Contents

In the News

Story 1:
Giant Impact Caused Difference Between Moon’s Hemispheres

Story 2:
NASA, ULA Find Launch Opportunity for Inflatable Heat Shield Demonstrator

Story 3:
NASA’s Juno Finds Changes in Jupiter’s Magnetic Field

Departments

The Night Sky
ISS Sighting Opportunities
NASA-TV Highlights
Space Calendar
Food for Thought
Space Image of the Week
1. Giant Impact Caused Difference Between Moon's Hemispheres

The stark difference between the Moon's heavily-cratered farside and the lower-lying open basins of the Earth-facing nearside has puzzled scientists for decades.

Now, new evidence about the Moon's crust suggests the differences were caused by a wayward dwarf planet colliding with the Moon in the early history of the solar system. A report on the new research has been published in AGU's *Journal of Geophysical Research: Planets.*

The mystery of the Moon's two faces began in the Apollo era when the first views of its farside revealed the surprising differences. Measurements made by the Gravity Recovery and Interior Laboratory (GRAIL) mission in 2012 filled in more details about the structure of the Moon—including how its crust is thicker and includes an extra layer of material on its farside.

There are a number of ideas that have been used to try and explain the Moon's asymmetry. One is that there were once two moons orbiting Earth and they merged in the very early days of the Moon's formation. Another idea is that a large body, perhaps a young dwarf planet, found itself in an orbit around the Sun that put it on a collision course with the Moon. This latter giant impact idea would have happened somewhat later than a merging-moons scenario and after the Moon had formed a solid crust, said Meng Hua Zhu of the Space Science Institute at Macau University of Science and Technology and lead author of the new study. Signs of such an impact should be visible in the structure of the lunar crust today.

"The detailed gravity data obtained by GRAIL has given new insight into the structure of the lunar crust underneath the surface," Zhu said.

The new findings from GRAIL gave Zhu's team of researchers a clearer target to aim for with the computer simulations they used to test different early-Moon impact scenarios. The study's authors ran 360 computer simulations of giant impacts with the Moon to find out whether such an event millions of years ago could reproduce the crust of today's Moon as detected by GRAIL.

They found the best fit for today's asymmetrical Moon is a large body, about 480 miles (780 kilometers) in diameter, smacking into the nearside of the Moon at 14,000 miles per hour (22,500 kilometers per hour). That
would be the equivalent of an object a bit smaller than the dwarf planet Ceres moving at a speed about one-quarter as fast as the meteor pebbles and sand grains that burn up as "shooting stars" in Earth's atmosphere. Another good fit for the impact combinations the team modeled is a slightly smaller, 450-mile (720-kilometer) diameter, object hitting at a mildly faster 15,000 miles per hour (24,500 kilometers per hour).

Under both these scenarios, the model shows the impact would have thrown up vast amounts of material that would fall back on the Moon's surface, burying the primordial crust on the farside in 3 to 6 miles (5 to 10 kilometers) of debris. That is the added layer of crust detected on the farside by GRAIL, according to Zhu.

The new study suggests the impactor was not likely an early second moon of Earth's. Whatever the impactor was—an asteroid or a dwarf planet—it was probably on its own orbit around the Sun when it encountered the Moon, said Zhu.

The giant impact model also provides a good explanation for the unexplained differences in isotopes of potassium, phosphorus and rare-earth elements like tungsten-182 between the surfaces of the Earth and Moon, the researchers explain. These elements could have come from the giant impact, which would have added that material to the Moon after its formation, according to the study's authors.

"Our model can thus explain this isotope anomaly in the context of the giant impact scenario of the Moon's origin." the researchers write.

The new study not only suggests an answer to ongoing questions about the Moon, but may also provide insight into the structure of other asymmetrical worlds in our solar system like Mars wrote the researchers.

