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THE COMA OF COMETS AND THE NEW INTERPRETATION OF THE EXTRANUCLEAR STRUCTURE OF THE SOLAR SYSTEM

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Abstract

The coma structure of a comet is believed to have been formed due to the outburst taking place on the surface of its nucleus. According to this concept, the sequential outbursts occurring on the surface of the comet generate streams of gases with dust which when expand develop the coma structure. This kind of understanding associated with many doubts such as: i) why the outburst occurs on surface of the nucleus when it crosses a planetary orbit? ii) Why the freely expanding gases and dust particles remain associated to the nucleus of the comet in a near spherical pattern inspite of extreme high velocity of the nucleus? iii) Why the powerful solar wind that forms the long ion tail instantaneously fail to deform the coma structure? iv) Is the coma structure bonded to the nucleus by some kind of force-field interaction? This article presents the mechanism of formation of coma structure where, over excitation of coma gives rise to the formation of a jet like structure in the nucleus considered different from the existing understanding. The typical structure of the coma can be better understood from the new shell model which describes the shells, sub-shells surrounding a celestial body[1]. Unlike other celestial bodies, the comets and the extra nuclear shell constituents are in excited states and emit radiations. Thus, the ultraviolet picture of Halley's Comet (Fig. 3.1) shows its own coma structure prominently. The shell structure of the coma undergoes fluctuations responding to a quantum energy change interaction when the comet crosses the shell structure of the solar system [2]. When, the formation of the shell structure in the coma is due to a universal phenomenon that governs the stability of extra nuclear structure surrounding a celestial body, and then the spacings in the shell structure must also satisfy the general correlation. The findings of this article aim at establishing the discrete shell spacing correlation as suggested earlier[1, 2].

Key words: *coma of comets, comets, Halley's Comet*

Introduction

Comets have large spherical envelopes of glowing cloud known as coma. This visible coma is as large as 100,000 km in diameter and a surrounding halo of hydrogen atoms extending to 10 times this distance. Different gases such as H_2O, C_2, C_3, CH, CN, CO, N_2, H_2, CO_2, NH_3 etc. have been identified in the coma of comets from the spectroscopic studies. Dust particles in the range of 10^{-17} to 10^{-6} gram are also found to be present in the coma. The coma is highly structured with the above constituents. From the very nature of the structural features, the coma appears to be an integral part of the comet. But the gravitational field strength of the nucleus in the region of coma is too weak to organise a coma structure similar to the atmospheric structure of a planet. This is more so as the coma extends to very large distance where it could not have a significant gravity field due to the small mass of the comet.

Present understanding

The existing scientific explanation is that, the coma constituents are continuously generated from the surface of the nucleus which subsequently expands outwardly forming the coma structure as a transient dynamic feature and finally the constituents get lost in the interplanetary space through the tails. During the orbital motion, when the comet is nearer to the sun, the comet's surface gets heated up by the strong solar radiations. It causes the volatile constituents on the surface of the nucleus to boil forming gases which along with the fine dust escape the nucleus at higher velocities. These gases carrying particles expand and form the transient coma of comets and their subsequent drift by the solar wind forms the ionic and dust tails. The jet structures seen in the comet go to provide scientific reasoning to different structural features of the coma. The formations of jets are thought to have been caused by regular outbursts of volatile constituents from the surface of the nucleus.

Analysis of possible dynamics: a new concept.

The formation of the coma structure by the above mechanism appears unrealistic for the following reasons. Comets attain velocities in the range of 30 to 50 kilometers per second, when they are towards the near end of the sun. The comets at such high velocities would normally give rise to the gaseous constituents to trail it. One would as well experience this fact by doing an experiment using an artificial satellite. However, if the radial expansion velocity is considered high compared to the velocity of the comet (a hypothetical case) then, one would expect an envelope of gas surrounding the nucleus. Such a gaseous envelope if formed would not have a near spherical shape to represent the typical coma structure. Once again the impact of solar wind is so high that some ions from the coma are knocked out to form an ion tail extending to distances as large as 150,000,000 km in the direction of the solar wind. One may wonder - why the powerful solar wind does not destroy the coma structure. It is, as if, the particles in the coma structure were bonded to the nucleus.

