A coupling of the origin of asteroid belt (planetary ring) and comet

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Abstract

It is a popular feature in the solar system that there are an asteroid belt and four planetary ring systems, various scenarios have been presented to account for their origins, but none of them is competent. Asteroid belt that is located between planetary orbits (Mars and Jupiter) is thin, circular, and parallel to the ecliptic, in contrast, planetary rings that are located between satellite's orbits are also thin, circular, and approximately parallel to their father planetary equatorial plane. This similarity in distribution and shape implies that asteroid belt and planetary ring is likely to derive from the same physical process. Here we show, the two bodies of a binary planetary system (satellite system) due to their orbital shrinkages occur a catastrophic collision, which shatters them into fragments to all around. But due to the effect of hierarchical two-body gravitation that is responsible for the association of celestial objects in space, the barycenter of the initial binary planetary system (satellite system) is survived in the collision and continues to orbit, which drags the barycenters of a series of subordinate hierarchical two-body associations of fragments to move. This successive hierarchical drag trends to constrain these separated fragments to form a circular belt (ring), and subsequently dynamical evolution confines the belt (ring) to become thin. The farther fragments are 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.

Key words: origin, asteroid belt, planetary ring, comet.

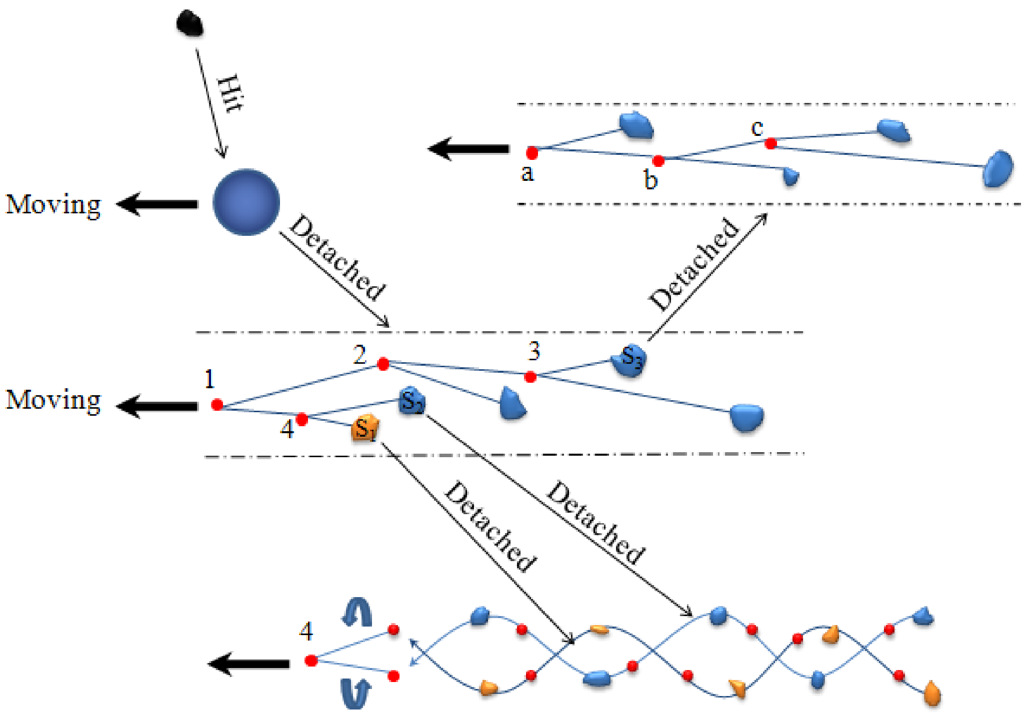
1 Introduction

Centuries-old observations have proved that there are an asteroid belt, four giant planetary ring systems, and countless comets in the solar system. In the past various theories had been presented to account for the origin of asteroid belt, planetary ring, and comet. The previous origin theory of asteroid belt believes that asteroids are fragment of a destroyed planet [1], 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 [2]. The origin theories of planetary ring are plentiful. Especially for Saturn's ring, they include tidal disruption of a small moon [3], unaccreted remnants from the satellite-formation era [4], collisional disruption of a small moon [5], and tidal disruption of a comet [6]. 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 and icy moons are subsequently spawned from the ring [7]. 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 [8] 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 [9]. In general, all the scenarios are more or less based on both solar nebula hypothesis [10] and Newton's gravitation. However, solar nebula hypothesis are still surrounded by a series of problems [11-15], high resolution photographs of well-regulated movement of asteroid family (group) [16], integrity of Saturn's narrow F ring [17], unique spokes in Saturn's B ring [18], and twisted arc in Neptune's Adams ring [19] indicate that Newton's gravitation cannot work these movements well. In addition, if Saturn's satellites are thought to be spawned from an identical ice ring [7], it is necessary for them to keep parallel to the ice ring and keep the same icy material, but observation shows that these satellites have different inclinations to the planetary equatorial plane that is parallel to the ring system, and they are also not composed of pure ice. Saturn's ring in appearance is very thin and there are countless gaps within it, and various spectrums indicate that it is composed of different materials, it is therefore impossible for Canup's model to account for such significant features. Comets are generally observed to run some very eccentric orbits, which in the Newton's gravitational frame require a strong variation of orbit energy to fit, both the Sun's gravitation and planetary perturbation cannot account for this eccentric movement. 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 [20]. In the last 20 years, a lot of Trans-Neptunian objects had been found from the proposed Kuiper belt, but there is no evidence to indicate that these Trans-Neptunian objects are directly relative to comets. In conclusion, the current understanding of the origins of asteroid belt, planetary ring, and comet are still incomplete. Asteroid belt and planetary ring in appearance are flat, circular, and parallel to respectively the ecliptic and planetary equatorial plane; they in distribution are embedded between planetary orbits and between satellites' orbits, respectively; In addition, asteroids consist primarily of carbonaceous, silicate, and metallic materials, this is very similar to the composition of the Earth and Mars. Relatively planetary ring consists primarily of ice and dust, which is very 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 that makes it look like a little solar system. 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 [21] indicates that comets are likely to derive from various origins. Yang recently proposed that all the objects in the universe are orderly organized in a series of hierarchical two-body systems with gravitation and the solar system is orderly built up from some small units through a hierarchical two-body pattern, and predicated that under the effect of gravitation the two components of a two-body system will finally take place a catastrophic collision due to their orbital shrinkages. In this present paper, a coupling of hierarchical two-body association and collision may responsible for the formation of asteroid belt, planetary ring, and comet.

2 Modelling

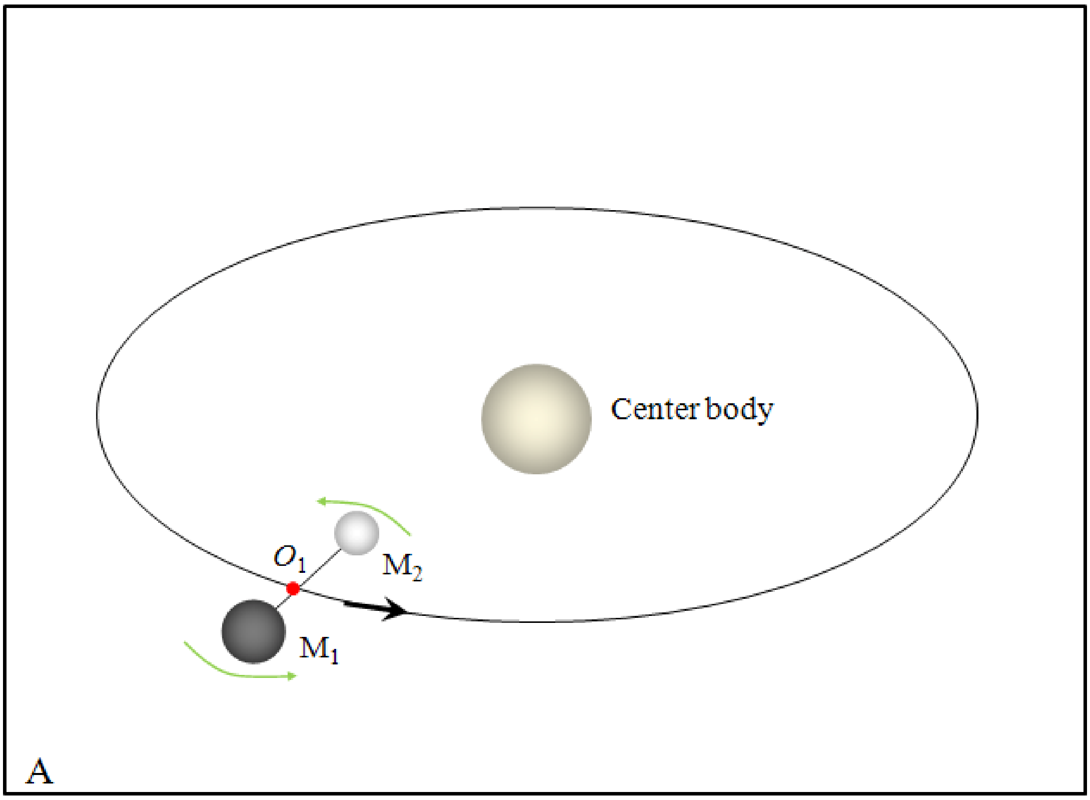
In the frame of hierarchical two-body association all bodies are indirectly fixed together with gravitation, this indicates that if a moving body is shattered into small fragments, these fragments are still constrained by gravitation in a series of hierarchical two-body associations, and the barycenter of the initial body is survived in the collision and may bring these associations of fragments to continue to orbit. As shown in Figure 1 that a moving body is shattered into some fragments that are still constrained by gravitation in a series of hierarchical two-body associations, some of these fragments are further shattered into smaller fragments that are also constrained by gravitation in a series of subordinate hierarchical two-body associations. All the associations of fragments are still brought by the barycenter of the initial body (point 1) to continue to orbit.

