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

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Article Summary

This article presents a new hypothetical framework for planet formation that utilizes a transformation rather than a derivation mechanism. Since this transformation mechanism takes a different approach to planet formation, it radically departs from orthodoxy in this field, an orthodoxy whose foundation, in my view, is built on the inherently unstable ground of the nebular or accretion hypothesis in all of its permutations.

Historical Background

Descartes' vortex cosmology was presented to the world in 1644 with the publication of his *Principles of Philosophy*. Although it is now a historical relic of scientific thought, its influence lasted for over a century, particularly on continental Europe. During its reign, the followers of the "tourbillon physique" - which included such Enlightenment luminaries as Leibniz, Hooke, Huygens, Rohault and Perrault - believed they were on the cutting edge of science. But, it eventually succumbed to Newton's synthesis of terrestrial and celestial physics.

While I will not review the details of Descartes' vortex cosmology or delve into the reasons for its demise - there are many scholarly works available on both subjects - there is one aspect of it that merits mention. This relates to the explanation given therein for the formation of planets. The mechanism involves the collapse or dissolution of a vortex in which a stellar body is embedded and its migration to another vortex as a transformed planet. This occurs when the stellar body becomes completely encrusted over by a type of gross matter, which Descartes identified with Galileo's then recently discovered sunspots, and causes the migration to occur.

Thus, Descartes envisioned the birth of planets as a transformation process that begins with the death of stars. Although he was careful to couch his planetogony in hypothetical terms – mindful of the fates that befell Galileo and Bruno at the hands of Cardinal Bellarmine – he most certainly believed that this process actually takes place in nature. Nonetheless, this transformation hypothesis was abandoned along with the rest of the vortex cosmology, ending the possibility for its further development by future generations of Cartesian cosmologists. But, we should ask, does this matter in light of the many subsequent attempts that have been made to explain the origin of planets based solely on the firm ground of Newtonian dynamics?

The ascendance of Newton's world system over Descartes' vortex cosmology engendered a tradition of theorizing that sought to explain the origin of the Solar System based on gravitational attraction. From the earliest efforts of the mid-18th century, with the work of thinkers like Buffon and Kant up to the present, the formation of our planetary system – and any other planetary system – has been accounted for by the cast off material of a massive central condensing body that further condenses into lesser orbiting bodies under the overriding influence of the central body's gravitational attraction. In this sense, these efforts can be characterized as derivative hypotheses. Whether the basic mechanism involves one central nebulous mass of condensing gas and dust or, in the cases of the so-called catastrophic hypotheses, where two interacting bodies are required - either two stars or a star and a huge grazing comet, from which the surplus gaseous material for planet formation is derived – the result is a collection of less massive planetary bodies orbiting a central massive stellar body.

It is clear that the Newtonian-inspired, derivative hypotheses are qualitatively different from the Cartesian transformation hypothesis. In derivative hypotheses, many lesser bodies issue from one or, at most, two central bodies, whereas the transformation hypothesis envisions the transformation of one star into one planet. It is as if Descartes had borrowed the image from biological nature in arriving at this metamorphic-like concept of planet formation. Moreover, despite Descartes' need to couch it in hypothetical terms to escape inquisitorial retribution, it represented the first evolution-based theory of planet formation. Nonetheless, irrespective of its demise, a familiarity with the refractory problems from which the various derivative hypotheses suffer should engender an appreciation for the relative simplicity and elegance of the Cartesian transformation hypothesis.

Although the judgment of history has gone against Descartes' vortex cosmology, which Newton succinctly summed up in the *Principia* as "pressed with many difficulties," this historical fact does not also automatically redound to the detriment of a transformation hypothesis as such. Indeed, this paper will explore the possibility that its updated revival – in harmony with some aspects of contemporary astrophysical theory and observation – can provide a framework that could lead to advances that were not heretofore apparent. Let us, then, discuss this possibility with an examination of the black dwarf star, the hypothetical end product of stellar evolution, using our own Sun as the subject.

