Monmatia Revisited

by Bill Laurune

Credit: NASA

A report for fellow students of the Urantia Book on the state of contemporary theories of solar system formation, and an interpretation of the Urantia Book's *Origin of Monmatia — The Urantia Solar System* in light of the latest observations of science. The question of the origin of the asteroid belt per *The Solar System Stage,* which contradicts the current scientific theory, is also considered.

In the early 20th century, as the papers of the Urantia Book [63] were being received, a popular theory of the formation of our solar system was that a star passed close enough to our sun to draw out a string of gaseous beads that condensed to become the planets [65]. Known as the Tidal Theory, it was advanced by James Jeans in 1916 [79] in an attempt to overcome problems with the previously accepted Nebular Hypothesis. However, in or about 1939 the Tidal Theory fell out of favor as astronomers such as Spitzer pointed out how improbable it was for one star to pass close enough to another to create such a "tidal wave," and furthermore that hot gases ejected from the sun would not condense but rather disperse. Afterward, a variation on the previously accepted Nebular Hypothesis became the standard model. This theory — the Solar Nebular Theory — has become so accepted that its unresolved problems are overlooked on the assumption that they will eventually be resolved [65]. Textbooks and other popular publications now usually take this theory as given, even if they admit that mysteries remain [83].

The fact that the Urantia Book espouses a model that involves tidal gravity action on the sun has caused some concern that the book simply contains outdated science, which can be construed as evidence of purely human origin, as Martin Gardner has asserted in his critical book [64]. However, the Urantia Book's model of solar system formation in is not as similar to the original Tidal Theory as readers of Gardner's book would be led to believe. Nor is the present-day theory of solar system formation as settled as it once seemed. Very recent observations of our solar system, together with unexpected properties of newly discovered "extrasolar" planetary systems, as well as new computer models of solar system formation, have led some scientists to declare that "the standard model cannot work" [4].

On the other hand, the new observations that are causing problems for the Solar Nebula Theory can be shown to be compatible with a close encounter with a black hole, which is what the Urantia Book actually describes (not a close encounter with a large star otherwise like our own sun, as in the old Tidal Theory). At the same time, contemporary observations of real-life black holes have revealed that a close encounter with a black hole is not nearly as improbable as it would have seemed just a few years ago. Several stellar-mass black holes have been observed in the past few years, and they are in motion relative to the normal procession of stars around our galaxy [15], thus making an encounter with a black hole more likely than an encounter with another star. Furthermore, it is now believed that stellar-mass black holes originate in supernova events, which all modern theories assert played some role in the formation of our solar system because elements heavier than iron are formed only when a star implodes.

This article describes the advantages and disadvantages of the popular Solar Nebula Theory and other contemporary theories of solar system formation, then proposes a theory based on the passage of a black hole carrying the debris of a supernova past the immediate vicinity our early sun.

I should advise readers of this article that I am not a professional astronomer, but rather a Urantia Book student who follows ongoing observations of the heavens in popular books and journals. For this article, I have also made use of such college lecture and thesis material as can be found on the Internet. I have included a large number of references to work by professionals. Where the professionals do not always agree, I have referenced those points of view most supportive of the theme of this article.

The diagrams in the article are my own, except where otherwise noted. None of the diagrams are to scale, since empty space is boring, and precise mathematical relationships have usually not been calculated. The pictures, and a few diagrams, are from NASA or other U.S. government websites and are not copyrighted. I have nevertheless given credit where credit is due.

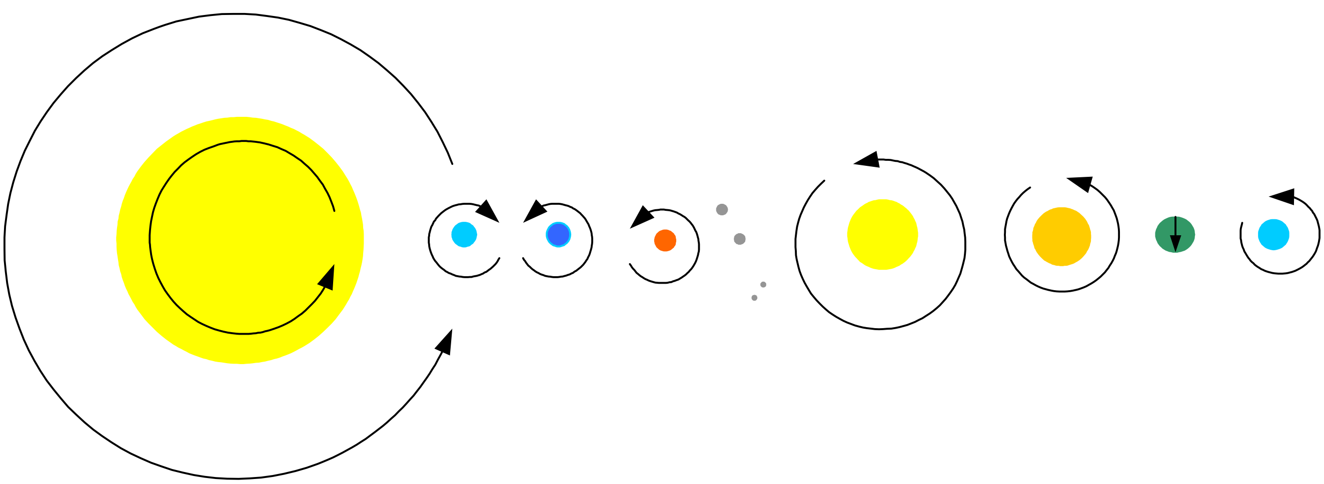
At the end of the article, I have listed my references. Most are (for now, at least) on the Internet. As lengthy as this article is, it by no means covers all the ground in depth. Serious students of the subject will want to follow the links. Those students of the Urantia Book who lack the time or background to study the matter carefully may wish to simply take comfort from my conclusion that *The Origin of Monmatia*, while using the terminology and concepts of the early 20th century, deviates from the popular theory of the day in ways that allow it to be extrapolated to modern times.

Mankind is continuing to explore the solar system. I fully expect that as the next generation of space probes and telescopes provide new observations, this article will have to be revised in order to remain current.

Overview of the Solar System

Whatever our solar system may have looked like in the past, at present the main components are — proceeding outward from the sun — a set of small, rocky planets, a belt of rock-like asteroids, two gas giants, two ice giants, the "Kuiper Belt" of rocky debris (in which many now include Pluto) and the relatively spherical "Oort Cloud" of icy debris.

Looking at the solar system from above, the sun rotates counter-clockwise, the planets orbit counter-clockwise around the sun, and most planets rotate counter-clockwise on their axis. The exceptions are Venus, which rotates in the opposite direction, and Uranus, which is tilted 98 degrees. Most of the major moons have a corresponding orbit, but some do not and are thus considered retrograde. The rotations and orbits of Venus through Neptune are shown below.



The Planets

Traditionally, the solar system has been considered to have nine planets. However, the recent discovery of two large objects in the Kuiper Belt has led to a debate about the definition of the word "planet" and whether Pluto should have that status, and if it does whether the new objects should as well [21]. The two new objects, Quaoar [17] and Varuna [74], are smaller than Pluto, but still large enough for gravity to have made them round and hence planet-like. Otherwise, the traditional planets, in order of their distance from the sun, are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto.

The innermost planets — the so-called "terrestrial" planets — are composed largely of rock; they are Mercury, Venus, Earth, and Mars. The "gas giants" are Jupiter and Saturn; they are by far the largest planets. The "ice giants" are Neptune and Uranus; sometimes also referred to as gas giants, they are smaller and far enough from the sun that what is gas on Jupiter may be liquid on them.

