A coupling of the origin of asteroid belt, planetary ring, and comet

Yongfeng Yang

Bureau of Water Resources of Shandong Province, Jinan, Shandong Province, China, Mailing address: Shandong Water Resources Department, No. 127 Lishan Road, Jinan, Shandong Province, China, 250014

Tel. and fax: +86-531-8697-4362

E-mail: roufengyang@gmail.com

Abstract

Various scenarios had been previously presented to account for the origins of asteroid belt, planetary ring, and comet, but none of them is incomplete or successful. Asteroid belt that is located between the orbits of Mars and Jupiter is flat, circular, and parallel to the ecliptic, similarly, planetary ring that is located between the orbits of planet and satellite is also flat, circular, and approximately parallel to its planetary equatorial plane. This implies that asteroid belt and planetary ring are likely to derive from a same physical process. Here we propose, the two bodies of a previous binary planetary (satellite) system due to their orbital shrinkage occurred a smashing collision to shatter into fragments to all around. The ejected fragments further gave rise to great bombardment on the objects they encounter in the travel, and thereby left craters and scrapes on the surface of these objects. At the same time, due to the effect of hierarchical two-body gravitation (non-Newton's gravitation), the barycenter of initial binary planetary (satellite) system was survived in the collision and continued to orbit, which drags the fragments by means of the barycenters of a series of hierarchical two-body systems to move. This successive hierarchical drag slowly confine these fragments to fall on a circular belt (ring), and subsequently dynamical evolution makes the belt (ring) become flat. The farther fragments were being dragged by the belt (ring) to run across the solar system back and forth, which gives rise to the advent of comets when close enough to the Sun and the appearance of meteors when close enough to the Earth.

1 Introduction

Long-term ground and spacecraft-based observations have proved that there are an asteroid belt, four giant planetary ring systems, and countless comets in the solar system. The previous origin theory of asteroid belt believes that asteroids are fragments of a destroyed planet (Herschel 1807), the currently accepted scenario believes that asteroids are rocks that in primordial solar nebula never accumulate to form a genuine planet due to a strong Jupiter's gravitational perturbation (Petit et al.2001). The origin theories of planetary ring are plentiful. Especially for Saturn's ring, they include tidal disruption of a small moon (Roche et al. 1847), unaccreted remnants from the satellite-formation era (Pollack et al. 1976), collisional disruption of a small moon (Charnoz et al. 2009), and tidal disruption of a comet (Dones 1991). Canup recently viewed the disabilities of these scenarios and developed a model to propose that planetary tidal forces strip ice material from a Titan-sized satellite to form a pure ice ring (Canup 2010). If Saturn's rings are evolved from a previous pure ice ring, it is necessary for them to keep identical material, but observation shows that there are various spectral characteristic in the rings, and different spectral characteristic corresponds to different material, a natural contamination from interstellar matter is unlikely to yield this parallel crossbedded distribution of different spectral rings. To support the production of icy moons, Canup employed another research by Charnoz et al that ring material spreading beyond the Roche limit accretes to form icy moons (Charnoz et al. 2010). However, the Roche limit itself is ambiguous because a lot of satellites whose distances to their father planets (Jupiter, Uranus, and Neptune, for example) are interior to the Roche limit are still survived, and some of these satellites are also embedded in the rings (Burns et al. 2001). Saturn's rings are broad and are divided by many gaps that seem like boundaries, the particles in each ring appear to orderly orbit in their realm and do not ride over these boundaries. It is very difficult for Canup's model to account for these significant features. The origin of comet includes Oort cloud hypothesis that proposes that comets reside in a vast cloud at the outer reaches of the solar system (Oort 1950) and Kuiper belt hypothesis that proposes a disc shaped region of space outside the orbit of Neptune to act as a source for short-period comets (Kuiper 1951). To some extent, all the scenarios are more or less based on solar nebula hypothesis (Woolfson 1993), but this hypothesis is still surrounded by a series of problems (Wurchterl 2004; Klahr 2003; Taishi et al. 1994; Andrew et al. 2002; Inaha et al. 2003), this makes the related theories uncertain. High resolution photographs of well-regulated movement of asteroid family (group) (Hirayama 1918), integrity of Saturn's narrow F ring (Murray et al. 2008), unique spokes in Saturn's B ring (Mcghee et al. 2005), and twisted arc in Neptune's Adams ring (Hammel 2006) seem to indicate that they do not obey the constraint of Newton's universal gravitation. Comets are observed to run very eccentric trajectories that cross the orbits of many planets, this in the Newton's gravitational field corresponds to a variation of orbital energy, but in practice we cannot find a mechanism to maintain this transfer. On the other hand, the orbital features of short period comets do not approve an origination from Oort cloud, and the mechanism by which the comets are supplied from Kuiper belt to planet-crossing orbits is still unclear (Duncan et al. 1988). In the last 20 years, though a lot of Trans-Neptunian objects had been found from the proposed Kuiper belt, there is no evidence to support that these Trans-Neptunian objects are closely linked to comets. In conclusion, the current understanding of the origins of asteroid belt, planetary ring, and comet are still incomplete. Both asteroid belt and planetary ring are flat, circular, and parallel to respectively the ecliptic and planetary equatorial plane; they are embedded in planetary orbits and satellites' orbits, respectively; In addition to this, asteroids consist primarily of carbonaceous, silicate, and metallic materials, which is similar to the composition of the Earth and Mars. Relatively planetary ring consists primarily of ice and dust, which is similar to the composition of icy satellites. On large scale, the Sun has a number of planets, each giant planet (Jupiter, Saturn, Uranus, and Neptune) also has a number of satellites. The similarity in these aspects suggests that the formation of both asteroid belt and planetary ring should share the same physics. The recent discovery of a population of comets in the main asteroid belt (Hsieh et al. 2006) indicates that comets may derive from various origins. The feature of various craters on the surface of planets and satellites suggests there had taken place some significant events in the solar system to create extensive bombardments. Recently a new model proposed that all objects in the universe are orderly organized in a series of hierarchical two-body systems to orbit and that under the effect of gravitation the two bodies of each two-body system will finally take place a catastrophic collision due to their orbital shrinkages (Yang 2011). In this present paper, we model physical collision of the two objects of a two-body system to account for the formation of asteroid belt, planetary ring, and comet at the same time, along with the topography of planet and satellite.

2 Modelling

In the frame of a hierarchical two-body model, all bodies are indirectly fixed together with gravitation (excluding the two bodies of a two-body system that are directly fixed together with gravitation), this indicates that if a moving body is shattered into fragments, these fragments are still constrained by gravitation in a series of hierarchical two-body systems, and the barycenter of the initial body can be survived in the disruption and may thus bring these systems of fragments to continue to orbit. Based on this physics, a theoretical model is here developed to demonstrate the formation of a belt (ring system) (Fig.1): A two-body system is orbiting a center body. With the passage of time, the two bodies of the two-body system due to their orbital shrinkages occurs a catastrophic collision to eject fragments in all directions. But due to the constraint of gravitation, these fragments form a series of hierarchical two-body systems in space. As the barycenter of the initial two-body system is survived in the collision, it continues to bring these systems of fragments to orbit. A successive hierarchical drag by means of the barycenters of related two-body systems automatically confines these fragments into a circular orbit. Some of the fragments are further shattered into small fragments to form a series of subordinate hierarchical two-body systems. As shown in Figure 1(D), the barycenter of the initial two-body system (point *O*) is dragging two components (point *a* and 1) to orbit, at the same time point *a* is also dragging two components (point *b* and *d*) to orbit, point *b* is also dragging two components (point *c* and one fragment) to orbit, etc. Because of this successive hierarchical drag from point *O* to related points, each fragment can always obtain some movement that is parallel to the movement of point *O*. For instance, we assumed that the angle between line *Oa* and the movement of the barycenter (point *O*) is α, the angle between line *ad* and line *Oa* is β, the angle between line *de* and line *ad* is γ, the angle between fragment M and line *de* is δ, thus the movement of fragment M that is parallel to the movement of point *O* fits to a relation of $\cos\alpha \times \cos\beta \times \cos\gamma \times \cos\delta$. Also because point 1 is also dragging a series of hierarchical two-body systems of fragments, each other fragment undergoes the same dynamical process as fragment M, thus all the fragments under the effect of this successive hierarchical drag trend to fall on a circular orbit. But because of orbital shrinkage, the barycenter of the initial two-body system is increasingly approaching the center body, this further leads the fragments to move toward the center body, the belt (ring) thus becomes flat.

