A New Paradigm for the Jovian System

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Abstract.
We propose a new paradigm for the cosmogony of the Solar System in which Jupiter, Saturn, Uranus and Neptune were the only primordial planets. The bulk of their accretion was a slow, cold process in which ice particles containing refractory grains melted and fell like snow, in the atmosphere of the protoplanet. As the pressure in the interior increased gas hydrates formed which incorporate the entire spectrum of elements. Therefore, these are solid low density planets. The terrestrial planets were created at later epochs, each as the result of unique, very high energy impacts on one of the great planets. This hypothesis stems from observations recorded in ancient myths, of the birth of proto-Venus from an enormously energetic impact on Jupiter, which we estimate occurred only 6,000 years ago. All aspects of the Jovian system observable today, that is, the Great Red Spot, the temperature excess, the atmospheric wind belts and zones, Jupiter's rotation rate, the Galilean satellites and even the main asteroid belt, are direct results of that impact, which *released* more than 10^{43} ergs over six millennia, some of which was discharged from clathrates, particularly methane. Ancient records combined with data from Earth observations, Galileo and Cassini, the impacts of Shoemaker-Levy 9 and from the NASA Galileo atmospheric probe, provide a wealth of information consistent with a solid Jupiter, accounting for a number of observations for which the current paradigm has no explanation.

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1. Introduction

The notion that Jupiter is a gaseous planet has devolved from a series of unfounded assumptions, not the least of which is the uniformitarian premise that all of the planets and satellites were created some 4.7 billion years ago and that the solar system has remained essentially the same since that time. We maintain that recent catastrophic events, triggered by the impact of an extra-solar-system body on Jupiter 6,000 years ago, releasing more than 10^{43} ergs, have shaped the solar system we see today. Since this catastrophic scenario begins with Jupiter, it is logical to examine this hypothesis in terms of how it explains the observed properties of the great Jovian planet and its adjuncts.

2. Cosmogony of the Solar System

In the beginning, four solid snow-ice-clathrate planets, Jupiter, Saturn, Uranus and Neptune accreted to form the proto-Solar System. Most gaseous H_2 had been lost from the solar nebula before the nuclei of the great planets had a chance to form. The fact that the total amount of gaseous hydrogen in our solar system is currently only a few percent of that needed to make all the giant planets, is one indicator. Also, a study of twenty young sun-like stars showed very little H_2 in their nebula.[*Zuckerman*, 1995]

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We maintain that the four great planets accreted from particulate matter in the outer solar system where ices of the volatile compounds were available to act as binders for the imbedded hard refractory compounds. IRAS astronomical images, which show *large amounts of particulate matter in the outer parts of many stellar nebulae,* are consistent with this scenario. Even more convincing is a July 21, 2002 STS ACS image of a nearby young star (HD 141569A) and its nebula, shown in Figure 1. Infrared images show that within about 2.8 billion miles of the star the disk is almost devoid of particulate matter. This implies that *planets are forming from the ice and dust in that region*. Of particular interest is the fact that *this is the same radius occupied by our solar system out to Neptune*. The two bright bands in the outer nebula may be the precursors of the Kuiper belt and the Oort cloud. Only after the accretion of the great planets was well along, were the terrestrial planets and the satellites of the great planets formed as the result of high energy impacts on them. Consequently each terrestrial planet has a unique age.

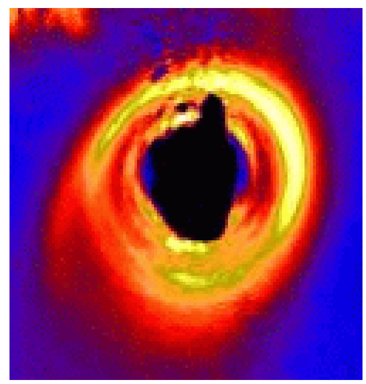

Figure 1. STS ACS image of HD 141569A

3. The Interior of Jupiter

The mass of Jupiter is roughly 318 times that of the Earth. It's average density, 1.3 g/cm^3, lies between those of Uranus and Neptune. Jupiter is currently thought to have the same relative abundances of the elements that are found in the Sun, whereas the less massive planets were unable to retain the lightest elements, hydrogen and helium, in gaseous form because their gravity was too weak. Being many times more massive than the Earth, is thought to have been able to retain these gases, and so should be primarily hydrogen. However, the capture of these gases required a pre-existing solid proto-planet with a gravitational attraction some ten times greater than the Earth. Moreover, studies of a number of sun-like stars shows that the hydrogen in their nebula is lost within the first ten million years, implying that most of the hydrogen had already escaped from the solar nebula before the nucleus formed.

The hypothesis that Jupiter is a gaseous planet resulted, in part, from the premise that rock and iron at its center would be crushed to such super-high density that the measured average density and moment of inertia factor could not be satisfied. Assuming that only hydrogen could produce the measured average density and moment of inertia factor under such compression, a quantum mechanical model of its interior was constructed. The quantum mechanical model actually failed to produce the measured value of these parameters, but the problem was 'fixed' by the insertion of a *'small' terrestrial body, some ten to twenty times the mass of the Earth*, at its center. This also solved the problem of how the hydrogen gas was captured in the first place. What has been glossed over in this model, is the fact that *this ad hoc addition violated the primary assumption leading to the premise of its hydrogen composition*. Moreover, the quantum mechanical model predicts that a conductive state of hydrogen, *which has never been observed*, comprises the bulk of the interior.