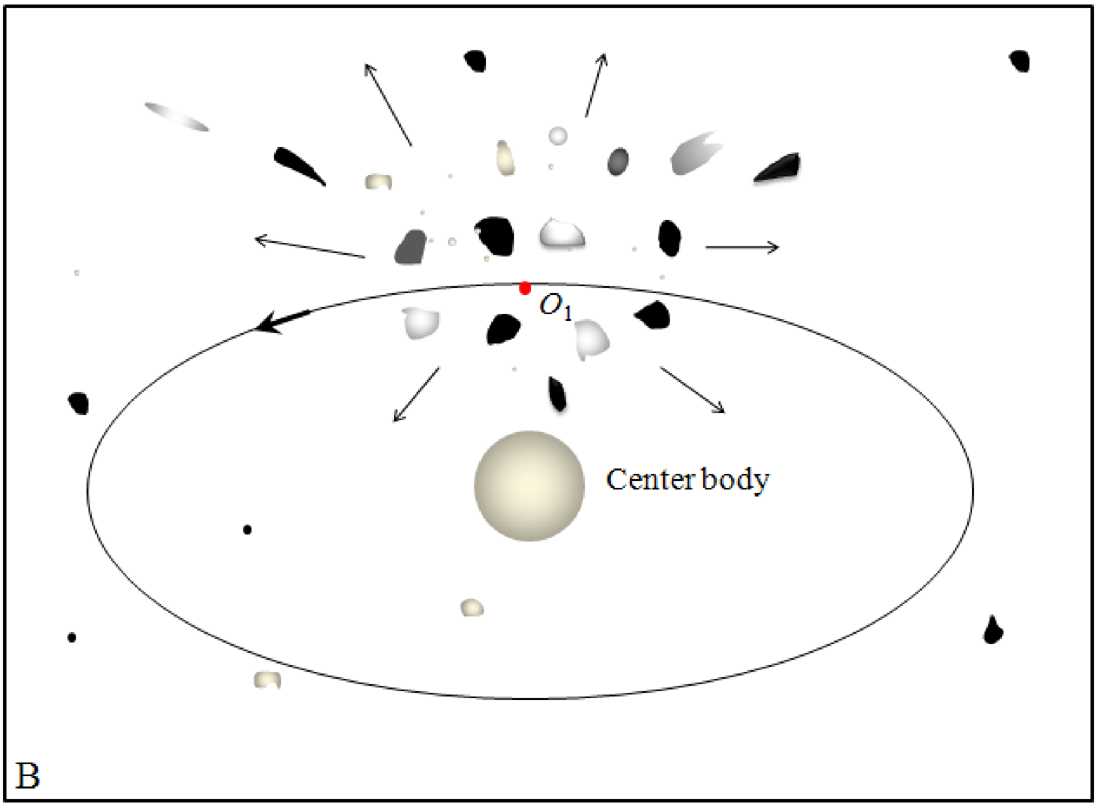
Figure 1: Simulation of the motions of detached fragments based on hierarchical two-body association. Fragments S_1, S_2, and S_3 are further detached to form a series of subordinate hierarchical two-body associations of fragments. In particular, fragment S_1 and S_2 before a second detachment obtained additional motions, which makes their subordinate associations enlace with each other orderly. Red dot represents the position of the barycenter of related two-body system in hierarchical two-body association. Large black arrow represents uniform movement of the associations of fragments along the direction of initial body.

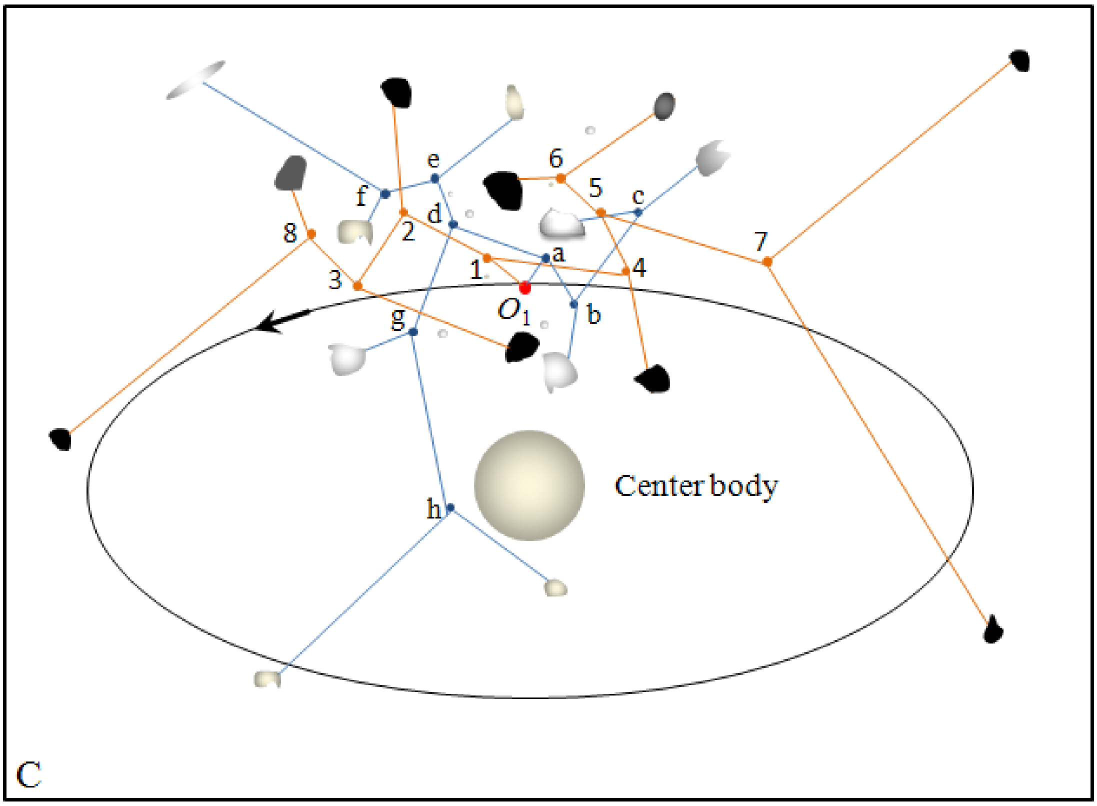


Based on this physics, a theoretical model is here developed to demonstrate the formation of an asteroid belt (planetary ring) and comet (Fig.2): A binary planetary system (satellite system) is orbiting the Sun (or a giant planet). With the passage of time, the two components of the two-body system due to their orbital shrinkages occurs a powerful collision to eject fragments in all directions. But due to the constraint of two-body gravitation, these fragments form a series of hierarchical two-body associations in space. As the barycenter of the binary planetary system (satellite system) is survived in the collision, it continues to bring these associations of fragments to orbit the Sun (or the planet). A successive hierarchical drag via the barycenter of related two-body system automatically confines these fragments to form an asteroid belt (planetary ring). As shown in Figure 2(D), the barycenter of the initial binary system (point O_1) 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, point *c* is also dragging two fragments to orbit, point *d* is also dragging two components (point *e* and *g*) to orbit, point *e* is also dragging two components (fragment M and point *f*) to orbit, point *f* is also dragging two fragments to orbit, point *g* is also dragging two components (a fragment and point *h*) to orbit, point *h* is also dragging two fragments to orbit. Because of this kind of hierarchical drag from point O_1 to other related points, each fragment may always obtain some movement that in direction is parallel to the movement of point O_1. We assumed that in space the angle between line O_1a and the movement of the barycenter (point O_1) is α, the angle between line *ad* and line O_1a 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_1 fits to a relation of $\cos\alpha \times \cos\beta \times \cos\gamma \times \cos\delta$. As point 1 is also dragging a series of hierarchical two-body associations of fragments, each other fragment also undergoes the same dynamical process as fragment M, thus all the fragments under the effect of this kind of hierarchical drag tend to fall on a circular orbit. Because of orbital shrinkage, the barycenter of the binary planetary system (satellite system) is also increasingly approaching the Sun (the planet), this further brings the barycenter of related two-body system to move towards the Sun (the planet), the asteroid belt (planetary ring) gradually becomes thin. As shown in Figure 2(F), when the barycenter (point O_1) slowly approaches the center body, it will also drag point *a* and 1 to approach the center body, and point *a* and 1 also drag respectively a series of hierarchical two-body associations of fragments to approach the center body, but due to the inertia, each fragment attempts to escape the drag, this determines that after a long term dynamical evolution, the association of all the fragments will become more and more thin. Some of the farther fragments are dragged by the asteroid belt (planetary ring) to run across the solar system back and forth, this may give rise to the bombardment to planet and satellite. Once some of the fragments approach the Sun's body, comets can be created. As fragments are ejected from the colliding point to all around, some of them under the interaction of their inertia and the drag from the asteroid belt (planetary ring) may have retrograde orbit.