The Sun's Evolution into a Black Dwarf Star

According to conventional stellar evolutionary theory, black dwarf stars are merely hypothetical objects since in a universe that has only existed for 13.7 billion years the passage of time required for them to fully evolve still lies far into the future. In the case of our own Sun, theory suggests that it will reach the black dwarf stage in approximately 1.5X10^10-2X10^10 years. At that distant time, the Sun will have gone through the normal fusion, and several red giant and white dwarf phases of its evolution. In the process of fusing various lighter elements, and alternately expanding and contracting, it will have depleted all of its nuclear and gravitational energy sources, and will have shed about one half of its mass. During the Sun's prolonged death throes, it also will have probably vaporized Mercury, possibly Venus and even the Earth, although some models provide a safe haven for the latter two planets due to its diminishing gravitational force and the concomitant increase in the latter two planets' respective orbits beyond the vaporization zone. When the Sun reaches the black dwarf stage, all of the remaining residual heat generated from thermonuclear reactions and gravitational collapse will have dissipated into space. Let us now make a more detailed examination of the mass-depleting mechanisms that will turn the Sun into a black dwarf.

During the course of the Sun's main sequence fusion phase, two main mass-depleting mechanisms are operative. They are the fusion of hydrogen into helium and the solar wind, which includes mass loss from coronal mass ejections, flares and prominences. Calculations based on invariable rates for both processes estimate that the Sun will lose approximately 3.3X10^27 kg. This is equivalent to about 1½ Jupiter masses (1.898X10^27 kg.) Since the Sun's mass (1.99X10^30 kg) is three orders of magnitude greater than Jupiter's mass, the total amount of mass it will lose from fusion and the solar wind is miniscule by comparison. Thus, at the end of its life as a main sequence star, the Sun will have lost about 1% of its mass.

At the end of its main sequence phase, the Sun will enter the red giant phase of its existence. It arrives at this phase when its core is depleted of hydrogen and the fusion process is displaced to its outer regions or shells where some hydrogen is still available for the production of helium and the release of energy. The displacement of the fusion process beyond the core results in an enormous swelling of its diameter. The helium in the core may also begin to fuse, creating heavier elements like carbon and oxygen and the release of energy. When the hydrogen in the fusing shell is depleted, the Sun contracts until radiation pressure from the fusing helium core ignites the next hydrogen-rich shell and it swells again. This expansion and contraction process continues until all of the helium in the core and all the hydrogen in the outer shells have been burned.

During the red giant phase, the Sun will also shed a prodigious amount of mass catastrophically, resulting in the creation of a planetary nebula that will surround the now small and dense helium core. Estimates of the amount of matter the Sun will lose to this explosive process vary, but there is a consensus view that it will be somewhere in the range of 45 to 50% of its original mass.

The Sun will then enter the white dwarf phase of its evolution. The primary physical characteristic during its white dwarf phase will be the total cessation of energy production from nuclear fusion in either its core or its outer shells. The resulting absence of any outward radiation pressure to offset the force of gravity will cause it to collapse into a very dense object of Earth-like dimensions, composed of degenerate matter with a mass on the order of 1X10^30 kg. A simple calculation shows that its density will be approximately 1X10^9 kg/m3. This is almost 2X10^5 times as dense as the mean density of the Earth.

Another characteristic of the Sun during its white dwarf phase will be an initially higher surface temperature than it had during its main sequence and red giant phases. Therefore, although it can no longer generate energy from nuclear processes, it will continue to radiate thermal energy into space. At this point the Sun will become stable and no further mass loss will occur. It will slowly cool to the eventual black dwarf phase over a great expanse of cosmic time and finally reach a point where it will no longer even emit thermal radiation. It will have become a cold, dense and totally invisible object with perhaps five or six planets still orbiting it.

