.0035.

The result from function (1) is a function of light intensity versus x-axis as follows.

$$f_1(x) = 8exp\left(-(2.9744)\left(1-\frac{9.6268}{x+23.024}\right)^2\right) \qquad (2)$$

And function (2),$f_2(j)$,is Gaussian equation in it δ_2 has increases with the distance whenever get away from the nucleus center.

$$f_2(j) = 8exp\left(-\frac{(j+13.4)^2}{2\delta_2^2}\right) \qquad (3)$$

where (j) is a variable between -20 to 20 by Δj = 0.1, when x-axis in Fig. 2 changes from (0 - 400).

And δ_2 changes from value (1.2) to (17.64) by $\Delta\ \delta_2$=0.041.

The result from function (2) is a function of light intensity versus x-axis as follows.

$$f_2(x) = 8exp\left(-(4.08\times10^2)\left(1+\frac{25.3285}{x-11.328}\right)^2\right) \qquad (4)$$

where

$$f_T(x)=f_1(x)+f_2(x) \qquad (5)$$

Temperature distribution of comet Hyakutake

Temperature can be estimated using total function in Eq.(5) has a maximum value, should be normalization by divide it upon this value to produce final equation, As follows

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

where maximum of $f_{final}(x)$=1.

If we supposed that the final equation for intensity of photons, where intensity of photons is changing with each step of change f_{final}, therefore,

$$N = N_\circ \frac{f_{final}(x)}{maxf_{final}(x)} \qquad (7)$$

We have Plank's relation connects between number of photons and temperature; it is for gases which radiant a photons at specified temperatures in volume V.

$$N = 2\times10^7 VT^3K^{-3}m^{-3}[7] \qquad (8)$$

where N is number of photons which are release from volume V at temperature T.

$$N_\circ = 2\times10^7 VT_\circ^3K^{-3}m^{-3} \qquad (9)$$

where $N_\circ$ is a maximum number of photons which are release from volume V at maximum temperature T_o.

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

$$T^3 = T_\circ^3\frac{f_{final}(x)}{maxf_{final}(x)} \qquad (10)$$

Eq.(10) gives us the temperature along final function, it give us the temperature distribution along the comet, starting from the coma to end the tail.

The gas of comet Hyakutake which surrounds comet's nucleus reaches to 4660K^o because the central wavelength of comet Hyakutake about 6200A^o[8]. Or it is maximum temperature; now draw a relation of temperature distribution, as shown in Fig.3.

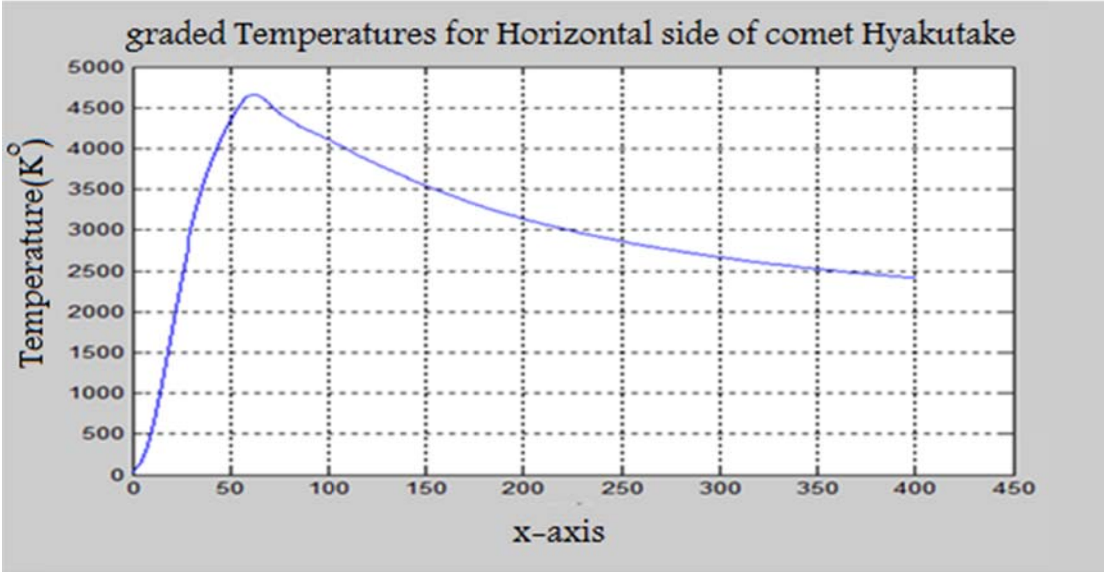

Fig.3: Temperature distribution along comet Hyakutake with maximum temperature equal 4660k at nucleus's center, versus x-axis line.