Figure 2: Simulation of the formation of a belt (ring) based on hierarchical two-body associations. A: a two-body system is orbiting a center body; B: the two bodies of the two-body system occur a catastrophic collision due to their orbital shrinkages, which shatters them into small fragments in all directions; C: the separated fragments are gravitationally constrained in a series of hierarchical two-body associations; D, E, F: the barycenter of the initial two-body system continues to orbit, which brings these fragments by means of the barycenters of all related two-body systems to move along a circular path. Red dot (marked with letter *a*, *b*, *c*, etc., and number 1, 2, 3, etc.) represents the position of the barycenter of related two-body system in the association. Blue (orange) line represents gravitation. Large black arrow represents the movement of the association of fragments.




O_1
Center body
B


e
6
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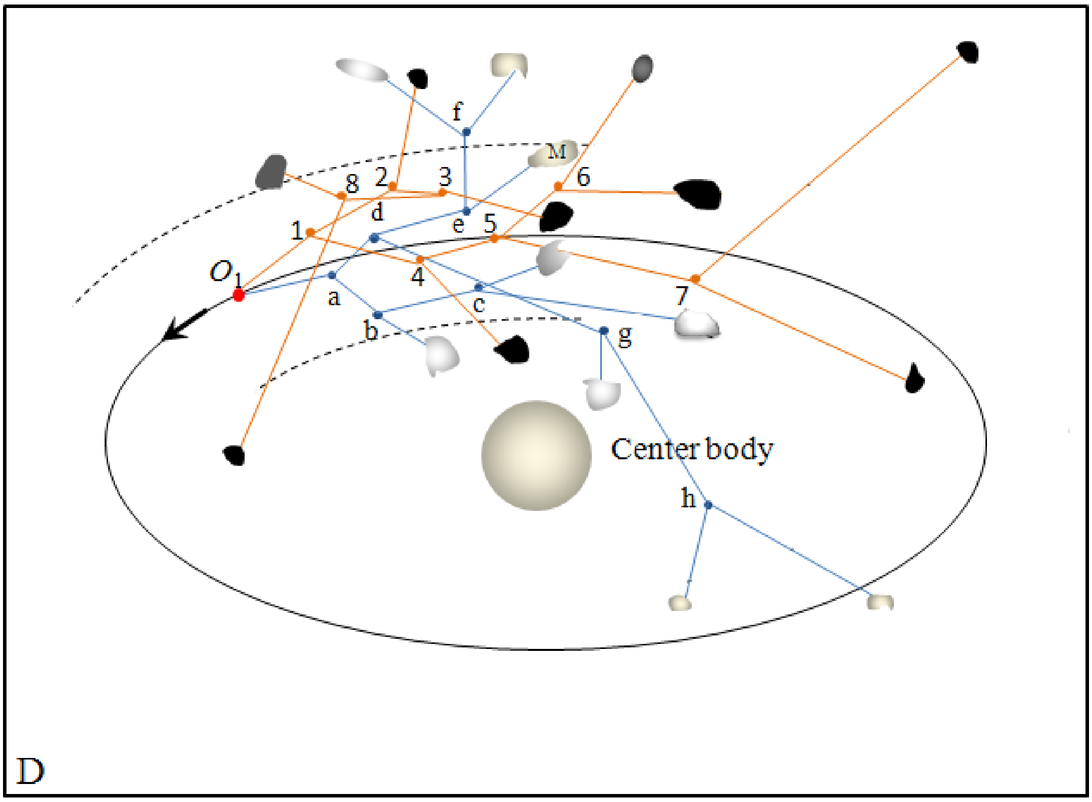
f
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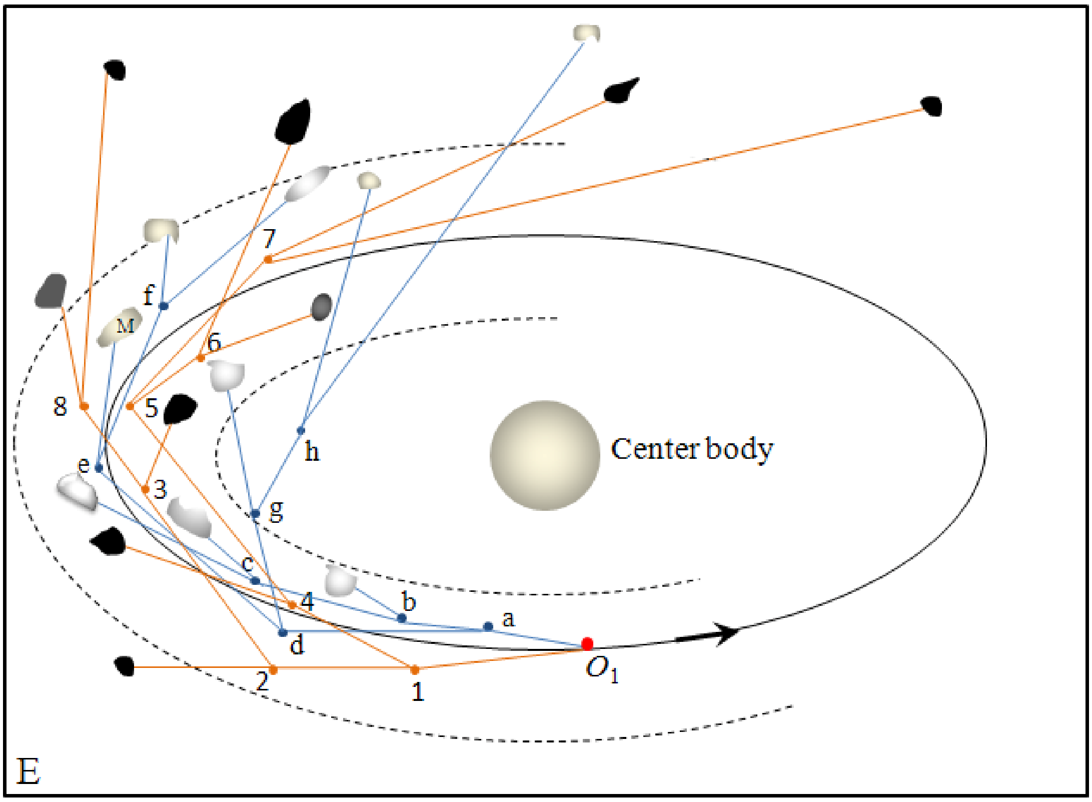
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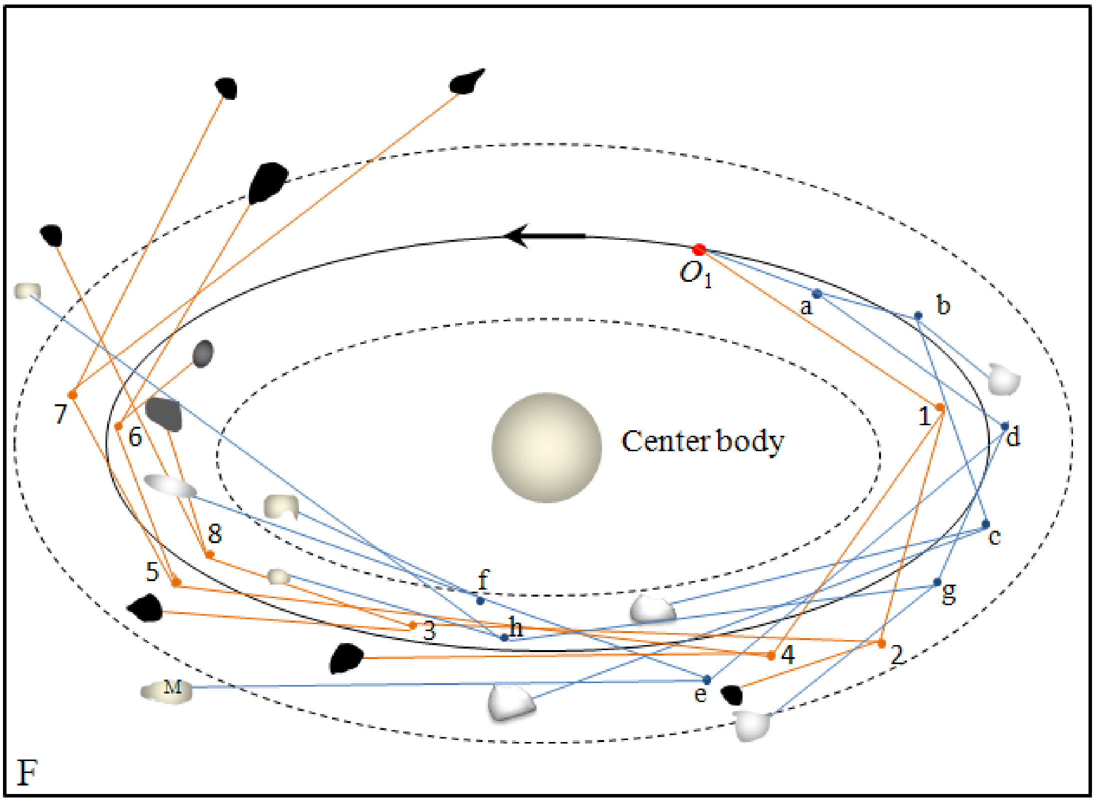
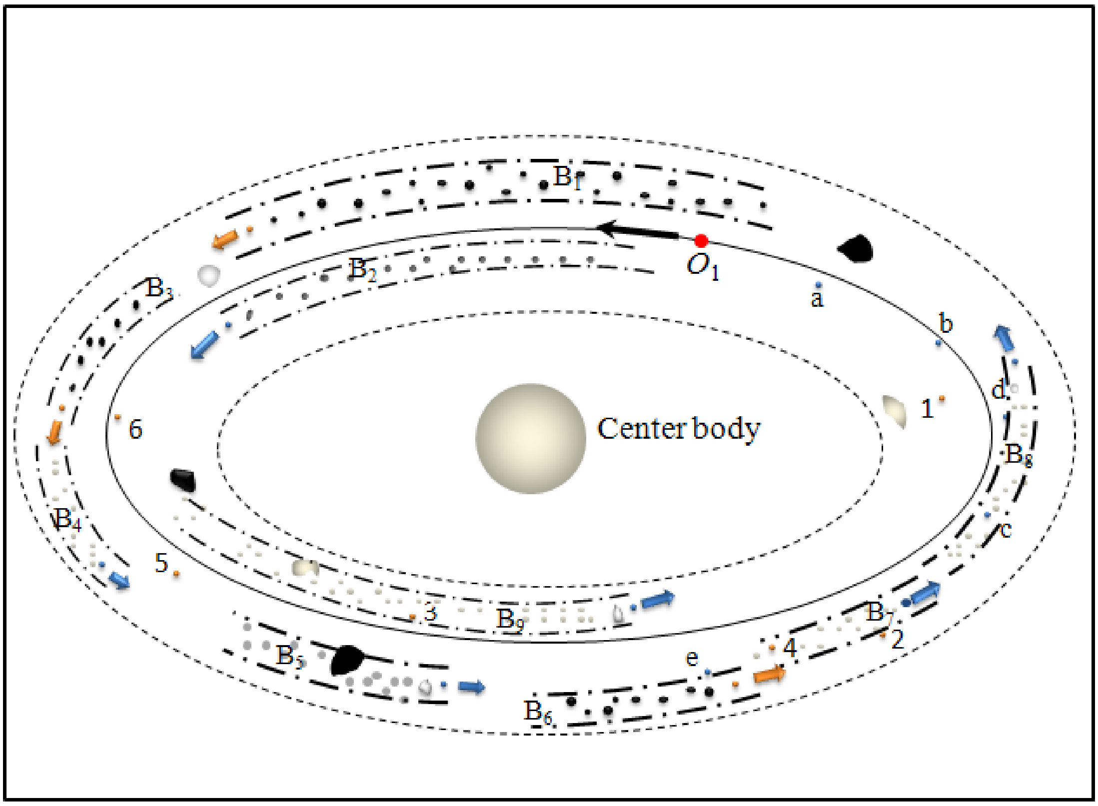