The main asteroid belt is between Mars and Jupiter, where Bode's Law of expected planet spacing predicts the fifth planet should be. However, if all the asteroids were put together, they would not be as big as the expected planet, or even as big as Earth's moon. Nor are all the asteroids in this belt; some have unusual orbits and the Trojan asteroids are in stable positions in the orbit of Jupiter around the sun.

The Kuiper Belt is a collection of ice and rock at or beyond the orbit of Pluto; it generally lies in about the same plane as that in which the planets orbit the sun.

The Oort Cloud is a relatively spherical collection of ice and debris beyond the Kuiper Belt.

Because the objects in the Kuiper Belt and Oort Cloud do not shine with visible light or other radiation, they are difficult to study, and we are still learning about them from observations with the Hubble Space Telescope. It is believed that comets originate from these areas of the solar system when collisions among them change their orbits.

Current and Historical Models of Solar System Formation

While there are some rather chaotic aspects to our solar system, it is for the most part fairly orderly. In addition to the common rotations noted earlier, planets are for the most part spaced in a regular way according to Bode's Law, and they mostly travel along the plane known as the ecliptic.

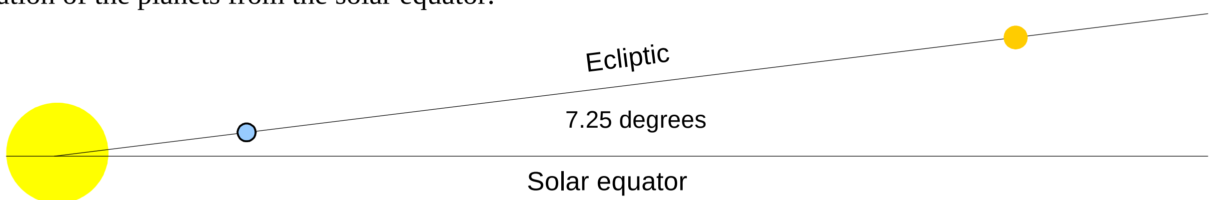
Bode's Law

Bode's law provides a mathematical prediction of planet spacing [27]. It is very accurate for planets from Mercury to Uranus. It was very useful when astronomers were still discovering the planets of our solar system, because it gave them some idea of where to look.

It was in part because Bode's Law predicted a planet at 2.8 astronomical units that astronomers discovered Ceres, the largest of the asteroids, and initially considered it a planet. However, the discovery of other asteroids caused Ceres to be reclassified. For a while thereafter, it was hypothesized that Ceres and the other asteroids were the remains of an exploded planet, but the contemporary theory (which I will shortly dispute) is that the asteroids are remnants of the solar nebula that never formed a planet due to the gravitational effects of Jupiter.

Plane of the Ecliptic

The diagram below illustrates the "plane of the ecliptic" relative to the solar equator. It is defined by Earth's orbit around the sun, and is about seven degrees from the plane defined by the equator of the sun, as illustrated below. All the planets, and some of the asteroids, are roughly in this plane, but many are further inclined by a few degrees, and Pluto (not shown) is inclined by about 17 degrees. Given that Jupiter and Saturn have most of the planetary mass of our solar system, their orbits are in some respects a better gauge of the true orbital deviation of the planets from the solar equator.



Other Solar Systems

Until recently, our solar system was the only one that could be observed from Earth. However, improvements in telescopes and observational techniques have allowed astronomers to detect Jupiter-sized planets around other stars. The current technique is based on measuring the "wobble" of the star as the planet orbits it, so only close stars with large planets can be studied [72]. At present, 116 planets have been detected [55] in 100 systems. Many of these planets are "hot Jupiters" — planets the size of Jupiter, or more often much larger — that are in a close orbit around the star, sometimes as close as Mercury is to the sun. These observations pose a problem for contemporary theories of solar system formation because in these theories, the reason the inner planets are "terrestrial" (rocky) is because the sun's heat drove away lighter gases of which Jupiter so largely consists. Because these observations surprised astronomers, who expected to find solar systems conforming to current models, they have renewed interest in models of solar system formation [22]. For decades, astronomers seemed content to accept the Solar Nebular Theory as given, but this is beginning change.

The Solar Nebula Theory

The Solar Nebula Theory is a modern variation of the Nebular Hypothesis, which was first proposed by Immanuel Kant in the mid 18th century. The theory asserts that the planets and the sun formed at roughly the same time from a contracting and swirling cloud of dust and gas. The cloud was predominantly hydrogen, but contained enough "dust" of heavier elements that the "rocky" planets such as Earth and Mars can form from the dust. The dust would have been at least partly composed of remnants of a supernova that were mixed in with the primordial hydrogen-helium gas cloud prior to its contraction into the solar system.

While it is intuitively attractive, and links planet formation to star formation, the Solar Nebula Theory has some problems:

- In some computer simulations, the dust does not condense at all, but remains as rings that may in fact disperse rather than condense [28].

- Recent analysis of Jupiter by the Galileo probe indicates that the Jovian atmosphere has far more inert gas — xenon, argon, and krypton — than does the sun or Earth. If the sun, the Earth, and Jupiter formed from the same nebula, they should have the same proportion of inert gases, or the sun should have more due to fusion of lighter elements into inert gases [7].

- The orbital plane of the planets is not exactly in the plane of rotation of the sun; the orbit of the Earth is off by 7.25 degrees. A rotating nebula should have been fully symmetric around the central plane, unless something huge collided with the sun or uniformly pushed the planets into inclined orbits. However, in the Solar Nebula Theory, this difference is considered small enough to ignore, or even to be evidence in support of the theory.

- Some computer models show that a nebular disk would not have had enough material to form planets the size of Neptune and Uranus in their present orbits [5].

- Triton, a large moon of Neptune, has a retrograde orbit, suggesting it did not form in the orbit as part of solar system formation. Quite a few moons of Jupiter also have retrograde orbits. Venus rotates in the opposite direction to what it should in the nebular hypothesis, and Uranus is tilted 98 degrees. These deviations are usually attributed to collisions of some sort.

- In the Solar Nebula Theory, the planets that formed from the swirling nebula should have the same relative angular momentum as the sun; however, the sun rotates some 400 times too slowly. The planets have most of the angular momentum of the system; the sun has relatively little. That is, the planets orbit too quickly relative to the sun's speed of rotation [28]. (One proposal for how this came to pass in the contraction model is that electromagnetic forces acted to speed up the dust that formed into planets [21], but most of the sources I've found still consider this an unsolved problem.)

- The one hundred or so other solar systems that have been observed thus far differ from our own in that their gas giant is usually in close orbit around the star and/or in a very elliptical orbit rather than nearly circular like that of Jupiter [71].

The Composition of Jupiter

The question of the composition of Jupiter, as recently observed, is worth examining in some detail, since it causes difficulties for all of the recently popular theories. In 1995, the Galileo spacecraft dropped into the atmosphere of Jupiter [22]. Its on-board spectrometer revealed that the Jovian atmosphere contains several times the amount of inert gases that would be expected if Jupiter formed from the same nebular material as the sun [7]. Certain other elements, such as carbon and sulfur, are unexpectedly abundant as well, but that is not considered as significant an anomaly.

The inert gases in question -- xenon, krypton, and argon -- freeze only at very low temperatures; for example, argon is a gas at any temperature above -185.7° C, a low temperature reached only at distances further from the sun than Saturn.

Inert gases do no react with other elements. Because they do not react to form molecules with other elements, they serve as tracers for the original composition of the Jovian atmosphere. Because they remain a gas under all but the very lowest temperatures, it is difficult to explain how Jupiter could accumulate additional inert gas since its formation; any such gas that came close enough to Jupiter would simply blow away on the solar wind. Either the gas was present when Jupiter formed, in which case it should match that of the sun, or the gas had to arrive on some sort of container, such as being locked up in the core of comets, or Jupiter had to be formed at least in part from material other than that which composes the sun, or Jupiter had to form far outside of its present obit in order to acquire frozen inert gases.