Gas's velocity distribution of comet Hyakutake

Velocity of particles which surrounding the nucleus and in the comet's tail are thermal velocity taken it by following relation:

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

where v is velocity of particles at temperature T, and m is constant mass of, m=*23.3*m_p[9], where m_p = mass of proton =1.6726× 10^{-27} kg

k=Boltzmann constant =1.38× 10^{-23}m^{2}kg s^{-2}k^{-1}

Put Eq.(10) in Eq.(11) to produce general equation of velocity distribution.

$$v^2 = \frac{3K}{23.3m_p} T_\circ \times \left[\frac{f_{final}(x,y)}{max f_{final}}\right]^{\frac{1}{3}} \qquad (12)$$

Can be representation Eq.(12) in Fig.4.

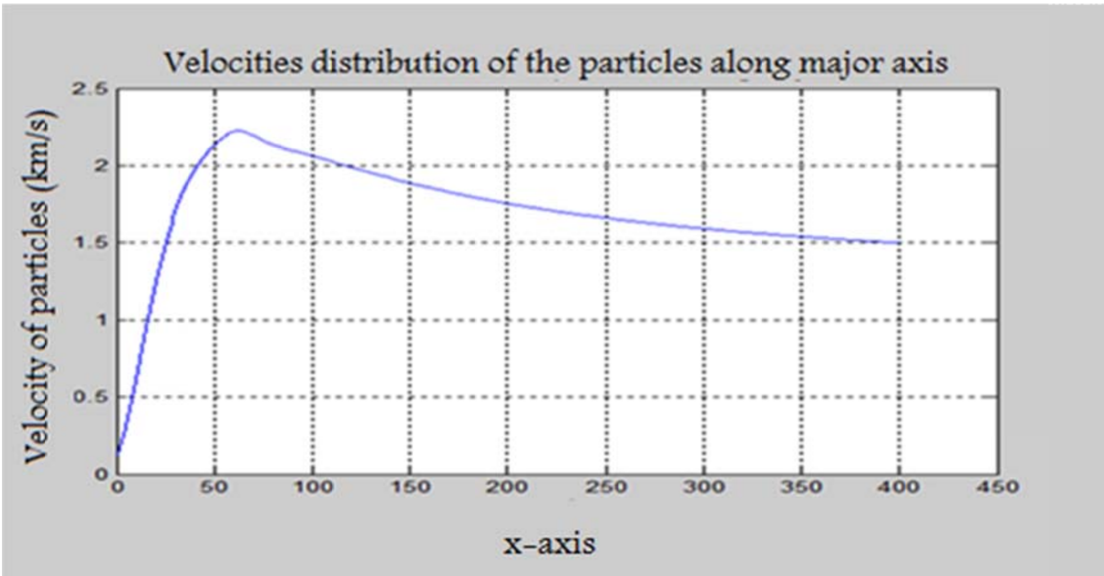

Fig.4: The distribution of particles velocities along x-axis of comet Hyakutake, where appears the maximum of velocity is 2.2249 km/s.

Intensity distribution

As we know the relation of intensity is, $\mathcal{P} = \frac{m}{V}$, where $\mathcal{P}$ (intensity kg/m^3), m is the mass (kg), and $V$is a volume (m^3).

If the gas is contain of (n) particles, and average mass of particle is equal 23.3 m_p[9], where m_p is proton mass, m_p=1.6726× 10^{-27} kg.

$$\mathcal{P} = \frac{n(23.3m_p)}{V} = \frac{n}{V}(23.3m_p) \quad (13)$$

The ratio (n/v) means a number of particles per unit volume, (particle/m^3), In comets we find that the number of the received photons must be equivalent the number of atoms which radiates these photons[8,9,10].