As each two-body system is always dragged by the barycenter of a superior two-body system to orbit, this determines that the fragments in a subordinate hierarchical two-body association may share some orbital elements. Also because the fragments in a subordinate hierarchical two-body association are derived from the disruption of a common parent body, this determines them to be with identical chimerical composition. As shown in Figure 3 (it is a dynamical evolution from Figure 2(F) that some of fragments are further shattered into smaller fragments to form a subordinate hierarchical association, gravitation here is hided in the diagram), the fragments in an association share similar orbital elements such as semimajor axis, eccentricity, period, and inclination, and their composition is also identical. Similarly, a fragment due to collision may shatter into smaller fragments to form a small scale hierarchical association, in which these smaller fragments also share similar orbital elements and identical composition. As every association in space is separated from one another, this may form gaps between associations.

Figure 3: Simulation of the evolution of a belt (ring) based on hierarchical two-body association. Some of the fragments are further shattered to form subordinate associations (respectively marked with B_1, B_2, etc.). Point O_1 is the barycenter of the initial two-body system (reference to Figure 2). Blue (orange) dot (marked with letter *a*, *b*, *c*, etc., and number 1, 2, 3, etc.) represents the position of the barycenter of related two-body system in the associations. All the associations and separated fragments are hierarchically ruled by these barycenters. Gaps are formed between associations (for instance, there is a gap between association B_1 and B_2). Large black arrow represents the motion of the barycenter of integral belt (ring), while short blue (orange) arrow represents the motion of each association.



It is now necessary to specify for asteroid belt that the center body in the model is replaced with the Sun, the initial binary planetary 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_{moon} = 27.32 days, R_{earth} = 6 370 km, R_{moon}

= 1 738 km, thus the orbital radius of the Moon in the Earth-Moon system is L_{moon} = (M_{earth}×$L_{earth\text{-}moon}$)/(M_{earth}+ M_{moon}) =379 330 km, the orbital velocity V_{moon} = 2πL_{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 V_{earth} = L_{earth}×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×$10^{28}$ J. When the Moon collides with the Earth, their gravitational potential energies are 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 = 2.93×10^{32} J, the total energy for the Earth-Moon system at the moment when the collision occurs will be $E = E_k$+ $E_p \approx$ 2.93×10^{32} J (we assumed that the collision occurs at the moment when $L_{earth\text{-}moon}$ = R_{earth} + R_{moon} = 8 108 km). A quantity of 2.93×10^{32} J energy is powerful enough to shatter the Earth-Moon system into fragments in all directions. The water component in the sample Earth-Moon system after the disruption are immediately freezed in the fragments, some of the gases are escaped while other gases like carbon dioxide are freezed in the fragments. The collision timescale for the sample Earth-Moon system is determined by the magnitude of orbital shrinkage, but it is currently unknown. We also specify for the planetary ring that the center body in the model is replaced with a giant planet (Jupiter, Saturn, Uranus, and Neptune), the initial binary satellite system in chemical composition is similar to the giant planet's satellite that is especially rich in icy material, and it is just placed more near to the planet than other satellites. The physical elements are similar to the present satellites (also note that the sample satellite system is a binary satellite system, while the present satellites are generally isolated), thus the estimated energy to support a catastrophic collision is theoretically feasible. In the collision, the binary satellite system are shattered into fragments to form a series of hierarchical two-body associations, subsequently these fragments are further shattered by collision into smaller fragments to form a series of subordinate hierarchical two-body associations. On the whole, every fragment may be eventually shattered into particles (with a diameter of meter or micron) to from a series of even subordinate hierarchical two-body associations. Some of the farther fragments that are ejected from the collision are dragged by the asteroid belt (planetary ring) by means of the barycenters of related two-body systems to run across the solar system back and forth. Once these fragments in the movements approach the Sun’s body close enough, comets may be created, while some of them that approach the Earth’s body may become meteorite. As shown in Figure 4 and 5 that the farther fragments under the drags from the asteroid belt and the Jovian ring system may have chance to become comets when close to the Sun’s body. Once the Earth crosses the orbits of these fragments, meteor shower may be created. Figure 6 shows that each of the four giant planets by means of its ring system drags some farther fragments to orbit, this integration fully covers the solar system.

Figure 4: Simulation of the constraint of fragments by the asteroid belt. Some fragments that are beyond the belt are being dragged by some gravitational points (they are the barycenters of some two-body systems) to orbit. The positions of these barycenters are marked with red dot. Orange line represents the gravitation form gravitational point to fragment. Note that hierarchical two-body gravitation is hided in the asteroid belt.