Traces of argon have in fact been found in a comet [23], so Jupiter may have obtained its argon from consuming huge numbers of comets during its formation. However, in a sense this just chases the problem: if comets formed from the same material as the rest of the solar system, why would they contain a higher proportion of argon than the sun? One might postulate that comets acquire their argon from the outermost parts of the solar system, where argon can freeze and accumulate from the interstellar medium. However, the hypothetical nebula would also have formed from that medium, and hence the sun would have the same relative composition.

There really seems to be no good explanation for this observation, hence the assertion, made in articles announcing the findings, that it has thrown theories of solar system formation into "disarray" [7]. However, for purpose of this article, the other theories are still worth considering because they are based on physics that will be used in development of a new theory based on the Urantia Book's *The Origin of Monmatia.*

The Condensation or Protoplanets Theory

The Condensation Theory is similar to the Solar Nebula Theory, but it assumes that an unusually dense cloud of tiny grains of ice and dust condensed to form the solar system [28]. The dust and ice particles formed clumps that aggregated into small protoplanets at the same time as the formation of the sun. According to some sources, this is now the current working model of planet formation [82].

While the Condensation Theory is free of some of the problems of the Solar Nebula Theory related to planet formation, other problems remain. In particular, the Condensation Theory does not explain the angle of the ecliptic and can only explain the composition of Jupiter by assuming that the sun passed through a region of space different from that in which the sun itself was formed.

The Encounter Theory

In this model, a star passed close enough to the sun to draw out a streamer of solar gas that condensed to form planets. This model was first proposed by Georges Buffon in 1745 and elaborated by Harold Jeffreys and James Jeans [29] becoming what is now called the Tidal Theory.

Advantages:

- The matter drawn off from the sun would have a bulge in the middle and be tapered at the ends, resulting the approximate distribution of mass in the present solar system.
- The matter from the sun would be on a single plane, but that plane need not be at the solar equator, hence accounting for the divergence of the ecliptic from the solar equatorial plane.

Disadvantages:

- Most of the gases drawn off from the sun, being intensely hot, would quickly disperse. It would then be blown away by the solar wind.
- It is highly unlikely that a star would come close enough to the sun because all the stars of the Milky Way are proceeding in roughly the same orbit around the center of the galaxy with many light years of intervening space. (Jeans acknowledged close encounters with another star to be very rare [79].)

The Capture Theory

The Capture Theory of solar system formation is somewhat the inverse of the Encounter Theory; whereas the Encounter Theory has another star extract material from Sol, the Capture Theory claims that Sol extracted material from a passing star [73]. The other star would not have been a main sequence star like our sun, but rather a protostar — a star in the process of formation — and as such still had a large cloud of gas and dust surrounding it.

Advantages:

- Accounts for the planets having more angular momentum than the sun by virtue of the momentum of the captured particles.
- Accounts for the plane of the ecliptic.

Disadvantages:

- Although a protostar's dust cloud would be far larger than the diameter of a star — roughly the diameter of our solar system — it is still unlikely that our sun would pass that close to a protostar, given that such a protostar would still be orbiting the galaxy in concert with other stars.
- A protostar does not remain in the protostar phase very long relative to the lifetime of a star or relative to the time it would take the protostar to move about the galaxy relative to other stars. Once the gravitational collapse begins, it proceeds quickly relative to astronomical time scales [67].

A Speculative Model

One idea recently put forward is that our solar system formed in a more chaotic region of the Milky Way Galaxy, such as Orion's Nebula, and subsequently moved out of it [4]. The advantage of this hypothesis, as a variation on the Solar Nebula and other contemporary theories, is that it could account for the composition of Jupiter by virtue of acquiring additional supernova debris after the formation of the sun.

The chief difficulty of this theory is that our sun is not presently moving very fast relative to nearby stars, so it is difficult to see how our sun could have been pushed out of a more active region but then slowed down, given that objects in motion in empty space remain in motion. However, this model makes for a good transition into describing the Angona Theory, in which a chaotic region of the galaxy is dragged past our sun by a black hole of origin in a supernova.

The Angona Theory

The Angona Theory — by which I mean a modern interpretation of the Urantia Book's *Origin of Monmatia* section — incorporates many of the most plausible aspects of the contemporary theories. Like the Condensation Theory, the Angona Theory postulates that cold ice and dust contributed to the condensation of the planets, and that the heat of the sun drove lighter gases out of the inner orbits. Like the Tidal Theory, the Angona Theory incorportates material extracted from the sun. Like the Solar Capture Theory, the Angona Theory posits that a region of dust around a passing object contributed to planet formation. Like all the contemporary theories, it proposes that remnants of a supernova account for the existence of elements heavier than iron in the planets.

Massive Stars, Supernovae, and Black Holes

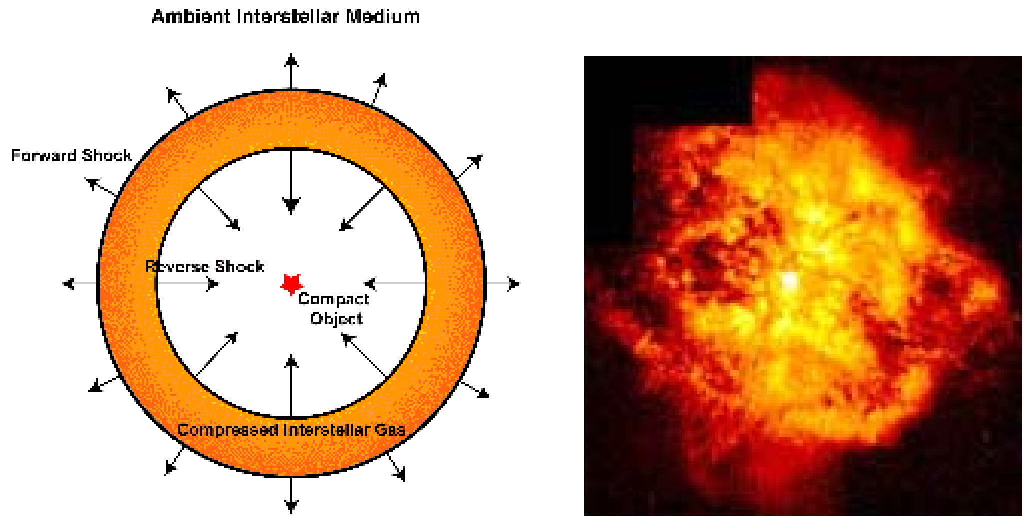
In order to begin at the beginning of the story of our solar system, we have to start with a star other than our own and describe its history. This is absolutely necessary because our own star cannot create elements with higher atomic numbers than iron, yet we have such elements even on the surface of the earth. Examples include copper, nickel, zinc, and lead.

A star shines becaues of the energy released by fusion of hydrogen into helium and the subsequent fusion of helium and hydrogen into still heavier elements such as lithium, carbon, sulfur, silicon, calcium, and so on. The fusion process in a shining star ends with iron, which is atomic number 26; uranium has the highest number of any naturally occurring element: 92.

If a star were releasing energy from a combustion (burning) reaction, then a larger star would burn longer than a small one. However, because a star is driven by fusion, and higher mass creates a larger fusion core, a large star actually has a much shorter lifetime than a smaller star. The very largest stars may burn out in millions of years. On the other hand, very small stars may shine with a dim red light for trillions of years [57].

