The satellites of Pluto

Wayne Spencer

In recent issues of *Journal of Creation*, John Hartnett and Danny Faulkner have both commented on discoveries regarding the satellites of Pluto from the July 2015 New Horizons mission.[1,2] There are many mysteries about the Pluto system that are sure to be the subject of much research and discussion for years to come. Hartnett and Faulkner addressed some difficulties for evolutionary naturalistic theories to explain the origin of Pluto's natural satellites. I would like to comment on the new theories being explored by planetary scientists regarding the Pluto system.

The New Horizons mission to Pluto has provided much new information that challenges planetary scientists.[3] More information may be coming in 2019 since plans are underway to conduct another flyby of a trans-Neptunian object (TNO) called 2014 MU_{69} with the New Horizons spacecraft.[4] (Trans-Neptunian objects are also known by the older term, Kuiper belt object.) The New Horizons mission has established definitive values for the densities of Pluto (1854 ± 6 kg m^{-3}) and Charon (1702 ± 17 kg m^{-3}).[5] From this and other data the implication is that Pluto is approximately 65% rock by mass while Charon is about 59% rock. Both Pluto and Charon are likely to have some ice in the interior and they may have thick ice layers from the surface to some depth or under a crust. There is debate as to whether Pluto could have a liquid layer. Questions about Pluto's interior cannot be fully answered from the New Horizons data because the gravity data is not sufficient. Gravity data is of limited usefulness in the case of New Horizons since it was a very rapid flyby. An orbiter would be needed to get better gravity data and thereby determine

Figure 1. Pluto's small satellites. The four small satellites are shown to approximately the same scale, and they range in size from approximately 10 to 40 km. Processed images are from the Long Range Reconnaissance Imager (LORRI) on the New Horizons spacecraft in 2015. (NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute).

more about Pluto's interior. Both Pluto and Charon have interesting geological features on the surface and Pluto has many interesting atmospheric phenomena as well.

The origin of Pluto has always been challenging from the point of view of naturalistic assumptions. The New Horizons spacecraft reached Pluto at a time in which there has been a revolution in solar system origins theories with the application of planet migration theory to the origin of the outer planets. The model that involves the migration of Uranus and Neptune is known as the Nice Model.[6,7] The Nice Model proposes that the four outer planets—Jupiter, Saturn, Uranus, and Neptune—formed closer to each other and closer to the Sun than in their present orbits and then migrated outward. This outward migration involved orbital resonances between Jupiter and Saturn, and between Saturn, Uranus, and Neptune. The Nice Model also assumes that the region from approximately 20 to 30 AU from the Sun once was filled with a disk of planetesimals far more massive than those of today's trans-Neptunian region. The trans-Neptunian region today has only approximately one tenth of an Earth mass of material.[8] But in the Nice Model this region is assumed to have included a large population of objects totalling approximately 35 Earth masses.[9] The migration of Neptune into this outer planetesimal disk is thought to have caused an 'instability' that scattered most of the planetesimals. This instability scattered planetesimals in all directions and caused many impacts and other interactions of objects. Some argue that this instability caused the Late Heavy Impact bombardment on the moon. However the timing of this instability is debated and so some would argue it had nothing to do with the Late Heavy Bombardment of impacts in the inner solar system. This migration of Neptune and the planetesimal scattering event has gained much acceptance in the scientific community today. This puts the origin of Pluto in a different context than in past theories.

In recent years, leading up to the New Horizons spacecraft's arrival at Pluto, a theory was developed that Pluto's large satellite Charon formed from a large impact with Pluto.[10] This impact formation concept is very similar to the proposed origin of Earth's moon via a large impact.[11] It is thought that Pluto and Charon are similar enough to each other in composition (with some rock and some ice) that a large impact could form a debris disk around Pluto that could coalesce into Charon. Then after Charon formed, it is thought there would be a period where Charon would migrate outward away from Pluto due to tidal effects until it reaches a point where it would be in synchronous rotation with Pluto. This is Charon's current orbital state. It has one side facing Pluto at all times and the time for one spin on its axis matches the time for one orbital revolution about Pluto. It is not surprising that Charon would be in this configuration since it is stable this way.