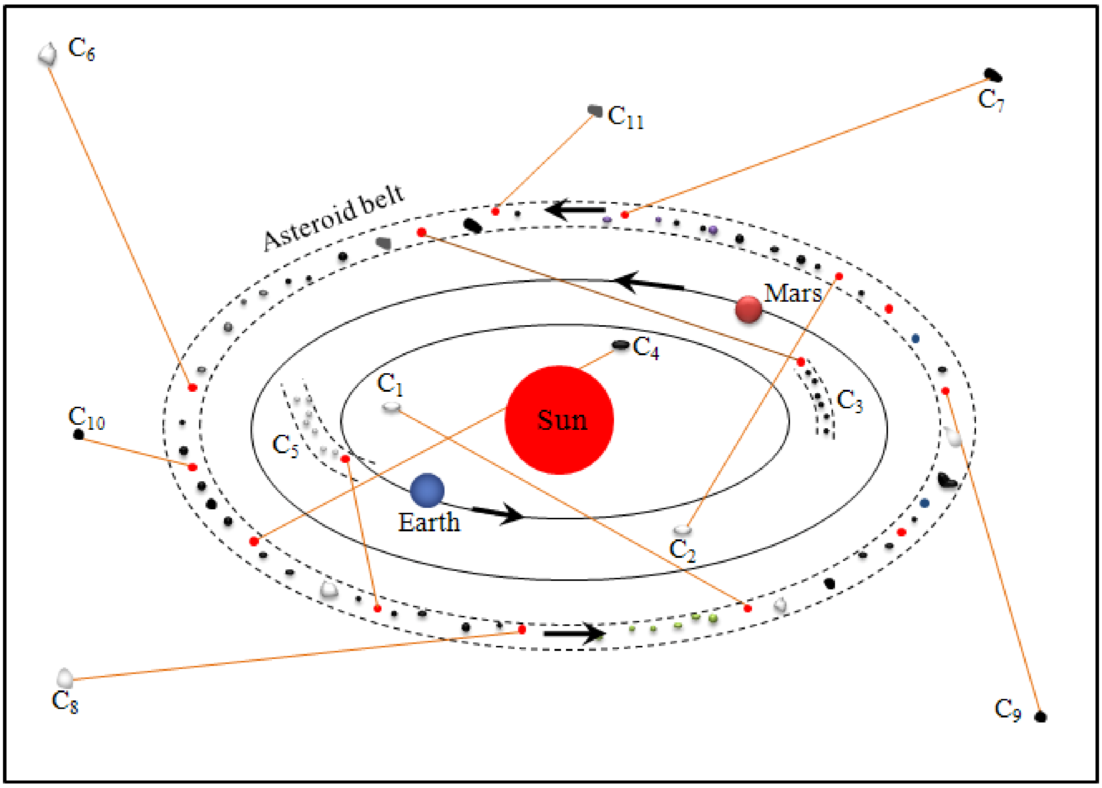


Figure 5: Simulation of the constraint of fragments by the Jovian ring system. Some farther fragments are being dragged by the Jovian ring system to orbit. Letter $C_{i=1,2,3,\text{ etc.}}$ represents different distance fragment from the Jupiter. Blue (orange) line represents the gravitation of Jovian ring to each fragment. Note that each fragment may be a subordinate hierarchical two-body association of smaller fragments.

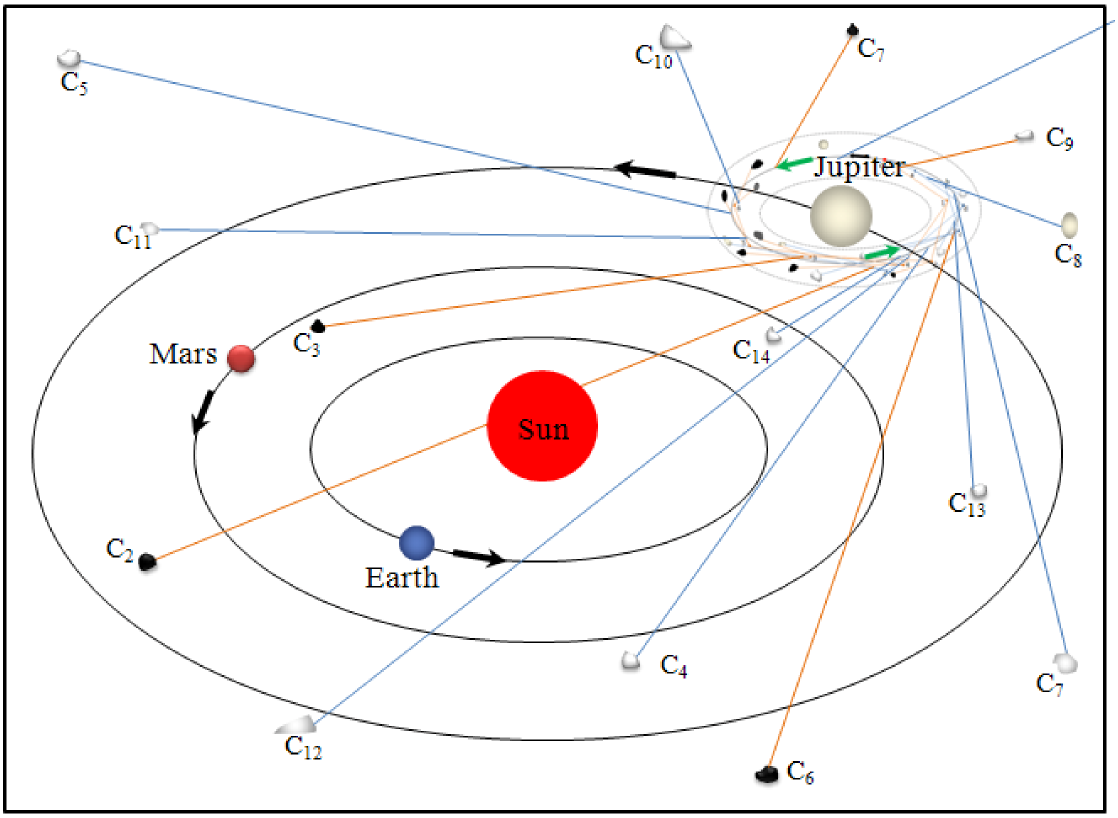
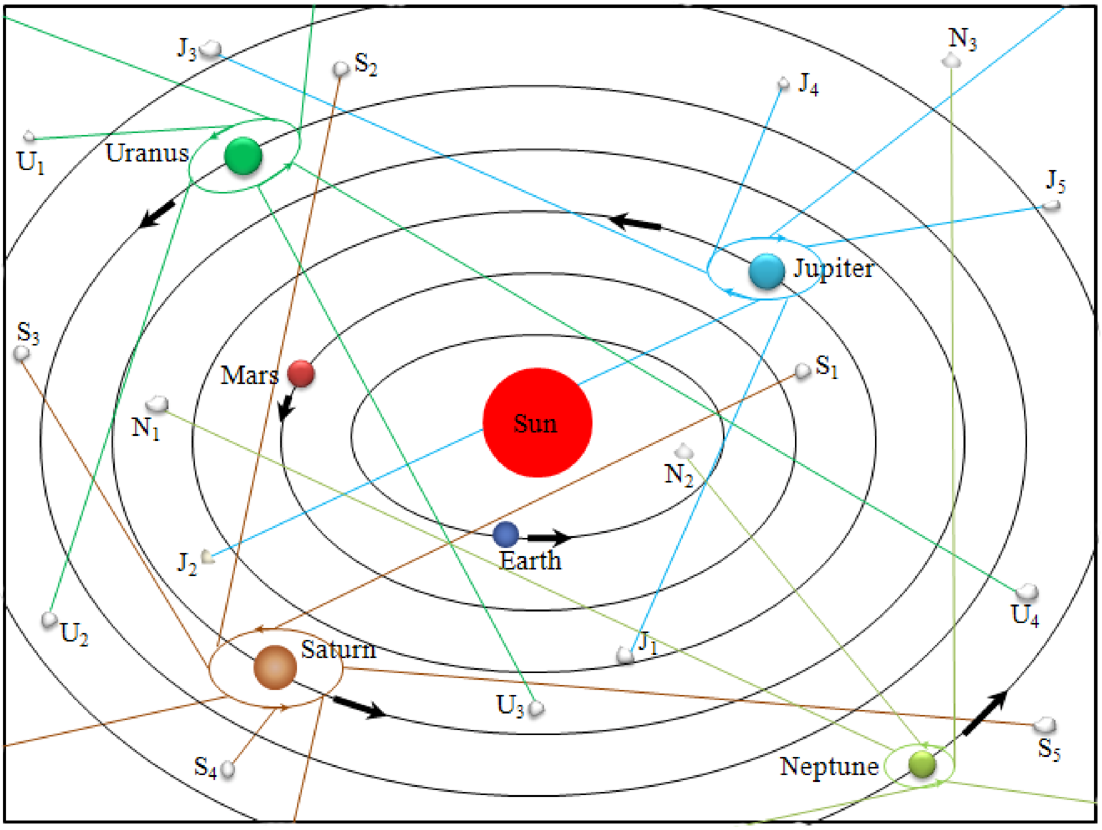


Figure 6: Simulation of the overall cover of fragments to the solar system under the drags of four giant planetary ring systems. Letter $J_{1,2,3,\ etc}$ ($S_{1,2,3,}$ etc, $U_{1,2,3,\ etc}$, $N_{1,2,3,\ etc}$) respectively represent the fragments controlled by their planetary ring system. Various color of straight line represents gravitation from planetary ring to fragment.