According to one model, however, the Sun will never actually reach the pristine black dwarf phase if the hypothetical process of proton decay, postulated by Grand Unified Theory physicists, actually occurs in nature. The Sun will continue to radiate energy released by the disintegration of its baryonic mass until it literally disappears. This process would require a time scale so much greater than the one contemplated for it to pass from the white dwarf phase to the black dwarf phase, in the "conventional" sense, that it is for all intents and purposes the equivalent of an eternity. An interesting consequence of this model is that as the Sun's nuclei decay, the degenerate state in which its matter was compressed will eventually revert back to a non-degenerate state and, accordingly, its density will decrease. Thus, the Sun will finally pass out of existence when its density reaches zero, leaving nothing behind but a fading signature of residual gamma radiation. And, by extrapolation, in the fullness of time, the universe consisting of a finite quantity of mass will ultimately disappear, as well. Thus, this rendition of Big Bang cosmology envisions a grand movement that begins with nothing and ends with nothing.

The Masses of Stellar and Sub-Stellar Objects

Looked at another way, however, the application of the proton decay hypothesis as the major component of a mass-reducing process holds out the possibility for explaining how stellar objects can transform into substellar objects. With this evolutionary interpretation in mind, a review of stellar and spherical substellar masses, starting with the heaviest objects and ending with the lightest objects, reveals just such a correlation.

Using the Harvard spectral classification scheme as a useful guide, we find that there are seven basic classes of stars designated by the letters O, B, A, F, G, K, M. The masses of these stars range from 10^32 to10^29 kilograms. The substellar brown dwarf stars follow with masses falling in the 10^29 to10^28 kilogram range. Next come the gas giant planets and their exoplanet counterparts, ranging in mass from 10^28 to10^25 kilograms. Following the gas giants are the terrestrial or rocky planets whose masses range from 10^25 to 10^23 kilograms. And, the final category includes the dwarf planets like our own Moon, Ceres, a number of gas giant moons, and several Kuiper Belt objects, including recently demoted Pluto. The masses of these objects fall in the 10^23 to10^19 kilogram range.

The apparent overlapping between each succeeding mass range category has led to efforts to determine and fix the parameters by which the objects in the five categories can be clearly distinguished from each other. In the furtherance of this effort, the International Astronomical Union (IAU) has recently adopted official definitions for stars, brown dwarfs, planets and dwarf planets. Although a distinction has been made here between "gas giants" and "rocky planets," the newly adopted IAU standard designates them simply as "planets."

It is worth noting that the classification of some objects has proven problematic. One typical example of this problem involved the binary star Wolf 424 in the constellation Virgo. In 1989, the two component stars were initially determined to be substellar brown dwarfs, but were subsequently reclassified in 1992 as red dwarf fusion stars. It is assumed that the 1992 reclassification came about as the result of the implementation of a more accurate mass-measuring technique. Nonetheless, it remains to be seen whether the revised classification of Wolf 424's two component stars will hold up to future analysis based on an even more refined mass-measuring technique.

Leaving aside the problems of classification, it is apparent that the descending mass scale of stellar and substellar objects outlined above demonstrates an unbroken continuum spanning thirteen orders of magnitude (ten trillion times) that separate the most massive stars from the lightest dwarf planets. In the context of the evolutionary process envisioned here, it is a small step, then, to view the objects in this continuum in such a way that the most massive stellar objects are relatively young, while the least massive substellar objects are relatively old.

Therefore, these relatively old substellar objects can be viewed as the "black dwarf" remnants of stellar evolution. If proton decay is a real process in nature, it is possible that a star like Eta Carinae – located in the southern hemisphere constellation Carina, with a mass on the order of 10^32 kilograms - could conceivably, over a great expanse of cosmic time, transform or evolve into an object no more massive than Saturn's tiny moon, Miranda, whose mass is on the order of 10^19 kilograms.

Such a transformation seems absurd, but, in fact, it is no more absurd than the transformation that occurs when a human zygote matures into an adult human being. The mass of a zygote is on the order of one nanogram (1X10^-12 kg), whereas the mass of a strapping human adult is on the order of 100 kilograms (1X10^2 kg). Indeed, the transformation that takes place between the zygote and the adult human over these fourteen orders of magnitude in mass represents a 100 trillion-fold increase. This is one order of magnitude greater than the transformation of an Eta Carinae-like star into a Miranda-like moon. The fact that we can confirm the human transformation by observing it - unlike the star-to-dwarf planet transformation, which we cannot - makes the sheer magnitude of the former transformation no less dramatic despite its now common certitude.