The notion that iron would become compressed to super high densities at the center of Jupiter is not consistent with laboratory experiments using diamond anvils, which show that at super high pressures H infiltrates the solid Fe lattice to form FeH*, the density of which is significantly less than pure Fe [Badding,*1991]. Moreover, the density and speed of sound of the solid core of the Earth is also consistent with an FeH composition.

Supporters of the current paradigm maintain that if water ice comprised the bulk of Jupiter, deeper layers would become compressed to super-high densities, making it impossible to satisfy the measured average density and moment of inertia factor. We maintain that another type of high pressure chemical reactions occurred to prevent this. Specifically, the formation of gas hydrates or clathrates. Gas hydrates comprise a whole class of solids in which water ice forms a hydrogen-bonded host lattice encasing a variety of 'guest atoms or molecules' like argon or methane. [Durham, Kirby, Stern & Zhang] have recently shown that at low temperatures and high pressures, such as exist within Jupiter, methane clathrate not only forms readily, but is *over twenty times stronger than water ice*. Its great strength implies that Jupiter's deep interior would not be compressed to super-high densities, overcoming the conventional argument based on polymorphs of pure water ice.

Referring to most of the smaller bodies in the outer solar system [Kargel] states that clathrates "may be the most abundant form of volatile material in the Solar System." He includes CO, CO_2, N_2, O_2, C_2H_6, and SO_2 as probable guest molecules in addition to the most prominant, CH_4. Still under the influence of the current paradigm, he does not go so far as to claim that the great planets are solid clathrate bodies.

On Earth clathrates are of great interest as the next source of natural energy, after petroleum, and there are many ongoing studies as to how the methane stored in these structures might be recovered. Therefore, a gas hydrate composition of Jupiter explains the magnitude and longevity of the resulting jet that shot out of Jupiter for some six millennia. Based on the slowing of the rotational period of Jupiter from one to ten hours in this period we estimated the impact delivered 10^{43} ergs. However, some of the energy involved in this process was probably energy released from the gas hydrates that make up the bulk of the solid planet, reducing the estimated energy of the impact itself. This is consistent with the presence of large amounts of atmospheric methane, used by [Porco] to study cloud motions.

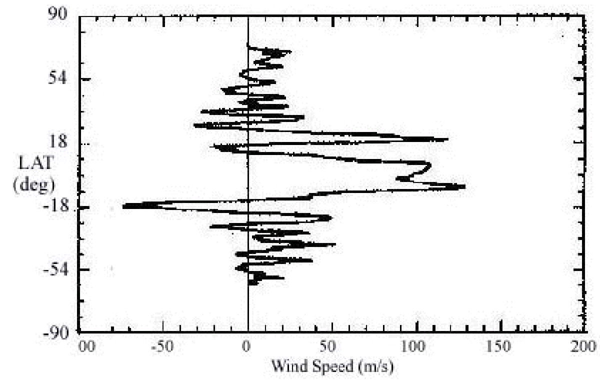

Figure 2. The asymmetry of Jovian wind speed (m/s) with respect to latitude is obvious. The only strong westerly occurs at the latitude of the Great Red Spot.

Another factor influencing the core density is the currently accepted assumption that the Jovian temperature excess is due to the leakage of primordial energy. This is part and parcel of the hydrogen model. It implies that the interior is hot (25,000 K). The failure of the Galileo atmospheric probe to detect the three touted cloud layers was a blow to the gaseous planet hypothesis, but was initially rejected because it supposedly entered a region of descending atmosphere. However, Cassini images [Porco] show that this is an area of rising atmosphere, thereby validating the probe's original finding.

We maintain that because the bulk of Jupiter formed as a result of a cold, snow-ice-clathrate accretion over hundreds of millions of years, it is not necessarily in hydrostatic equilibrium. Due to the strength of the clathrates and internal friction, some of the weight of each layer is distributed laterally and not completely supported by the layers below. The effect of internal friction is illustrated when one tries to compact a snowball from cold snow. No matter how hard it is squeezed it cannot be compressed. If the interior of Jupiter is not in hydrostatic equilibrium, the pressure at the center would be less than anticipated, as would the average density.

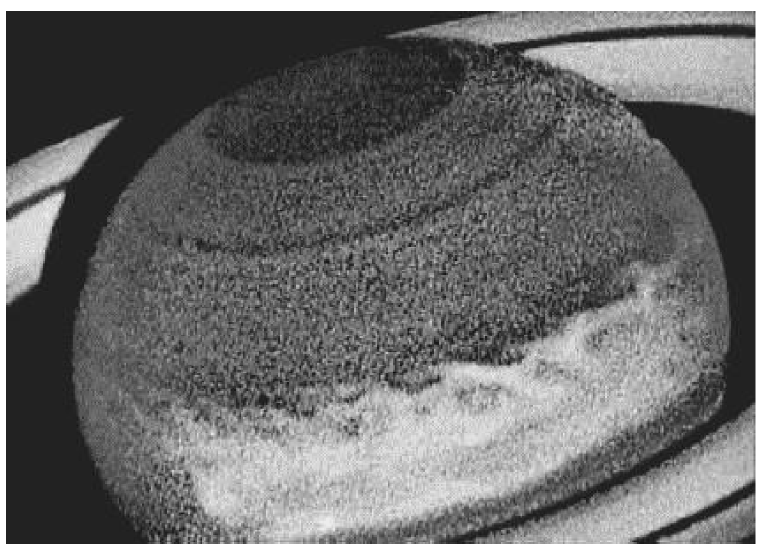

Figure 3. The planet Saturn showing the bright new bands extending around the planet from the Great White Spot which suddenly appeared in 1990. The faint belts and zones from an earlier impact can be seen further north.