3 Fits to observation

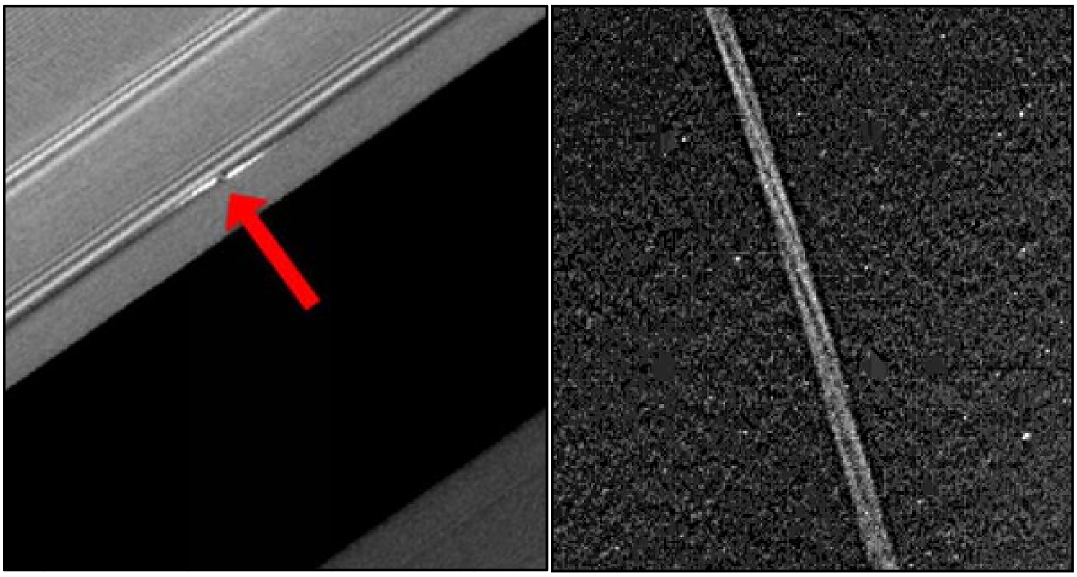
3.1 Asteroid belt

It has been proved that many asteroids belong to some independent families or groups, in which these asteroids share nearly identical orbital elements [16, 22]. Three prominent bands of dust within the main belt have been found to share similar orbital inclinations as the Eos, Koronis, and Themis asteroid families, and so are possibly associated with those groupings [23]. 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 [24]. There are many Kirkwood gaps 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 [2]. It can be inferred from Figure 2(F) that under the frame of a series of hierarchical two-body associations, every fragment must have a companion. 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 moons. This quantity appears to be too low relative to the number of observed minor planets in the asteroid belt, but we should keep in mind that a series of hierarchical two-body associations of asteroids in practice is very difficult to be observed. We believe that more extensive investigation may reveal this feature of hierarchical two-body association. Taken altogether, all these results are fully consistent with the expectation from this model.

3.2 Planetary ring

Most of the giant planet's satellites are icy, which is nearly identical with the ring's composition that is composed of water ice and dust. Some of the rings like Saturn's B ring are observed to have countless smaller rings that are separated with gaps. All these features are consistent with the expectation from this model. The propeller-shaped and ringlet structures in Saturn's ring and the twisted Fraternity arc in Neptune's ring fit to the model in Figure (1): as the two bodies of a two-body system are derived from the disruption of a common parent body, in the disruption each of them may obtain additional movement due to the transfer of momentum, as the barycenter of the two-body system continues to drag the two bodies to orbit, thus the two bodies under the interaction of the barycenter's drag and their own movements may display a two-armed or propeller structure in space. If each body is further shattered to form a subordinate association of particles, and then the two associations may perform some kind of rotation, which makes them look like a twisted strap or rope in space. If one body of the two-body system 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 rotation, each association of particles itself looks like a long ringlet.

Figure 6: A closeup of both the propeller-shaped structure of Saturn's ring in Cassini's image (left) and the Fraternity arc of Neptune's ring in Voyager 2 image FDS 11412.46 looks like a twisted rope and (right) (by courtesy of NASA).

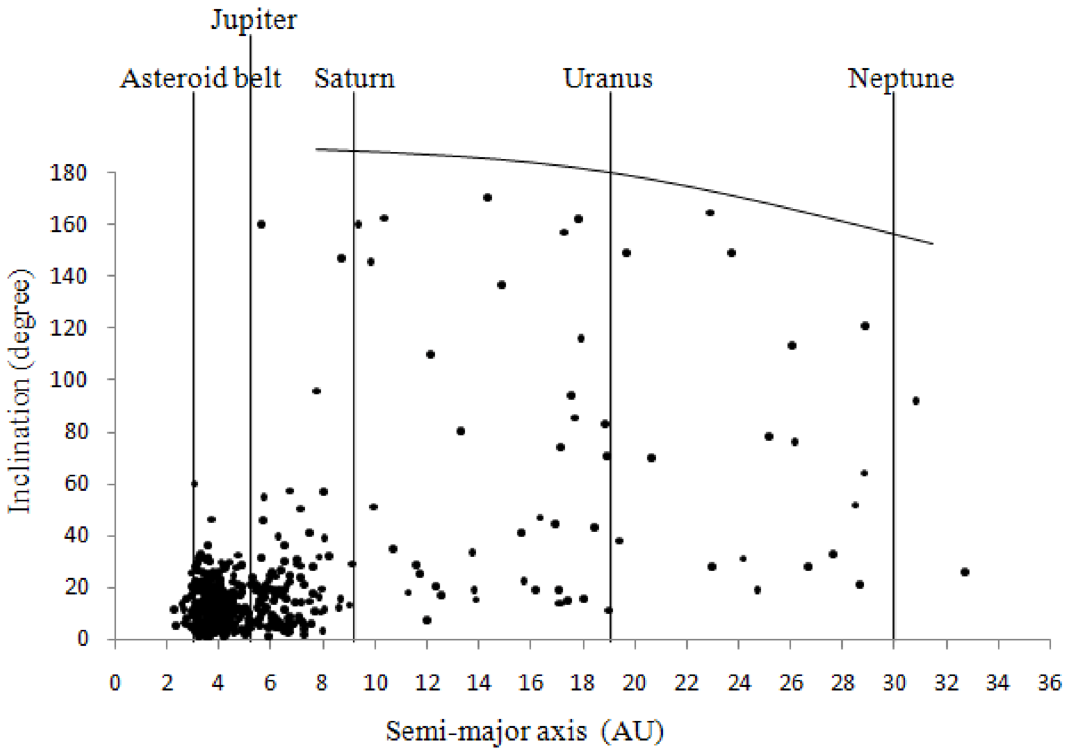


The most prominent feature in Saturn's B ring is radial spoke. Spokes were first observed by the Voyagers in 1981, and the recently frequent appearance captured by Cassini was between 2008 ~ 2009, they are therefore thought to be a seasonal phenomenon, which corresponds to a coupling of solar radiation and spokes [25]. The leading theory regarding the spokes' composition is that they consist of microscopic dust particles suspended away from the main ring by electrostatic repulsion that relates to the magnetosphere of Saturn [26, 27], but a recent analysis of the spectrum of a Saturn ring spoke from Cassini/VIMS suggests that spokes are composed of water ice [28]. In Saturn's ring spokes are rare but water ice is plentiful, this significant difference is impossible to fit that spokes are composed of water ice. Although most of the Saturn's satellites are icy, their composition is various, for example, Titan has a lot of hydrocarbons and other gases such as cyanoacetylene, carbon dioxide, and so on. Image from NASA/ESA/ASI Cassini-Huygens spacecraft shows that Saturn's ring has a temperature generally below -163 degrees Celsius. Our model here proposes that Saturn's ring is derived from the collision of a binary satellite system, thus after the disruption of the two bodies the majority of their materials at such a low level of temperature are likely to be freezed in the ring. But if solar radiation is properly supplied, some volatile materials which have higher freezing point may vaporize. For instance, dry carbon dioxide has a freezing point of -78.5 degrees Celsius. If a large number of volatile materials are efficiently vaporized by solar radiation, it may form a clump of gas across the ring plane. It is very important to note that spokes were observed to be darker than the rings in backscattered light but brighter than the rings in forward scattered light. This suggests that the vaporized materials above the ring plane may partly shade the ring plane from the Sunlight. As a result, when the ring plane brings the vaporized materials to orbit, the shadows from these vaporized materials may create spoke structures on the ring plane. D'Aversa et al employed Cassini/VIMS spectrometer to detect the composition of a spoke [28], it is very possible that they detect the material just below the spoke rather than the spoke itself. Saturn’s ring is composed of mainly water ice and dust, the rapid spoke looks like very thin, both of them easily deceives Cassini/VIMS spectrometer. A careful comparison of video between Voyager and Cassini may find that spokes are commonly light-footed, which really looks like some kind of shadow in the ring plane. Saturn’s narrow F ring holds unusual features like transient clumps, a central core surrounded by multistranded structure, a regular series of longitudinal channels associated with Prometheus, but it is fully competent for surviving in a chaotic environment [17]. Uranus has been found to possess more than 13 rings that are composed of large bodies of 0.2–20 m in diameter, the majority of the rings are only a few kilometers wide, this requires some mechanism to hold these bodies together, otherwise, the rings would quickly spread out radially [29]. 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 [30]. To be effective, the masses of the satellites should exceed the mass of the ring by at least a factor of two to three [31]. 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 [32]. It is again important to note that the rings are composed of separated bodies, these bodies appear to be aligned orderly to encircle the planet, this orderliness does not reflect a strong clue of perturbation from external object, moreover, even if the perturbation is assumed to be existed, the two shepherd satellites - Cordelia and Ophelia cannot confine a large number of separated bodies in a very narrow and long ε ring to orbit the planet. Newton’s universal gravitation that has to yield an *n*-body entanglement is impossible to account for this integrity, but if all the bodies in the rings are orderly organized in a series of hierarchical two-body associations, and each association is independently self-control, it is not difficult for us to understand the existence of these unusual structures. Tiscareno et al in 2010 reported that rings dominated by self gravity wakes appear to be mostly empty space, with more than half of their area taken up by local optical depths around 0.01 [33], this discovery fully fits to the model proposed here that the gravitational control points in a series of hierarchical two-body associations are located in mainly empty space but not in each fragment's body (reference to Figure 2(F) and Figure 3).