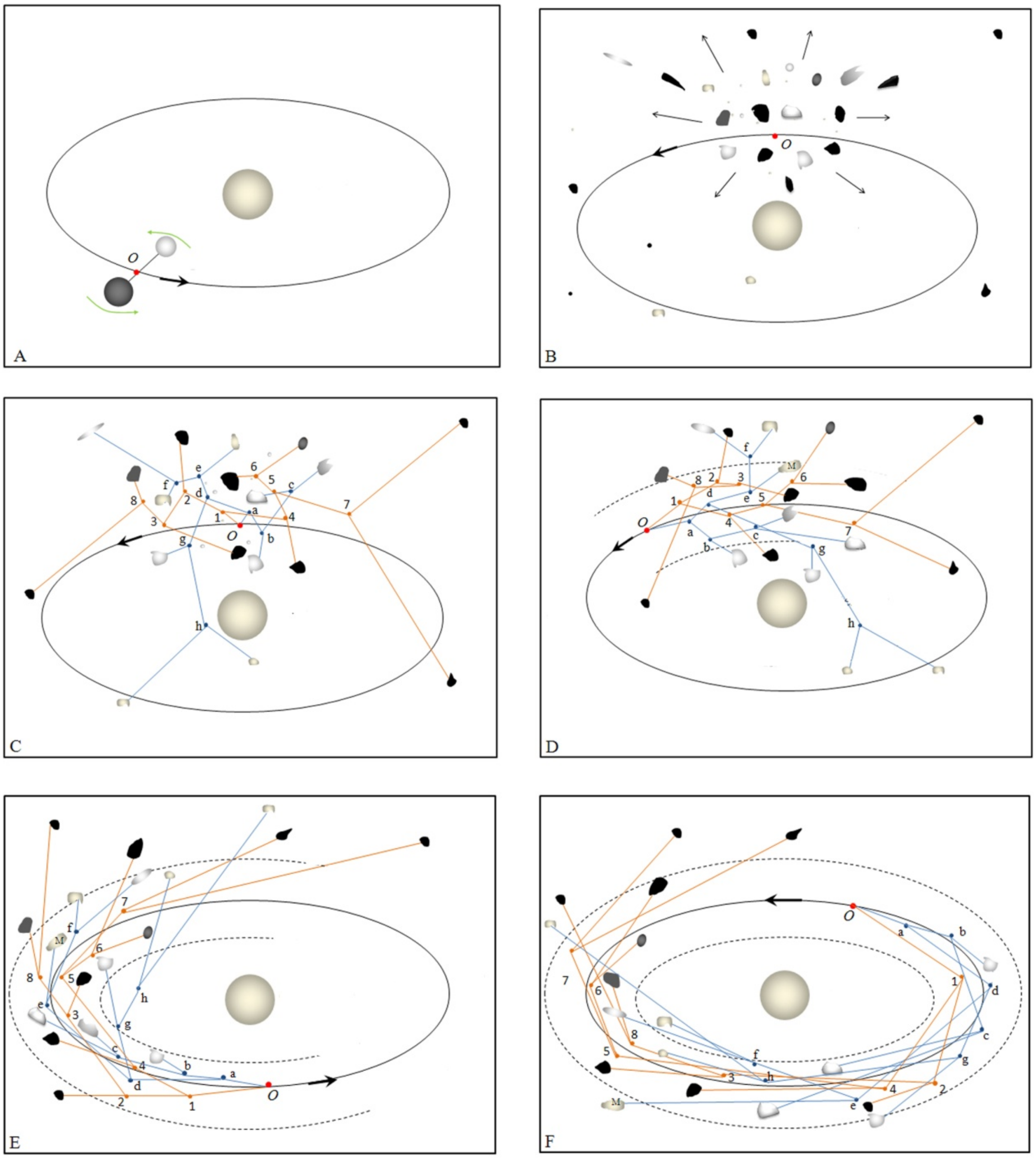

Figure 1: Simulation of the formation of a belt (ring system) based on hierarchical two-body gravitation. From A, B, C, D, E to F, it demonstrates the formation of a belt (ring system). Point *O* (marked with red dot) denotes the barycenter of the system. Blue (orange) dots (marked with letter *a*, *b*, *c*, etc., and number 1, 2, 3, etc.) represent the barycenters of related two-body systems in the associations. Blue (orange) line represents gravitation. Large black arrow represents the movement of the integral association. Dashed circle denotes the boundary of the belt (ring system).

It is now necessary to specify parameter for the formation of asteroid belt that the center body is replaced with the Sun, the initial two-body system in both physical element and chemical composition is similar to the Earth-Moon system (especially it is rich in the composition of carbonaceous, silicate, and metallic material), and it is just placed between the orbits of Mars and Jupiter. Estimate of energy follows this process. Due to $M_{\text{earth}} = 5.97\times10^{24}$ kg, $M_{\text{moon}} = 7.35\times10^{22}$ kg, $L_{\text{earth-moon}} = 384\,000$ km, $P_{\text{moon}} = 27.32$ days, $R_{\text{earth}} = 6\,370$ km, $R_{\text{moon}} = 1\,738$ km (where M_{earth} and M_{moon} are respectively the mass of the Earth and Moon, $L_{\text{earth-moon}}$ is the distance between the Earth and Moon, P_{moon} is the orbital period of the Moon, R_{earth} and R_{moon} are respectively the radius of the Earth and Moon), thus the orbital radius of the Moon in the Earth-Moon system is $L_{moon} = (M_{earth}\times L_{earth\text{-}moon})/(M_{earth}+M_{moon})$ =379 330 km, the orbital velocity is $V_{moon} = 2\pi L_{moon}/P_{moon} = 1.0$ km s^{-1}, the orbital radius of the Earth in the Earth-Moon system will be $L_{earth} = L_{earth\text{-}moon} - L_{moon}$ = 4 670 km, the orbital velocity is $V_{earth} = L_{earth}\times V_{moon}/L_{moon} = 0.012$ km s^{-1}. The kinetic energy for the Earth-Moon system will be $E_k = (M_{earth}\times V_{earth}^2 + M_{moon}\times V_{moon}^2)/2 = 3.72\times10^{28}$ J. When the Moon collides with the Earth, their gravitational potential is converted to kinetic energy, thus $E_p = GM_{earth}M_{moon}[(1/R_{moon1}-1/R_{moon2})+(1/R_{earth1}-1/R_{earth2})]$ (where R_{moon1} is the distance of the Moon to the barycenter of Earth-Moon system when the collision occurs, R_{moon2} is the initial distance which is equal to L_{moon}. R_{earth1} is the distance of the Earth to the barycenter of Earth-Moon system when the collision occurs, R_{earth2} is the initial distance which is equal to L_{earth}. After a deduction, R_{moon1}= 8 009 km, R_{moon2} = 379 330 km, R_{earth1}= 98 km, R_{earth2}= 4 670 km), thus the gravitational potential work is worked out to be $E_p = 2.93\times10^{32}$ J, the total energy for the Earth-Moon system at the moment when the collision occurs will be $E = E_k+E_p \approx 2.93\times10^{32}$ J (we assumed that the collision occurs at the moment when $L_{earth\text{-}moon} = R_{earth} + R_{moon}$ = 8 108 km). The water component in the sample Earth-Moon system after the disruption are freezed in the fragments to form water ice, some of the gases are escaped while the remaining like carbon dioxide are freezed in the fragments. The collision timescale is determined by the magnitude of orbital shrinkage. We also specify parameter for the formation of planetary ring that the center body is replaced with a giant planet (Jupiter, Saturn, Uranus, and Neptune), the initial two-body system is a binary satellite system, their composition is similar to the giant planet's icy satellites, and it is placed more near to the planet than other satellites. The collisional timescale here is not specified. After the disruption of the two bodies, some of the fragments due to collision are further shattered to form a series of subordinate hierarchical two-body systems. By order, each fragment is eventually shattered into small particles (with a size of meter or micron) to form a series of even subordinate hierarchical two-body systems. For two types of model, some of the farther fragments that are ejected from the collision are dragged by the asteroid belt (planetary ring) to run across the solar system back and forth, this gives rise to the bombardment to planet and satellite. Once some of the fragments approach the Sun's body, the freezed water and gases in the fragments may be vaporized to form comets.

3 Fits to observation

3.1 Asteroid belt

It can be inferred from Figure 1(F) that, as each two-body system is always dragged by a superior two-body system to orbit, the fragments in the same association may share similar orbital elements such as semimajor axis, eccentricity, period, and inclination. Also as the smaller fragments in the same association are derived from the disruption of a common parent body, this determines them to be with identical composition. Also as each hierarchical two-body association is an independent system, there may form space (gap) between the associations of fragments. Observation shows that many asteroids in the asteroid belt belong to some independent families or groups, in which these asteroids share nearly identical orbital elements (Andrew et al. 2002; Anne 2004). Literature shows that approximately one-third of the asteroids in the main belt are members of an asteroid family. Three bands of dust within the main belt have been found to share similar orbital inclinations as the Eos, Koronis, and Themis asteroid families (Love et al. 1992). The accepted conception strengthened by theoretical and observational results believes that members of a family are the fragments produced by the disruption of a common parent body resulting from a catastrophic collision (Zappala et al. 2002). Many Kirkwood gaps have been found in the asteroid belt. Although the current asteroid belt is believed to contain only a small fraction of the mass of the primordial belt, numerical simulations suggest that the original asteroid belt may have contained mass equivalent to the Earth (Petit et al. 2001). It can also be inferred from Figure 1(F) that under the frame of hierarchical two-body association, each fragment will have one companion that may be one body or a series of hierarchical two-body associations. According to Johnston's Archive of “Asteroids with Satellites”, as of October 2009, 67 asteroids that are in the main asteroid belt had been discovered to have companions (moons). The current belt is observed to be composed primarily of three categories of asteroids: C-type or carbonaceous asteroids, S-type or silicate asteroids, and M-type or metallic asteroids, this fits to the sample Earth-Moon system. Figure 2 models an asteroid belt around the Sun, all asteroids in the belt are orderly organized in a series of hierarchical two-body systems of families.