Saturn, Uranus and Neptune comprise the same makeup as

Jupiter. Their temperature excesses are also due to relatively recent large impacts. Proof that their temperature excesses are not primordial, is provided by Uranus, which has no temperature excess. The total mass, average density, and moment of inertia factor of all four planets can be satisfied by a snow-ice-clathrate interior with a rock/iron body at the center.

4. The Great Red Spot

The currently accepted view is that the GRS is a large disc-shaped storm trapped between a belt and a zone of easterly and westerly winds *which have kept it at the same latitude for over 340 years, since it was first observed.* Until quite recently (2003) it has not been considered a unique feature, just a 'storm' which is larger than the other transient Jovian vortices. However, based on Cassini images [Porco] describes it as follows: "A deep stationary disturbance associated with the Great Red Spot must keep the atmosphere convectively unstable; this would explain how such features persist in the same location in the midst of a turbulent, rapidly changing local flow at the visible cloud top level." Here we see the dawning realization that the GRS has an deeper origin than all the other features. Another difficulty with the storm hypothesis, is that unlike storms on Earth, which are low pressure centers, the GRS is a high pressure center, which rises well above the visible cloud tops.

In our recent catastrophic scenario, a body from outside the solar system impacted Jupiter 6,000 years ago, *releasing* more than 10^{43} ergs over the last six millennia. Only a few percent of this energy went into the rebound of mass that formed proto-Venus. Most of it remained in the Jovian system and is the source of every feature observed today.

The GRS is formed by material still streaming out of the deep crater formed by the impact and rising above the cloud tops. This is why it forms an atmospheric high pressure center. The fact that it has remained at the same latitude for as long as it has been observed (over 340 years) is strong evidence that its origin is on the solid surface of Jupiter. *No storm could remain at the same latitude on such a rapidly rotating planet with an enormous Coriolis force.*

5. Belts and Zones

The zonal wind belts are currently thought to be generated by incoming solar energy or primordial heat from the interior. However, both sources should result in winds with latitudinal symmetry. As shown in Figure 2, the measured wind speeds are far from symmetrical, with a unique westerly maximum at the latitude of the GRS

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The fact that impacts produce spots and that the spots, in turn, *drive the winds* to their north and south in opposite (westerly and easterly) directions, was graphically illustrated (Figure 3) on Saturn in 1990 [*Beebe,1992*]. A white spot about the size of the Earth suddenly appeared, and scientists declared their amazement that such a 'large storm' could arise in a day. Of course, it *had to be* a storm under the current paradigm, because Saturn is thought to be gaseous, like Jupiter. They then observed the propagation of a belt and zone of white material slowly being spawned immediately to its north and south. The cause and effect of the spot and the resulting belt and zone is undeniable, yet the notion that the GRS is trapped between a belt and zone on Jupiter has never been revisited in light of this evidence. We suggest that the spot was formed by the unobserved impact of a large body, probably on the far side of Saturn, and that the belt and zone were 'spun off' the rising column of gases from the impact crater. It is interesting that planetary science books cite the great planets as providing 'protection' for the Earth by absorbing the impacts of asteroids or comets that might otherwise hit the Earth, yet scientists fail to recognize the possibility that the spots, rings and temperature excesses on all the great planets are records of this very type of event.

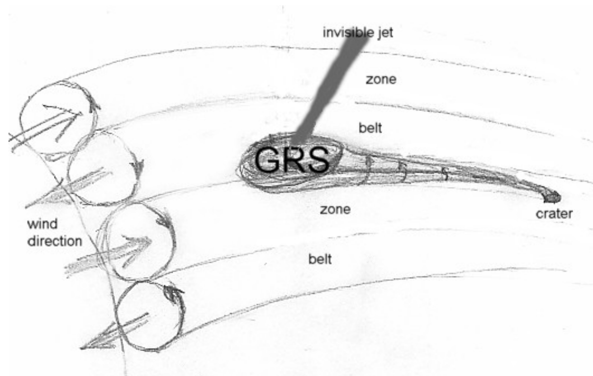

Figure 4. The vorticity of the fast rising gases from the crater drive the wind direction and induce a horizontal vorticity in the belts and zones.

Instead of being trapped between a wind belt and zone, *the GRS is the source of all the belts and zones on Jupiter.* The gases shooting out of the crater develop vorticity due to the Coriolis effect and it is transmitted to the local air mass by the horizontal snaking of the rising column of gases. This spawns the belt and zone to the immediate north and south, which inherit vorticity about horizontal axes. Opposite vorticity is subsequently induced in a secondary zone and belt adjacent to these, creating the entire ensemble of zonal wind bands that cover Jupiter (Figure 4.) Their coloration derives from refractory elements which are vaporized in the crater and crystalize as they rise through the Jovian atmosphere. The driving function of the GRS is evidenced by the directions of the 'trade winds' in the atmosphere of Jupiter (Figure 2.) The only significant westerly wind is at about -18 degrees latitude, where the GRS is and *has been located, for the entire time it has been observed, some 340 years*.