3.3 Comet

Comets are observed to be composed of water ice, rock, dust, and frozen gases [34], planetary ring also consists of mainly water ice and dust. The similarity in material indicates that both comets and planetary ring is probably related. It can be found from Figure 3, 4, and 5 that the fragments are being dragged by the asteroid belt and four planetary ring systems to cross the orbits of one or more of the planets, some of them whose distances from their owners are close to the distances of these owners to the Sun may have chance to approach the Sun and thus form comets. Based on this feature, the comets that are derived from these fragments can be classified into 5 types: asteroid belt comet (assumed a is close to 2.8AU), Jupiter comet (a is close to 5.2AU), Saturn comet (a is close to 9.54AU), Uranus comet (a is close to 19.19AU), and Neptune comet (a is close to 30AU), where a is semi-major axis of a comet. As both the orbits of four giant planets and their equatorial planes have inclinations to the ecliptic (reference to planet fact sheet from NASA: 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 also 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 have smaller inclinations than those dragged by the Saturn, Uranus, and Neptune. Statistical result indicates that comets have various inclination of orbit [8], and long period comets are generally on high-inclination orbits while short period one are mostly on low-inclination prograde orbits [35]. We further through JPL Small-Body Database Browser abstract 578 short period comets to study 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 AU~30.0 AU, while 94.18 % the comet population whose inclination is less than 60 degrees generally have a semi-major axis of between 2AU~9.54AU (note that the orbital radius of the Saturn and Neptune are respectively 9.54 AU and 30 AU) (Fig.7). This fits to the expectation from this model.

Figure 7: Orbital inclination and semi-major axis of short period comets.



In the past decades some small celestial bodies (they are currently named after Centaurs) had been found to orbit the Sun between Jupiter and Neptune and crosses the orbits of one or more of the giant planets [36]. From the model presented here, there may be 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, we therefore classify 2060 Chirion, 1994 TA, 1995 Dw2, and 10370 Hylonome to be dragged by the Jupiter, 5145 pholus, 7066 Bessus, 1995 GO, 5576 Amycus, 8045 Asbolus, and 7066 Nessus to be dragged by the Saturn, while 1997 CU2 and 10199 Chariklo to be dragged by the asteroid belt. As of 2008, three centaurs such as 2060 Chiron, 60558 Echeclus, and 166P/NEAT have been found to display cometary coma, water ice signatures have been confirmed on a number of centaurs like 2060 Chiron, 10199 Chariklo, and 5145 Pholus [37]. The similarity of material indicates that both planetary ring and centauri is likely to share the same origin. It is very important to keep in mind that a comet or Centauri in the distance cannot or very difficult to be observed because it has a very small size and is also obscure, the value of aphelion is theoretically derived from a Keplerian estimate but not from observation, thus it has a high uncertainty. This may thus significantly influence the precision of the classification of Centauri.

Table 1: Classification of Centaurs.

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	31.0
	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 = 2.4 AU)	1997 CU_2	13.0	18.5
	10199 Chariklo	13.08	18.66

Note: values of perihelion and aphelion are derived from JPL Small-Body Database Browser.

We further classify Encke and Halley comet to be respectively ruled by the asteroid belt and Uranus's ring system. The perihelion and aphelion of Encke comet are respectively 0.33 AU and 4.11 AU, therefore the value of (aphelion - perihelion)/2 is equal to 1.89 AU, this is roughly close to the orbital radius of the asteroid belt. Reference to Figure 4, we here assumed that Encke comet is dragged by a gravitational point of the asteroid belt to orbit, the orbital radius and period of this point around the Sun is 2.4 AU and 4 years, while the orbital radius and period of Encke's comet around this gravitational point is 2.7 AU and 1.7 years, the inclination of orbit of the point to the ecliptic is zero, while the inclination of orbit of Encke's comet to the ecliptic is 11.78 degrees. The established observation confirms that Encke's comet reached its perihelion on 6 August 2010. We further through JPL horizon system pick up the heliocentric vector coordinate of Encke's comet on the moment: x_{Encke} = - 0.3149 AU, y_{Encke} = 0.1290 AU, z_{Encke} = - 0.0037 AU. As the coordinate of the gravitational point is unknown, it is necessary to employ a mathematical skill to work out. Because at the moment when Encke's comet is at perihelion, its projection on the *xy* plane must lie in the same straight line of the Sun and the gravitational point. It is assumed that the distance between Encke's comet projection and the gravitational point is equal to the length of the orbital radius of Encke's comet around this point, therefore according to geometry, the coordinate of the point is worked out to be x_{point} = 2.2189 AU, y_{point} = -0.9150 AU, z_{point} = 0.0000 AU. Based on these coordinates and related orbital elements, the motion of Encke's comet relative to the Sun may be written as

$$x_t = 2.7 \times \sqrt{(1 - [\sin(\alpha + \frac{360}{1.7}t)]^2 \times [\sin\beta]^2} \times \cos(\gamma + \frac{360}{1.7}t) + 2.4 \times \cos(\gamma + 180 + \frac{360}{4}t)$$

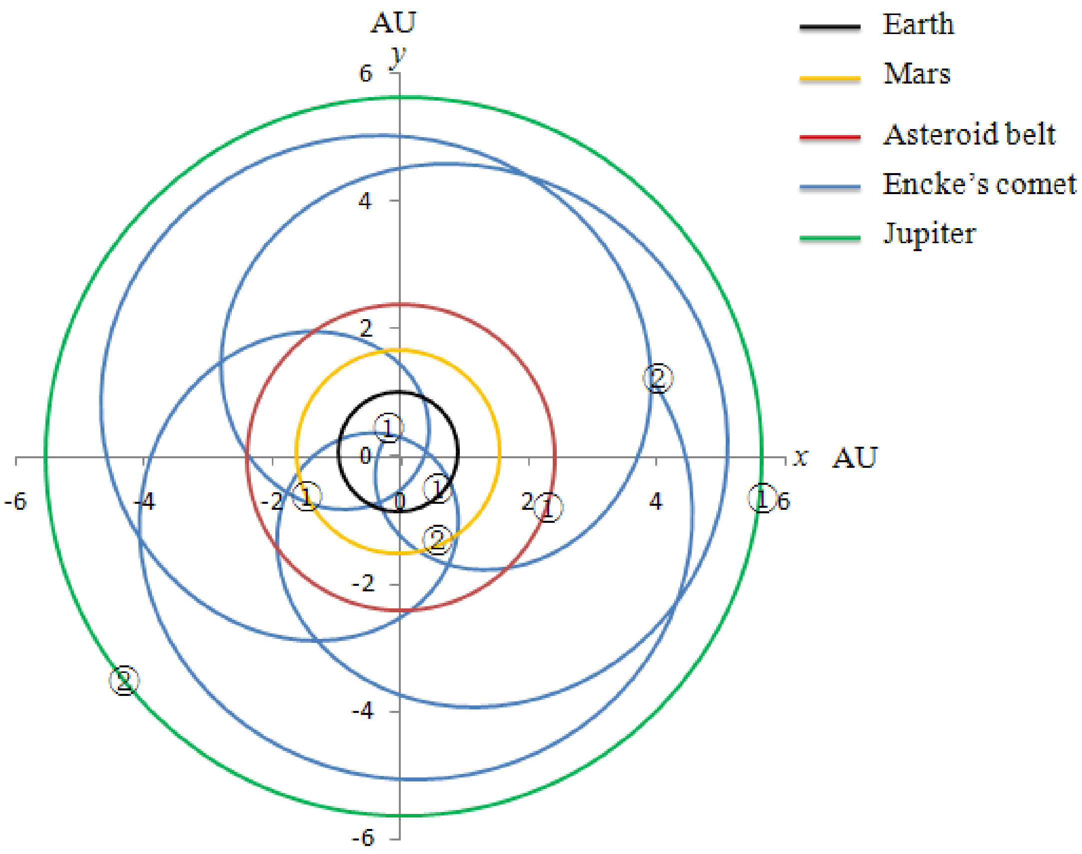
$$x_t = 2.7 \times \sqrt{(1 - [\sin(\alpha + \frac{360}{1.7}t)]^2 \times [\sin\beta]^2} \times \sin(\gamma + \frac{360}{1.7}t) + 2.4 \times \sin(\gamma + 180 + \frac{360}{4}t)$$

$$z_t = 2.7 \times \sin(\alpha + \frac{360}{1.7}t) \times \sin\beta$$

Where *t* is time, unit is year. α is the initial angle of Encke's comet to the intersection line of its orbit and the ecliptic. β is the inclination of Encke's comet orbit to the ecliptic that is equal to 11.78 degrees. γ is the initial angle of its projection to the *x* axis. According to the given parameters, α and γ are worked out to be respectively 359.62 and 154.79 degrees.