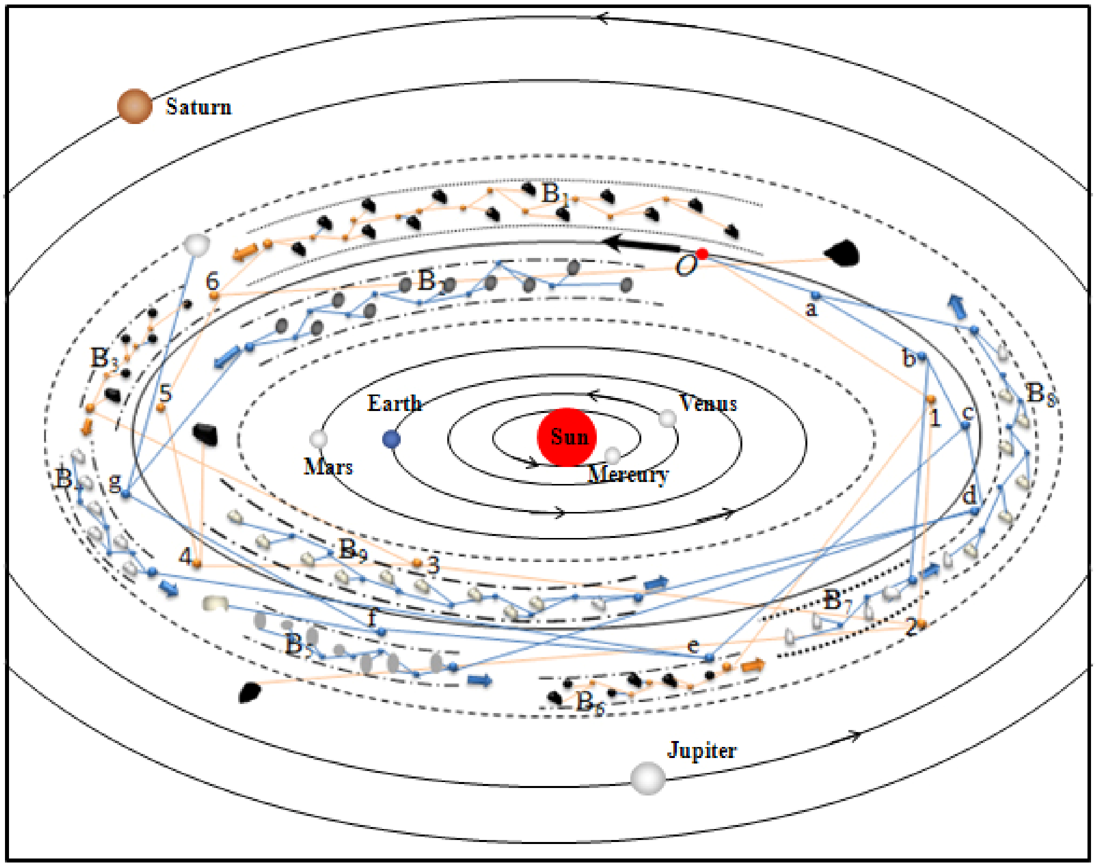

Figure 2: A modeled distribution of asteroid belt. The dashed circle interval is the scope occupied by the asteroid belt. Point *O* (marked with red dot) denotes the barycenter of asteroid belt. B_1, B_2, B_3 etc. denote some families that consist of a series of subordinate hierarchical two-body systems of smaller asteroids. Blue (orange) dots (marked with letter *a*, *b*, *c*, etc., and number 1, 2, 3, etc.) represent the barycenters of related superior two-body systems that control these families through gravitation. Blue (orange) line represents gravitation in. Large black arrow represents the movement of integral asteroid belt, while short blue (orange) arrow represents the motion of each family.

3.2 Planetary ring

It can be inferred from Figure 1(F) that, with the passage of time, the fragments continue to disrupt into smaller fragments (particles), each hierarchical two-body association of smaller fragments eventually encircles the center body to form a belt (ring), all the associations may at the same time form many rings that are divided by gaps. Observation shows that planetary rings are mutually parallel, and that there are many gaps between them (for example, Saturn's ring system). As some of the fragments are shattered to form the rings, while the others are survived, this determines that the survived fragments will be embedded to accompany the rings to orbit. This sort of fragments is currently named after irregular satellites. For example, Adrastea and Metis are observed to be embedded in the Jupiter's main ring, while Amalthea is embedded in the Gossamer ring. Satellites Mimas, Enceladus, and Tethys are embedded in Saturn's E ring. As the two bodies of the binary system are likely to be composed of different materials, different fragment in the collision may hold different material, as a result, when these fragments are further shattered into smaller fragments (particles) to form rings, different spectral characteristic's rings are determined. As every ring is composed of a series of hierarchical two-body systems of small fragments that are derived from a parent body, this means different rings may have different inclinations. Figure 3 models a Saturn's ring system, in which the particles are orderly organized in a series of hierarchical two-body systems to orbit, all rings therefore keep parallel to orbit the planet.

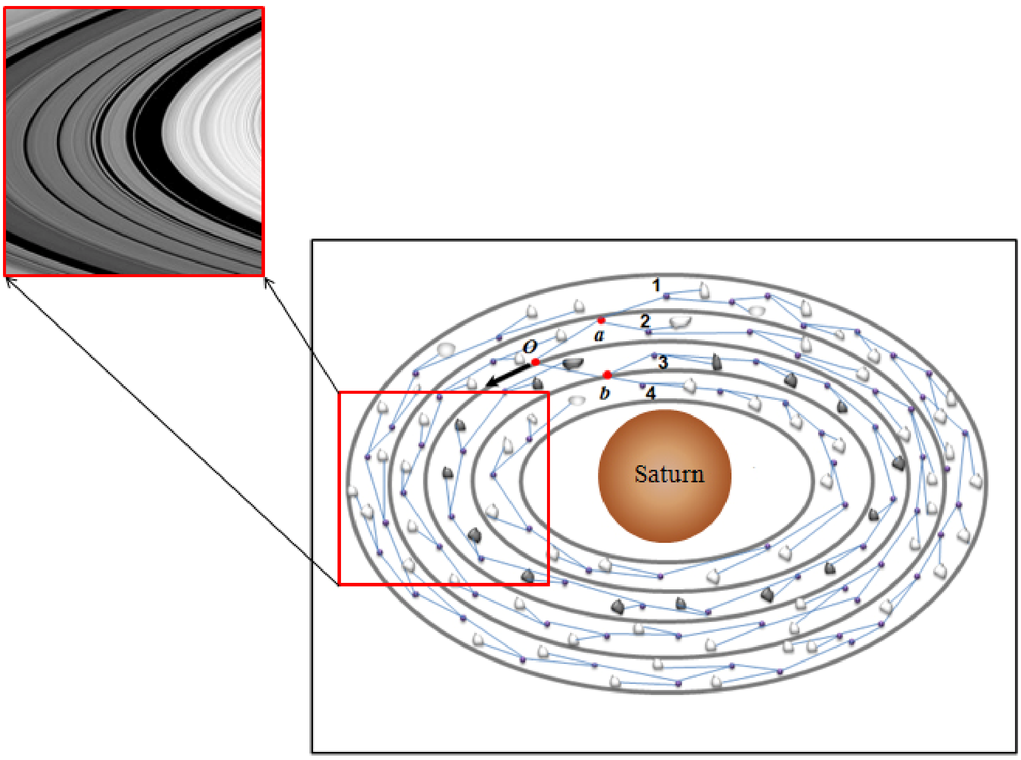

Figure 3: A simulated hierarchical two-body association of particles in Saturn's ring system. Point *O* is the barycenter of the ring system that drags point *a* and *b* to orbit the planet, at the same time point *a* drags point 1 and 2 to orbit, point *b* drags point 3 and 4 to orbit, while point 1, 2, 3, and 4 respectively drags a series of hierarchical two-body associations of particles to orbit, which forms rings around the planet. Red (brown) dot denotes the barycenter of related two-body system, blue line denotes gravitation. Large black arrow denotes the motion of the integral ring system. Large circle denotes each ring's boundary (gap). The fitted image of Saturn's A and B ring (left top) is from Cassini-Huygens (PIA12735) (courtesy of NASA).

The propeller-shaped and ringlet structures in Saturn's ring and the twisted Fraternity arc in Neptune's ring may be explained as follows (Fig.4): because the two bodies of a two-body system are derived from the disruption of a common parent body, in the disruption they may obtain additional movements due to the transfer of momentum, as the two-body system is always dragged by a superior two-body system to orbit, the two bodies under the interaction of drag and additional movements can form some kind of rotation, this makes them look like a two-armed propeller if they are embedded in the particles of the ring. If the two bodies are at the same time shattered to form two subordinate hierarchical two-body associations of particles, the two associations can also perform some kind of rotation, which makes them enlace with each other (like a twisted strand or rope). If only one body is shattered to form an association of particles, while another is survived, the survived body will accompany the association to orbit, which makes it look like a shepherd. Because of additional movement, each association of particles itself looks like a long ringlet.