A star will remain in a relatively balanced state in which heat overcomes gravity as long as it has fusible materials. When a very large star runs out of fusible material (elements lighter than iron) gravity wins, and the core of the star implodes, releasing energy that explodes away the outer margins. The resulting explosion has enough energy to fuse some of the iron and other elements into elements heavier than iron [32], and some of these elements are mixed in with the shock wave of expanding debris.

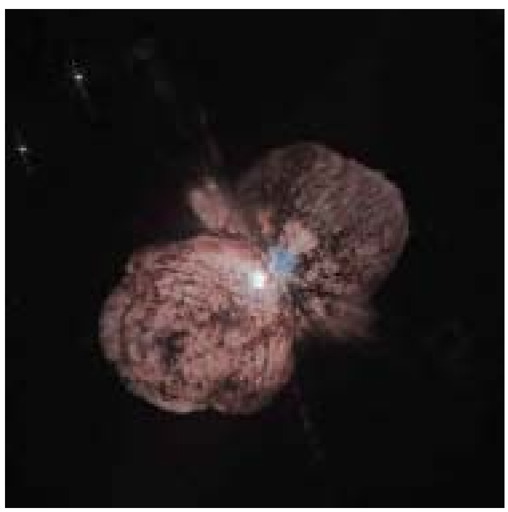
If the imploding star is large enough — at least 10 times the mass of our sun — a black hole results [61]. A great deal of such a star's mass is blown away in the explosion, but the core forms a black hole, a small object with gravity so strong even light cannot escape, and which has interesting properties relevant to the Angona Theory.



Mechanics of a Supernova Explosion (Credit: NASA)

Another result of a supernova explosion is that the remaining core of the star may be ejected from whatever gravitational collection of stars to which it belongs and thus begin to travel through the galaxy much faster than the usual procession of stars [30], or even across the usual orbit of stars around the galaxy [2]. The existence of such roving black holes is no longer just theoretical. Several have now been observed, either because they have a companion star and can be observed directly, or, if they lack a companion star, because of the effect of gravitational lensing as the black hole passes between earth and stars under observation [8]. The latter event is especially rare, so the fact that this has been observed indicates that there may be a great many such black holes in our galaxy. One scientist has speculated there may be on the order of a million such black holes [30].

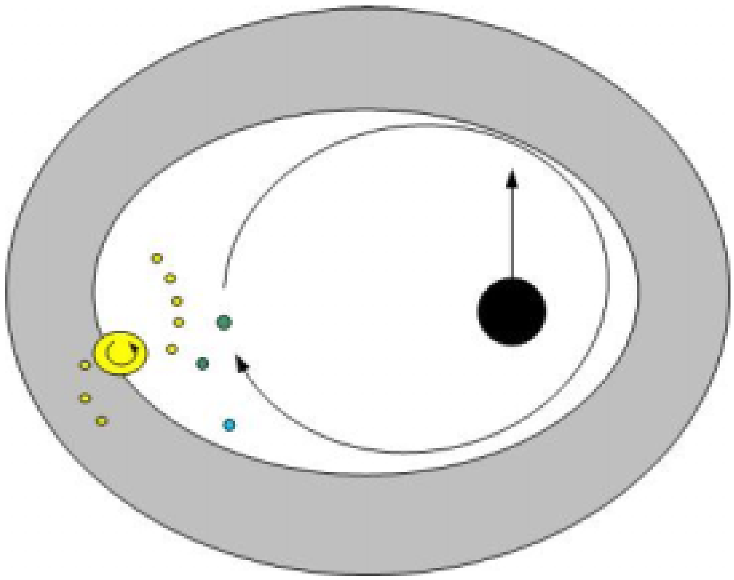
When a supernova forms a black hole and sets it in motion, the black hole would eventually move through its own debris field. Some of that debris would fall into the black hole, but some would also go into orbit. The larger pieces of rocky debris from the outer layer of the black hole might quickly form planets: they would initially be hot and molten, but would be exposed to interstellar space and so radiate heat until they reached the temperature of interstellar space. Thus a traveling black hole can be the center of a system of planets, dust, ice, and gas. As the system traveled through interstellar space, it would lack any source of heat once dust stopped falling into the black hole, and so the system would be very cold, and even inert gases could freeze. The picture below shows an exploding star; it is a useful way to envisage the process, even if this one didn't necessarily create a black hole.



Stellar Explosion (Credit: NASA)

Angona Approaches Sol

Following the Urantia Book's lead, I will call the black hole "Angona," and I will call the system of black hole and debris the "Angona system." The diagram below illustrates the Angona system passing our sun (Sol).

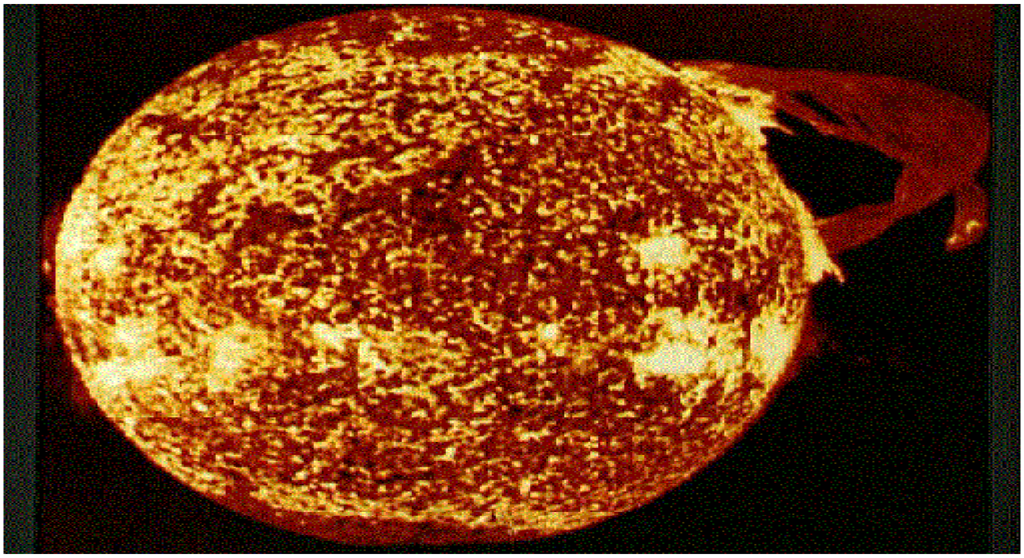


Angona's planets would have accreted the dust and ice in their orbits, thus clearing out that part of the system to some extent. As the Angona system approached Sol, the center of gravity would shift slightly toward Sol, such that debris, planetoids, and outer planets of the Angona system would form slightly elliptical orbits. Those that came past the point of gravitational balance between Angona and Sol would have been captured by Sol. As you picture the Angona system in motion in the direction of the arrow, bear in mind that these various layers would have passed by Sol over a period of many hundreds of thousands of years.

The Angona Theory solves the problem of angular momentum, in part, by asserting that the material that formed the planets was extracted from the sun (as large solar flares) over a period of time during which it picked up angular momentum from the passage of Angona. It also adds three captured planets to the mix, as will be described later. The hypothetical orbits of the captured planets can be seen in the diagram above. These added spheres would have had considerable momentum relative to Sol, and could have contributed to the angular momentum of the planetary system once they encountered the matter extruded from Sol.

The Angona Theory solves the problem of the composition of Jupiter (with respect to inert gases) by asserting that the extra gas came from ice that originated in the supernova and was carried here by Angona. The solar winds probably kept gas away from the sun. Jupiter may also have picked up an entire frozen planet, and thereby acquired its gases.

