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The Origins of the Nebular Hypothesis – Or, the Genesis of a Theoretical Cul-de-sac

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Introduction

Although the nebular hypothesis has risen to paradigmatic status within the corpus of the conventional astrophysical sciences, it is still just a hypothesis. And, as such, it is subject to eventual supersession, as are all outmoded hypotheses, if it cannot support the incorporation of new data that proves inconsistent or "anomalous," in the Kuhnian sense, with its theoretical architecture. In previous papers, I have endeavored to present these inconsistencies, as they relate to both established facts about the Solar System and new facts about it and exo-solar systems, and reinterpret them within the framework of the transformation hypothesis.(1)

This paper will examine the origins of the nebular hypothesis. It is generally believed that the nebular hypothesis was developed during The Enlightenment, but its roots can be traced back to a few Renaissance thinkers and ultimately to the speculations of several ancient Greek philosophers. It is hoped that the historical sketch to follow will help to shed light for the reader on how the nebular hypothesis has become so firmly entrenched in contemporary science even though its central conception has no bearing on the formation of solar systems.

However, it will not examine the several varieties of catastrophic hypotheses for the Solar System's formation that have been promulgated over the past two and a half centuries, whose lineage can be traced back to 1745, in the work of Buffon. Nonetheless, as was pointed out in the first paper of this series, these catastrophic hypotheses are classified as "derivative" hypotheses in the sense that the material from which the planets are formed comes from the debris that is blasted from the Sun, either by another passing star or a very big comet after a collision or interaction has occurred.(2)

The History Of The Nebular Hypothesis

The Ancient Greeks

In its most basic form, the nebular hypothesis posits the coalescence of celestial bodies from a primitive cloud of tenuous matter that fills all of space and is set in motion by some fundamental force. This scheme can be found in the cosmogony of the 5th century BC, Greek thinker, Anaxagoras of Clazomenae. For Anaxagoras, "nous" or mind played the dual role of being the tenuous matter and the motive force that gives rise to the visible universe. For him, nous is "…the thinnest of all things and the purest…" and it "…set in order all things that were to be, and all things that were and are not now and that are, and this revolution in which now revolve the stars and the sun and the moon, and the air and the aether that are separated off."(3)

The schools of Leucippus, Democritus and Epicurus, replaced the virtually insubstantial nous with an infinite variety of material atoms. These atoms are in a state of eternal vortical motion in the infinite void. The bodies of the visible cosmos form when the atoms commingle to create a dense mass, this being the physical equivalent of what would eventually be referred to as a nebula by Enlightenment thinkers. These material bodies persist for a time and, then, dissolve back into the constituent atoms from which they were formed. Throughout this endless process of coming to be and passing away, however, the atoms themselves remain unchanged. The Roman poet and philosopher Lucretius, an adherent of the Epicurean school, gives a detailed account of the world's creation by this process in his *On The Nature Of Things*.(4) It is interesting to note that in this ancient version of the nebular hypothesis, it is the Earth that forms in the center of the condensing mass from the grossest elements while the lightest parts move to the periphery of creation to become the ether, with Sun, moon and stars taking up positions midway between the two.

These early attempts at a materialistically based evolutionary cosmogony, with its nascent nebular hypothesis, eventually succumbed to the static Aristotelian/Ptolemaic cosmology, which, owing to its incorporation into the Christian worldview, would come to dominate western thought for the next fifteen centuries. This stranglehold on scientific progress began to loosen, however, in the latter part of the Renaissance period.

The Return To An Evolutionary Cosmogony

Nicholas of Cusa, Giordano Bruno and Rene Descartes, whose works span the 15th, 16th and 17th centuries respectively, stand out as forerunners for what would become the "modern" cosmological worldview. Each thinker, in his own unique way, challenged the authority of the Aristotelian/Ptolemaic-based cosmology and, in so doing, weakened its rotting foundation that others who followed in their paths would completely demolish. In taking on this project, they played a dangerous game with the Church authorities, which led to suspicion in Cusa's case, Bruno's execution(5), and voluntary exile in Holland for Descartes. How fortunate, then, are the dissident cosmologists of today whose works are merely ignored by the "orthodox" scientific community.

Although Nicholas of Cusa did not produce an evolutionary based cosmogony, he did put forward the ideas, scattered in his numerous writings, that the universe is infinite (although prudence moved him in later writings to revise this position to "indeterminate"), that the Earth has motion and is not the "center" of creation, and that it and the stars are essentially alike and composed of similar substances. Nicholas also opposed the sacrosanct Aristotelian notion that heavenly bodies revolve with perfect circular motion, thus anticipating Kepler's discovery of elliptical orbits in 1609, one hundred thirty-five years after his death in 1464.