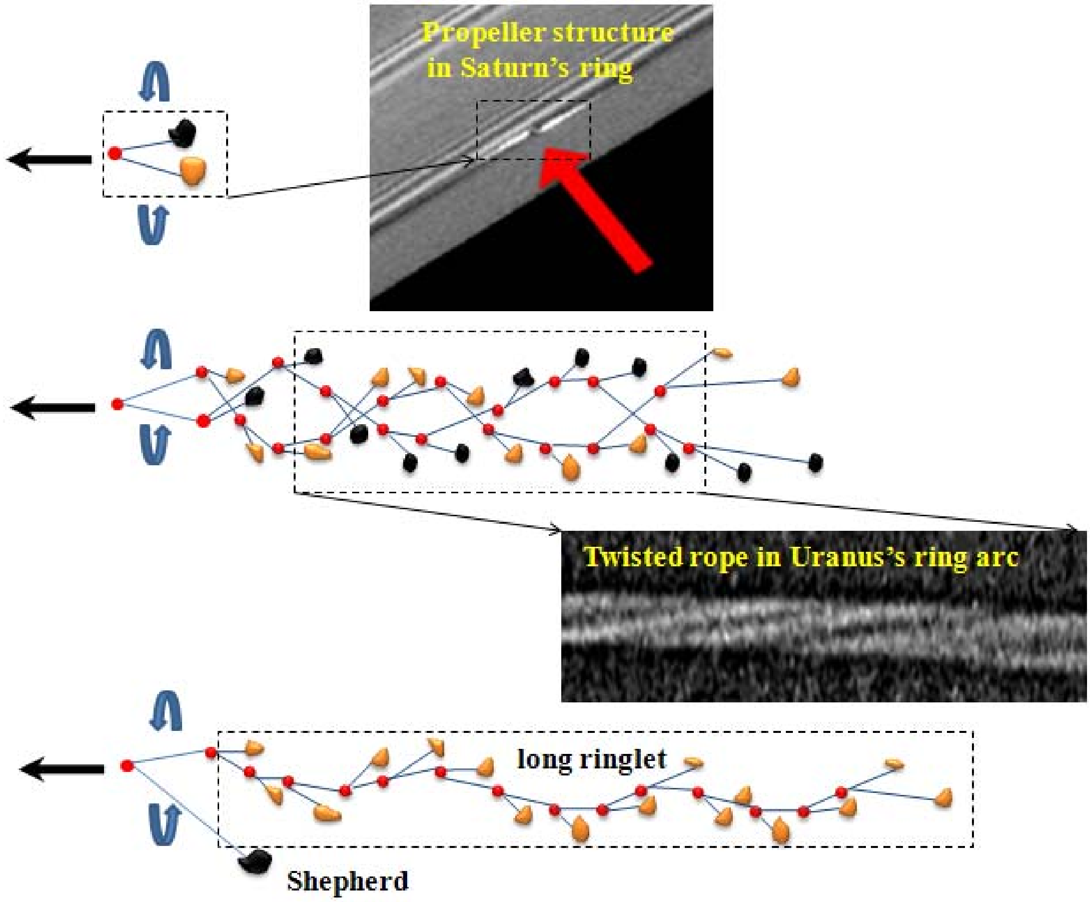

Figure 4: Model of the formation of unusual structures. Top shows a moving rotational two-body system that fits to yield a propeller structure in Saturn's ring; Middle does a moving hierarchical two-body association of particles that fits to yield a twisted strand (rope) in Uranus's Fraternity arc. Also note that in the image there are at least three hierarchical two-body associations of particles to build up this twisted rope; Bottom does a moving two-body system that consists of a shepherd (satellite) and a long ringlet (a subordinate hierarchical two-body association of particles). Red dot denotes the barycenter of related two-body system. Large black arrow denotes the motion of an integral system (images by courtesy of NASA).

Uranus has been found to possess more than 13 rings that are composed of bodies of 0.2–20 m in diameter, the majority of them are only a few kilometers wide, this requires some mechanism to hold the bodies together (Esposito 2002). The most widely model proposed initially by Goldreich and Tremaine is that a series of small satellites exert gravitational torques to confine the rings in radius (Goldreich et al. 1979). To be effective, the masses of the satellites should exceed the mass of the ring by at least a factor of two to three (Porco et al. 1987). But so far only the ε ring is observed to have two small companions - Cordelia and Ophelia, no satellite larger than 10 km in diameter is known in the vicinity of other rings (Smith et al. 1986), this in turn indicates that the narrow rings are not confined by satellites but by other mechanism. Also note that the rings are not solid objects but composed of countless particles with sizes from dust to small moons, the particles in the rings seem to be arranged to orderly encircle the planet, which does not reflect a perturbation from external object. Images show that Saturn's F ring has at least two additional strands and a background dust population that extends across ≥ 700 km in radius (Porco et al. 2004 and 2005; Murray et al. 1997), the shepherd satellite-Prometheus penetrates the inner dust region each orbital period of 14.7h, Murray et al explained the streamer-channels as a consequence of Prometheus dragging out materials from the ring (Murray et al. 2005). Please note three features that the relative precession rate between Prometheus and F ring is 0.057^{o} d^{-1} (Murray et al. 2005), which indicates both F ring and Prometheus are synchronously moving forward, the channels relative to Prometheus (see image PIA08397) are moving backward, and there are a series of channels along F ring (reference to PIA11589). Prometheus in its orbit may periodically penetrate the ring region, but it is very difficult to drag out materials from the ring to maintain these separated channels when it is far away from the ring body, because Newton's gravitation is universal and its magnitude is determined by inverse square law. Here I would like to employ this hierarchical two-body model to explain the formation of longitudinal channel. As all particles in F ring and the background dust region are organized in a series of hierarchical two-body systems, when Prometheus approaches and penetrates the ring region, it at first collides with the particles of near side and then pushes some of them into the particles of far side, the ejected particles by means of the barycenters of related two-body systems further drag the particles of downstream two-body systems to move. But as the downstream two-body systems are always being brought by upstream two-body systems to orbit, the ejected particles will eventually be dragged to return to their initial positions, this gives rise to an impressive effect: the particles are successively pushed away from their positions, but then they are successively dragged to return to these positions, a wave-like appearance (look like a channel) is therefore determined to move backward along the ring. Also because the ejected particles further activate the local particles, a bright feature is formed for the channel. When Prometheus next time penetrates the ring region and collides with particles, another wave-like appearance (channel) is formed to move backward along the ring. Periodical collision between Prometheus and the ring region eventually yields a series of separated channels in the ring. Figure 5 models a non-timescale collision between Prometheus and the F ring to form a channel. Prometheus has a potato-like shape (about 145 by 85 by 62 km^3), movie sequence from Cassini images (PIA08397) shows that as Prometheus approaches the F ring, it often performs some kind of rotation in space. This determines that, when Prometheus periodically collides with the elliptical F ring, the difference in collisional scale is likely to result in different channel. Figure 6 is a reproduction of PIA08397 that records how Prometheus interacts with F ring. It may see that when Prometheus approaches the ring (from **a** to **b** where it is the closest approach), there is no clue of gravitation. If there were gravitation, according to inverse square law, Prometheus's attraction has to drag the ring to become convex, but before the collision the ring is always the original shape. It is also clear that after the collision the F ring becomes concave (see $\mathbf{c_1}$ and $\mathbf{d_1}$).

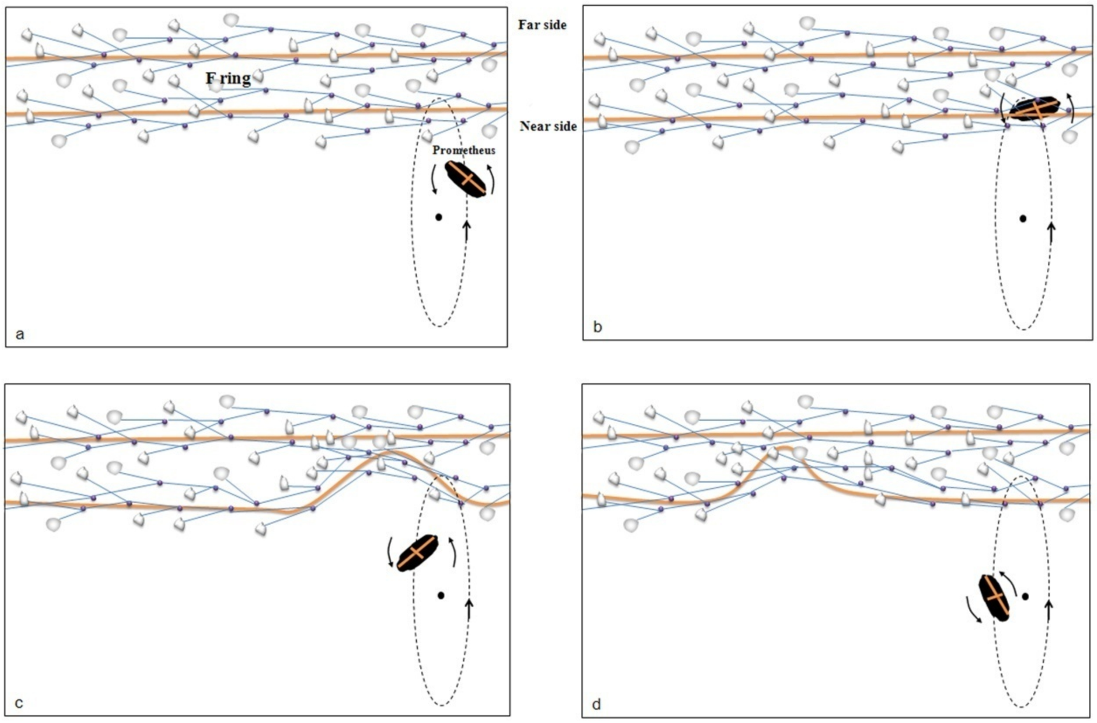

Figure 5: Modelling the creation of a channel in F ring. From **a**, **b**, **c** to **d**, it succesively demonstrates how Prometeus interacts with the ring particels. Blue line denotes gravitation, the dashed circle denotes Prometheus's orbit.