"This is a paper that will be very provocative," said Steve Hauck, a professor of planetary geodynamics at Case Western Reserve University and Editor-in-Chief of the JGR: Planets. "Understanding the origin of the differences between the nearside and the farside of the Moon is a fundamental issue in lunar science. Indeed, several planets have hemispherical dichotomies, yet for the Moon we have a lot of data to be able to test models and hypotheses with, so the implications of the work could likely be broader than just the Moon."

The topographic (A), crustal thickness (B), and thorium distribution of the Moon show a dramatic difference between the nearside and farside. The star on the nearside represents the center of the proposed impact basin. The black dashed lines represent the boundary of Imbrium (Im), Orientale (Or), and Apollo (Ap) basin, respectively. Credit: JGR: Planets/Zhu et al. 2019/AGU.

Source: Phys.org/American Geophysical Union
2. NASA, ULA Find Launch Opportunity for Inflatable Heat Shield Demonstrator

A flight demonstration of an inflatable heat shield that could be used to retrieve reusable engines from United Launch Alliance’s next-generation Vulcan rocket, and for the delivery of heavier cargo to the surface of Mars, is planned for launch in late 2021 or early 2022 as a piggyback payload on an Atlas 5 rocket with a NOAA weather satellite.

The inflatable re-entry decelerator will launch as a joint project between NASA and ULA, which foresee different uses for the technology.

ULA aims to recover engines from the company’s new Vulcan rocket, set to debut in 2021, using an inflatable heat shield and a parafoil. A helicopter equipped with a boom will snag the parafoil in a mid-air recovery, preventing contamination from salt water if the engines splashed down in the ocean.

The inflatable heat shield is much lighter than a rigid heat shield, such as thermal protection systems used on crew capsules, and take up less volume inside a rocket’s payload fairing. The technology will allow future NASA missions to deliver more massive rovers, landers, and eventually human-rated habitats to the Martian surface.

The heaviest spacecraft ever landed on Mars using current technology was the Curiosity rover, which weighed less than a ton at touchdown in 2012.

Inflatable heat shield technology could also protect materials manufactured in space during the return trip to Earth.

“It has the potential for returning substantial mass back to Earth,” said Jim Reuter, associate administrator of NASA’s space technology mission directorate, during an April 30 meeting of the NASA Advisory Council’s technology, innovation and engineering committee.
The Low Earth Orbit Flight Test of an Inflatable Decelerator will test a nearly 20-foot-diameter (6-meter) heat shield, the largest blunt body atmospheric entry vehicle ever flown in space.

NASA and ULA have identified room for the re-entry testbed, known by the acronym LOFTID, as a secondary payload on an Atlas 5 launch in late 2021 or early 2022 from Vandenberg Air Force Base, California, with NOAA’s Joint Polar Satellite System-2, or JPSS 2, weather observatory heading for polar orbit, according to Reuter.

Officials said NOAA recently agreed to launch the LOFTID experiment with the JPSS 2 satellite, after a search for excess capacity on Atlas 5 missions launching from Vandenberg over the next few years.

Therese Griebel, deputy associate administrator for programs in NASA’s technology division, said a recent review with JPSS 2 program managers concluded the addition of the LOFTID experiment on the launch would add no significant risk to the mission.

“It looks like we've gotten everybody on-board (with launching LOFTID with JPSS),” Reuter said.

The JPSS 2 satellite has a targeted launch readiness date in the first quarter of fiscal year 2022, or late in the calendar year 2021, according to John Leslie, a NOAA spokesperson.

The LOFTID re-entry vehicle will weigh around 2,700 pounds (1,224 kilograms).

Under the terms of a no-funds-exchanged Space Act Agreement, NASA will provide the re-entry vehicle and its inflatable aeroshell. ULA will supply the high-pressure tanks to inflate the heat shield in space and the Atlas 5 launch services at no cost to NASA.

NASA’s Langley Research Center in Virginia heads the agency’s work on the LOFTID experiment.

NASA awarded ULA a separate $1.9 million contract last year to demonstrate mid-air retrieval of the LOFTID entry vehicle, using an ocean-going ship capable of transporting a helicopter to the recovery zone.