The Angona Theory solves the problem of the inclination of the plane of the ecliptic by postulating that Angona passed at an angle to the equator of the sun. The diagram below illustrates how the sun would have been stretched by the tidal gravity of the Angona system, and how a solar flare could erupt at the angle at which Angona passed. This diagram is a real solar flare, but the image has been stretched and the solar flares brought on by the passage of Angona would have been much, much larger. As Angona first approached, the flares would have fallen back into the sun, but as Angona neared, its gravity would have detached flares, which would have condensed in, and merged with, the icy dust in the Angona system's outer reaches.



Partial Disruption of Sol (Original Image Credit: NASA, Skylab)

Planet Formation

One of the difficulties of any theory in which planets form by aggregation of dust is to explain how one gets from cold dust grains and molecules of gas to planets. The force of gravity can act over long distances, but for very small objects it is very weak, almost nonexistent. Intuitively, if the objects pulled together were molten rock or metal, they might merge like gobs of wax, but in the deep cold of space, small objects do not remain hot for long, rather, they radiate away their heat. Thus, if cold objects are in a common orbit and nothing makes them stick together when they do collide, they may simply bounce around. For example, the rings of ice around Saturn show no signs collapsing into a moon.

Saturn and its Rings

Credit: NASA

As noted previously, an objection to the original Tidal Theory is that material ejected from the sun would evaporate due to its tremendous heat. It is therefore important to stress those aspects of the Angona Theory that differ from those of the Tidal Theory in this regard:

- In the Angona Theory, extremely cold ice (frozen oxygen, nitrogen, etc.) and dust were circulating around the sun. As Angona approached Sol, new ice and other debris flowed past and perhaps began to orbit Sol. (Not only was Angona moving, but the material was orbiting Angona and being affected by the gravity of Sol.) The initial temperature of this debris would have been roughly that of the interstellar medium, which is relatively close to absolute zero (under 100 degrees Kelvin). Since they resulted from an exploding star, the debris particles would probably have been of varying size — everything from molecules, to grains of sand-like material, and perhaps even objects like present-day comets or asteroids.
- In the Angona Theory, the material ejected from the sun was not ejected as a single event as in the traditional Tidal Theory. Rather, as Angona came closer and closer, the solar flares grew larger and larger, initially falling back into the sun but eventually becoming detached as Angona got close. As these flares mixed with the cold dust, they would have formed balls of fused carbon, sulfur, iron, calcium and other elements from the sun, along with whatever was in the supernova remnant. By the time of the major eruption, this process would have been going on for half a million years, and the area of the solar system in which the planets now orbit would have been full of cooled "solar meteorites." At the time Angona was the closest, the largest solar extrusion would have intercepted the orbiting globs of dust and aggregated solar material, collecting it into small planetoids. Once small planets were formed, they would naturally have gathered up and merged with any other small orbiting bodies with eccentric orbits. The forming planets would have the average orbit of the intercepted bodies, becoming nearly circular over time.
- In addition to the force of gravity, electrical charge may also have been a factor. Theoretical models of black holes predict that black holes can evaporate by a quantum-mechanical process called *Hawking Radiation* in which, to make a long story very short, black holes may develop a charge [68]. Thus it may be that the dust around Angona was electrostatically charged, and attracted to the Sol's ejected material. (The Urantia Book states that the core of the Angona system was "highly charged.")

Testing the Theory

Having explained the origin of our solar system as the result of the passage of a black hole carrying the remnants of a supernova past our sun, it would help prove the case if we could find other evidence of the passage of the Angona system. There are several possible tests of the theory:

- If a black hole passed close enough to the sun that it, in combination with the sun's own explosive power [80], extracted most of the material of the solar system, then we should expect that this black hole also gave the sun enough of a tug to set it in motion relative to nearby stars.
- If Angona passed through our part of the galaxy, some other stars should have similar solar systems. In particular we should find a line of such systems among the stars that lie in Angona's path. (Close encounters will be very rare, however, so we would need telescopes that can look a long way out.)
- Comets should have a higher concentration of elements found in supernovae than does the interstellar medium, since Angona would have carried the supernova remnants here directly, whereas supernova remnants in the interstellar medium would have been mixed with lighter gases.
- Solar systems just like ours should be fairly rare. (On the other hand, if the Solar Nebula Theory is correct, then all or most stars like our sun should have solar systems roughly like ours.)

It is in fact the case that the Sun is moving relative to the local standard of rest [24]; it is traveling towards the galactic center, orbiting the galaxy faster than nearby stars, and is migrating northward out of the galactic plane. In general, it is moving toward Vega [58]. However, given that most stars have their own motions, it cannot be claimed that this is proof, only that a necessary condition is fulfilled. (Our sun could even have been moving away from Vega at the time Angona came along and reversed its motion in this direction.)

Given the present technology, distant solar systems can only be inferred from the wobble of the stars. Small planets cannot be detected directly. However, astronomers have detected a dust disk and what seems to be a planet the size of Neptune around Vega [56], one of the stars closest to us. Although this does not prove the correctness of the Angona hypothesis, it is encouraging, since we can image that Angona came past our sun moving toward Vega, imparting some momentum to our sun in the direction of Vega, and then moving on to create a solar system of some sort around it. If Vega has just one large planet like Neptune, it may be in part because Angona did not manage to disrupt this star, which is more than twice as massive as our sun. Instead, Angona may have merely contributed a planet and some dust to it.

If the Stardust probe [66] succeeds in returning uncontaminated samples of both comet dust and interstellar dust, the hypothesis that comets have more supernova remnant material than average interstellar dust can be tested, assuming that the cores of comets have remained uncontaminated by the interstellar medium, which may not be the case [76]. Our local interstellar medium may also have changed since the formation of our solar system due to a nearby supernova [75].

The Formation of the Asteroid Belt

Another point of discrepancy between popular contemporary theories and the Urantia Book concerns the origin of the asteroid belt. For a time, the "exploded planet" hypothesis was the prevailing explanation of formation of the asteroids, in large part because the bulk of the asteroids, by mass, are in the orbit predicted by Bode's Law. However, this theory was eventually dismissed because:

- There is not enough mass to account for a planet. All the asteroids together have far less mass than our moon.
- There is no reason for a planet to spontaneously explode.

The contemporary theory, which goes hand in hand with the Solar Nebula Theory, is that the asteroids represent a planet that failed to form because Jupiter attracted too much of the mass from the rotating nebula. The present theory seems to have some obvious problems:

- If, as some computer models indicate, the dust of the primordial solar nebula would not form planets, neither would it form asteroids.
- The asteroids are relatively solid and irregularly shaped. They are not mere dust balls. They have survived impacts that would have shattered a dust ball.
- The asteroids have variable composition: some are "stony" while others are largely iron [42]. If they all formed from the same part of the primordial nebula, they should all have a similar composition.

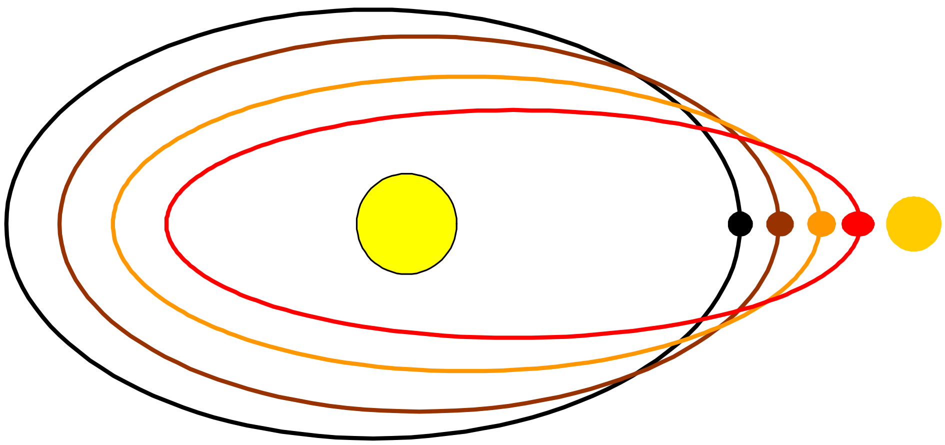
Those who hold that the asteroids are remnants of a fragmented planet attribute it to a collision with another object, or perhaps nuclear fission of uranium that sank to the molten core.

