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Danny R. Faulkner
Answers in Genesis

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THE CURRENT STATE OF CREATION ASTRONOMY II

Danny R. Faulkner, Answers in Genesis, PO Box 510, Hebron, KY 41048 dfaulkner@answersingenesis.org

ABSTRACT

It has been nearly twenty years since the previous review of the state of creation astronomy. Since then, much progress has occurred in developing a creation model of astronomy, and some of the recommendations of that earlier review have been carried out. Both the number of papers on astronomical topics published in the creation literature and their depth of coverage have increased tremendously. There has been less concern with criticism of evolutionary ideas as creationists have begun to develop their own models of astronomy. While emphasis on indicators of recent origin is not as great as it used to be, that continues to be a topic of discussion. The number of proposed solutions to the light travel time problem has doubled. New cosmologies have appeared. We have debated the interpretation of craters within the framework of six-day recent creation. The discovery of many extrasolar planets has shed light both on the difficulty of the naturalistic origin of planetary systems and the uniqueness of earth. Creationists are divided on the existence of dark matter and the cause of cosmological redshifts. I offer recommendations for future study.

KEY WORDS

Light travel time problem, cosmology, redshifts, quantized redshifts, dark matter, craters, extrasolar planets

INTRODUCTION

Two decades ago, I reviewed the state of creation astronomy (Faulkner, 1998a). That review, in turn, was twenty-five years after the first such review (Mulfinger, 1973). I had hoped that I would have done a third review before now. However, the time since the last review simply means that there is that much more material to discuss. I am pleased to report that since the last review, much progress has been made in developing a creation model of astronomy, and that some of my earlier recommendations have been carried out. In my earlier review, I identified three broad themes that had dominated creationists' writings on astronomy:

- Criticisms of evolutionary ideas, but particularly the big bang model
- Arguments for design
- Evidence that suggested young age and hence recent creation

In my discussion of the criticisms of evolutionary ideas, I noted that some criticisms relied upon an improper understanding of the concepts under discussion. For instance, the big bang model often was incorrectly portrayed as an explosion. Furthermore, few creation alternatives were offered. However, over the past two decades, creationists' criticisms of the big bang model have improved to more properly represent the model (for instance, see Faulkner [2004] and Williams and Hartnett [2005]). Furthermore, some true creation models of astronomy have emerged. I also commented on a common criticism of the theory of star formation that creationists often use, that star formation allegedly violates the second law of thermodynamics. I did a simple calculation to show that this is not the case. Since then, I have revisited the question with a more detailed treatment (Faulkner, 2001). It appears thus that in the creation literature today there is less improper criticism of evolutionary ideas in astronomy than there was two decades ago.

Unfortunately, there has not been nearly as much progress regarding the argument of design. In my earlier review, I pointed out that some creationists see evidence of design where there may not be any clear evidence of design. A large part of the problem is that within the creation literature there exists no concise definition of design (though Dembski [1998] has made some progress, he is not a recent creationist), *particularly a definition that is applicable to astronomy*. Absent such a definition, design, like beauty, is in the eye of the beholder. There has been no attempt to address this lack of a workable definition of design in astronomy, and hence this continues to be a shortcoming (Faulkner, 2014a). Over the past two decades there appears to have been a more conservative approach in the use of the teleological argument in astronomy among recent creationists. On the other hand, old-age creationists have pursued the design argument (e.g., see Gonzales and Richards [2004] and Ross [2008]). Recent creationists would disagree with many of the arguments found in these sources, but they would agree with others. Recent creationists need to take up this mantle once again. For instance, it would be helpful if a recent creationist would publish a book on design in astronomy.

In my discussion of evidence for the recent origin of astronomical bodies, I described eight arguments that recent creationists had used, and I introduced a new one—lunar ghost craters. There has been progress on this front as well, but I will defer discussion to a later section of this review.

THE LIGHT TRAVEL TIME PROBLEM

I concluded my earlier review with a summary of the light travel time problem, terming it "probably the single biggest problem that recent creationists face today" (Faulkner, 1998a, p. 212). At that time, there were only three serious proposed solutions—a change in the speed of light, mature creation (i.e., light created "in transit"), and Humphreys' white hole cosmology. The mature creation solution appears to have fewer proponents than it once did, though there still creationists who support it (DeYoung, 2010; Davis 2013). These three proposals have not changed much during the past two decades, but four more suggested solutions have joined them. Or perhaps it would be more accurate to say that three new proposed solutions have come along, while one was replaced. Humphreys has abandoned his earlier white hole cosmology (Humphreys, 1994b) in favor of a modified proposal (see Humphreys 2007; 2008a; 2017). Humphreys still relies on general relativity to argue for time dilation in the early universe. However, his new model introduces achronicity, or timelessness. A stretching of the fabric

of space-time during the Creation Week introduced a region of space in which there was no passage of time (what Humphreys calls a "timeless zone), while much time passed in other regions of the universe, thus allowing for light to travel great distances in only a short time as measured on the earth. A further refinement in Humphreys' model is a second stretching event that occurred at the time of the Flood in association with sped-up radioactive decay. Despite Humphreys abandonment of his white hole cosmology, that model remains popular. For instance, Samec and Figg (2012) and Samec (2014a; 2016) continue to attempt to constrain the white hole cosmology model.