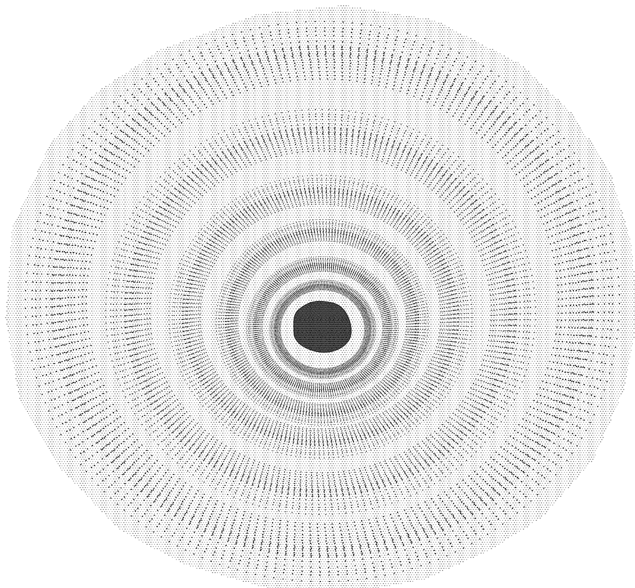

Fig. 3.1 SCHEMATIC VIEW OF COMET HALLEY IN THE FAR ULTRAVIOLET (Ref:cover page colour photograph

The comet system (the nucleus and the coma) appears to have an integral association like the association of planets with the sun, the satellites with the planets or the electronic structure with the nucleus of an atom. Thus, one cannot possibly ignore the feasibility of stronger interaction forces other than gravity for the stability of the coma structure. Hence, besides gravity, the electric charge force interaction may be one of the sound propositions to justify the coma structure. It is also seen from the records of spacecraft (Vega 1) that predominant charge activity including the magnetic polarity change are conspicuously present in the coma structure. An unexpected rotation of magnetic vector and an increased level of magnetic field turbulence have been recorded[3]. The spacecraft Suisei passed through the strong interaction region where solar wind flow was seriously perturbed by the pickup of ions of cometary origin and abrupt change in the plasma parameter was recorded around 4.5 x 10^5 km. These records[4] shows that the electric charge forces are predominant in coma. It may be interesting to note that a reduction of spread of starting times of different ions is thought to have been caused by the disturbances of the electric field by the ion cloud space charge. In view of these observed phenomena, can Halley's Comet (and other comets) be regarded as electrically charged bodies for a better interpretation of the coma structure?

This article does not intend to study the mechanism of shell structure formation in the coma but only records that the shell spacings are not arbitrary but arranged in a definite pattern following the general correlation model discussed in Ref.1. The shells in the coma exhibit a norm of outwardly expanding order of spacings as in the case of the shell structure of the solar system and planetary systems. Thus, extending the logic of the stability of orbital bodies, it may be presumed here that, the coma constituents originally released from the nucleus of the comet and expanding outward find relatively stable sites at these shells, sub-shells of the field features. However, the coma constituents can jump from one shell to another under external excitation. Comets are excited to a great extent by solar radiation and therefore, the cometary ions etc. jump from shell to shell while escaping from the extra nuclear structure of the cometary system (nucleus and coma). This new concept is in contrast to the existing concept, where the timely outbursts producing jets of gases and dusts form the shells in the coma while expanding outwardly. It may be seen here that the existing concept fails miserably to account for a mass balance. It was noticed by Vega 1 that the dust flux in the jets is not more than 3 times the flux in the coma[5]. In the new concept, the shells and subshells in extranuclear structure is formed due to a natural phenomenon and thus, it is not required to satisfy the dynamic mass balance as the continuity of flow (expansion) is coupled up with a period of residence in the shell locations. Hence, in the new concept the particle density in the coma is independent of the density of particles in the jet.