But, for the sake of argument, even if proton decay were conceded without empirical confirmation, many would argue that the universe is still too young for such a process to have transformed stars into planets. The oldest stars, like the prosaically named HE0107-5440 in the constellation Phoenix, have been determined to be nearly as old as the universe. Therefore, assuming that the proton's half-life lies in the speculative range of 10^31 to 10^36 years, very little stellar mass loss could be attributed to the proton decay process in a mere 13.7 billion years. However, this immediately raises the question of the validity of the assumed age of the universe.

The Age of the Universe

Since the general public and the overwhelming majority of cosmologists, astronomers and astrophysicists believe that the Big Bang theory is essentially correct and that the universe began some 13.7 billion years ago, it is almost the secular version of blasphemy to suggest that this broad consensus view is based more on blind faith than sound science. The Big Bang hypothesis – and it is just a hypothesis - has been faced by an ever-growing number of problems nourished by a continually accruing body of data that is contrary to its fundamental thesis. And, as this data is absorbed and synthesized, the resulting body of critical literature - all too often written off as "misguided," or even worse, "pseudo" science by the initiates of orthodoxy – can only be ignored at the expense of real scientific progress.

I will not, however, pass in review the salient points made in this critical literature against the Big Bang hypothesis. It is readily available elsewhere. Nor will I promote the alternative hypothesis of the Steady State universe. Instead, I will take the middle approach of the skeptic and simply state that, as far as the feasibility of utilizing the transformation hypothesis as an evolutionary mechanism for planet formation is concerned, a universe of indeterminate age will suffice. But, in opting for a universe of indeterminate age, I also recognize that the frontier of time must be pushed back to incredibly great ages. In doing so, it is appropriate to recall Hubble's characterization of the history of astronomy as "…a history of receding horizons." He was speaking of the newly discovered recession of the galaxies, but it is equally applicable in the case of the age of the universe, although the irony, in this context, cannot easily go unnoticed given the foundation this discovery provided for the construction of the Big Bang hypothesis.

The adoption of the position that the universe is of an indeterminate age in conjunction with the transformation hypothesis accomplishes two things. First, it frees us from the time restrictions imposed by the Big Bang hypothesis with respect to stellar evolution. And, second, it allows for the examination of the significance of the proton decay hypothesis as the predominant mass-reducing mechanism, operating over extraordinarily long spans of time, that is responsible for transforming stellar into non-stellar objects.

Moreover, postulating an indeterminately aged universe does not suffer from the cardinal defect of both the Big Bang and Steady State hypotheses. Neither of them can be definitively proved or disproved since they are not amenable to scientific analysis. Rather, they belong in the realm of metaphysics where, depending upon a particular ideological orientation, one hypothesis is chosen over the other. However, this suspension of belief does not preclude the possibility that the universe did have an absolute beginning. Nor does it prelude the possibility that it had no beginning. It simply means that within the context of the transformation hypothesis neither the finite universe nor the infinite in time universe hypotheses are necessary preconditions upon which its success or failure hinges.

An objection may be raised that the proton decay hypothesis must necessarily carry with it the implication that the universe cannot be eternal since a time will come when the last proton disintegrates and all matter has disappeared, leaving nothing behind but remnant gamma radiation which will eventually dissipate into nothingness. Similarly, an counter objection to the first one could invoke the possibility of continuing baryogenesis such that a balance is struck between proton decay and proton synthesis with the end result being akin to a steady state of matter existing in the universe. In other words, we are back to the same dichotomy, only in this case the argument revolves around a limited versus an unlimited quantity of protons rather than time.

Of these two objections, it is clear that the first one assumes something that cannot be verified since such verification would depend upon the observation of the universe eventually passing out of existence. And, the possibility of making such an observation is clearly absurd. On the other hand, the decay and synthesis of protons is at least theoretically verifiable, without implying a steady state universe, since both hypothetical processes can occur in a universe of indeterminate age without running the risk of falling into the same absurdity. The verification of both processes may suggest that the universe is in a steady state, but it is beyond the limits of science to conclude from these observations that the universe actually exists eternally in a steady state.