6. Jupiter's Temperature Excess

The temperature excess of Jupiter, *which is responsible for 40 percent of the planet's radiation*, is currently thought to be due to primordial heat still escaping from the interior after some 5 billion years. This is thought by some to be the result of helium raining down through the conductive hydrogen layer. Others believe that the temperature at the top of this layer is still too high to allow the helium rain. We maintain that the hot gases still being expelled from the 6,000 year old crater heat the dense atmosphere causing the temperature excess.

7. The Jet

In past millennia the expelled gases constituted a much more spectacular feature - a jet which shot hundreds of thousands of kilometers into space. The striking nature of the jet was observed at the time of the inter-stellar traveler's impact 6,000 years ago. It was described as a spear with which the warrior child Pallas-Athene (proto-Venus) was born. The amazing energy and longevity of the jet is graphically illustrated in a 9th century A.D. arabic document, shown in Figure 5. It pictures Jupiter, the upper left-most drawing, with an enormous jet, greater than the diameter of the planet, shooting out into space. Given the jet's appearance at that time, and extrapolating back 5,000 years to the impact, we conclude that *it originally encompassed the* *orbits of all the Galilean satellites at that time and has very gradually diminished in strength over six millennia.*

The implications of the jet are enormous. First, its original highly directional nature, described as a spear, implies a unique crater similar to a gun barrel, the depth of which is greater than its diameter. This is obviously unlike any known crater. This is likely a clue to the clathrate composition of Jupiter. The enormous amount of energy that has flowed from the crater for six millennia reinforces this hypothesis. The possibility that the impactor was an exotic, super-dense body cannot be ruled out. Experiments on impacts in clathrates would help clear up this matter.

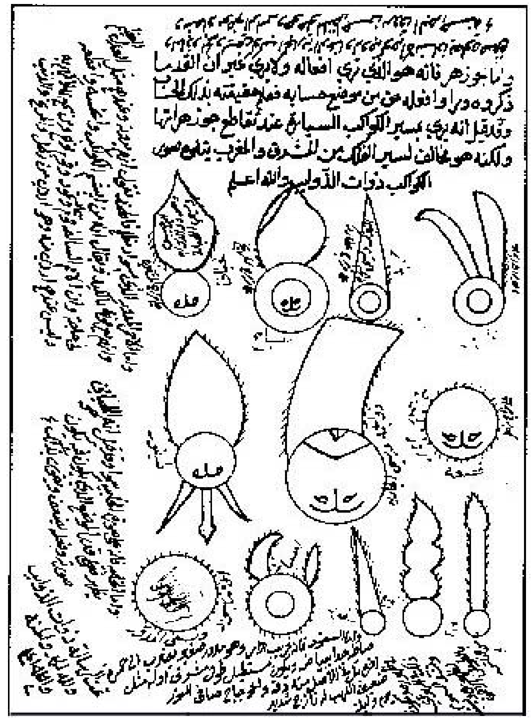

Figure 5. A 9th century A.D. arabic document showing an enormous jet shooting out of Jupiter (upper left drawing). (Translation courtesy of Everett K. Rowson, Director, The Middle East Center, The University of Pennsylvania, Philadelphia PA)

Recent corroboration of the fading but still present jet has been provided by an Oxford University team studying NASA Galileo NIMS data, who reported *a swirling jet of 'water' at the center of the GRS* [*Taylor*,1998]. Further corroboration comes from the higher than expected atmospheric temperature and density encountered above the cloud tops by the Galileo atmospheric probe. We suggest that this is due to material still being ejected above the clouds by the jet, not material being spalled off Amalthea, as currently thought. The jet may also supply the material that comprises the tenuous Jovian rings.

8. Jupiter's Slowing Rotation

Comprehending the potential power and longevity of the jet provides the answer to the 'longitudinal drift' of the GRS, shown in Figure 6. The change in the rotational period of the GRS is plotted since 1910. Because its period has been varying relative to an assumed constant rotational period for Jupiter determined in recent decades by studying its radio emanations, it has been assumed that the GRS has been 'drifting' In fact, this drift is the primary characteristic cited to 'prove' that the GRS is strictly an atmospheric phenomenon, which it must be if Jupiter is a gaseous planet. But the monotonic nature of the curve between 1910 and 1940 raises questions.

We suggest that *the angular momentum ejected by the jet has been slowing down Jupiter's rotation for the last 6,000 years.* That is, the *plotted curve actually shows the tail end of a real* *increase of the rotational period of Jupiter.* The curve shows that the deceleration of Jupiter only ceased around 1935. The GRS period variations that remain are truly drifts, probably due to variations in the strength of the jet and its interactions with the 'trade winds.'