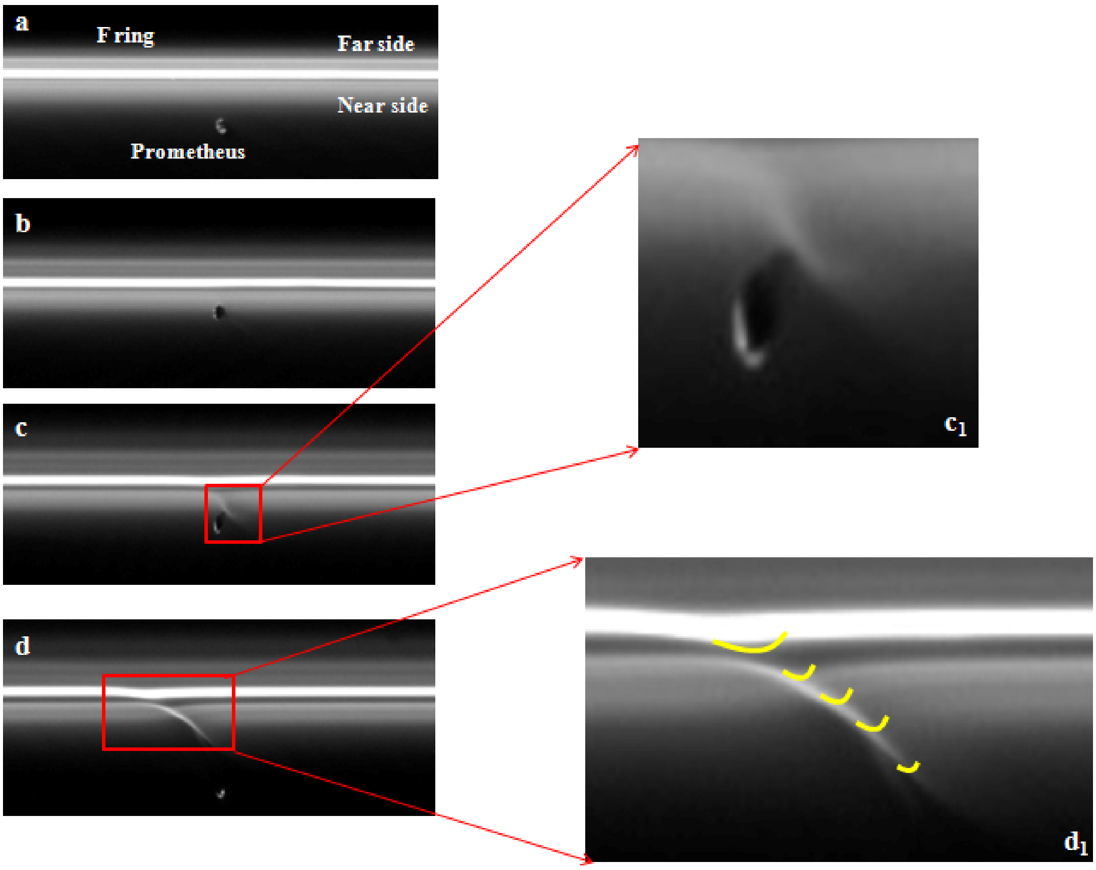

Figure 6: Images of the interaction of Prometheus and the F ring. $\mathbf{c_1}$ shows that the collision pushes

the ring to become concave, while $\mathbf{d_1}$ does that a long concave channel is created. Note that in **b** diagram Prometheus is at the closest approach to the ring, but there is no clue of perturbation of gravitation.

3.3 Comet

It may infer from Figure 1 that, as fragments are ejected from the colliding point to all around, some of them under the interaction of inertia and drag from the asteroid belt (planetary ring) may run back and forth, which fully covers the solar system (Fig.7). The orbits of four giant planets around the Sun and their equatorial planes have certain inclinations (the inclinations of Jupiter, Saturn, Uranus, and Neptune to the ecliptic are respectively 1.31, 2.49, 0.77, and 1.77 degrees, their axial tilts are respectively 3.13, 26.73, 97.77, and 28.32 degrees), and each planetary ring plane is parallel to its planetary equatorial plane, thus in the movement the angle between each planetary ring plane and the ecliptic is variable, this determines that the orbits of fragments may have various inclinations to the ecliptic. But as the distances of the asteroid belt and Jupiter to the Sun are shorter than that of the Saturn, Uranus, and Neptune, while the axial tilts of the asteroid belt and Jupiter are less than that of the Saturn, Uranus, and Neptune, this determines that the fragments dragged by the asteroid belt and Jupiter may have smaller inclinations than those dragged by the Saturn, Uranus, and Neptune.

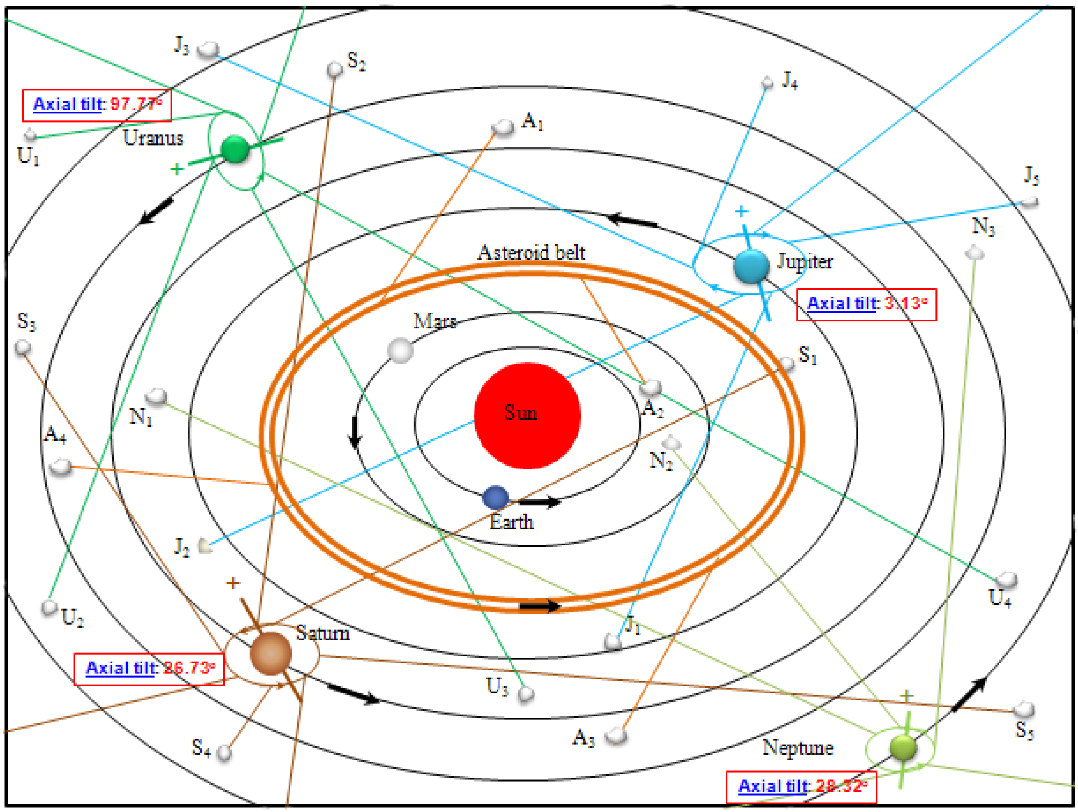

Figure 7: A cover of fragments over the solar system. Letter $A_{1,2,3,\text{etc}}$ ($J_{1,2,3,\text{etc}}$, $S_{1,2,3,\text{etc}}$, $U_{1,2,3,\text{etc}}$, $N_{1,2,3,\text{etc}}$) respectively denote the fragments dragged by asteroid belt (four planetary ring systems). Various color of straight line represents the gravitation from asteroid belt (planetary ring) to fragment. "+" denotes the north pole of the planet.