The point to be taken here is that the transformation hypothesis requires more time than allowed by the Big Bang hypothesis but less time than the eternity contemplated by the Steady State hypothesis. Stars are physical objects that must be viewed in a physical setting. The proponents of the Big Bang and the Steady State hypotheses each imagine universes that are colored by metaphysics. And, while this metaphysical desire to believe that the universe either had an absolute beginning or is infinite in time cannot be blithely dismissed, it must be recognized that such desires fall outside of the purview of science.

Conclusion

The claim has been made that planets should be viewed as the end products and not the by-products of stellar evolution. The overlapping gradations in mass between the heaviest and lightest spherical objects - presented above for heuristic purposes and without any consideration to individual variations - suggests just such an evolutionary continuum. It was pointed out that the germ of the transformation hypothesis traces its lineage to Descartes' vortex cosmology. And, for reasons that were very briefly touched upon, it was superseded by Newtonian physics and consigned to the dustbin of history. However, in reviving the idea, I have endeavored to show that in some not insignificant aspects it is consistent with contemporary stellar evolution theory if the time restriction imposed by the Big Bang hypothesis is abrogated.

In a universe of indeterminate age where stellar objects lose mass from nucleosynthesis, solar wind, red giant phase envelope shedding and finally proton decay, the focus of stellar evolution shifts from exotic objects like neutron stars, magnetars, preon stars, quark stars and black holes to mundane objects like brown dwarf stars, gas giant planets, rocky planets and dwarf planets. This is so because the supposed density levels predicted for the aforementioned exotic objects turn out to be spurious since the depletion of an object's mass and the contraction of its radius occur simultaneously, if we take the known densities of the non stellar objects in our Solar System as preliminary evidence. Thus, the need to wrestle with tortured descriptions of hyper-dense matter is no longer necessary.

Moreover, if proton decay is a property of matter, such a process should contribute to the overall background gamma radiation observed in the universe, now attributed to other causes, including the remnant cosmic microwave background (CMB) radiation that, it is conventionally assumed, was initially generated in the aftermath of the Big Bang. It should not be surprising, then, that some researchers have explored the possibility that foreground gamma radiation has an influence on CMB radiation levels, although they do not cite proton decay as the cause.

Furthermore, proton decay should be detectable wherever matter exists. It so happens that in 1994, terrestrial gamma ray flashes (TGFs) were detected in the Earth's upper atmosphere. Searching for a possible mechanism for the phenomenon, some observers have opined that this native gamma radiation in the high atmosphere is caused by high-energy electrical discharges associated with the generation of lightning. Thus, if proton decay does occur and gamma radiation is an end product of this process, it is possible that the cause of TGFs could actually be due to proton decay, just as the presumed remnant CMB radiation may also be a manifestation of ambient gamma radiation.

Although mass depletion – the central issue facing the transformation hypothesis – has been discussed within the context of standard stellar theory and the speculative concept of proton decay, there may very well be other mass-depleting mechanisms at work that are still unknown, although the disintegration (and constitution) of fundamental matter is conceptually consistent with both the Big Bang and Steady State hypotheses. Nevertheless, it is not without the realm of possibility that "mass" depletion may obtain from an electromagnetic phenomenon of which we, as yet, have very scant knowledge.

We should keep in mind that the history of astronomy is replete with seemingly absurd propositions that have ultimately proven to be true. The ancient age of the Earth, its spherical shape and motions, its position in the Solar System, the mutability of the heavens, and the extra-terrestrial origin of meteors and comets are but a few examples of "absurd" notions that have proven to be true. Indeed, in similar fashion, the foregoing outline based on a transformation hypothesis challenges us to reconsider the origin of planets and a greatly expanded timeframe wherein such transformations can take place. In doing so, however, the problem of whether the universe had an absolute beginning or is infinite has been characterized as a meaningless scientific question and, therefore, should be left to the ruminations of the metaphysicians.

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