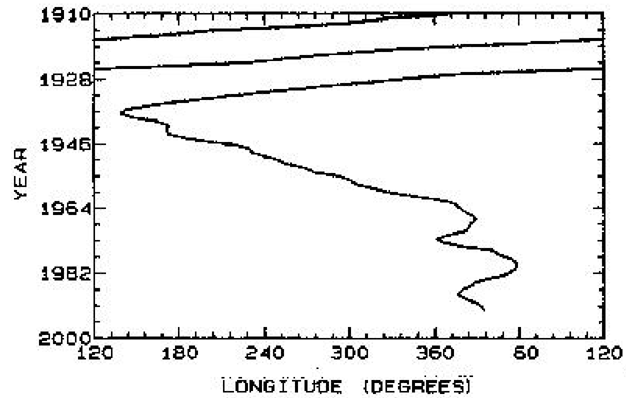

Figure 6. The longitudinal 'drift' of the GRS in degrees per year since 1910.

Sir Fred Hoyle [*Hoyle*] attempted to calculate the primordial rotational period that Jupiter would have attained as the result of the accretion of solid particles with finite momentum (not gas), in order to demonstrate how accretion from the rotation of the solar nebula would produce a prograde rotation of the planet.

Interestingly, he obtained a period of about one hour, and was unable to account for the discrepancy with the currently accepted value of about ten hours. Accepting his calculated primordial period and assuming that the loss of angular momentum due to the jet has increased it to about ten hours in the last 6,000 years, *then the total energy released by the impact must have exceeded 10^{43} ergs.* As mentioned above, all of this energy was not necessarily imparted by the impact. Some was undoubtedly released from the methane and other clathrates. This also helps explain the great longevity of the jet.

Consistent with the hypothesis that the emissions from the crater are dying down, are recent reports (Jan 2002) that the GRS is fading. Just as Figure 6 shows the conclusion of the effect on the rotation of Jupiter around 1935, now the fading of the GRS implies that the lingering effects of the impact 6,000 years ago, are coming to an end.

9. Comet Shoemaker-Levy 9

Comet Shoemaker-Levy 9 did more than just demonstrate the results of impacts on Jupiter. It clearly showed that the impacts of the more massive fragments produced different effects than their smaller counterparts. Although almost all the comet fragments produced fireballs, the impacts of the larger ones were characterized by large energetic infrared plumes in the atmosphere, which appeared a full six minutes after the impact precursors. We claim that planetary scientists have failed to realize the implications of these plumes.

9.1 The Fireballs

The current interpretation of the fireballs is that all the comet fragments exploded high in the atmosphere and were blown back into space through the evacuated atmospheric tunnel 'bored' by the incoming body. Their initial temperatures were over 7,000 K but fell to 500k in 60 seconds.

Spectra of a number of compounds never before observed on Jupiter were detected following some impacts. Due to the number of different observing instruments with differing fields of view and differing spectral ranges located around the globe and in space, there has not been a comprehensive compilation of the elements detected, in particular whether they were seen in the fireballs or in the delayed plumes from the larger fragments. This discrimination is important.

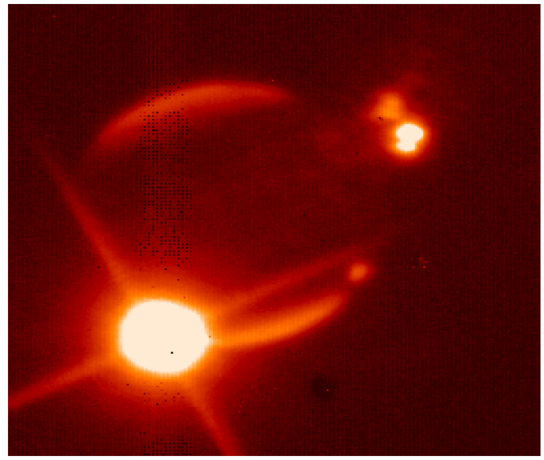

Figure 8. Crash site of S-Levy 9 fragment G 12 min. after impact. The intensity of this plume relative to Jupiter implies much greater energy than in the fireball. (ANU 2.3 m. telescope, at Siding Spring.)

9.2 The 'Main Events'

The large infrared plumes in the atmosphere, which appeared 6 minutes after the impacts of the larger fragments, radiated much greater energy than the fireballs, and were thus named 'the main event.' It was suggested by Mac Low, a respected theoretician, that these were the result of the fireball molecules falling back into the atmosphere and heating it up. Most other scientists went along with this explanation. The one exception was Eugene Shoemaker who said, "It's nonsense," arguing that the cold, spent material falling back into the atmosphere would not impart nearly enough energy to cause the intense plumes. We agree with Eugene Shoemaker. Since the fireballs cooled to 500 K in just one minute, the material would have completely cooled five minutes later, yet the plumes were as big as the earth, had temperatures as high as 10,000 K, and lasted a hundred times longer than the fireballs. The radiation from the plumes saturated infrared sensors on earth telescopes, indicating that the process which created them was much more energetic than the fireballs. This can be appreciated by comparing the brightness of the fireball in Figure 7 and the atmospheric plume in Figure 8, relative to the brightness of Jupiter itself. It makes no physical sense that the small number of spent fireball molecules could have caused the enormous long-lasting plumes. Furthermore, most of the comet fragments caused fireballs which reached the same altitude, but only the larger fragments produced plumes. Large quantities of some elements were detected via absorption lines in the atmospheric plumes. Some of these lasted for months. Water equivalent to a one kilometer sphere and an estimated 10^{14} grams of sulfur (S_2, CS, CS_2, H_2S) were detected in the fragment G plume. The immediate explanation was that such