It is suggested that the outburst phenomenon in the comet is closely linked to a new quantum interaction when the comet crosses the shells and sub-shells of the solar system. Let us examine, how exactly the quantum interaction takes place. When the comet approaches a shell of the solar system (say, the shell that houses a planet) it meets the shell constituents (atoms, molecules, ions, electrons etc) which interact strongly with the constituents present in the shells of the coma giving rise to abrupt changes those result in strong breathing of hydrogen coma. Apparently, these abrupt changes in the coma caused by the above interactions of shell constituents do not have a bearing with the jet structure seen on the surface of the comet. We shall now discuss the formation of the jet structure from a different consideration altogether. The cosmic rays entering into the earth's atmosphere are guided along the geomagnetic lines to reach the poles. Now, if somehow, a dense flux of cosmic rays enters the earth's atmosphere or abruptly the plasma density increases in the ionosphere, then a large number of these particles while being guided along the geomagnetic lines would produce an air glow/glowing cloud near the poles due to a high concentration of activated species. A picture of this air glow if photographed from a distance would resemble a converging cloud with increasing density in the path closer to the poles. Thus, when there is a sudden increase of charge particles in the coma due to the interaction with the shells of the solar system, it produces an abrupt rise in the charge particle density in the part near to the magnetic poles of the comet. The comets under such accelerated ion activity in the coma structure and near the poles show a picture of dust-cum-gas cloud configuration resembling a jet structure emanating from the comet surface. The jet features photographed by Vega 1 (or evidenced otherwise) might be due to the cause discussed above. The illusive concept of the jet picture has further given rise to imaginary outburst taking place on the surface of the comet. Hence, it may be interesting here to note that the jet structure does not form the coma but the coma forms the jet.

Careful examination of the dust-cum-gas shell might as well reveal the new shell, sub-shell structural features in the coma with existence of fine structures. If now, the recorded events taking place at different distances from the nucleus of the comet are considered as characteristic interactions of specific shell or sub-shell, then the shell distances may be found to follow the general correlation given in Ref.1. A list of events along with their distances from the nucleus of Halley's Comet is presented in Table 3.1. These measured distances are now compared with the theoretically computed distances worked out following the extra nuclear shell model (Table 3.2). The percentage of deviation is found to be within limits of approximation inspite of the shells having been deformed from the spherical geometry under the action of external force fields. Thus, the new shell model of the extra nuclear structure of a celestial body also works well for the structure of the coma. A clear understanding of the mechanism and the nature of force interaction will perhaps reveal many mysteries of the solar system.

TABLE 3.1
A RECORD OF SOME IMPORTANT EVENTS IN THE SHELLS OF COMA OF HALLEYS COMET AT DIFFERENT DISTANCES FROM THE NUCLEUS

DISTANCE	EVENTS	REFERENCE
300 km	The three channel spectrometer (TKS) aboard the Vega 2 space-craft recorded infrared and visible spectra near the nucleus of comet Halley. Spectra in the range 0.95-1.9 mm at a distance of 300 km from the nucleus reveal the H_2O 1.38 mm and OH band.	Krasnopolsky, V.A. et al., *Nature* **321**, 269-271 (1986)
500 km	In the internal part of coma, 500 km from nucleus, H_2O and CO_2 were identified by their infrared spectra IKS and TKS Experiments	Sagdeev, R.Z. et al, *Nature* **321**, 259-262 (1986)
1000km	Visible spectra of comet Halley was measured at 1000 km distance from the optical axis to the nucleus.	Krasnopolsky,V.A, *Nature* **321**, 269-271 (1986)
2450 km	The near ultraviolet and visible channel (V) of TKS instrument carried by Vega 2 reports the brightness of the OH (0,0) band to be around 1.2, 1.4, and 1.8 MR (Megarayleigh; IR = 10^6 photons $cm^{-2}S^{-1}$ $(4pSr)^{-1}$ at distances of 4900, 2450 and 1000km	Moreels, G., et al., *Nature* **321**, 271-274 (1986)