The small satellites

Pluto's small satellites—Styx, Nix, Kerberos, and Hydra (figure 1)—complicate and challenge the above scenario. First, the small satellites are much icier and have significantly less rock than Pluto and Charon.[12,13] Though their density is not yet well

known, it seems they are icier than Charon and may be icier than many TNOs. It has been estimated that all four of the small satellites have geometric albedos greater than 50% and that the albedo of Hydra may be near 85%.[13] They are in nearly circular orbits and their orbits are very nearly in the same plane. If a satellite has a circular orbit and its orbit inclination is close to the same plane as the equator of the parent object, then it is normally considered 'regular' and it is assumed to have formed with the parent object. However, this is not likely for Pluto's small satellites by known physical processes, since they are of a different composition than Pluto and Charon. Planetary scientists may take the view that the current set of small satellites is not the original set that would have formed with Pluto and Charon, but this makes an assumption on the history of the Pluto system that may not be valid. Scientists have investigated scenarios in which the small satellites would migrate outward as Charon migrates outward. It was thought there could have been multiple orbital resonances at work between Charon and the small satellites that would move the small satellites into their current orbits. Also, it was assumed that interactions of the small satellites with Charon could explain the rotation behaviour of the small satellites. However this is not bearing out as planetary scientists have worked on computer models.

Pluto's four small satellites are currently following nearly circular and coplanar orbits which are in resonances with Charon (Styx 3:1, Nix 4:1, Kerberos 5:1, and Hydra 6:1 (figure 2)). A study of the origin of Pluto's small satellites in connection to an impact origin of Charon was published in 2014.[14] The concept explored was that as Charon migrated outward due to tidal effects, the small satellites could accrete from material left over from the large impact. Then the small satellites could migrate outward in multiple simultaneous resonances, migrating together. Simulations were attempted of this scenario. Some resonant migration occurred in some cases, but not for all four satellites simultaneously. Even if some of the satellites migrated to the proper orbital distances their orbits were significantly more eccentric than they are found today. If these small bodies' orbits became too eccentric or they migrated to distances somewhat different, it tended to make their orbits unstable. It was concluded that it was unlikely for Styx, Nix, Kerberos, and Hydra to all migrate to their current orbits in this way. The authors of the 2014 study, Cheng, *et al.*, make this statement: "We conclude that the placing of the small satellites at their current orbital positions by resonant transport is extremely unlikely."[15]

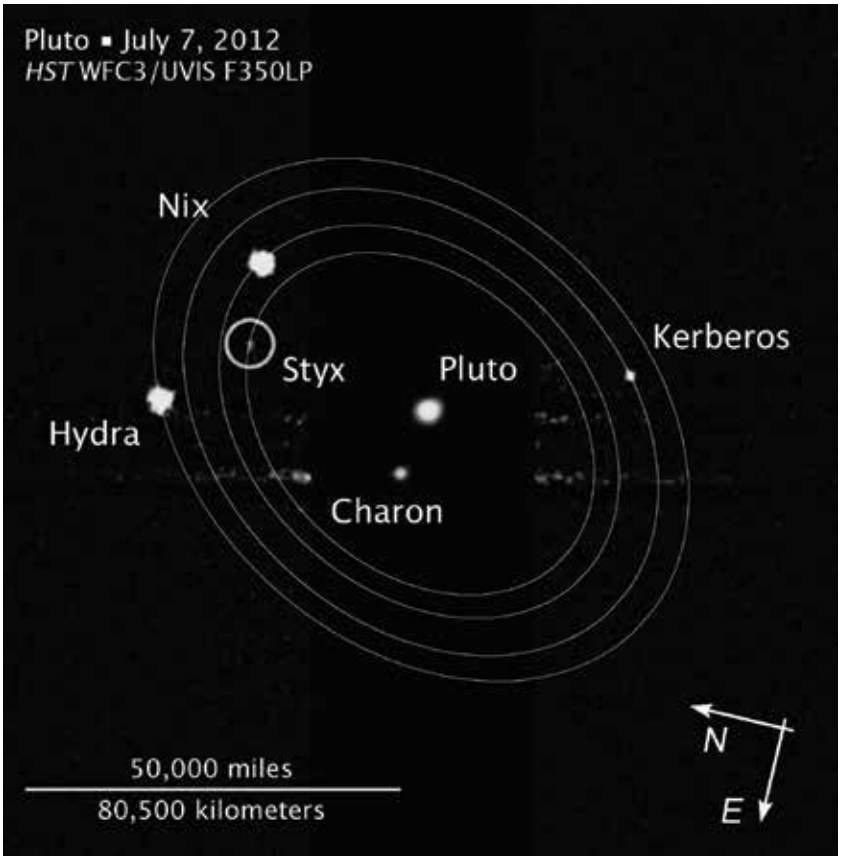

Figure 2. Pluto, and its satellites with their orbits. Image from the Hubble's Wide Field Camera 3 from July 2012. (NASA, ESA, and the Space Telescope Science Institute).