Observational and statistical results support this expectation. we abstract 578 short period comets through JPL Small-Body Database Browser to examine their orbital features and find that more than 86% the comet population whose inclination is greater than 60 degrees generally have a semi-major axis of between 9.54 ~ 30.0 AU, while 94.18 % the comet population whose inclination is less than 60 degrees generally have a semi-major axis of between 2.0 ~ 9.54 AU (Fig.8). In addition to this, statistical result indicates that long period comets are generally on high-inclination orbits while short period one are mostly on low-inclination prograde orbits (Duncan et al. 1988). We again abstract 3089 comets through JPL Small-Body Database Search Engine to show that within some special inclination range a great number of comets are crowdedly featured, more than 1200 comets have inclinations of between 140 ~ 150 degrees. This special distribution may be thought to be relative to the interaction of planetary ring system and planetary orbit around the Sun. For instance, as shown in Figure 7, because of the angle (equal to axial tilt) between Saturn ring system and Saturn orbit around the Sun, at the moment Saturn's satellites and ring system from view of Earth are regressive, but when the Saturn moves to another side of its orbit, these satellites and ring system from view of Earth become prograde. As a result, planetary ring system in motion may control the comets of various inclinations.

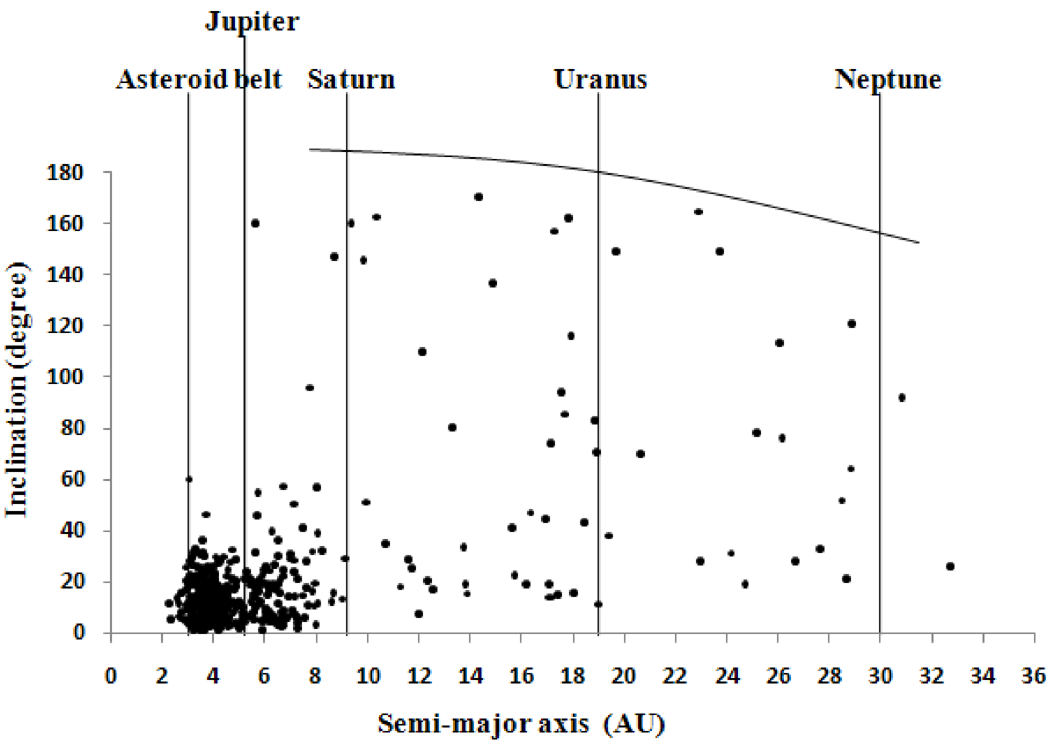

Figure 8: Orbital inclination out to semi-major axis for short period comets. Asteroid belt and four giant planets are arranged by their orbital radius.

From figure 7 only the fragments whose distances from their owners (asteroid belt and four giant planets) are close to the distances of these owners to the Sun may have chance to approach the Sun and become comets, and the fragment density per unit region in the inner solar system that is controlled by the asteroid belt and the Jupiter is larger than that of by the Saturn, Uranus, and Neptune. Figure 8 shows that the semi-major axis of the majority of short period comets is very close to the orbital radius of the asteroid belt and the Jupiter, this is consistent with the expectation from figure 8. It may see that there is an orbital relation that the value of (aphelion – perihelion)/2 of a fragment is equal to the orbital radius of its owner (planet or asteroid belt) around the Sun. Encke's and Halley's comet therefore may be classified to the control by the asteroid belt and Uranus's ring system, respectively. The perihelion and aphelion of Encke's comet are respectively 0.33 and 4.11 AU, the value of (aphelion - perihelion)/2 is equal to 1.89 AU, this is roughly close to the orbital radius of the asteroid belt (2.67 AU). The orbit of Halley's comet from the Sun is between 0.586 and 35.1 AU, the value of (aphelion - perihelion)/2 is equal to 17.26 AU, this is roughly close to the orbital radius of the Uranus (19.23 AU). Uranus's ring plane has a high inclination of 97 degrees to the ecliptic, this corresponds to a retrograde motion with aspect to the motion of planet around the Sun, Halley's orbit is also retrograde. In the past decades some small celestial bodies (they are currently named after Centaurs) had been found orbiting the Sun between Jupiter and Neptune and crossing the orbits of one or more of the giant planets (Horner et al. 2008), some of the centaurs are here classified (Tab.1). It is very important to keep in mind that a comet or centaur in the distance cannot or very difficult to be observed because of its very small size and obscure appearance, the value of aphelion is theoretically derived from a Keplerian elliptical estimate but not from observation, and thereby has a high uncertainty to influence the precision of this classification.

Owner	Name	Perihelion (AU)	Aphelion (AU)
Jupiter (a = 5.2AU)	2060 Chiron	8.4	18.9
	1994 TA	11.7	21.9
	1995 Dw_2	18.9	31
	10370 Hylonome	18.9	31
Saturn (a = 9.3AU)	5145 pholus	8.7	31.8
	7066 Bessus	11.8	37.5
	1995 GO	6.8	29.4
	5576 Amycus	15.21	35.09
	8045 Asbolus	6.8	29.31
	7066 Nessus	11.8	37.48
Asteroid belt (assumed a = 2.67 AU)	1997 CU_2	13	18.5
	10199 Chariklo	13.08	18.66

Table 1: Classification of Centaurs. Note the values of perihelion and aphelion are derived from JPL Small-Body Database Browser.

Figure 9 demonstrates how the Jupiter responsible for the orbits of a comet and a centaur. The orbits of the comet and centaur are assumed to be parallel to the elliptic, the orbital period around the Jupiter are respectively 4.5 and 6.0 year, the orbital radius are respectively 5.5 and 13.6 AU, the initial position are respectively x_{comet} = 5.5 AU, y_{comet} = - 5.2 AU; x_{centaur} = 13.6 AU, y_{centaur} = - 5.2 AU, the Jupiter's orbital radius and period around the Sun are respectively 5.2 AU and 11.86 year. It may see that the centaur runs an eccentric orbit that crosses the orbits of Saturn and Uranus, and that the comet also runs an eccentric orbit and enters the inner solar system from one corner of the sky and then drops out, but next time it enters from another corner of the sky.

This may significantly make people believe that it is two different comets. Planetary ring system has inclination to the orbit of plant around the Sun, and the ring itself is always rotating, this determines that a comet dragged by a rotating ring may enter the inner solar system in different time from different corner of the sky.

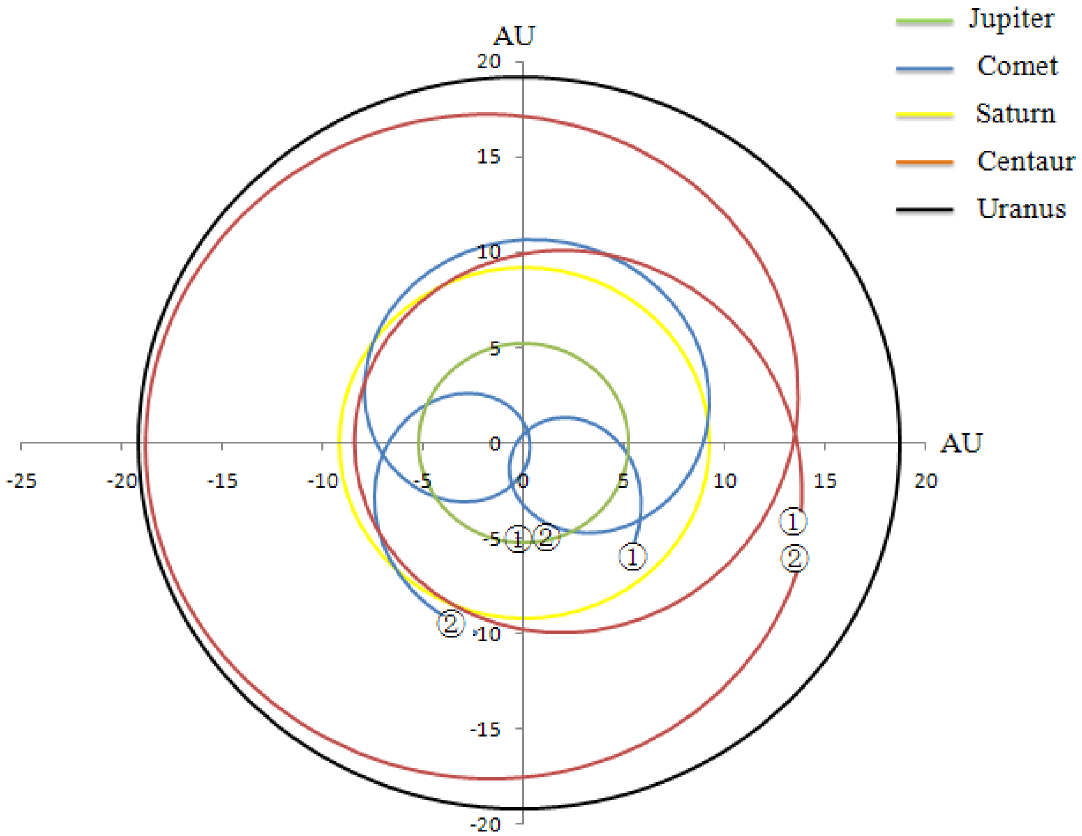

Figure 9: Simulation of the orbits of a comet and a centaur that are dragged by the Jupiter. The Sun is located at the center. Time interval is 12 years. ① represents the initial position of the comet and centaur, while ② represents the final position.