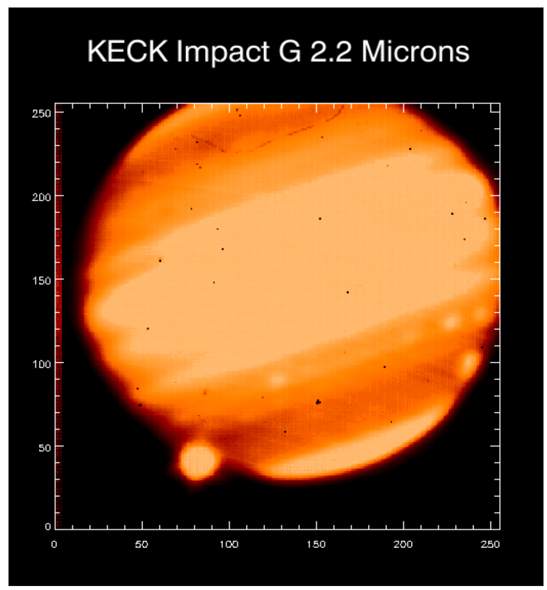

Figure 7. The fireball which rebounded into space above Jupiter's cloud tops due to the impact of the G fragment of Shoemaker-Levy 9. (Keck Telescope).

large quantities must have come from the cloud layers of Jupiter (NH_3, NH_4SH, and H_20), however the Galileo atmospheric probe, which arrived later, found no such cloud layers, casting greater doubt on the origin of this material. The plumes also exhibited the spectra of a number of elements never before observed on Jupiter. The STS Faint Object Spectrograph (FOS) detected silicon and metals such as magnesium and iron near the limb of Jupiter. Manganese was also detected.[*Roos-Serote*, 1995] Because they had never been detected on Jupiter, these elements were attributed to the comet fragments.

9.3 Larger Comets Impacted Surface

Our paradigm has no trouble explaining the spectra of any of these elements. We claim that the larger S-L 9 comet fragments penetrated the atmosphere and struck the solid surface, whereas the smaller ones burned up in the atmosphere and therefore did not produce the same phenomena. The impacts of the larger fragments resembled enormous nuclear explosions. Although a small fraction of the impact energy may have escaped through the rarified tunnel to contribute to their fireballs, *the vast majority of the energy rose through the Jovian atmosphere in a great mushroom cloud and was not observed until it penetrated the opaque cloud* layers. *This was the reason for the 6 minute delay in their appearance.* The impacts of these fragments vaporized the surface ices and all the refractory elements frozen in them - releasing the entire spectrum of elements frozen in the primordial surface of Jupiter.

9.4 The Expanding Rings

The rings are difficult to explain in the context of the hydrogen model. These were observed expanding away from the impact sites of the larger fragments (Figure 9). It is thought that the explosion of the comet fragments occurred in the atmosphere and the downward shock wave reflected from a boundary of some sort in order to be manifested at the top of the cloud layer. Some scientists suggested that the hypothetical layer of water clouds might constitute the boundary if it were some ten times the anticipated thickness. Unfortunately, no water cloud layer at all was found by the Galileo atmospheric probe. *We maintain that the expanding rings are the manifestation, at the cloud tops, of shock waves resulting from the impact of the larger comet fragments on the solid surface of Jupiter.*

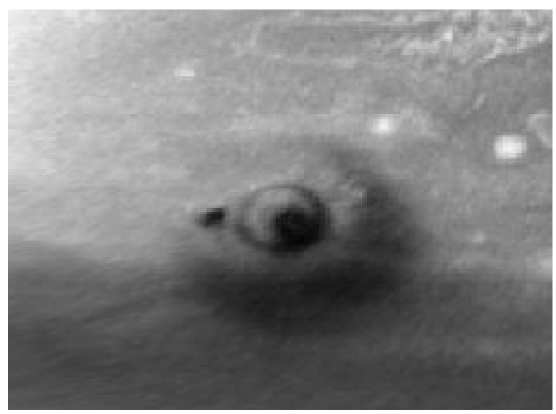

Figure 9. The dark markings caused by fragments A (left) and G as seen by HST.

10. The Galileo Atmospheric Probe

The probe encountered higher upper atmosphere densities and temperatures than expected, implying that hot gas was being projected above the cloud-tops. As it descended, it failed to find any of the touted cloud layers, NH_3, NH_4SH and H_2O, predicted as condensation in the hydrogen model. The explanation for their absence was that the probe just happened to enter a dark area where the ‘air’ was descending. However, Cassini ‘movies’ of Jovian clouds showed just the opposite - that the dark areas comprise rising air. Cassini also detected a cloud of neutral atoms stretching away from the planet as a "hot neutral wind," reported by Dr. Stamatios Krimigis of Hopkins' Applied Physics Laboratory. The magnetic field holds charged particles in, but neutral ones escape to create a nebula of particles that extends beyond the magnetosphere. This provides additional corroboration of the presence of material still being ejected from the GRS.