The LOFTID experiment will test a flexible thermal protection system using braided synthetic fibers that are 15 times stronger than steel, according to a NASA fact sheet. Unlike rigid heat shields, the material allows the structure to be folded and packed in a tighter volume that can fit inside the payload envelope of existing rockets.

During the LOFTID demonstration, the heat shield will inflate after the Atlas 5 rocket releases the JPSS 2 spacecraft in orbit. After inflation, the Atlas 5’s Centaur upper stage will execute a deorbit burn on a trajectory heading back into the atmosphere, then deploy the LOFTID vehicle for re-entry.

ULA’s interest in inflatable heat shield technology stems from the company’s plan to recover first stage engines from the next-generation Vulcan rocket for refurbishment and reuse. The Vulcan rocket is scheduled for its inaugural launch from Cape Canaveral in 2021. Two BE-4 main engines, built by Blue Origin, will power the Vulcan’s first stage.

Unlike SpaceX, which lands entire Falcon 9 first stage boosters to be reused, ULA plans to jettison the BE-4 engine pod from the base of the Vulcan first stage. The engines will be shielded by an inflatable decelerator, similar to the system to be demonstrated by the LOFTID experiment, then unfurl a steerable parafoil for a helicopter to capture in mid-air.

The BE-4 engines, which burn methane and liquid oxygen, are designed to be reusable. Blue Origin’s own New Glenn rocket, also set for a debut in 2021, will also use BE-4 engines on its first stage. Like SpaceX, Blue Origin intends to land the New Glenn’s first stage intact for refurbishment and reuse.

ULA will discard the BE-4 engines on the initial flights of the Vulcan rocket. The company plans to begin retrieving the engines around 2024.
3. NASA's Juno Finds Changes in Jupiter's Magnetic Field

This animation illustrates Jupiter's magnetic field at a single moment in time. The Great Blue Spot, an-invisible-to-the-eye concentration of magnetic field near the equator, stands out as a particularly strong feature. The gray lines (called field lines) show the field's direction in space, and the deepness of the color corresponds to the strength of the magnetic field (with dark red and dark blue for regions with strongly positive and strongly negative fields, respectively). Credits: NASA/JPL-Caltech/Harvard/Moore et al.

NASA's Juno mission to Jupiter made the first definitive detection beyond our world of an internal magnetic field that changes over time, a phenomenon called secular variation. Juno determined the gas giant's secular variation is most likely driven by the planet's deep atmospheric winds.

The discovery will help scientists further understand Jupiter's interior structure — including atmospheric dynamics — as well as changes in Earth's magnetic field. A paper on the discovery was published today in the journal Nature Astronomy.

"Secular variation has been on the wish list of planetary scientists for decades," said Scott Bolton, Juno principal investigator from the Southwest Research Institute in San Antonio. "This discovery could only take place due to Juno's extremely accurate science instruments and the unique nature of Juno's orbit, which carries it low over the planet as it travels from pole to pole."

Characterizing the magnetic field of a planet requires close-up measurements. Juno scientists compared data from NASA's past missions to Jupiter (Pioneer 10 and 11, Voyager 1 and Ulysses) to a new model of Jupiter's magnetic field (called JRM09). The new model was based on data collected during Juno's first eight science passes of Jupiter using its magnetometer, an instrument capable of generating a detailed three-dimensional map of the magnetic field.

What scientists found is that from the first Jupiter magnetic field data provided by the Pioneer spacecraft through to the latest data provided by Juno, there were small but distinct changes to the field.

"Finding something as minute as these changes in something so immense as Jupiter's magnetic field was a challenge," said Kimee Moore, a Juno scientist from Harvard University in Cambridge, Massachusetts. "Having a baseline of close-up observations over four decades long provided us with just enough data to confirm that Jupiter's magnetic field does indeed change over time."
Once the Juno team proved secular variation did occur, they sought to explain how such a change might come about. The operation of Jupiter's atmospheric (or zonal) winds best explained the changes in its magnetic field. These winds extend from the planet's surface to over 1,860 miles (3,000 kilometers) deep, where the planet's interior begins changing from gas to highly conductive liquid metal. They are believed to shear the magnetic fields, stretching them and carrying them around the planet.