4 Discussion

Celestial objects are commonly believed to be constrained by gravitation to orbit, and the effect of gravitation is to drag object to mutually approach each other, thus with the passage of time the orbit of each celestial object will be forced to shrink, and then the collision between objects is destined. In the solar system, the Earth has a satellite -the Moon. As of October 2009, more than 180 minor planets have been found to have moon (s) (reference to Johnston's Archive: Asteroids with Satellites). Each of four giant planets (Jupiter, Saturn, Uranus, and Neptune) generally holds a number of satellites, which makes it look like a small solar system. It is possible that some of these satellites in the past hold their own moons, but due to orbital shrinkage these moons had lost to the collision with their father satellites. Countless craters on the surface of both planets and satellites suggest that planets and satellites after their formation were severely bombarded, this naturally requires some events to responsible for. The difference of the craters on the surface of planets and satellites requires these events to be unique. For instance, the far and near side of the Moon have different quantity of craters on them, which requires some special physical process to create. The ejected fragments from the collision between the two bodies of the proposed binary planet (satellite) system may fit to this demand. In recent years a number of irregular satellites have been found to orbit the Jovian planets, they form some groups and families that are similar to the asteroids in the main belt (Huebner 2000). It is reasonable to deduce that these irregular satellites are the farther fragments that were ejected from the collision of the two bodies of a binary satellite system, but a hierarchical two-body association is confining them to orbit the planet. The low density of Saturn's small moons and their spectral characteristics similar to those of the main rings, closeness to the rings and rapid disruptive timescales have long suggested that their origin may be linked to the planet's icy rings (Mcghee et al. 2005; Jewitt et al. 2006; Nesvorny et al. 2003; Porco et al. 2007), the collision between the two bodies of a binary satellite system proposed here may fit to this expectation. The well known Titius-Bode Law once predicted a planet that is located between the orbits of Mars and Jupiter, but observation does not support its existence. Based on this research, we conclude that the predicted planet might be a planetary system that holds a satellite and had existed in the past, but many years ago the planetary system due to a catastrophic collision had been shattered to form the present asteroid belt. In the smashing collision, the ejected fragments due to the conservation of momentum are likely to symmetrically distribute around the barycenter of the planetary system. This means that the average orbital radius of the fragments around the Sun is approximately equal to the planetary system's orbital radius around the Sun. We through JPL Small-Body Database Search Engine search for asteroids located in a belt range between Mars' and Jupiter's orbit (1.52AU $<R<5.2$ AU). Around 536818 asteroids are found here and their average semi-major axis around the Sun and inclination with respect to the elliptic are worked out to be 2.67 AU and 8.30 degrees, respectively. These should be the constraints of the proposed planetary system orbiting the Sun at the moment. Titius-Bode Law has an experience expression of $a= (n+4)/10$ (where a is the semi-major axis of a planet around the Sun and n=0, 3, 6, 12, 24, 48 ...). Consider the distribution of established planets (like Mercury, Venus, Earth, Mars, Jupiter …) with respect to the Sun, the position of the proposed planetary system from this formula is expected to be $a= (24+4)/10 = 2.8$ AU. About 3.77 % the indexed asteroids are recorded with certain diameter and totally hold a volume of 1.77 billion Km^3, not more than 0.11 % the Earth's volume. It is possible that the majority of the mass of the proposed planetary system in the smashing collision had been ejected away.

If such a smashing collision for the proposed planetary system had occurred in the past, a natural aftermath is that the ejected fragments from the planetary system would fly outward and inward from their origin (refer to Figure 1(B)), and thereby can bombard the objects they encounter in the travel. Generally speaking, the nearer the objects are close to the origin of collision, the more the objects can encounter the fragments from the collision, the more the objects can be bombarded by these fragments. As shown in Figure 10, when the fragments from the origin of collision fly outward and inward, the Mars and Earth in their respective orbit can inevitably be bombarded by some inward fragments. As the Mars is more close to the origin of collision than the Earth, the Mars along with its satellites can receive more bombardment than the Earth and Moon. In particular, the synchronous rotation of the Moon around the Earth can get its far side receive more bombardment than the near side. As stated in the second part of this paper, the ejected fragments under the effect of hierarchical two-body gravitation can be finally confined to form a flat circular belt to orbit, also because the Moon is a sphere and has an inclination of 5.15 degrees to the elliptic, this means that the Moon in motion has to repeatedly run through the fragment belt. In this process, the south and north poles of the Moon may encounter more bombardment than the near side of the Moon (Fig.11). In particular, some of the fragments can run tangential collision to scrape the Moon's spherical surface, by which some shaped-line structures can be formed. The images of the Moon and Mars' satellites provide good evidence to support this deduction. From figure 10, we conclude, the satellites of the Mars (Deimos and Phobos) might had hold perfect spherical structure like the Earth's satellite- the Moon, but subsequently they were severely bombarded by the fragments from the collision of the proposed planetary system and left the present disabled structures. The distribution of ejected fragments from the proposed planetary system and the motion of the Earth-Moon system may result in the topography difference between the two hemispheres of the Moon.

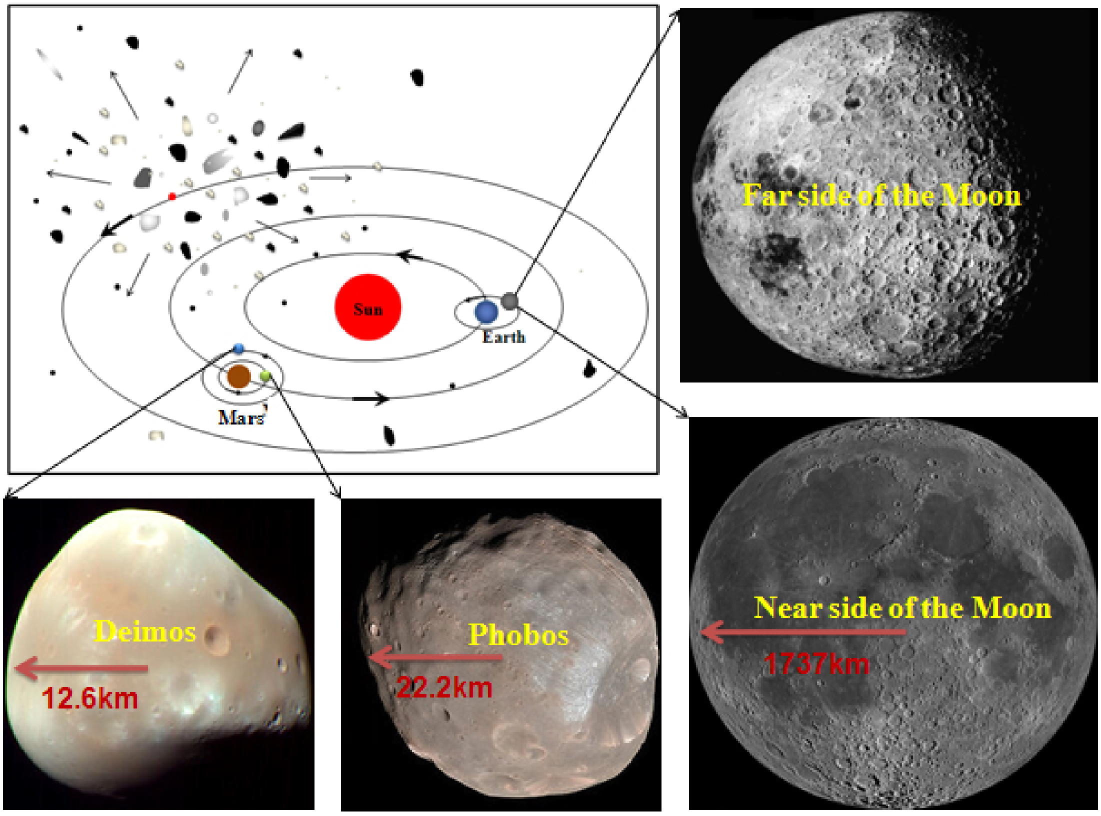

Figure 10: Ejecting fragments inward bombard planets and their satellites to form various craters. Red dot in the model diagram represents the barycenter of the proposed planetary system. Images of Deimos, Phobos, far side of the Moon, and near side of the Moon are by the courtesy of NASA.