Bruno accepted much of Nicholas' teachings, although he didn't hedge with respect to his belief that the universe is infinite. It was a certainty for him. He also embraced the new Copernican heliocentric worldview. He accepted the atomism of Democritus and Epicurus, and rejected virtually all of Aristotle's cosmology, often sniping at its various tenets in biting and sarcastic language. For him, the real world consisted of "…an infinite Plenum and an infinite Vacuum, the one placed within the other."(6)

As mentioned above, Bruno's universe consists of the plenum, which contains the various elements and the bodies they form like the Earth and the Sun. The plenum is contained in the vacuum, which is another name for an all-pervading ether-like substance. The ether is like a substratum in which the elements and bodies reside. One might think of it as the evanescent "glue" that suffuses the visible world and holds it together. Within this elemental soup bodies are "…constantly dispersed and constantly reassembled: they send forth their substance, and receive within themselves wandering substance."(7)

Curiously, Bruno is not definitive about whether the Earth and other bodies had an absolute beginning or are "eternal." However, he does allow that if they are eternal, "…it is not so by virtue of the stability of any one part or individual, but through the vicissitudes of many parts, some being expelled therefrom, and their place taken by others."(8) Thus, if the eternity of bodies is accepted as a fact, it is the form that persists, what he calls "soul and intelligence," while the matter or elemental parts are in a state of continual flux.

Although this scheme does not evoke the explicit image of a condensing nebula composed of elementary material, it is evolutionary in the sense that bodies undergo a process of "external" material change. Thus, while, for example, there is only one "essential" or noumenal Earth, there are, throughout eternity, many "accidental" or phenomenal Earths. Nonetheless, although this may not seem to represent much of an advance over the Aristotelian/Ptolemaic cosmology from a modern scientific perspective, it was, in fact, a significant leap forward in thinking. By embracing the Democritean and Epicurean notion of atoms mixing in a void, Bruno was able to impart a dynamic quality to his cosmogony that the orthodox view current in his time completely lacked.

Descartes, however, attempted the most thoroughgoing and ambitious evolutionary cosmogony during this period, although he prudently couched it in hypothetical terms in order to escape the reproach of the Church inquisitors. What commends his system to the

modern scientific mind, despite its obvious flaws, is its thoroughly mechanistic character. His hypothetical universe is an indeterminately large plenum consisting of two types of matter. Like Bruno, the finest matter forms the substratum, which can be identified with "space," and the grosser types of matter form bodies like the Earth, stars, planets, and comets. God sets both types of matter into motion. Once set in motion, the grosser types of matter begin to spiral in countless vortices. The lightest of this type of body-constituting matter condenses at the centers of the vortices to produce stars. The subsequent intrusion of grosser matter into the centers of the vortices contaminates the stars and forces them to move outward towards other vortices, now transformed either as planets or comets, depending on the degree of the contamination.

While Descartes' cosmogony does not employ a "classic" condensing nebula to account for heavenly bodies, the centers of his vortices act as focal points where matter accumulates and the resulting concentrations form into stellar objects. It should be pointed out, however, that knowledge of nebulae, what we now know to be either planetary nebulae within the Milky Way galaxy or external galaxies, was not widespread in the 17th century. Although Peiresc telescopically observed the Orion Nebula in 1610, it didn't receive widespread notice until 1656, six years after Descartes' death, when Christiaan Huygens brought its existence to the general public's attention.

What distinguishes the foregoing cosmogonies from the ones that will follow in the next section is the manner in which stars and planets are created. Each creation is a singular event. This is very clear in the case of Descartes' cosmogony. A star forms in the center of a vortex and subsequently transforms either into a comet or a planet. The classic nebular hypothesis, on the other hand, envisions the creation of the Solar System; complete with the central Sun and its attending orbiting planets, from one unique process.

The Nebular Hypothesis

We find the first inkling and subsequent maturity of the classic nebular hypothesis emerging in the 18th century, the dawn of The Enlightenment, in the works of Swedenborg, Kant and Laplace. It is of some interest to point out that the term "solar system" came into general use during the first decade of the 18th century, and its importance cannot be underestimated since it represents a particular theoretical orientation and direction the aforementioned thinkers would take that would lead to the current state of affairs in Solar System studies. The Sun and the bodies that orbit it began to be viewed as a "system" of celestial objects. And, as a system, it must, then, have had a common origin. Therefore, any theory worth its salt had to devise a physical mechanism that would account not only for this common origin but also for its dynamical and physical characteristics. Science was on the threshold of a theoretical cul-de-sac and, upon entering, has been trapped in it ever since.