From Eq.(8) we have,

$$N = 2 \times 10^7 V T^3 K^{-3} m^{-3}$$

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

Put Eq.(14) in Eq.(13) to produce

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

with Eq.(10) we get.

$$\mathcal{P} = 4.66 \times 10^8 T_\circ^3 m_p \frac{f_{final}(x,y)}{max f_{final}} \text{m}^{-3}\text{k}^{-3} \quad (15)$$

The Eq.(15) is general equation of intensity distribution which can be representation in Fig.5, for comet Hyakutake.

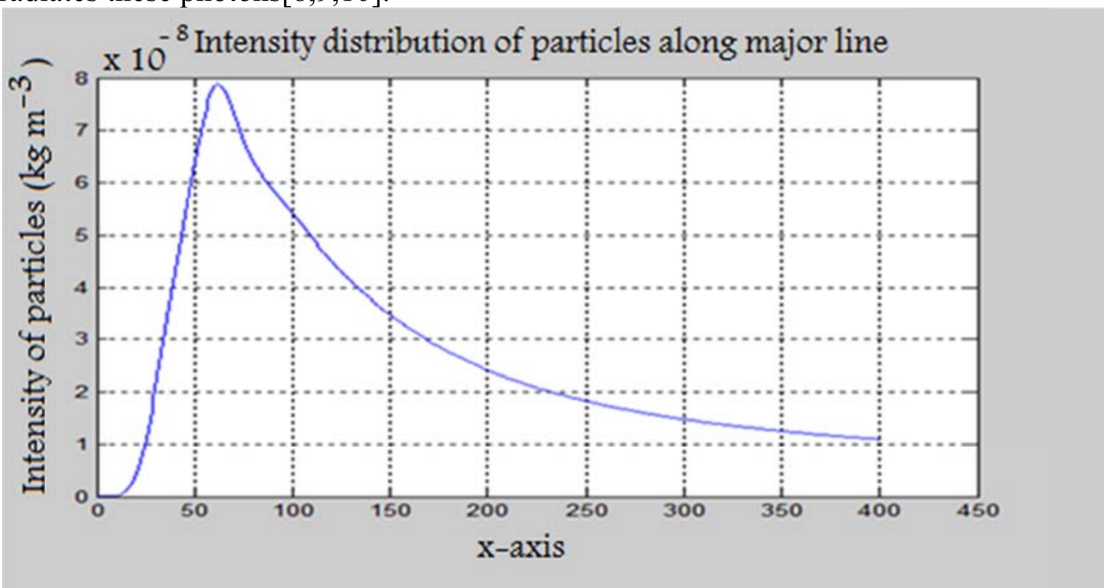

Fig.5 : Intensity distribution in comet hyakutake along the major axis of the comet, where was the intensity at nucleus center is 7.8874× 10^{-8} ***kg/m3, in maximum its value.***

Distribution of intensity number

Unit of Intensity number is (particle/m^3).

So, from Eq.(14)

$$\frac{N}{V} = 2 \times 10^7 T^3 K^{-3}$$

This relation for atoms number per unit volume (particle/m^3).

We have distribution of temperature from Eq. (10).

$$T^3 = T_\circ^3 \frac{f_{final}(x,y)}{max f_{final}}$$

So, general solution for find distribution of particles number at specific temperature as follows.

$$\frac{N}{V} = 2 \times 10^7 T_\circ^3 \frac{f_{final}(x,y)}{max f_{final}} \text{k}^{-3} \quad (16)$$

Fig.6 for representation Eq.(16) of comet Hyakutake.