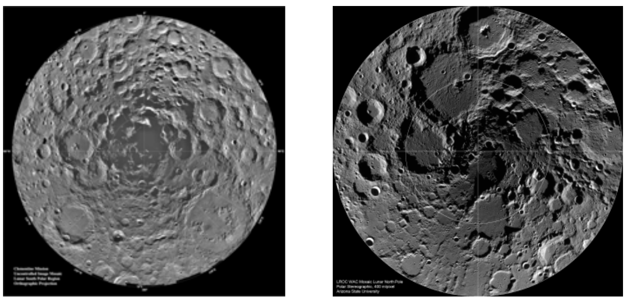

Figure 11: South (left) and North (right) Poles of the Moon. Images are by the courtesy of NASA/JPL/USGS.

Similarly, if planetary ring is derived from the same mechanism as asteroid belt undergoes, a smashing collision between the two objects of a binary satellite system is necessarily occurred in the past, the ejected fragments from the binary satellite system would naturally bombard other brother satellites of the same planet. Evidence from the images of the satellites of the Uranus supports this deduction (Fig.12). In the comparison of Figure 10 and 12, a common feature is that per unit area the satellite's surface that is close to the collisional origin receives more bombardment than that of farther satellite. As Miranda, Ariel, Umbriel, Titania, and Oberon hold synchronous rotation around the Uranus and their orbital radiuses are large than the radius of Uranus's ring, this means that the near side of these satellites can receive more bombardment than that of their far sides as long as the bombardment is occurred later than the satellite's lock by the Uranus. Strange shaped- triangle feature on the Miranda's surface might be created by the scrapes of several fragments. It is not easy to compare the bombardments encountered by planets after a long astronomical time, because the resulting effect is closely determined by the physical condition of both the ejected fragments and the planets, for instance, planetary atmosphere, rotation, and geological activities (volcano and Earth plate movement） can moderate the bombardments from the ejected fragments. A latest analysis of dust particles from near-Earth asteroid 25143 Itokawa shows that the asteroid is likely to be made of reassembled pieces of the interior portions of a once larger asteroid, and its age is very primitive (Nakamura et al. 2011). This means once larger asteroids might had been further shattered into some smaller asteroids. If the proposed binary planetary system several billions of years ago had been shattered into fragments, and the fragments in the collision were ejected inward to form the inner asteroid belt, these fragments would not encounter a deep evolution if the collision cannot arouse them to be melt, they may thus be sealed as primitive material in space. Various craters offer evidence that planets and satellites had been severely bombarded in the distant past, this event is currently called the late heavy bombardment, especially for the Moon. Proposed causes for this bombardment include gas giant migration (Gomes et al. 2005) and Late Uranus/Neptune formation (Levison et al. 2001). Gas giant migration has at least two uncertainties, the first one is it firstly assumed a rich trans-Neptunian belt to interact with giant planets, but so far no evidence can approve the existence of this trans-Neptunian belt, the second one is it cannot account for the significant difference of crater distribution on the Moon, for instance, there are more craters on the far side, south and north poles than on the near side. The proposal of late Uranus/Neptune formation still does not win support from numerical simulation. In recent years NASA John Chambers and Jack Lissauer proposed a fifth planet (V) that exists between Mars and the asteroid belt to increase crater rate, but Planet V and its disruption are also no evidence. Instead, this kind of smashing collision of binary planetary (satellite) system, as we proposed here, may match all observations at the same time.

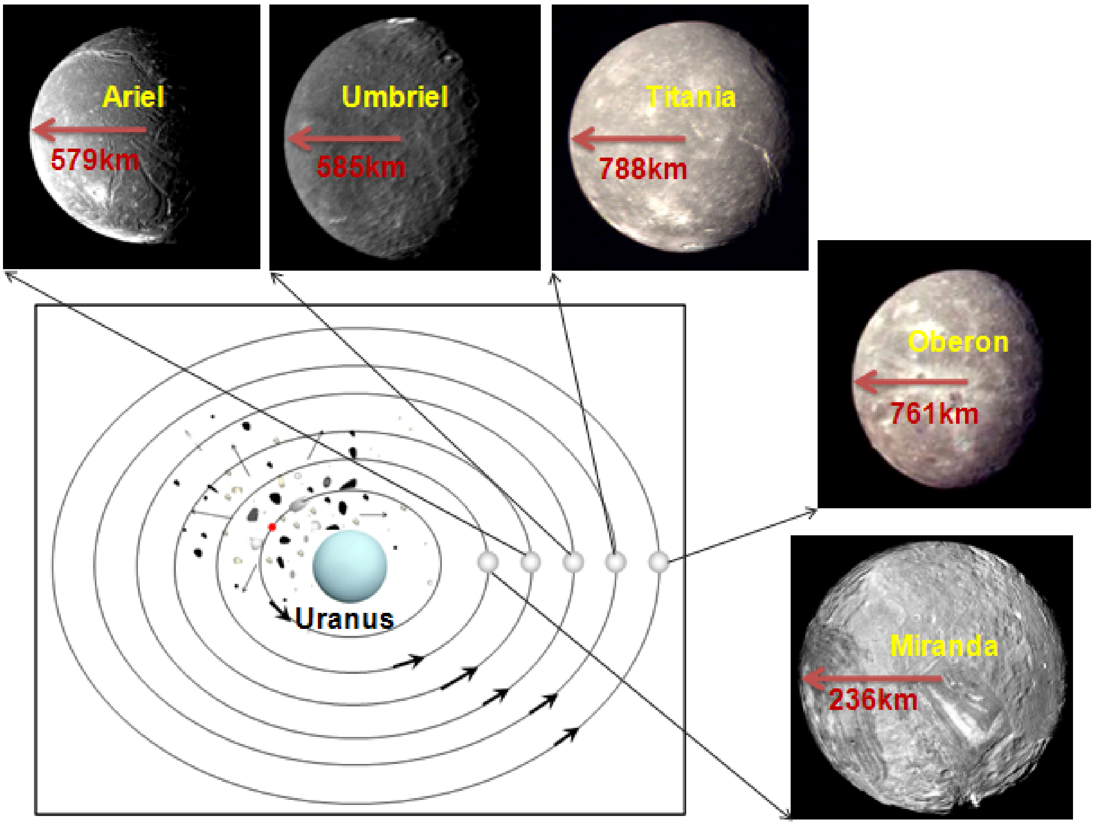

Figure 12: Ejecting fragments outward bombard satellites of the Uranus to create craters and scrapes on the surface. Red dot in the model diagram represents the barycenter of the proposed binary satellite system. Images of Miranda, Ariel, Umbriel, Titania, and Oberon are by the courtesy of NASA.

Jan Oort in 1950 statistically found that there is a strong tendency for aphelia of long period comet orbits to lie at a distance of about 50,000 AU and then proposed that comets reside in a vast cloud at the outer reaches of the solar system (Oort 1950). Also note that the so-called aphelia of long period comet orbits is derived from a theoretical estimate, nobody in person sees that the aphelia of a cometary orbit is located at such a distant place. On the other hand, when we observe a comet, the Earth is rotating around its axis, at the same time the Earth and Moon are also rotating around their common center of mass, and this center is also revolving around the Sun, the Sun is also moving, what we observe for the comet is a compositive effect of multiple motions, it is very difficult to determine that comet's proper motion. Both two make Oort Cloud Hypothesis uncertain. In addition to this, the solar system is flat, it is very difficult for people to think why there will exist a spherical cloud of comets around the solar system. The Kuiper Belt that is proposed to account for short period comets encounters at least two significant obstacles: 1) the mechanism by which the comets are supplied from Kuiper belt to planet-crossing orbits is unclear (Duncan et al. 1988); and 2) there is no observation to indicate that short period comets are really originated from Kuiper Blet Objects. Some people are highly likely to argue that comets can employ their own angular momentum to run eccentric orbits around the Sun. I don't think so, because within a changeable gravitational field there must be a third part to work. For instance, bird can fly in the sky up and down, plane can fly from ground to high altitude, evidently, both of them in motion rely on the service of a third part (chemical energy in their bodies) fighting against the Earth's gravitation. So, can planet, satellite, and comet in motion rely on what fighting against the Sun's gravitation? Note angular momentum is vector, any change of angular momentum must employ an external force to work. Planets and comets are observed to have different motional directions in space, as the effect of force is mutual between any two objects, when the Sun works an object to move by means of gravitation, the object in turn has to work the Sun to move. As a result, the Sun itself is impossible to work these objects to move at the same time. The only explanation for this discrepancy is the established understanding is seriously disabled. This is the reason why I strongly introduce a hierarchical two-body model in previous work (Yang 2011), and thus account for the comet's motion. Most of comets are composed of water ice, rock, dust, and frozen gases (Poulet et al. 2003), planetary ring also consists of mainly water ice and dust. As of 2008, three centaurs such as 2060 Chiron, 60558 Echeclus, and 166P/NEAT have been found to display cometary coma (Coradini et al. 2009). This similarity indicates that both planetary ring and comet (centaur) may be related. The collisional scenario of a binary planetary (satellite) system proposed here is too conceptual to cover its timescale in the evolution of the solar system, nevertheless, it provides a hopeful point to integrally consider the origin of asteroid belt, planetary ring, and comets, future work in both observation and numerical simulation may strengthen the expectation of this model.

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