Emanuel Swedenborg, who is known primarily as a theologian and Christian mystic, published his *Principia* in 1734, which contains a version of the nebular hypothesis broadly based on Descartes' vortex physics.(9) Although it relies on a vortex mechanism for the evolution of celestial bodies, it differs from the Cartesian transformation

hypothesis in one significant respect: the planets are derived from matter cast off from the Sun. The derivative mechanism that Swedenborg employs makes it the first of many nebular hypotheses that will follow over the course of the next two and a half centuries, although superficial commentators cite Kant and Laplace as its originators.

What should commend Swedenborg's nebular hypothesis to contemporary Solar System researchers is his idea that the planets originally formed at closer distances from the Sun and subsequently, through the action of its vortex, moved out or "migrated" to more distant and permanent positions.(10) Kant and Laplace, on the other hand, both envisioned a more extensive primordial nebulous cloud wherein the planets formed at the distances from the Sun they now still occupy.

The publication of Immanuel Kant's cosmogony in 1755, marked the beginning of a specific approach to the problem of the Solar System's origin that is quite apparent in the full and rather lengthy title of his book, *Universal Natural History and Theory of the Heavens: An Essay on the Constitution and Mechanical Origin of the Whole Universe treated According to Newton's Principles*.(11) Utilizing Newton's revolutionary theory of universal gravitation, Kant proceeds to fashion not only the Solar System, but the entire universe, as well. Subsequently, all conventional theories of the Solar System's origin up to the present day would continue in the Newtonian tradition that he began.

Kant's universe begins with a chaotic mixture of elements of differing specific densities spread throughout an infinite space whose "…universal repose could last only a moment."(12) A combination of attractive and repulsive forces act on these elements to produce the star systems or galaxies, as we call them today, that astronomers in the 18th century were just beginning to realize existed beyond our own Milky Way. The attractive force caused the elements to condense around central points, while a repulsive or centrifugal force acting on them created a sideways impetus that produced curvilinear or, more correctly, elliptical motions to the condensing bodies.

These external star systems, the so-called "nebulous stars," existing beyond the Milky Way, appeared to the astronomers observing them to have elliptical shapes. Following Thomas Wright's prescient conjecture that our own Milky Way also has the same elliptical shape as these nebulous stars, Kant reasoned by analogy that the same physical process that formed them formed the Solar System, as well. Thus, at the onset of its development, the proto-Solar System resembled a nebulous cloud in miniature that subsequently condensed into the Sun, the then known six planets and their satellites, and comets. The fact that the planets and, in particular, comets described elliptical orbits of varying eccentricities, giving the entire system the same overall elliptical shape as the nebulous stars, convinced Kant that his analogy with them was correct.

Herein lies the crux of the problem with the nebular hypothesis. By viewing the Solar System as a miniature star system, it was an inevitable step for Kant to conclude that it must have a common origin, like the star systems, which, according to him, also form "…by the attraction of a body of incomparably mightier attraction, and acting from the center of their regulated positions."(13) Thus, Kant promoted the idea that one cannot

conceive of a "solar system" without also conceiving that it has a "common origin." And, of equal importance, he endorsed, to the exclusion of any other physics (read Cartesianism), the use of Newtonian physics as the tool with which the origin of the universe can be explained.

Even though Kant's cosmogony was to lay fallow until the mid-19th century, the success of Newtonian physics eventually led to the cosmogonical work of the French mathematical genius, Pierre Simon, Marquis de Laplace. By the time his version of the nebular hypothesis appeared in 1796, Descartes' vortex physics had become a useless relic, consigned to the history of science. Halley's prediction of the return of the comet now bearing his name - which was last seen in 1682 and suspected of being periodic - in 1758, was in the words of one commentator, "…a triumphant vindication of Newton's theory of gravity and the laws of mechanics spelled out in the *Principia*..."(14) There was no going back. The only game in town at the end of the 18th century was Newtonian physics.