The deeper atmosphere is much dryer than expected, requiring a major change in the current ideas concerning the abundance of water or its distribution on Jupiter. This remains an item of controversy among scientists, none of which can field a convincing hypothesis. Also unexpectedly, neon is depleted relative to its solar concentration. The finding that helium is present in approximately solar concentration also creates problems for the current paradigm. This is counter to the notion that the temperature excess of Jupiter is due to the denser helium raining down toward the center of the planet through the conductive hydrogen layer. The probe also found that strong winds below the clouds blow at 700 km/hour and are roughly independent of depth. This implies that they are not produced by the influx of solar energy, leaving only heat from some interior source as a possible driver.

10.1 Probe Data Implies a Solid Jupiter

We attribute the higher-than-expected density and temperature in the upper atmosphere to hot gases still being ejected from the crater, which rise above the clouds via the jet at the center of the GRS. The absence of the three predicted cloud layers is a clear indication that the hydrogen model is not a correct representation of Jupiter. The small quantity of water measured in the atmosphere is the result of its being frozen in the solid body of the planet. Enormous masses of hydrogen, oxygen, carbon and nitrogen are present on Jupiter, but they are in the form of ices of H_2O, NH_4OH, CH_4, and CO_2.

We maintain that most of the primordial atmospheric gases have become entrained in the jet and expelled from the planet in the last 6,000 years. They have been replaced by gases long frozen in the interior, which have been vaporized and expelled from the crater, possibly including argon, krypton, xenon, neon and helium. We would expect an abundance of argon 40, due to the release of radiogenic argon that has been accumulating in refractory grains for billions of years, in addition to the primordial argon originally trapped in the ices. The same is true for non-gaseous elements, such as carbon and sulfur, and for phosphine and arsine, discovered remotely. Indeed, we suggest that all the known elements are frozen in the primordial body of Jupiter and therefore are issuing from the crater. Many of these form solid compounds as they rise and cool, causing the coloration of the clouds. The same materials were released by the impacts of the larger S-L 9 fragments, producing long-lasting smudges but not recognizable spectra. We claim that the unexpected depth of the east/west zonal winds is due to their being driven by the swirling column of gases which extends in a tortuous path from the crater through the atmosphere to the cloud tops (Figure 4.) Because of the rapid rotation of the planet, this column has a horizontal as well as a vertical component and thereby induces vorticity as well as wind direction to the belts and zones which extend throughout the depth of the atmosphere, which we estimate is somewhat less than 1000 kilometers deep.

11. The Galilean Satellites

In the currently accepted paradigm, Io, Europa, Ganymede and Callisto were created at the same time as Jupiter and the rest of the planets, more than 4.7 billion years ago. It has been noted by some scientists that the great differences in their composition imply that a strong energy field surrounded Jupiter at the time of their creation. This is reflected in their average densities (g/cm^3): Io (3.55), Europa (3.04), Ganymede (1.93), Callisto (1.9). These densities reflect primarily the ratio of H_2O to rock/iron comprising each body. It is difficult to imagine how the slow accretion of Jupiter, currently thought to have taken several hundred million years, could have created such a strong temperature gradient. Furthermore, the notion that the Galilean moons formed directly from the solar nebula is inconsistent with their periods, which imply accumulation times of approximately 10,000 years.

11.1 Jupiter's Tidal Q

The assumption that the heating of the Galilean moons is due exclusively to a tidal transfer of energy from Jupiter leads to serious contradictions. In an attempt to prove that Jupiter is gaseous, William B. Hubbard [1984], one of the authors of the hydrogen model, calculated its *tidal Q* based on the assumption that the Galilean moons are primordial and that Io originated just outside the Roche limit. The tidal Q, the reciprocal of the 'lead angle' between the bulge on the primary and the line to the secondary, canonically should be infinite for a gaseous body and approximately 100 for rigid bodies like the Earth or Moon. He initially obtained a value of 10^6, which he declared "cannot be explained by any [known] theory." In order to refine his analysis he takes into consideration the heat radiated by Io, assuming it is all due to tidal dissipation. This gives a relationship between the tidal Q of Io and Jupiter and results in a tidal Q of 1.0 for Io - a non-physical value. It also leads to a value for Jupiter of $4x10^4$, "a somewhat embarrassing result, since it is too small by about a factor of two to be compatible with Io's present orbit. The reason for the discrepancy is not understood."

Understanding of the discrepancy comes easily in our paradigm. We claim that the Galilean satellites are less than 6,000 years old. Therefore, the tidal Q cannot be calculated based on the supposed influence of Jupiter on Io's orbit over the last 4.7 billion years. The proto-Galilean moons formed from material splashed from the impact crater with less than escape velocity. The *refractory cores* of the proto-moons accreted rapidly, due to the localization of the ejected material, which went into orbit around Jupiter. *They formed in their current orbits with the resonances we observe today.* The larger amounts of *volatile material* ejected into orbit around Jupiter could not condense due to the high temperatures of the cores and the heat from nearby Jupiter, which had absorbed most of the impact energy. We estimate that just after the impact, Jupiter was emanating 10^{12} times its current energy excess. This has decreased exponentially over the last six millennia but still represents forty percent of the total radiant energy. The heat was not all due to radiation.