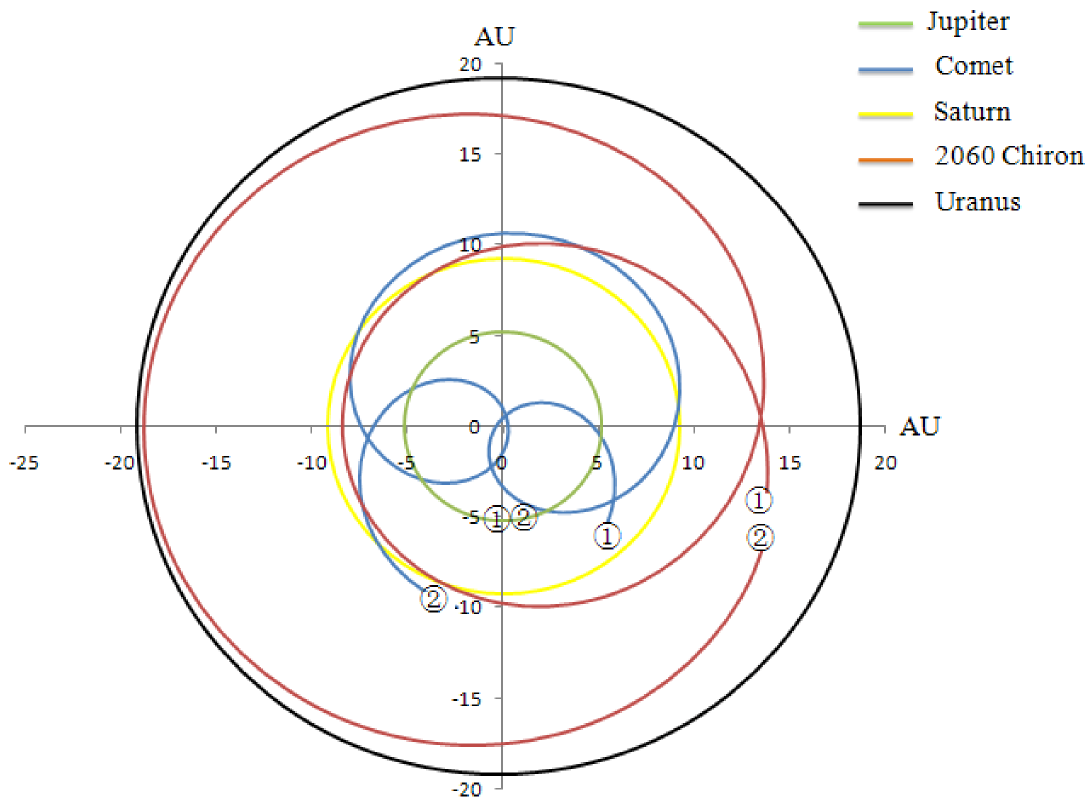
The simulated orbit for Encke's comet is therefore plotted (Fig.8). The time length is 8 years that are just the two orbital periods of the gravitational point around the Sun. It can be found that Encke's comet runs a very eccentric orbit around the Sun, and repeatedly crosses the orbits of Mars and Earth, but never contacts with the Jovian orbit. The simulation also shows that although Encke's comet is defined an orbital period of 1.7 years around a gravitational point that lies in the asteroid belt, due to the motion of this point itself around the Sun, the Encke's comet perihelion between its two adjacent orbits around the Sun displays a time span of around 3 years. The perihelion is estimated from the model to be 0.34 AU, while aphelion is 5.12 AU. The accepted orbital elements for Encke's comet are currently period = 3.03 years, perihelion = 0.34 AU, aphelion = 4.09 AU (also note that aphelion is a theoretical estimate from Keplerian elliptical orbit but not from observation, it thus has an uncertainty). As a result, this simulation in principle fits to the observation.

Figure 8: Simulation of the orbits of Encke's comet relative to the Sun and planets. Time span is 8 years. The Sun is located at the center. ① represents the initial position of each object on 6 August 2010, while ② represents the final position on 6 August 2018. Note that the Sun and the gravitational point return to their initial position after 8 years.



Halley's Comet has an orbital period of around 75 ~76 years, though this period has varied between 74 and 79 years since 240 BC [38], and its orbit from the Sun is between 0.586 and 35.1 AU (reference to Horizon Online Ephemeris System). Uranus has a semi-major axis of 19.23 AU and a period of around 84 years, the orbit of Halley's Comet appears to be evenly cut by Uranus's orbit; 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. These similarities imply that 1P/Halley is very likely to be dragged by Uranus's ring to orbit. Figure 9 shows that the Jupiter is responsible for the orbits of a comet and centaur-2060 Chirion. The Chirion runs an eccentric orbit that is located mainly between the orbits of the Saturn and Uranus (note that the equation above is employed to yield this diagram and some parameters need to be adjusted). The comet enters the inner solar system from one corner of the sky and then drops out, but next time it enters the inner solar system from another corner of the sky. This may significantly mislead people believe that it is two absolute different comets. In reality, planetary ring plane often has inclination to the ecliptic, and even importantly the ring is always rotating around the planet, this determines that a comet that is dragged by the ring may enter the inner solar system in different time from different inclination. It may safe to infer that the number of comet that is currently accepted is severely overestimated.

Figure 9: Simulation of the orbits of a comet and 2060 Chiron that are dragged by the Jupiter. The Sun is located at the center. Time space is 12 years. ① represents the initial position of the comet and Chiron, while ② represents the final position on 6 August 2018.



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 there is no preferential direction from which comets come, and then proposed that comets reside in a vast cloud at the outer reaches of the solar system [8]. It is very important to note that the so-called aphelia of long period comet orbits is generally derived from a theoretical estimate of Keplerian elliptical orbit, nobody observes that the aphelia of comet orbit is indeed located at such a distant place. On the contrary, comets are observed to run a very elongated orbit (that in appearance looks like an ellipse) around the Sun, but this appearance does not indicate that the Sun has to lie at a focus of this so-called elliptical orbit. It is also important to keep in mind that when we observe a comet, the Earth itself is rotating around its axis, 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 in the space. What we observe for the comet is a compositive effect of a series of motions, it therefore is very difficult to determine the comet's proper motion. Regardless of Oort Cloud Hypothesis, the Kuiper Belt that is proposed to account for short period comets encounters at least three obstacles: (1) the number of Kuiper Belt Objects (KBOs) that have been observed is too low to fit to the number of comets; 2) the mechanism by which the comets are supplied from Kuiper belt to planet-crossing orbits is unclear [20]; and 3) there is no evidence to support that short period comets are indeed from Kuiper Blet Objects. The insufficiency of both Oort Cloud and Kuiper Belt thus requires us to seek for a newly explanation of the origin of comet. The model proposed here thus may offer this possibility. Let planetary rings drag comets to orbit, and at the same time let the planets drag their rings to orbit the Sun, this may lead comets to approach the Sun in all directions of the sky.

Celestial objects are commonly constrained by gravitation to run some curved orbits, 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 the collision between objects is inevitable. As all celestial objects in space are arranged by distance to orbit, the two bodies of a two-body system (because they have a shortest distance relative to any third body) will prefer to collide with each other. In the solar system, the Earth has a satellite-the Moon, as of October 2009, more than180 minor planets have been found to have moon (s) (reference to Johnston's Archive: Asteroids with Satellites). Four giant planets (Jupiter, Saturn, Uranus, and Neptune) generally have a number of satellites around them. It therefore is possible that some of the satellites of giant planets in the past might had possessed moons, but due to orbital shrinkage, these moons had lost to the collision with their mother satellites. A large number of craters that are observed on the planets and satellites indicate that planets and satellites had undergone significant bombardment since their births, this requires some special event to fit. The ejected fragments from the collision between the two bodies of a binary planetary system (satellite system) may satisfy 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 [39]. These irregular satellites are likely to be the farther fragments that are ejected from the collision of the two bodies of a binary satellite system, a hierarchical two-body association organizes the bodies of these groups and families together. The well known Titius-Bode Law once predicted a planet that is located between the orbits of Mars and Jupiter, but subsequent observation does not support its existence. It may infer from the model proposed here that the predicted planet might had existed, but many years ago it due to a catastrophic collision had been shattered to form the present asteroid belt. Yang speculated that due to the orbital shrinkage, the Earth and Moon will collide with one another within the following 1 billion years, if possible, at the time another asteroid belt will be created.

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