Hartnett (2003a; 2007a; 2007b; 2008) also has relied on general relativity in his solution to the light travel time problem, but has modified the normal four dimensions (three of space and one of time) with a fifth dimension (one of velocity). Within his 5D model, Hartnett has attempted to explain various astronomical phenomena, such as quasars and dark matter, in terms of recent creation.

Another recent solution is the anisotropic synchrony convention (ASC) proposed by Newton (2001) and Lisle (2010). All direct measurements of the speed of light involve a round trip of outgoing light reflecting off a mirror and returning to the point of origin. Most physicists assume that the speed of light is the same in all directions. Hence, the speed of light is determined to be the total distance traveled (twice the distance to the mirror) divided by the travel time. However, what if the speed of light is not the same in both directions? More specifically, what if the speed of incoming light is infinite, but the outgoing speed of light is half of what we normally think of as being the speed of light (as assumed by ASC)? The travel time will be the same, so direct measurements of the speed of light would yield the same result. One must *assume* that the speed of light is isotropic or anisotropic, because the experiment itself cannot distinguish between the two. Both the isotropic and anisotropic assumptions are consistent with general relativity. However, many people consider the anisotropic assumption to be weird or, at the very least, contrived. That may be the reason ASC has not acquired very many adherents. Recently, Hartnett (2015a, 2015b) has extended ASC and shown that this extension is similar to his 5D model. One aspect of the ASC has been misunderstood. Many people have thought that the ASC proposes that light truly has two speeds, infinite in one direction and half the accepted speed of light in the other direction. Lisle (2010) certainly gives that impression, but that paper merely was attempting to explain in more technical terms time conventions in astronomy and general relativity. The heart of the ASC model was better described by Newton (2001), where astronomical creation was along a shell that contracted at the speed of light to reach the earth at the center of the shell on Day Four.

Finally, I have proposed my *dasha*, or *matured creation*, solution to the light travel time problem (Faulkner, 2013a). Rather than relying upon a physical mechanism as most of the other solutions do, I suggest that God rapidly made the astronomical bodies on Day Four and then miraculously brought their light to the earth on the same day. This is similar to the rapid growth of plants that took place on Day Three, as well as many other rapid directed processes that God used during the Creation Week.

Forty years ago, mature creation was the only solution to the light travel time problem, but many people saw difficulties with it. Therefore, it is encouraging that we have so many proposed solutions the light travel time problem. However, are any of those solutions even close to being correct?

COSMOLOGY

Over the past two decades, there has been progress in developing a biblical cosmology. For a long time, biblical creationists had assumed that Genesis 1:1 describes God's creation of the space of the universe at the beginning of Day One, while the *rāqîa'* (firmament or expanse) of Day Two referred to the earth's atmosphere. However, creation scientists increasingly have suggested that the *rāqîa'* made on Day Two is what we call *outer space* (Humphreys, 1994a), or possibly outer space and much of the atmosphere as well (Faulkner, 2016b). Neither author has been clear about one point: there must have been space prior to Day Two, because the primordial earth and its water created on Day One required the existence of at least some space. More properly, this emerging view of Day Two involves the creation of primordial and relatively small space that God expanded into the universe on Day Two. Without a proper understanding of when God made the space of the universe (and when He expanded it), it is not likely that a good biblical cosmology is possible. Therefore, if this emerging idea is the proper understanding of Day Two creation, then it is a firm foundation upon which to construct a biblical cosmology.

What will a biblical cosmology entail? Several things. The *rāqîa'* is something that was stamped, or spread, out. This meaning is captured well by the word *expanse*, which is how *rāqîa'* is translated in many modern English versions of the Bible. In Genesis 1:8, God called the *rāqîa'* "heaven." This understanding of the *rāqîa'* is reinforced by the more than a dozen Old Testament passages that refer to the heavens being stretched out. Humphreys (1994c, p. 66) has discussed this at length, but Anderson (2017) recently has called into question some of Humphreys' conclusions on theological and textual grounds. The purpose of the *rāqîa'* was to divide the waters below from the waters above. The waters below probably are the earth's oceans, so the *rāqîa'* likely stretched from the earth. If the expanse of Day Two is properly identified with outer space, we can draw three conclusions (Faulkner, 2016b). First, the universe is finite in size and probably has an edge. This is contrary to most cosmological models today, which posit that the universe is infinite or, that if the universe is finite, it has no edge. Second, if the expansion of the *rāqîa'* was reasonably symmetrical, it implies that the earth is near the center of the universe. Again, this contradicts most modern cosmologies in that they do not allow the universe to have a center, and even of those models that do, they suggest it is extremely improbable that the earth would be anywhere near that center. I shall return to this point later. Third, there is water lying at the edge of the universe.