Faulkner also commented that it is unlikely the four small satellites were captured, as suggested by Hartnett. I concur with this since captured objects would have highly eccentric orbits and would not be in the same plane, unless perhaps they were once part of one object that was disrupted. Hydra is in the outermost orbit and is spinning extremely rapidly, as Hartnett points out. This is challenging to explain unless it is simply there from creation. A collision might spin up an object but it would also make the orbit more eccentric. Planetary scientists will take the view that Hydra is a composite of multiple planetesimals that collided and joined into one body. But again, this kind of collision would not be likely to leave the orbit nearly circular. In my opinion, Hydra's high rotation rate in combination with its circular orbit is not easy to explain from any collision scenario.

In addition to the above, the origin of the four small satellites is even more

puzzling in light of the Nice Model for the origin of the outer solar system. In the Nice Model, Pluto would have begun as one of many other large planetesimals in the region between approximately 20 and 30 AU in the early solar system before Neptune migrated outward to its current orbit. In current theories, planet migration facilitates objects coming into orbital resonances. Thus, Neptune and Uranus migrated outward in the Nice Model and this migration is believed to explain how Pluto could come to be in the unique 3:2 orbit resonance that it has with Neptune. But as Neptune migrated outward in the Nice Model, Pluto and Charon, as well as the four small satellites, would have to survive the migration and migrate with Neptune. It is thought Pluto and Charon had to form early, before Neptune's migration, because the large collision forming Charon requires an extremely low relative velocity between the impactor striking Pluto and Pluto itself.[16] This low velocity would seem to only be possible early in the solar system, not later as Neptune is migrating or after Neptune excited the instability that scattered planetesimals in the outer solar system. Although computer simulations do show that some satellites can stay in orbit around a migrating planet, their orbits are altered. It is often just assumed that after their orbits are altered they would stabilize and eventually circularize. But it is not at all clear this would work. Also, the Nice migration scenario requires millions of years, which conflicts with a young-age timescale.

The rotation rates of the small satellites of Pluto require more research and better data. There is a need to have better photos of Styx, Nix, Kerberos, and Hydra. There is also a need to know their sizes and densities to more precision. The high spin rate of Hydra is so fast that the other small satellites and even Charon would have little effect on it. Small collisions could help explain the spins of Styx, Nix, and Kerberos, but Hydra requires a different explanation. Another significant fact is that the New Horizons spacecraft did not discover any additional new small satellites of Pluto during the flyby. This was surprising to planetary scientists. If the four small satellites formed in a collision event, it seems likely more small objects would have been found. Therefore, whether the small satellites originated early at the time Charon formed or they were captured later, there are serious problems with explaining their origin. If they formed early along with Charon, why would their composition be so different than Charon and different from other Kuiper Belt objects? Currently planetary scientists seem to have no workable theory for the naturalistic origin of the four small satellites of Pluto.

Conclusions

A creation perspective is likely to find support from the Pluto system from the difficulties with naturalistic models. However, I would recommend that creationists should avoid drawing too many conclusions too early, especially regarding young-age arguments. Creationists should watch the ongoing research on the Pluto system. The small satellites of Pluto are in a complex dynamic relationship with Charon and Pluto. Computer simulations of satellites of Pluto show that many orbit configurations are unstable or do not end up as circular, like we find the orbits today. The unusual spins of the small satellites of Pluto may never reach a 'tidal lock' configuration due to the unique influence of Charon and the way the small satellites influence each other. Hydra's extremely rapid spin is mysterious. I have found it most fruitful to assume that most characteristics of things in the solar system stem from how they were created in the Creation Week, several thousand years ago. In a young-age timescale many processes assumed to have operated for millions of years by secular scientists have not had time to make significant change. Long periods of time and natural processes do not solve scientific mysteries. But, not every feature goes back to creation. Catastrophic and chaotic events are possible in the solar system. But our solar system exhibits both intelligently designed order and surprising creative features that point to a powerful Creator.

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