Nowhere was Jupiter's secular variation as large as at the planet's Great Blue Spot, an intense patch of magnetic field near Jupiter's equator. The combination of the Great Blue Spot, with its strong localized magnetic fields, and strong zonal winds at this latitude result in the largest secular variations in the field on the Jovian world.

"It is incredible that one narrow magnetic hot spot, the Great Blue Spot, could be responsible for almost all of Jupiter's secular variation, but the numbers bear it out," said Moore. "With this new understanding of magnetic fields, during future science passes we will begin to create a planet-wide map of Jupiter's secular variation. It may also have applications for scientists studying Earth's magnetic field, which still contains many mysteries to be solved."

NASA's JPL manages and operates the Juno mission for the principal investigator, Scott Bolton, of the Southwest Research Institute in San Antonio. Juno is part of NASA's New Frontiers Program, which is managed by NASA's Marshall Space Flight Center in Huntsville, Alabama, for the agency's Science Mission Directorate. The Italian Space Agency (ASI) contributed two instruments, a Ka-band frequency translator (KaT) and the Jovian Infrared Auroral Mapper (JIRAM). **Lockheed Martin Space in Denver built and operates the spacecraft.**

Source: [NASA](https://www.nasa.gov)
The Night Sky

Tuesday, May 21

• This is the time of year when Leo the Lion starts walking downward toward the west, on his way to departing into the sunset in early summer. Right after dark, spot the brightest star fairly high in the west-southwest. That's Regulus, his forefoot.

Wednesday, May 22

• Vega is well up in the east-northeast after dark. Look for its faint little constellation Lyra, the Lyre, dangling down from it with its bottom canted to the right.

Thursday, May 23

• A gigantic asterism you may not know is the Diamond of Virgo, some 50° tall and extending over five constellations. It currently stands upright in the south after the stars come out. Start with Spica, its bottom. Upper left from Spica is bright Arcturus. Almost as far upper right from Arcturus (as you face south) is fainter Cor Caroli, 3rd magnitude, almost overhead. The same distance lower right from there is Denebola, the 2nd-magnitude tail-tip of Leo. And then back to Spica.

The bottom three of these stars, the brightest, form a nearly perfect equilateral triangle. Maybe we should call this the "Spring Triangle" to parallel those of summer and winter?

In you have a dark sky or binoculars, look halfway from Cor Caroli to Denebola for the very large, sparse Coma Berenices star cluster. It spans some 4°, about the size of a ping-pong ball held at arm's length.

See Fred Schaaf's tour of this area in the May Sky & Telescope, page 45.

Friday, May 24

• Meanwhile the Summer Triangle is making its appearance in the east, one star after another. The first in view as night descends is Vega, the brightest star in the east-northeast. Lower left it (by two or three fists at arm's length) is Deneb. Farther to Vega's lower right is Altair, rising above the horizon not long after dark.

Saturday, May 25

• Have you ever seen Alpha Centauri?! At declination –61° it's permanently out of sight if you're north of latitude 29°. But if you're at the latitude of San Antonio, Orlando, or points south, Alpha Cen skims just above your true southern horizon for a little while late these evenings.

When does this happen? Just about when Alpha Librae, the lower-right of Libra's two brightest stars, is due south over your landscape. At that time, look straight down from there!