In what form does this water now exist? Opinions vary. Most commentators prior to the 20th century thought that the water above was in the form of clouds and moisture in the air. This agrees with the *rāqîa'* being the atmosphere, but it hardly seems viable if the *rāqîa'* primarily is space. Within the early modern creation movement, it was common belief that the waters were in the form of a vapor canopy. However, belief in the vapor canopy has waned considerably among biblical creationists, so we ought to rethink the cosmology underlying it. What are the options if this the *rāqîa'* includes what we now call outer space? Hartnett (2003b, 2006b) suggested that this water is in the form of ice inside comets and other objects in the outer solar system. This would place the stars beyond the expanse made on Day Two. Earlier, Humphreys (1994a) proposed that this water was synthesized into matter that eventually formed the astronomical bodies on Day Four. However, later, Humphreys (2008a) suggested that most of the waters above

remain today at the edge of the universe, albeit probably in the form of ice. Hebert (2017) concurs that the waters above reside at the edge of the universe, though he did not identify what phase the waters above may be in. Faulkner (2016b) agrees, except that he believes that the water remains in the liquid form, based upon the fact that the Hebrew word for water used in the Day Two creation account means only liquid water where it is used elsewhere in the Old Testament, and that there are Hebrew words meaning ice or water vapor, if either of those was the intended meaning.

In my earlier review, I observed that one of the reasons the creation model of astronomy had not advanced much was because of the lack of biblical specifics. There are primarily two specifics—God created space on Day Two, and God made astronomical bodies on Day Four. The lack of details could be viewed as an encumbrance, but it can be quite liberating in the sense that we are free to consider any number of possibilities, provided they do not contradict direct statements of Scripture. Nor should we be afraid to reevaluate our positions. For instance, did God create the astronomical bodies *ex nihilo* on Day Four, or did He make them from material that He created earlier in the Creation Week? The text of the Day Four account does not tell us clearly. The majority opinion has been that God created the heavenly bodies *ex nihilo*, but previously I had preferred the concept that God made the astronomical bodies on Day Four out of matter that He created earlier in the Creation Week (Faulkner, 2004). I had based my belief on two things. First, I had believed that God created space and the matter of the universe in Genesis 1:1 (but I since have changed my thinking on this – see below). The second reason was the use of the Hebrew verb *asah* rather than *bara* consistently during the Day Four creation account. But the expanse of Day Two may have been empty, so there was no matter from which to make the astronomical bodies. Therefore, I now am reconsidering *ex nihilo* creation on Day Four.

A related question is whether God created the astronomical bodies instantaneously, or was there some (rapid, directed) process involved? Again, the Genesis account does not reveal the answer to that question, so we are free to explore various options. There were many processes during the Creation Week. For instance, God made man from the dust of the ground (Genesis 2:7). Similarly, God formed the land and flying creatures from out of the ground (Genesis 1:24; 2:19). Furthermore, God caused plants to grow rapidly out of the ground (Genesis 1:11–12; 2:9). Similarly, on Day Three God gathered together the waters below the sky to form seas and let the dry land appear. All these creative acts imply processes. With this pattern observed on other days of the Creation Week, is it likely God followed a similar pattern on Day Four?

What effect did the Fall have on astronomical bodies? At one time, biblical creationists nearly universally believed that the second law of thermodynamics came into existence at the time of the Fall. However, over the years there has been much retreat from this position. A large part of this belief was based upon a faulty view of the Fall and the curse (Anderson, 2013). I have noted that belief that the second law of thermodynamics began at the time of the Fall can lead to some peculiar thinking about the initial state of astronomical bodies (Faulkner, 2013b). This is particularly true of craters, a topic that I shall discuss in a later section.

The cosmic microwave background (CMB) is the single great prediction of the big bang model, the 1965 discovery of which led to the widespread acceptance of the big bang. Biblical creationists reject the big bang model, so how can we explain the CMB? One possibility is that the CMB is not cosmic at all, but rather could be locally generated (Faulkner, 2014b). Assuming the CMB truly is cosmic, what possible explanations do creationists have? An early attempt to explain the CMB was absorption and re-emission of starlight by dust (Ackridge, Barnes, and Slusher, 1981), but that mechanism does not work (Steidl, 1983). Two proposals recently have appeared in the creation literature. Humphreys (2014) proposed a new picture of how gravity works where the CMB is explained in terms of the Unruh effect. As part of my proposal that water is at the edge of the universe (Faulkner, 2016b), I suggested emission from this water may be the source of the CMB. These two proposals require further work, and additional explanations would be welcome.