The Nebular Hypothesis Matures

Laplace presented his version of the nebular hypothesis in a popular work entitled *The System of the World*, published in 1796. And, although by this time, Kant's cosmogony was beginning to gain some currency, Laplace had no knowledge of it. "Buffon was the only one whom I have known, who, since the discovery of the true system of the world, has endeavored to investigate the origin of the planets, and their satellites."(15) In fact, it was in reaction to Buffon's catastrophe-based cosmogony, that Laplace developed his own nebular hypothesis, based solely on Newtonian principles, which, in his view, adequately explained five observed "phenomena" of the Solar System. (I should mention in passing that these five phenomena are identical to the ones Kant used in his rendition of the nebular hypothesis.) On the other hand, Buffon's Sun-grazing comet mechanism could only account for the first one, which explained why all the planets "…move nearly in the plane which passes through the center of the Sun…" and in the same direction(16).

The other four phenomena are the motion of the planets' satellites in the same direction and nearly in the same plane as their primaries, the planets' rotations being in the same direction as the Sun's rotation,(17) the nearly circular or small eccentricities of the planets' and their satellites' orbits, and, lastly, the high eccentricities of cometary orbits. In Laplace's view, all of the above phenomena can be explained by postulating that the Sun, "…in consequence of excessive heat…" was once surrounded by an extensive "atmosphere," which "…extended beyond the orbits of all the planets, and that has gradually contracted itself to its present limits…"(18)

Interestingly, Laplace speculated that this extended solar atmosphere may have been caused by a nova-like outburst and cites the nova of 1572 (Tycho's supernova in the constellation Cassiopeia) as illustrative of such a possibility. The planets formed at "…successive bounds of this atmosphere…" where zones of "condensation" developed in the plane of the Sun's equator.(19) The planets' satellites formed by a similar process, but on a much smaller scale, in condensation zones of their extended atmospheres. Thus,

his primitive nebula differs markedly from Kant's since the Sun had apparently already formed and, then, underwent some instability, causing it to create the enormously extended atmosphere from which the system's constituent orbiting bodies condensed.

Laplace makes some further observations regarding the universe at large, mentioning other suns and the possibility of attending planetary systems, star systems and an "…infinite number of nebulas…" without, however, going into the depth of detail we find in Kant's work on these subjects. He does broach one subject worth mentioning that now seems prescient, from the conventional astrophysical perspective, and this involves the possibility of the existence of black holes. The passage reads, in part, "A luminous star, of the same density as the Earth, and whose diameter should be two hundred and fifty times larger than that of the Sun, would not, in consequence of its attraction, allow any of its rays to arrive at us; it is therefore possible that the largest luminous bodies in the universe, may, through this cause, be invisible."(20)

Concluding Comments

The further development of speculation in the 19th and 20th centuries regarding the origin of the Solar System - or what can now be viewed as the cornerstone of "solar system physics" – followed the traditional approach to the problem first laid down by Kant and Laplace in the previous century. The central concept of the Solar System forming from a primitive state of undifferentiated matter was consistent with the growing awareness that evolutionary laws govern the natural world. Certain difficulties with the nebular hypothesis led to a revival of the Buffon inspired catastrophic approach in the late 19th century by Alexander Bickerton and in the first two decades of the 20th century, first by Thomas Chamberlin and Forest Moulton, and later by James Jeans and Harold Jeffreys.(21) However, these catastrophe-based approaches to the Solar System's origin suffered from their own inherent defects and failed to capture the collective imagination of the astronomical community.

Newer versions of the nebular hypothesis began to appear in the mid-20th century and its central concept has once again become the favored approach to the problem, even though both it and the catastrophic versions of the Solar System's origin ultimately fall under the category of what I call the "derivative hypothesis."(22) Simply stated, any hypothesis that attempts to explain the development of our planetary system from matter that originated in the Sun - regardless of whether it is either the outcome of a primitive condensing solar nebula, or the result of a catastrophic interaction between the Sun and another body - is a derivative hypothesis.

In general, the derivative hypothesis assumes, as a given, that the various dynamical characteristics exhibited by the planets – what Laplace, for example, called the five "phenomena" in his rendition of the nebular hypothesis - must be the result of a common origin. But, is it not equally valid to assume that the dynamical characteristics of the planets and the other bodies constituting the "system" merely reflect how the Sun's gravitational field influences their motions, not as an originating cause, but, rather, as an

ordering cause? The following metaphorical illustration should clarify the difference between an originating cause and an ordering cause, as they pertain to the Solar System.