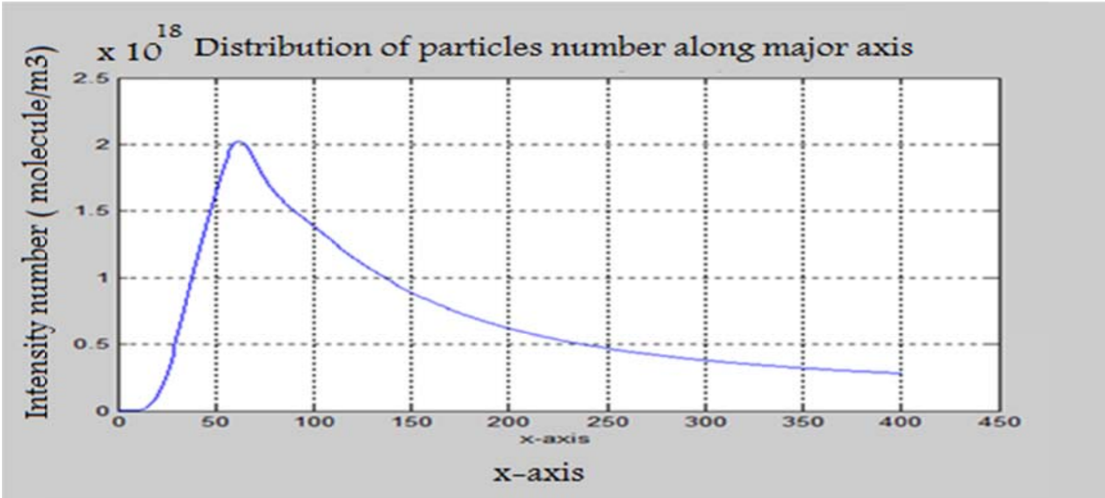

Fig.6: Intensity number distribution of the particles in comet Hyakutake along x-axis, major axis, where the maximum value was 2.0239× 10^{18} particle/m^3.

Results and conclusions

1- The curve of light intensity is contain from two functions, by collect both functions as shown in Fig.2, this case occur due to some particles have a low energy and the other some particles have a high energy.

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

All particles which surrounds nucleus will changes their sigma in Gaussian function, but this change increases whenever particles energy in decreases, therefore we note 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, we cannot description intensity curve of any comet by constant sigma in Gaussian function, because an effect the solar wind at different energies, certainly change their sigma at different energies of particles, therefore the sigma is not constant in description the gases that around the comet.

2- In known one of physical characteristics of the comets is the constant 1 km/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 it 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 will found it at middle the visible spectrum

The value 1km/s appeared in our study approximate average velocity, as shown it in Fig. 4 where it was 1.1 km/s, exactly such as expected and such as observed. It is apply with the standard measurements.

3- Planck relationship of the number of photons at any temperature, as well as the kinetic energy can be obtained on the relationship of particle density and number density of any point move in the comet. Standard measurement for intensity number was 10^{18}-10^{20} molecule/m^3 [10].

This value of comet Hyakutake was equal 2×10^{18} molecule/m^{3}as shown in Fig.6. They are good approximate results with standard measurements.

These values are maximum point in the curves and they are decreases whenever go away along the tail.

4-The tall tail meaning high intensity of particles which have high temperature near the core "nucleus", and we can account tail's length in real measures without back to observing by the telescopes and perform conclusion in spectroscopy measures or even photometry measures, but by one clear image of the comet and follow same the steps of the searching, by account the temperature of the particles in far point and account its energy, to look up do it in visible region or not, where we can account also length of tail at visible region and its length in non-visible.

References

[1] S.E.Eckleben, Bang, United States of America, 2004, pp. 82-83.

[2] E. D. Wire. The Florida Night Sky. Printed in the United States of America, 2002, pp. 248-249.

[3] K. R. Lang, "The life and death of stars", Printed in Singapore by KHL. Printing Co. 2013, pp.112-113

[4] N. Bone. Aurora "Observing and recording nature's spectacular light show". Viking Canada, 2007. pp. 38-39

[5]Kenneth, P. Seidelmann, The explanatory supplement to the Astronomical Almanac, (Mill Valley, Cal.: University Science Books, 1992, pp. 716, 730

[6] D. Ceravolo, 'Ceravolo Images Comet Hyakutake', Ceravoloimages. com, 2015.

[7] Alan Durrant, John Bolton, "Quantum physics of matter", CRC Press, London, 2000, pp. 34-35.

[8] Lisse, C.M. "The Nucleus of Comet Hyakutake (C/1996 B2)". Icarus140, 1999, pp. 189–204.

[9] L. Wilkening, "Comets" the University of Arizona press Tucson. 1983, pp. 548-548.

[10] M. L.Finson. R. F. Probstein. Astrophysical Journal. 154, October (1968) 328.