NATURE OF REDSHIFTS

Beyond the basic biblical questions related to astronomy that I just raised, there are other questions of cosmological consequence prompted by astronomical observations where creationists disagree. One question is the nature of redshifts. It is an observational fact that most extragalactic objects exhibit redshifts, and that redshifts at least generally correlate with distance (the Hubble relation). At one time, many creationists doubted the reality of the Hubble relation, but fortunately, much of that doubt has faded. Accepting the reality of the Hubble relation, what does it mean? The simplest interpretation is that the universe is expanding. If the universe is expanding, we say that redshifts are cosmological. Creation astronomers generally believe that redshifts are cosmological, but some prominent creation physicists do not. For instance, Hartnett (2003b, 2004b, 2005c, 2011b, 2011c, 2014), drawing heavily from the work of Halton Arp, has called cosmological redshifts into question.

Many Christians have suggested that the numerous Old Testament mentions of God stretching out the heavens refer to the expansion of the universe. However, Hartnett (2011a) has called into question this interpretation of these passages. I, too, have questioned this (Faulkner, 2016a, p. 50) on the basis that this interpretation did not begin to appear until rather late in the twentieth century, long after Hubble's 1929 discovery of the expansion of the universe. Certainly, the stretching of the heavens had to mean something to the authors and the original readers of these passages. They likely would have understood this in relation to God's act of constructing the *rāqîa'* God made on Day Two. God called the *rāqîa'* "heaven" (Genesis 1:8), and knowing that the *rāqîa'* is something that has been stamped or spread out, it is easy to identify the spreading of the heavens with the expansion of the *rāqîa'* on Day Two. That is, the spreading of the heavens is a *past* event, not an ongoing process. Creation scientists concerned with cosmology appear to be converging on this understanding, but with a difference of opinion as to when this happened. Hartnett (2005b) and Humphreys (2008a) believe that this stretching of the heavens was on Day Four. However, there is no hint of expansion in the Day Four account (Genesis 1:14–19), though there is a strong indication of expansion in the Day Two account (Genesis 1:5–8). Therefore, it is a more natural reading of the creation account to identify any past expansion of the universe with Day Two rather than Day Four. Resolving this difference ought to be a priority within the creation astronomy community.

While biblical passages that refer to the spreading of the heavens may not necessarily refer to the expansion of the universe, that does not preclude the possibility that the universe is expanding. Cosmic expansion is the most straightforward interpretation of the Hubble relation (Faulkner, 2018a; 2018b), but not all creationists agree with this interpretation (Hartnett, 2003c; 2004a; 2011a; 2011b;

2011c). It is incumbent upon creationists who doubt universal expansion to offer a plausible alternate interpretation. However, for nearly a century there have been many attempts to do so without any success. This question of cosmological redshifts thus warrants much more discussion among creationists.

QUANTIZED REDSHIFTS

A second question is the possibility of quantized redshifts. For more than 40 years, data have accumulated that suggest that redshifts of galaxies are not uniformly distributed, but rather histograms of galaxy redshifts have peaks at certain values. The term *quantized redshifts* is a bit of a misnomer in that it suggests redshifts of galaxies fall into distinct bins, when in reality there are many galaxies with redshifts in the valleys between the peaks of the histograms. The simplest interpretation of quantized redshifts is that galaxies generally are situated in concentric spherical shells around our location (Humphreys, 2002a; Hartnett, 2004c), though not all creationists agree with that interpretation (Bishard, 2006). If galaxy redshifts truly are quantized, then it would have profound cosmological ramifications. As previously mentioned, few big bang models permit the universe to have a center, and even among those models that do, it is extremely unlikely that we are situated near that center. Furthermore, concentric shells of galaxies would violate the cosmological principle, the foundation of modern cosmology. However, as Humphreys (2002a) has suggested, quantized redshifts could work well within a biblical creation model. For instance, in Humphreys' white hole cosmology, there could have been episodic releases of matter concentrically from the event horizon of the white hole during the Creation Week. Furthermore, Hartnett (2004c) has attempted to explain quantized redshifts in terms of his model.

While the earth being situated at the center of concentric shells of galaxies is the simplest interpretation of quantized redshifts, it is not the only possibility. Hebert and Lisle (2016a; 2016b) have studied a possible bias in the data. It is very clear that galaxies clump into clusters that often contain a thousand or more galaxies. These clusters in turn tend to clump into much more irregular shapes, such as filaments and sheets, with near voids in between. As we measure the redshifts of galaxies, we tend to cut through these sheets and voids. It could be that the quantized redshifts that we observe may be merely the artifact of this sampling.