Source: Sky and Telescope  

Return to Contents
ISS Sighting Opportunities (from Denver)

<table>
<thead>
<tr>
<th>Date</th>
<th>Visible</th>
<th>Max Height</th>
<th>Appears</th>
<th>Disappears</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tue May 21, 9:43 PM</td>
<td>2 min</td>
<td>22°</td>
<td>22° above NNW</td>
<td>11° above NNE</td>
</tr>
<tr>
<td>Tue May 21, 11:21 PM</td>
<td>&lt; 1 min</td>
<td>10°</td>
<td>10° above N</td>
<td>10° above NNE</td>
</tr>
<tr>
<td>Wed May 22, 8:51 PM</td>
<td>3 min</td>
<td>33°</td>
<td>33° above NNW</td>
<td>10° above NE</td>
</tr>
<tr>
<td>Wed May 22, 10:29 PM</td>
<td>&lt; 1 min</td>
<td>11°</td>
<td>11° above N</td>
<td>10° above N</td>
</tr>
<tr>
<td>Thu May 23, 00:07 AM</td>
<td>1 min</td>
<td>12°</td>
<td>12° above NNE</td>
<td>10° above NNE</td>
</tr>
<tr>
<td>Thu May 23, 9:39 PM</td>
<td>1 min</td>
<td>14°</td>
<td>14° above N</td>
<td>10° above NNE</td>
</tr>
<tr>
<td>Thu May 23, 11:16 PM</td>
<td>1 min</td>
<td>11°</td>
<td>11° above N</td>
<td>10° above NNE</td>
</tr>
<tr>
<td>Fri May 24, 00:51 AM</td>
<td>&lt; 1 min</td>
<td>15°</td>
<td>11° above NNW</td>
<td>15° above NNW</td>
</tr>
<tr>
<td>Fri May 24, 8:49 PM</td>
<td>2 min</td>
<td>18°</td>
<td>18° above NNW</td>
<td>11° above NNE</td>
</tr>
<tr>
<td>Fri May 24, 10:26 PM</td>
<td>1 min</td>
<td>10°</td>
<td>10° above N</td>
<td>10° above NNE</td>
</tr>
<tr>
<td>Sat May 25, 00:03 AM</td>
<td>&lt; 1 min</td>
<td>17°</td>
<td>15° above N</td>
<td>17° above NNE</td>
</tr>
</tbody>
</table>

Sighting information for other cities can be found at NASA’s Satellite Sighting Information.

NASA-TV Highlights  (all times Eastern Time Zone)

May 21, Tuesday
- 1 p.m. - What’s New in Aerospace? – Pit Stops and Space Toilets: A Conversation with NASA astronaut Drew Feustel (All Channels)

May 22, Wednesday
- 12:20 p.m. - International Space Station In-Flight Educational Event with the Milby High School in Houston, Texas, and NASA astronaut Nick Hague (All Channels)
- 3 p.m. – NASA Science Live: Storms Across the Solar System (All Channels)

May 23, Thursday
- 1 p.m. - Administrator Jim Bridenstine speaks at the Florida Institute of Technology (All Channels)