The maturation of the Galilean moons entailed a multiple step process, the stages and timing of which differed for each body, due to their different distances from Jupiter. In addition to the material 'splashed' from the original impact, the mass ejected by the high temperature jet, which initially encompassed the four satellite orbits and was swept around by Jupiter's rotation as rapidly as once per hour, contributed most of the material that makes up the outer layers of these bodies. Therefore, the great difference in the temperatures and radial compositions of the four moons is due to (a) the radiation field surrounding Jupiter for millennia after the impact, (b) the high temperature of the jet as a function of distance from Jupiter and (c) the fact that both gradually decreased in temperature and range over six millennia, bathing the inner moons longer than the outer ones.

11.2 Io

The hypothesis that the excess heat within Io is due to a 'gravitational tug of war' between the tidal forces of Jupiter and Europa, with which it is in perfect resonance, is now accepted as inadequate by planetary scientists. William Hubbard, as a result of his analysis of the tidal Q of Jupiter published in 1984 [*Hubbard*], concluded that this cannot explain the great heat of Io. Numerous observations of Io by Galileo have revealed that the total energy emitted by Io is an order of magnitude greater than that used by Hubbard.

Some lava flows on Io are the hottest in the solar system - with temperatures as high as 3900 F. This is hotter than any flows that have occurred on Earth for billions of years. As a result, some scientists have proposed that studies of Io might reveal information about the early development of the Earth. Others have proposed that the entire interior of Io might still be molten rock [*Keszthelyi, 1999*]. This is one more measurement that the current paradigm cannot explain.

We claim that Io is hot due to its recent cataclysmic accretion, 6,000 years ago. It receiver far greater heat from Jupiter in the millennia just after the impact because of its proximity to Jupiter. In addition to radiative flux, it was repeatedly bathed in the gases of the jet which were hotter closer to Jupiter and which reached its orbit longer than it did the other moons. Io remains so hot that although massive amounts of water vapor have been delivered to its vicinity for almost 6,000 years after the impact, very little has condensed on the moon. The great differences in the Galilean moons are a direct result of the temperature gradient surrounding Jupiter and the slow dying out of the jet of hot gases emanating from the impact crater.

11.3 Europa

The apparent presence of a liquid ocean beneath the ice crust presents a dilemma for those who believe Europa is 4.7 billion years old. The satellite is too small to have retained sufficient primordial heat to keep the ocean liquid. Radioactive decay is insufficient and just as the 'tidal tug of war' cannot explain the heat of Io, neither can it explain the heat within Europa. The almost complete absence of impact craters implies that the ice crust formed relatively recently. If this is true, why did the ocean not evaporate completely into the vacuum of space during its supposedly long lifetime?

We maintain that Europa was close enough to Jupiter so that no volatiles could condense on its surface for several millennia after the impact 6,000 years ago. As with Io, the proto-moon quickly formed from the mass of material ejected from Jupiter after the impact. Only the refractory elements, similar to those on Io, which could accrete in this period, formed its rocky/iron central body. Being farther from Jupiter Europa cooled enough to allow the condensation of H_2Ohe jet still extended well beyond its radius. As a result, it continued to supply enormous amounts of H2O to Europa. This, combined with the water already in orbit, accumulated the great ocean we see today. Rock-ice 'moonitesimals' condensed from the jet and continued to fall as its ocean volume increased. We maintain that the paucity of impact craters implies that the surface froze less than a millennium ago.

11.4 Ganymede and Callisto

These moons, being further from Jupiter, formed cooler, but the temperature at Ganymede was high enough to facilitate differentiation of the interior, while this was not true at Callisto. The impact craters now visible on their surfaces are due to 'moonitesimals' from the original impact or rock/ice bodies which solidified from the jet gases and then crashed into the moons. These were mixtures of rock and ice. The craters on these moons slumped due to the heat of Jupiter, more so on Ganymede because it is closer.

12. The Main Belt Asteroids

Given the incredible magnitude of the impact 6,000 years ago, perhaps10^{42} ergs, it would be expected that it would have profound repercussions for the entire solar system. The true nature of these has yet to be understood by planetary scientists. Given the magnitude of the event, it should not come as a great surprise that its effects would be felt outside the Jovian system. We maintain that the main belt asteroids are not primordial as currently thought, but that they formed as a direct result of this impact. There may be two classes. The first comprising material splashed from Jupiter at the time of the impact. The second class may have resulted from the condensation of some of the jet material which was imparted escape velocity in the few millennia following the impact.

It is possible that the very low density C type asteroids, such as 253 Mathilde, comprise the second class. The fact that Gaspra and Ida possess magnetic fields implies that they condensed while still within the magnetic field of Jupiter. This is a further indication that they formed well after Jupiter became a mature planet. Because of their low densities (1.3 g/cm^3), they are currently thought to be unconsolidated rubble piles. We suggest they are heavily hydrated, cinder-like solid bodies which condensed from the jet gases in the weightless environment.

We suggest that the youth of the main asteroid belt is implied by their donut-shaped distribution, which should have collapsed into the plane of the solar system in a relatively short time, astronomically speaking.

13. Conclusions

The scenario in which a great impact devastated Jupiter only 6,000 years ago, leads to the hypothesis that Jupiter is a solid snow-ice-clathrate planet and that the Galilean satellites and main belt asteroids are less than 6,000 years old. This paradigm of recent cosmic catastrophism fits all observations of the Jovian system.

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