Why do creationists find quantized redshifts so attractive? Part of the motivation may be the desire for a silver bullet to destroy the big bang model. If redshifts truly are quantized, then the big bang model almost certainly is eliminated. Part of the appeal may also be that something akin to a geocentric (more properly a galactocentric) cosmology is compatible with special creation. Nothing in Scripture demands the universe have a center or that earth be near the center. Furthermore, contrary to common misconception, the medieval church did not embrace geocentrism because being at the center of the universe conveyed special status to the earth. Quite to the contrary, the idea of being at the center of the universe was the result of the earth being in a very *unprivileged* position, and it was of ancient (pagan) Greek origin (Faulkner, 2017c, p. 41). How, then, is a near geocentric position consistent with special creation? If, as previously discussed, the *rāqîa'* is best identified with space (and at least part of the atmosphere), then space expanded outward from the earth, suggesting at least the possibility that the earth is near the center of the universe (though not necessarily *precisely* at the center). However, this would be an inference from our creation model, not a demand of Scripture.

DARK MATTER

A third important question is dark matter (DeYoung, 1999). Faulkner (2017b) recently has pointed out that there are good observational reasons for the existence of dark matter. Most creation astronomers concur with this assessment, though creation physicists often disagree (e.g. Hartnett, 2006a). What is the reason for discounting dark matter? One reason may be a perception that dark matter is required for the big bang, with dark matter being invoked as a rescuing device for the big bang or other evolutionary ideas. However, this is an excellent example of the difference between observational/experimental science and historical science. Once astronomers and cosmologists came to appreciate the good observational basis for dark matter, they began to exploit it to solve difficulties with evolutionary theories. It has become another free parameter to manipulate within the big bang model. While dark matter is a fixture in current versions of the big bang model, it has not always been, and its role quickly would disappear within the big bang cosmogony if astronomers no longer saw a necessity for dark matter from the data. Therefore, denial of dark matter is not a silver bullet against the big bang.

Another reason for opposition to dark matter among creationists may be a desire to promote evidence for recent origin (Oard and Sarfati, 1999). The outer regions of galaxies rotate far faster than can be accounted for by the visible matter present. Furthermore, galaxies within clusters are moving too quickly to be in bound orbits based upon the amount of visible matter within the clusters. However, if the masses of galaxies, particularly in their outer regions, are dominated by dark matter, these high velocities are accounted for. Some creationists may argue that the outer regions of galaxies (Davies, 2010) and clusters of galaxies are unstable and thus indicate recent origin (Slusher, 1980a, pp. 7-14; Slusher, 1980b, pp. 59-66). But is this not a bit inconsistent? Creationists often comment on the stability that exists in the universe, suggesting design; but now some creationists want to throw this stability and design argument away in their haste to discard dark matter.

If dark matter does not exist, then how can one explain the data for dark matter? Worraker (2002) favors modified Newtonian dynamics (MOND). Hartnett (2005a) has developed his cosmological model with Carmelian physics which he says can explain the data without dark matter. The question of dark matter warrants further discussion in hopes of developing a consistent viewpoint.

YOUNG AGE INDICATORS

I will give brief updates of some of the young-age indicators I described in my earlier review. I also will mention a few others.

1. Comets

I noted in my earlier review that comets long had been a staple of recent origin arguments. I also pointed out that, beginning in the 1980s, the Oort cloud (the proposed source of long-period comets) had undergone many changes and the Kuiper belt (the proposed source of short-period comets) had been resurrected to help explain comets; but these developments had attracted little attention in the creation literature. Fortunately, several papers on comets have appeared in recent years in the creation literature (e.g., Newton, 2002b; Worraker, 2004; Spencer, 2014a).

The Oort cloud still has not been observed, but many astronomers think that the Kuiper belt has. Astronomers generally assume that the many trans-Neptunian objects (TNOs) orbiting the sun beyond Neptune are KBOs (Kuiper belt objects). However, there are problems with equating TNOs with KBOs, the latter presumably being comet nuclei. For instance, objects in the

Kuiper belt are supposed to be pristine samples of the early solar system, but perhaps the largest TNO, Pluto, shows evidence of much reworking (discussed in a later section). Furthermore, there is a problem with the densities, and hence composition, of trans-Neptunian objects (TNOs). In an unpublished work, I have taken the inferred composition of comets and found that the maximum density possible is 1.25 gm/cm^3. However, the measured densities of several TNOs, such as Pluto and its satellite Charon, are close to 2.0 gm/cm^3. Creationists are encouraged to continue monitoring developments on comets.

2. Lunar dust

I pointed out in my earlier review that one of the arguments for recent origin, lunar dust, had been debunked in the creation literature. The problem was that very early, indirect, measurements of the influx rate of meteoritic material was anomalously high; later, more direct, measurements were orders of magnitude lower. Despite this, some recent creationists continue to use the moon dust argument. Hallick and O'Brien (2013) recently published a new measurement of lunar dust accumulation that may raise the influx rate once again. However, there are other, and probably better, ways to interpret this new data. While this new data has been discussed some among creationists, nothing has yet appeared in print concerning it. Therefore, it appears that the measured amount of lunar dust still is not a good argument for recent creation, but recent creationists are encouraged to monitor the situation.