As far as I have been able to determine, tidal gravity of Jupiter has not been considered, probably because the main asteroid belt is far from Jupiter. However, tidal gravity disruption of a small planet by Jupiter overcomes both objections to an exploded planet hypothesis: the planet exploded due to the heating induced by tidal gravity stresses, and the explosion occurred at the point of closest approach to Jupiter, so much of the ejected material was captured by Jupiter. The captured material may very well have become some of the recently discovered asteroid-like retrograde moons of Jupiter [25]. Further, the planet probably experienced eruptions of matter prior to the final disruption.

Contemporary theories explain the fragmented nature of asteroids, their varied composition, by asserting that asteroids were once larger, with greater differentiation of materials, and that collisions have reduced them from their original size. However, such concepts merely indicate the need for a larger mass and a subsequent catastrophe in the formation of asteroids.

A Tidal Gravity Disruption Theory of Asteroid Formation

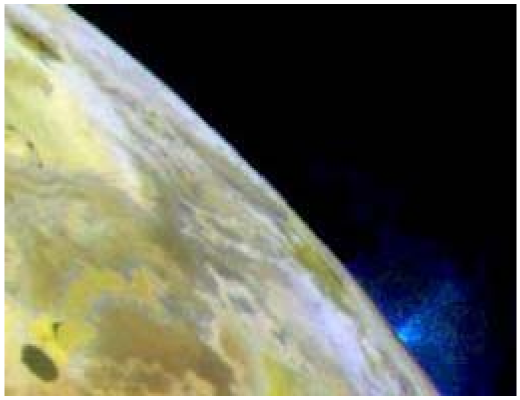
As the planets formed in the inner solar system, the fifth planet (which I call Ceres in honor of its largest remaining fragment) would have slowly grown and cooled as did Earth, Mars, and Venus. However, the planet Jupiter would also have continued to grow, and to grow much faster because it attracted more material and there was more material in its orbit. Even if the Ceres began with a relatively circular orbit, the growth of Jupiter would cause a slight tug each time Ceres was in conjunction with Jupiter, causing its orbit to become ever more elliptical. As the Ceres' orbit became more elliptical, the effect of each conjunction with Jupiter would have had a progressively greater effect, rendering the small planet hotter and hotter as it was squeezed by tidal gravity. In the diagram below, the original orbit (in black) becomes more elliptical with each encounter with Jupiter over many millions of years.



Ceres swings closer and closer to Jupiter over time. (Not to scale.)

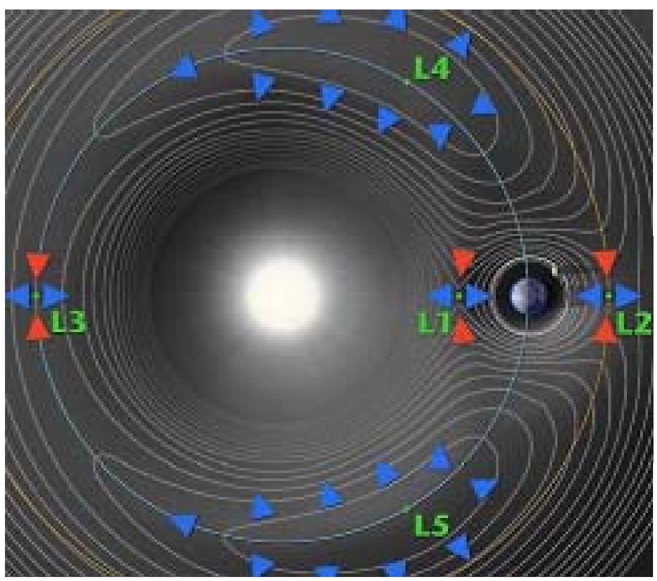
Initially, as Ceres was just beginning to approach Jupiter, the effect on Ceres would have been much like the effect of Jupiter on Io [77]. The tidal flexing of Io causes it to be in a state of continual volcanic eruption [69]. As Ceres approached Jupiter, the stress would have become greater and greater. The small planet's crust would cool and harden during the years it did not approach Jupiter; when Ceres did approach Jupiter, it would be stretched, and the stretched rock would crack and heat. Enormous volcanoes would form, ejecting material from Ceres. Because this happened early in the history of the solar system, Ceres would still have been small, not having accumulated meteors and comets that have since greatly enlarged the remaining planets. Ceres was probably about the size of the planet Mercury, which isn't much larger than Earth's moon, and of similar composition: a metallic core and outer crust of rock [81].

Even Earth, an old and stable planet with scant external stresses, has volcanoes that pack tremendous energy. Some have speculated that Krakatoa had the energy of 100,000 hydrogen bombs [34]. But the volcanoes on Ceres would have dwarfed the Krakatoa eruption. Ceres was smaller and much hotter than Earth is today, and it was being heated by tidal gravity just as Io is today. Hence some of the material from the volcanoes may have reached escape velocity even prior to the final disruption, spewing blobs of molten rock and metal into space. (Assuming Ceres was about the size of our moon, its escape velocity would have been much lower than that of the Earth, so natural events could reach escape velocity; for example, some meteorites found on Earth are thought to have been knocked off of Mars by impacts [22].) The image below is that of a plume from a volcano on Io, which is being heated by tidal gravity that is minor compared to what Ceres would have experienced.