If we imagine a carousel whose platform is divided into several independently rotating segments such that the innermost one moves most swiftly and each succeeding one moves more slowly, the outermost one from the center moving the slowest. And, let us further imagine the builder/operator of the carousel who, in addition to running the motor from a location in its center, also has the job of directing riders to the mechanical horses located on the various segments. We can view him, then, as the cause of their order on the horses. But, it is obvious that even though the builder/operator is the cause of the carousel and the cause of the positions of the riders, he is not the cause of the riders themselves. And, any observer coming on the scene, subsequent to the builder/operator's ordering of the riders and starting the carousel, would be mistaken to conclude that the entire phenomenon – builder/operator, carousel, mechanical horses and riders - has one common origin. It is clear that in our illustration the builder/operator represents the Sun, the carousel represents its gravitational field, the mechanical horses represent orbital positions and the riders represent the planets.

There is no reason, other than the one based on tradition, compelling us to conclude that the Solar System came into complete existence by way of some originating cause at some specific time in the distant past. Indeed, calling the ensemble of Sun, planets and other bodies a "system" is indicative of the ideological predisposition that tradition has imposed on the astrophysical sciences. Conventional theorists cannot "think" the Solar "System" without also thinking that it must have come into existence through one evolutionary process. To them, the idea that its current composition is the result of a piecemeal accumulation over an indefinite period of time is unthinkable.

And, so long as Solar System researchers embrace the nebular hypothesis paradigm, they will continue to interpret and order facts according to the idea that it had a common origin. One can say that they are comfortable within the confines of the paradigm, and consider their work to be normal and straightforward. They do not question the premises upon which the latest, updated nebular hypotheses are erected. For them, there is no crisis of confidence, and this is the crux of the problem. They are like so many surgeons, working diligently over a patient, but are unaware that he has already expired.

Footnotes

1) Anthony J. Abruzzo, "Are Planets the End Products Rather than the By-Products of Stellar Evolution?" *The General Science Journal*, August 15, 2008

"Interpretations of Solar System Phenomena According to the Transformation Hypothesis," *The General Science Journal*, September 20, 2008

"The Formation and Age of the Solar System," *The General Science Journal*, October 27, 2008

"Brown Dwarf Stars – The Missing Link," *The General Science Journal*, November 20, 2008

"The Transformation of Gas Giant Planets into Rocky Planets," *The General Science Journal*, December 11, 2008

"The Planet Migration Hypothesis – Saving the Paradigm," *The General Science Journal*, April 14, 2009

2) "Are Planets the End Products Rather than the By-Products of Stellar Evolution?"

3) John Burnet, *Early Greek Philosophy*, Meridian Books, Cleveland and New York, 1969, pp 259-260

4) Lucretius, *On The Nature Of Things*, Book V, 432-533

5) Although Bruno's adherence to the Copernican worldview played some role in his condemnation and execution, his chief "crimes" centered on his espousal of hermetic beliefs.

6) Giordano Bruno, *On The Infinite Universe And Worlds*, 1584, Second Dialogue, The entire text in English can be found at, positiveatheism.org/hist/brunoiuw0.htm

7) Ibid.

8) Ibid.

9) The full title is *The First Principles of Natural Things, Being New Attempts Towards a Philosophical Explanation of the Elementary World*

10) I explained the contemporary concept of migrating planets in "The Planet Migration Hypothesis – Saving the Paradigm."

11) In point of fact, although Kant's cosmogony was printed, his publisher went bankrupt and all of his stock, including Kant's book, was impounded. And, even though his ideas eventually became known to a small circle of scholars, including Johann Lambert, they did not gain widespread currency until the mid-19th century.

12) Immanuel Kant, *Universal Natural History and Theory of the Heavens*, Ann Arbor Books, 1969, p 75

13) Ibid, pp 137-138

14) John Gribbin, *The Scientists, A History of Science Told Through the Lives of its Greatest Inventors*, Random House, New York, 2004, p 202

15) Pierre Simon, Marquis de Laplace, *The System of the World*, 1796, Volume 2, Book V, Chapter VI

16) Ibid. Book V, Chapter VI

17) It is worth mentioning that Venus, Uranus and newly demoted Pluto have retrograde rotations, although we cannot fault Laplace for his ignorance of these facts, especially in Pluto's case, which wasn't discovered until 1930.

18) Op. cit. Book V, Chapter VI

19) Ibid, Book V, Chapter VI

20) Ibid, Book V, Chapter VI (In all fairness, this idea was first articulated in 1783 by John Michell. But there is no evidence that Laplace knew about it. See Gribbin, *The Scientists*, pp 293-294 for a brief discussion.)

21) Stephen G. Brush's, *A History of Modern Planetary Physics*, gives an exhaustive account of theories of the Solar System's origin from Laplace to the present.

22) See "Are Planets the End Products Rather than the By-Products of Stellar Evolution," where I explain this categorization in more detail.