3. Planetary magnetic fields

In my earlier review, I briefly described Barnes' pioneering work on the earth's decaying magnetic field in the creation literature, as well as Humphreys' continuing work, such as correctly predicting the magnetic fields of Uranus and Neptune using a creation model of magnetic fields. Humphreys (2002b, 2011) has published further on earth's decaying magnetic field, as well as criticizing the dynamo model that supposedly maintains the earth's magnetic field on evolutionary time scales (Humphreys, 2013). Humphreys (2012) also documented how Mercury's magnetic field is decreasing, in concordance with expectations within the creation model. Humphreys (2008b) also applied his creation theory of magnetic fields to explain cosmic magnetic fields. Recently, Humphreys and De Spain (2016) have summarized much of Humphreys' work on magnetic fields.

4. Solar neutrinos

Beginning in 1980 and for a few years afterward, there were several papers in the creation literature promoting the idea that the sun was deriving its energy from gravitational potential energy and that astronomers consequently had measured a decrease in the sun's diameter. If this were true, it would be a powerful argument against the assumed 4.6-billion-year age of the sun. Alas, it is not true, as was demonstrated by DeYoung and Rush (1989). I did not discuss this in my previous review, because it ought to have been a dead issue. However, even today this question comes up frequently. Perhaps what helped keep this idea alive was the solar neutrino problem that arose in the late 1960s. Measurements of the neutrino flux from nuclear reactions within the sun had consistently been about one-third of those predicted. This suggested that the sun was deriving at most one-third of its power from nuclear reactions. Presumably, the sun was obtaining two-thirds of its power from gravitational contraction. However, the solar neutrino problem has been definitively solved by the discovery that neutrinos oscillate between the three types (Newton, 2002a). I urge creationists not to use the argument that the sun is shrinking or the solar neutrino problem.

5. Faint young sun paradox

One of the young-age indicators that has come about since my earlier review is the faint young sun paradox (Faulkner, 1998b). According to stellar evolution theory, early in its history the sun was much fainter than it is today. With much less solar influx, the early earth ought to have been about 17 C cooler than today. Since the earth's average temperature now is 15 C, one would expect the early earth to have been encased in ice. However, no one thinks that the early earth was like this. There have been many attempts to explain the faint young sun paradox, but none of the proposed solutions seem to work (Oard, 2011; Coppedge, 2013).

6. Interacting Binary Stars

In a series of papers, Ron Samec (Samec 2014a; Samec 2016; Samec, et al. 2010; Samec and Figg 2012; Samec and Shebs 2014) has shown that the rate of evolution of many close binary stars is much faster than had been thought. This has obvious implications regarding the age of such systems. This work is very promising as a possible young-age indicator, and it ought to be pursued.

7. Neutron Stars in Globular Clusters

Nethercott (2016) recently drew attention to the presence of neutron stars in globular star clusters. The progenitors of neutron stars are thought to be massive stars. Stars with sufficient mass to produce neutron stars ought to have short lifetimes, certainly less than a billion years. Astronomers think that globular clusters are at least ten billion years old, and that globular clusters have not had significant star formation for most of the past ten billion years. Yet, there are significant numbers of neutron stars in globular clusters. Furthermore, neutron stars often have high space velocity, probably from impulsive kicks they received from an asymmetry in the explosions that formed them. Therefore, neutron stars ought to depart globular clusters rapidly, in a matter of thousands of years. These two lines of evidence suggest that globular clusters are not nearly as old as generally thought.

8. Interior heat of the Jovian Planets

If the solar system were billions of years old, then primordial heat of planetary bodies would have dissipated long ago. For instance, temperature increases with depth inside the earth. In the nineteenth century, Lord Kelvin modeled this temperature gradient to calculate the earth's *maximum* age as a few tens of millions of years. We now know that radioactive decay within the earth's core maintains the current temperature gradient, so earth's maximum age is far older than Lord Kelvin computed (since this is a maximum age, the earth could be far younger). However, three of the four Jovian planets, Jupiter, Saturn, and Neptune, emit significantly far more energy than they receive from the sun (Henry, 2001). Radioactive decay cannot power this excess. There is no known physical mechanism that can explain the interior heat of these three planets, other than primordial heat. This is consistent with the creationary timeframe, but not the evolutionary one (Samec, 2000).

9. Volcanic Satellites

Related to the internal heat of three of the Jovian planets is the internal heat of some of the satellites of the Jovian planets. In 1979, Voyagers 1 and 2 revealed that Jupiter's satellite Io was active volcanically, more active than the earth or any other body in the solar system. Given Io's relatively low density, it cannot contain significant amounts of radioactive material to heat it sufficiently to cause volcanism. Since Io orbits so closely to Jupiter, most astronomers concluded that tremendous tides raised on Io led to flexing that produced frictional heat sufficient to cause volcanism. However, Spencer (2003) has analyzed this mechanism and

concluded that it is not capable of explaining Io's internal heat. Therefore, Io's hot interior suggests that Io is at most a few million, not billions, of years old.