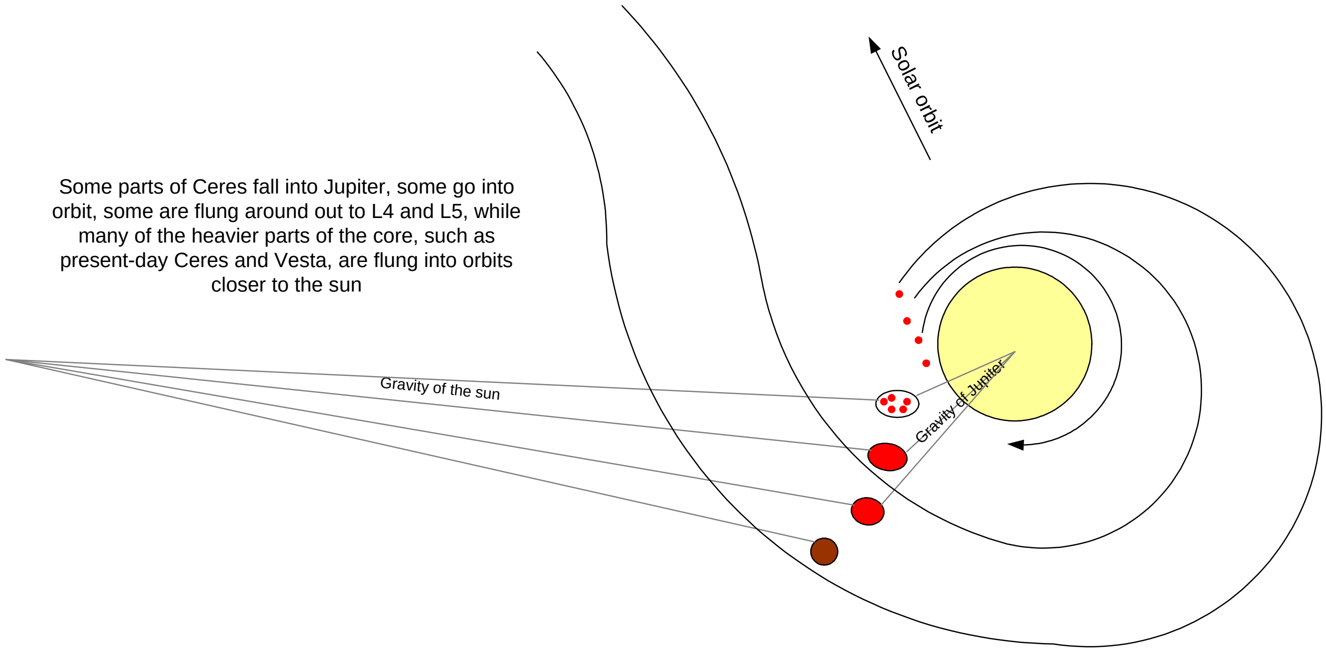
A volcano on Io. Credit: NASA

The materials ejected from Ceres at various points in its orbit would have taken different trajectories. Some would have hit Jupiter, some would have gone into orbit around it, and some would have undergone a gravitational slingshot [33] into various erratic solar orbits, giving rise to the asteroid belt, the irregular moons of Jupiter, and perhaps various comets and meteor swarms. Quite a few fragments also could have settled in the two Lagrange points [48] in Jupiter's orbit. There are more asteroids in L4 than in L5, indicating an asymmetric originm whch prevailing theories cannot explain [49]. If they originated from an explosion of Ceres, then naturally Ceres' orbital momentum would have carried more debris to Jupiter's L4. The L5 point would have picked up debris only from a slingshot effect or by subsequent drift of scattered debris into the L5 point. The diagram below shows the Lagrange points of Earth, but the same system obtains around Jupiter.



Lagrange Points (Credit: NASA)

The bulk of the asteroid belt, in terms of mass, is located at about 2.7 astronomical units, where Bode's Law predicts the fifth planet. However, the Tidal Disruption Theory, does not claim that the asteroids formed there, nor that all of the exploded material conveniently went into that orbit. Rather, the debris went to many places, but only the debris that went to that orbit, or certain other stable places, has survived to bear witness to the event. Several distinct forces were at work on the fragments: the spin of Ceres itself, its orbital, the pull of Jupiter, and the motion of Jupiter along its orbit. The debris was widely scattered, and only the parts induced into orbits that don't come close to the orbits of the planets have survived.



Of course, it is not necessarily the case that all the present asteroids originated from the disruption of Ceres. Lumps of matter left over from the formation of the solar system may also remain as asteroids, more or less as present theories suggest. In particular, the asteroids composed of lighter elements may be either fragments from Ceres' crust and atmosphere or globs of matter that have even to this day escaped capture by any planet.

The Many Moons of Jupiter

As of late 2003, Jupiter was known to have 61 moons [25]. Since many small moons have been discovered just in the past few years, more may remain to be discovered. The smaller moons are irregularly shaped rocks. And at least one of the larger moons (Almathea) seems to be a collection of rocky debris rather than a solid body [39], so it may be a collection of larger asteroids.

As mentioned earlier, one of the traditional objections to the "exploded planet" hypothesis is that there is not enough mass in the asteroid belt to have been a planet. Of course, by some definitions, the asteroid Ceres itself could be considered a "planet." But, definitions of "planet" aside, if the planet was disrupted by the tidal gravity action between Jupiter and the sun, then it is reasonable to assume that some of the mass of the disrupted planet ended up in orbit around Jupiter, a large portion was consumed by Jupiter itself, while a lesser fraction became asteroids and meteorites, many of which were later captured by other planets. Basically, the objections to the hypothesis assume the explosion took place in the present orbit, which is not necessarily the case. There are clearly mechanisms in the solar system for changing orbits, including gravitational slingshots and of course the explosion itself. There are also mechanisms for clearing out certain sections of the solar system by gravitational attraction and gravitational assist, as in the Kirkwood Gaps [84].

Of the known irregular satellites of Jupiter, 25 orbit Jupiter in retrograde, that is, directly or nearly opposite the usual direction, thus indicating they were captured rather than forming in conjunction with Jupiter, although it is presently somewhat of a mystery to astronomers how Jupiter could have neatly captured so many objects in similar orbits [26].

The Moons of Mars

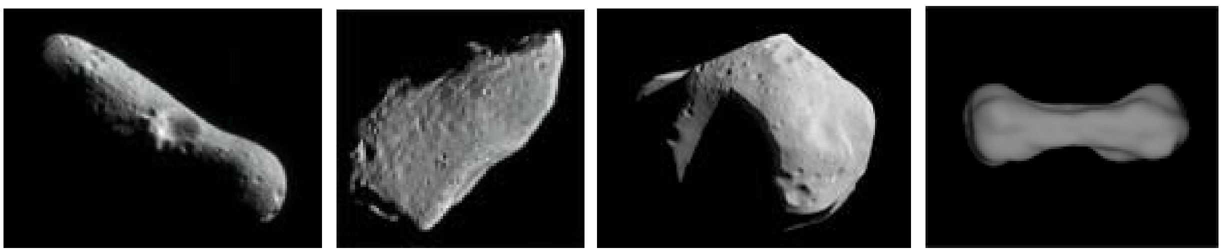
The moons of Mars may be captured asteroids as well [50], indicating that asteroids could not only have been flung to their present average orbit, but to Mars or even farther.

Phoebe

The planet Saturn also has a moon that is probably a captured asteroid. Phoebe has an eccentric retrograde orbit [51].

Composition of Asteroids

Most asteroids look like big rocks. It is not hard to imagine that they originated as semi-molten shards of a disrupted planet's mantle and core, or sharp fragments of rocky crust, rather than just dust left over from the creation of the solar system. Of course, even if they are not made of dust, they are certainly covered in dust; the larger asteroids are big enough to have sufficient gravity to attract fine bits of dust. Some asteroids even hold boulders on their surface. So of course there is a fine powder on the surfaces of asteroids, just as there is on the surface of the moon. But if they were only dust, the meteors that caused the small craters would have dispersed the asteroids rather than leaving just a dent in some superficial dust.



Left to Right: The Asteroids Eros, Gaspra, Mathilde, and Kleopatra
Credit: NASA

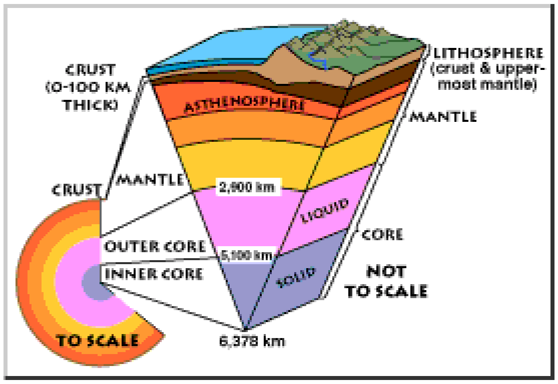
In 2000, a probe called NEAR (Near Earth Asteroid Rendezvous) orbited, and then landed on, the asteroid Eros [40]. The data from NEAR suggest that Eros is a "a cracked but solid rock." And not solid iron. However, certain asteroids that have struck earth contained a large quantity of iron and nickel; one of the world's largest nickel mines, in Sudbury, Ontario, is the site of an asteroid impact [41].

Meteorites — asteroids that strike earth — can be classified as "stony" or "iron" [42]. Iron meteorites contain such an abundance of pure metals that futurists like to speculate that mankind will eventually set up mining operations in space to mine the metals from asteroids [45].

A difficulty with the failed-planet theory of asteroid formation is the fact that asteroids vary in composition: some are relatively metallic, and some relatively "stony." If they all formed from the same nebular dust, they should all have the same composition. Nor can this be explained by segregation of the dust into layers by weight in space; materials only separate by weight in fluids; in space, a light object will retain its orbit as well as a dense one [70].