	from the nucleus	
4900 km	- do -	- do -
1.04×10^4 km	For a pointing centered on the nucleus 70% of the observed H_2O molecules are in the sphere whose radius is equal to the projected size of our aparture radius at the comet (1.04×10^4 km)	Weaver, H.A, et al., *Nature* **324**, 441-444 (1986)
2×10^4 km	Close to comet the water group of ions are dominant. The H_3O^+/H_2O ratio increases with decreasing distance and exceeds unity at distance 20,000 km.	Krankowsky,D. et al., *Nature* **324**, 326-329 (1986)
4×10^4 km	A sudden increase in cometary plasma density was registered by the PLASMAG experiment at a distance of 40,000 km from the cometary nucleus.	Sagdeev,R.Z., etal., *Nature* **321**, 259-262 (1986)
7×10^4 km	On the out bound pass,the cometary ions reappear in SDA (Solar Direction Analyser) Vega 2, at 7×10^4 km from the nucleus.	Gringauz,K.I., et al., *Nature* **321**, 282-285 (1986)
1.5×10^5 km	An increased number/density of dust particles in the mass range of 10^{-16} to 10^{-15} g which may be interpreted as the inbound crossing of the dust paraboloid for	Sagdeev, R. Z., et al., *Nature* **321**, 259-262 (1986)

	small particles took place at a distance of only 1.5 x 10^5 km from the nucleus.	
3 x 10^5 km	At a distance of 3 x 10^5 km from the nucleus, the solar wind proton population becomes comparable to the cometary implanted ions (Vega 2 data)	Gringauz, K.I., *Nature* **321**, 282-285 (1986)
5.8 x 10^5 km	Expansion of hydrogen atom produced photo dissociation of the water outburst from a shell structure, propagating with time in the hydrogen coma, because the velocity of hydrogen atoms is much higher than that of the parent molecules. the image shows such a shell with a radius of about 0.58 x 10^5 km.	Kaneda,E. et al., *Nature*, **320**, 140-141 (1986)
1.15x10^6km	At the time of Giotto encounter the bow shock was located at a distance 1.15 x 10^6 km from the nucleus.	Grard, R. et al., *Nature* **321**, 290-291 (1986)
1.2 to 2.5x 10^6 km	An increase in electric field strength was detected at distances of 1.2 -2.5 x 10^6 km from the nuclus. It is not clear, wheather this increase is connected with the bow shock.	Grard, R. et al., *Nature* **321**, 290-291 (1986)

5 x 10^6 km	A large turbulent region extends upstream of the bow-wave for 5 x 10^6 km from the nucleus. Here fluctuation in electron distribution occur, characterized by abrupt variation in the electron heat fluxes with Ro often reaching a value of unity; i.e. equal forward and reverse heat fluxes.	Reme, H. ey al., *Nature* **321**, 349-351 (1986)
1 x 10^7 km	Waves due to plasma instabilities associated with the pickup of cometary ions by solar wind were observed within a region almost 107 km from the comet nucleus.	Oya, H. et al., *Nature* **321**, 307-310 (1986)

TABLE - 3.2
MATCHING OF OBSERVED EVENTS CORRELATING TO NEW SHELL-STRUCTURE

Observed distance from nucleus x 10^4 km	Estimated distance from nucleus x 10^4 km	Deviation x 10^3 km	Percentage of error
0.03	0.0306	+0.006	+2.00
0.05	0.0612	-	-
0.10	0.1225	-	-
0.245	0.2450	0.000	0.000
0.490	0.4900	0.000	0.000
1.040	0.9800	-0.600	-5.77
2.000	1.9600	-0.400	-2.00
4.000	3.9200	-0.800	-2.00
7.000	7.8400	+0.8400	+12.00
15.000	15.6800	+0.6800	+4.30
13.000	31.3600	+18.3600	+4.53
58.000	62.7200	+4.72	+8.14
115.000	125.4400	+10.440	+9.18
(120-250)	250.8800	-	-
500.000	501.7600	+1.7600	+0.35
1000.000	1003.5200	+3.5200	+0.35

Conclusion

The shell structure of the coma of a comet is similar to the shell structure of large celestial bodies and the placement of shell; sub-shells are also in GP series. Thus, the shell pattern appears universal.

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