There are two other volcanically active satellites in the solar system, Saturn's Enceladus (Walker, 2009; Spencer, 2015c) and Neptune's Triton. The primary volcanic material on Io is sulfur, but on Enceladus and Triton, the volcanic material primarily is water. With a much lower temperature required for molten water, the volcanism of Enceladus and Triton is called *cryovolcanism*. Even though the temperature regime is less on these two satellites than on Io, a similar constraint on time applies. Surprisingly, little about these two satellites has appeared in the creation literature. This subject needs to be explored more. Spencer (2015c) has called attention to the fact that Jupiter's Europa and Uranus' Ariel have low crater density, suggesting recent geological activity, even though these small planets lack an internal heat source to drive the geology.

10. Pluto

One of the more pleasant surprises in astronomy for creationists in recent years was the arrival of the *New Horizons* mission to Pluto in the summer of 2015. The cameras aboard the spacecraft returned stunning photos of about half the surfaces of Pluto and its largest satellite, Charon. In the evolutionary paradigm, everyone expected that the surfaces of both bodies would be saturated with craters. However, the photos revealed very few craters. This and other characteristics of Pluto and Charon are difficult to explain in terms of the evolutionary paradigm of billions of years. There is much evidence that Pluto and Charon are far younger than generally thought (Spencer, 2015b). Evolutionary scientists will be evaluating this information for a very long time. While no creationist predicted this startling result, it is the sort of thing that we might expect from bodies that were recently created.

Additionally, the four smaller satellites of Pluto rotate faster than they revolve (Hartnett 2016). Of Pluto's five satellites, only Charon rotates synchronously, meaning that it rotates and revolves at the same rate. This is typical of planetary satellites in the solar system. Synchronous rotation normally is attributed to tidal locking, a mechanism that requires great time (Davis, 2017). Therefore, biblical creationists must assume that most satellites were created with synchronous rotation, with a yet unknow purpose.

CRATERING

Perhaps the reason no creationist predicted the outcome of the *New Horizons* mission is that creationists have not yet developed a coherent theory of how and when craters formed in the solar system. For a long time, many creationists assumed that most craters in the solar system were the result of impacts during some catastrophe, such as the Flood (Unfred, 1984), with the possibility of some later catastrophes. Some creationists have suggested that many craters occurred at the time of the Fall, but this would appear to go far beyond the effects of the curse. At any rate, there has been reluctance to the concept of at least some craters dating from the Creation Week. As previously mentioned, this idea may result from an improper view of the meaning of "very good" in Genesis 1:31. Faulkner (1999) has offered an alternate proposal in which many craters throughout the solar system date from the Creation Week, in an event planetary scientists call the early heavy bombardment, with a second episode of much fewer, but larger, impacts at the time of the Flood, an event planetary scientists call the late heavy bombardment. Understandably, this proposal met with some early opposition, but that opposition has softened recently (Maurer and DeYoung, 2014; Spencer, 2014b). Much of the reason for this softening of opposition is due to considerations of physical difficulties (such as heat generation) with such intense bombardment in a very short period (Oard, 2012). If craters were part of the miracle of creation, physical difficulties can be avoided. Consequently, two camps have emerged. One camp believes that most craters date from the Flood (Froede, 2002; Oard, 2009a; 2009b; 2013; Holt, 2013; Spencer, 1994; 1998; 2008). The other camp believes that many craters originated on Day Four, but that some impacts date from the Flood (Faulkner, 1999; 2014c; Maurer and DeYoung, 2014; Samec, 2008a; 2008b). Both models ought to be more fully developed.

Related to the question of cratering is the question of the likely source of impacting bodies that caused craters, asteroids (minor planets) and comets. Other than the role comets play in limiting the age of the solar system, very little has appeared in the creation literature on small solar system bodies (SSSBs), as these objects are collectively known. Therefore, creationists have not developed a theory as to the origin and history of SSSB's. Of course, the fallback position is that God created SSSBs on Day Four along with other astronomical bodies. However, some creationists still consider a disrupted planet to be a viable explanation for the asteroid belt (Parks, 1990; Froede and DeYoung, 1996), though this proposal is problematic. Creationists have not discussed what changes SSSBs may have undergone since their creation. Related to this, in a series of papers Snelling (2014a; 2014b; 2014c; 2014d; 2014e) has studied radioisotope dating of meteorites, presumably samples of minor planets. In another development that may be of interest as we strive to understand SSSBs within the creation paradigm, there has been a blurring of the distinction between comets and asteroids (cf. Faulkner, 2015). Clearly, much work remains in addressing SSSBs.