Furthermore, few if any of the asteroids are big enough to have ever been hot enough to melt the dust particles into solid rock. Other notions for how asteroids were at one time molten include nuclear fission reactions and impact; however, the only way enough uranium would have come together is if there was a large enough mass of molten substance such that the uranium would sink and accumulate. And any impact hard enough to cause uniform heating would simply shatter the asteroid if it were still a ball of dust or grains.

On the other hand, if the asteroids are fragments of a planet, it is easy to see how some would be metallic and others stony: the fragments extruded from the core of the planet would be mostly iron and nickel, while fragments of the crust would consist of silicates, carbonates, and other oxidized minerals, just as in our Earth. The diagrams below show how metals have migrated to the core, while silicates and other light oxidized elements floated to the top. Other planets may not have exactly the same structure, but in general the heavy metals sink and the lighter stone floats to the top while the planet is molten due to frequent bombardment from debris during the early days of solar system formation.



Composition of Earth (Credit: USGS [46])

About 20,000 to 50,000 years ago, an asteroid about 80 feet in diameter hit the earth in what is now Arizona [37]. Clearly, the object that made this hole was very solid. A mere collection of rubble would have shattered upon hitting the atmosphere.

Asteroid Crater in Arizona (Credit: JPL)

The Kleopatra asteroid is especially interesting. Radar reflections indicate that is made of metal, probably iron and nickel. How it formed is considered a "perplexing mystery" [52]. However, if you imagine a stream of hot molten metal extruded from a planet under the stress of tidal gravity disruption, it's not hard to visualize it rotating into a "dog bone" shape. As it rotates end over end around a center of gravity in the middle, the molten material would surge toward the ends until the metal had cooled by radiating the heat away into the cold depths of space.

The Origin of the Kuiper Belt

In the Angona model of solar system formation, the Kuiper Belt probably consists of icy debris from the Angona supernova remnant along with just a bit of warm mass extracted from Sol. Pluto, and large Kuiper Belt objects such as Quaoar and Varuna may have formed from small amounts of warm material from Sol being pulled into the orbiting debris field. It is also possible that some elements of the Kuiper Belt were formed closer to the sun, but were ejected to the Kuiper Belt by a gravitational slingshot. Comets taking under 200 years to orbit the sun are believed to originate in the Kuiper Belt [10].

The Origin of the Oort Cloud

In the Angona model, the Oort Cloud is the supernova dust and debris that was inside the balance of gravity of Sol during the passage of Angona. It is so cold that even inert gases freeze, or more correctly, remain frozen, for that is how they arrived. Comets that require more than 200 years to orbit the sun are believed to originate in the Oort Cloud [10]. However, some of these may also be vestiges of objects that formed further in and were ejected outward by a gravitational slingshot.

Sol's Capture of Three Angona Planets

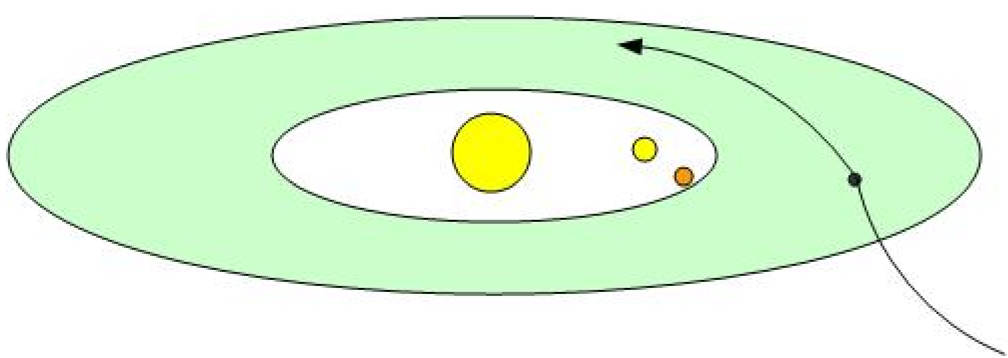
In the Urantia Book, three "major planets" of the Angona system were in such distant orbits relative to Angona that they came close enough to Sol to be detached from Angona and become part of our solar system. This may account for certain unusual rotations and obits in our solar system:

- Venus rotates opposite the normal rotation.
- Uranus is tilted 90 degrees from the normal rotation.

Postulating the capture of the core of Uranus would solve the problem of its perpendicular spin, as well as the problem that computer models of solar-system formation don't show the formation of planets as large as Uranus and Neptune [47. But this leaves us with a "major planet" to account for another problem: the angular momentum problem. It has been said that the distribution of angular momentum in our solar system is a problem for the encounter hypothesis, although it is a problem for any nebular hypothesis as well. One way to use the third major planet is to suppose it crashed into the primordial solar system and merged with what eventually became the core of Jupiter, which would account for its angular momentum and its odd composition.

One potential problem with the theory that Sol captured the cores of certain of the existing planets is the improbability that the Angona system came past Sol with a planetary system that was symmetric with respect to what is now the ecliptic. However, two factors make the capture of planets along the ecliptic more likely:

- First, given the chaotic origin of the Angona system, it probably had planets in various orbits, as opposed to having all of them being in more or less the same plane.
- Those planets orbiting Angona which came close enough to Sol to be captured would have encountered a disk of material extracted from the sun. We might envisage this disk as somewhat like the rings of Saturn, but with large comet-like bodies instead of just small rocks. If a planet in orbit around Angona crossed through the plane of the ecliptic, it would have captured a considerable amount of the material that orbited Sol, and so begin to take on a similar orbit. For example, Uranus is believed to have a rocky core that comprises only a fraction of the total mass of the planet [62], although that core is large enough to be called a "planet" in its own right. If this core crossed through the rings of material in the ecliptic, it would be slowed as it gathered material to itself. On the other hand, if a planet crossed through the very thin dimension of the rings, it would keep right on going, possibly being flung by gravitational slingshot out of both Sol's and Angona's systems.



The Accumulation of Mass Selects Angona Planets in the Plane of the Ecliptic

The Number of Planets

To students of science, one of the most disturbing statements in *Origin of Monmatia* has been the statement that "the twelve planets soon formed in miniature." Since the current generation of readers has been brought believing that there are nine planets, this statement smacks of rampant mysticism, as if three mystery planets remain to be discovered. Curiously, however, an argument has recently been made that there are twelve planets known at present [19]. In addition to the traditional nine, if "planet" is defined as a body large enough for gravity to shape it into a sphere and it orbits the sun without also orbiting a larger body, then the asteroid Ceres, as well as two recently discovered Kuiper Belt objects, Quaoar and Varuna, all count as planets. (We can think of the asteroid Ceres as the largest remaining fragment of the former fifth planet, so it is the fifth planet either way.)

However, it may also be the case that certain moons were originally planets in their own right, but were captured by larger planets. For example, Triton, a moon of Neptune, is large enough to be a planet in its own right. It orbits Neptune opposite the orbit of Neptune's other moons, and opposite that of the rotation of Neptune itself; it also has a different composition from that of Neptune's other moons. Charon, the moon of Pluto, but about half the size of Pluto itself, may also once an independent planet.

Although not impossible, it seems unlikely that any large planets remain to be discovered in the plane of the ecliptic beyond Pluto. Not only would they reflect enough light to be visible, they would also have cleared more of the Kuiper Belt.

Conclusions

I hope I have demonstrated that the model of solar system formation presented in the Urantia Book, far from being just "old science" as critics have claimed, may actually be the best theory at a time when standard scientific models are having difficulty with the latest observations.

Comments and suggestions related to this article may be sent to sciencearticles@yahoo.com.

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