PLANETARY ASTRONOMY

Related to cratering (and volcanism) is the need of a creation theory of planetary science. Unfortunately, there has not been much in the creation literature on this topic. As previously mentioned, there has been some discussion of the surfaces of some of the satellites of the Jovian planets. Hill (2008) has discussed the sparse density of craters on the surface of Venus, concluding that this indicates Venus underwent catastrophic resurfacing in the past. However, Oard (2009a) disagrees with Hill's interpretation. Creager (2008) and Samec (2013, 2014b) have similarly interpreted Mars in terms of a catastrophic episode or episodes on its surface. It is ironic that evolutionary planetary scientists readily accept catastrophic resurfacing on Venus and flooding of biblical proportions on Mars, yet they steadfastly refuse to believe that either process could have occurred on earth (Faulkner, 2003).

This progress in understanding planets, satellites, and SSSBs has been piecemeal. We need a broader theory for interpretation. Part of the problem is a lack of an agreed-upon coherent cratering theory. However, this would focus merely on the surfaces of solar system bodies. Virtually nothing in the creation literature has appeared to address planetary atmospheres. For instance, did Venus always have the sort of atmosphere that it now has? Mars could not always have had its current atmosphere, because its surface bears testament to huge liquid water flows on its surface, as well as massive bodies of water on its surface, yet its current atmosphere is far too cold and thin to support liquid water. Obviously, Mars once had a much denser, warmer atmosphere. Was it created with a substantial atmosphere that it since has lost? Or was a thicker atmosphere and abundant water catastrophically added to Mars, whereupon it lost both? If so, when did this happen, and what

was the mechanism? The only discussion of this in the creation literature is that of Samec (2014b). Clearly, much work remains in the field of planetary science within the creation model.

EXTRASOLAR PLANETS

At the time of my previous review, the search for extrasolar planets was in its infancy, with the first extrasolar planet discovery just five years earlier. With the number of known extrasolar planets approaching 4,000 (and surely rising), the field has matured. The impetus for this search is to show that planets are common, planetary systems are common, and most importantly, to show that earth-like planets where life might exist, are common. The discovery of earth-like planets would have a profound effect on the evolution/creation debate. However, no earth-like planets have been found (Spencer, 2010; 2015a; 2017). Faulkner (2017a) recently called for the conclusion that we are alone in the universe which conforms to the dominant creation view but opposes the dominant evolutionary view.

CONCLUSION

Clearly, since my previous review of creation astronomy there has been a noticeable increase in published work in the creation model of astronomy. For instance, my earlier review covered 25 years and contained 58 references, of which 18 did not come from the recent creation literature, leaving 40 references from the creation literature. This review covers less than 20 years, contains 130 references, with only four not being from the recent creation literature. Therefore, this review has 126 references coming from the creation literature, more than three times greater than in my earlier review, even though the time under consideration was 20% less. And this increased amount of work largely has been positive. There has been remarkable progress in developing a creation model of astronomy. There has been less reliance on criticism of evolutionary ideas and more emphasis on constructing creation models. This trend must continue.

In the past twenty years, several books dealing with astronomy from a creation perspective have appeared. Lisle's (2006) provocatively entitled book is a call to reclaim astronomy from evolutionary ideas. I have published a book on biblical astronomy (Faulkner, 2016a), as well as a companion book on creation and astronomy (Faulkner, 2017c). At least four books on cosmology have appeared (Byl, 2001; Faulkner, 2004; Hartnett, 2007b; Williams and Hartnett, 2005). Whitcomb and DeYoung (2003) published a book about the moon, which has since gone to a second edition (Whitcomb and DeYoung, 2010). This list does not include less technical treatments of astronomy. We can look forward to an expanded list of books on creation astronomy.

Much groundwork has been laid in developing a biblical cosmology, but much work remains. There is disagreement about the reality of dark matter among creationists, but there has been almost no discussion of dark energy. The key issues of when the heavens were stretched and when major cratering occurred must be resolved. These two issues, as important as they are, leap from the smallest astronomical scale (within the solar system) to the grandest scale (the universe). This leaves the middle ground of stellar astronomy virtually untouched. Much work still is needed there. For instance, biblical creationists reject the naturalistic origin of stars, so a good, up-to-date review of the latest thinking on star formation is needed within the creation literature. Astronomers have well-developed theories of how stars change with time. How much, if any, of this can creationists accept?

Despite the good progress in developing the creation model of astronomy, some areas lag. Little progress has been made in developing a good definition of design in astronomy. More work awaits on planetary astronomy. With the increased pace of creation astronomy papers of recent years, hopefully many of these issues will soon be addressed. I look forward to further reviews of creation astronomy.

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THE AUTHOR

Danny Faulkner received his Ph. D. in astronomy from Indiana University, and is Distinguished Professor Emeritus at the University of South Carolina Lancaster. Since 2013, he has been the astronomer at Answers in Genesis. Dr. Faulkner serves on the board of directors of the Creation Research Society, and he is the editor of the *Creation Research Society Quarterly*. He has published four books on creation and astronomy, as well as numerous articles in the creation literature.