Watch NASA TV online by going to the NASA website.
Space Calendar

- May 21 - [Apollo Asteroid 217628 Lugh Closest Approach To Earth](#) (1.388 AU)
- May 21 - [Asteroid 9618 JohnCLEese](#) Closest Approach To Earth (1.451 AU)
- May 21 - [Seminar: Primordial Black Holes' Dark Dresses - Roads Towards a Discovery and Possible Implications](#), Barcelona, Spain
- May 21-22 - [Space Tech Expo](#), Pasadena, California
- May 21-22 - [Space Forum Conference](#), Luxembourg
- **May 21-22** - [NOAA ESRL Global Monitoring Annual Conference 2019](#), Boulder, Colorado
- May 21-22 - [Australasian Satellite Forum 2019](#), Sydney, Australia
- May 21-23 - [2019 European Lunar Symposium](#), Manchester, United Kingdom
- May 21-23 - [NASA Biological Diversity and Ecological Forecasting Annual Team Meeting](#), Arlington, Virginia
- May 21-24 - [7th International Conference Space Technologies: Present and Future](#), Dnepr, Ukraine
- **May 22** - [RISAT-2B PSLV-XL Launch](#)
- May 22 - [Moon Occults Saturn](#)
- May 22 - [Comet 322P/SOHO At Opposition](#) (1.128 AU)
- May 22 - [Comet C/2019 H1 (NEOWISE) Closest Approach To Earth](#) (1.217 AU)
- May 22 - [Comet P/2019 A8 (PANSTARRS) At Opposition](#) (1.679 AU)
- May 22 - [Event: Women in Leadership](#), San Diego, California
- May 22 - [Committee Teleconference: Committee on Astrobiology and Planetary Sciences](#)
- May 22-23 - [7th International Conference on Earth Science, Climate Change & Space Technology](#), Rome, Italy
- May 22-24 - [International Association of Geodesy (IAG) Reference Frame Sub-Commission for Europe (EUREF) 2019 Symposium](#), Tallinn, Estonia
- May 22-24 - [Joint Urban Remote Sensing Event](#), Vannes, France
- May 22-25 - [10th China Satellite Navigation Conference (CSNC)](#), Beijing, China
- May 23 - [Moon Occults Dwarf Planet Pluto](#)
- May 23 - [Seminar: Hayabusa2 at Ryugu](#), Houston, Texas
- May 23 - [Seminar: 3D Imaging of the Emission from the Inner Ejecta of SN1987A](#), Barcelona, Spain
- May 24 - [Apollo Asteroid 2019 JF7 Near-Earth Flyby](#) (0.038 AU)
- May 24 - [Asteroid 2956 Yeomans](#) Closest Approach To Earth (1.503 AU)
- May 24 - [NASA Marine BONE All Hands Meeting](#), Arlington, Virginia
- **May 25** - [Towel Day - Annual Tribute to Douglas Adams](#)
- May 25 - [Aten Asteroid 66391 (1999 KW4) Near-Earth Flyby](#) (0.035 AU)
- May 25 - [Aten Asteroid 2015 KQ18](#) Near-Earth Flyby (0.027 AU)
- May 25 - [Austin Astronomical Society Inks Lake Star Party](#), Inks Lake State Park, Texas

Source: [JPL Space Calendar](#)
There is no doubt that our world is in the midst of a climate crisis. Between increasing levels of carbon dioxide in our atmosphere, rising temperatures and sea levels, ocean acidification, species extinctions, waste production, diminishing supplies of fresh water, drought, severe weather, and all of the resulting fallout, the “Anthropocene” is not shaping up too well.

It is little wonder then why luminaries like Stephen Hawking, Buzz Aldrin, and Elon Musk believe that we must look off-world to ensure our survival. However, there are those who caution that in so doing, humans will simply shift our burdens onto new locations. Addressing this possibility, two distinguished researchers recently published a paper where they suggest that we should set aside “wilderness” spaces in our Solar System today.

This paper, which recently appeared in the journal *Acta Astronautica* under the title "How much of the Solar System should we leave as Wilderness?", was written by Dr. Martin Elvis and Dr. Tony Milligan. Whereas Dr. Elvis is the senior astrophysicist at the Harvard-Smithsonian Center for Astrophysics (CfA), Dr. Milligan is a teaching fellow in ethics and the philosophy of religion at King’s College London.

For the sake of their study, Elvis and Milligan took the long view of human space endeavors and asked the fundamental question, “How much of the Solar System should be off-limits to human development?” Taking their cue from humanity’s most pressing existential threats – overpopulation and climate change – the team recommended that limits be established now before exponential growth strips our System of its resources.

As Dr. Elvis explained to Universe Today via email, the inspiration for this study came from recent statements to the effect that the first trillionaires will be the people who exploits asteroid mining in the coming decades:

"So we thought we would calculate how big it would get in a century depending on how fast it grew. The answers surprised us. Quite reasonable growth rates made it really big; China-like growth rates made it huge! Naturally, that made us wonder how long that could keep on going. Since the resources of the Solar System are vast – millions of times larger than we can get to on Earth – we assumed the answer would be thousands of years. But we were
wrong. Exponential growth (like compound interest) has a way of surprising. The answer was a few hundred years. That's a long time, but not so long that it's unimaginably, safely, distant.”

Another source of inspiration for the paper was modern human history. If one were to examine the past few centuries, one can see this exponential trend at work. Since the Industrial Revolution began in earnest in the 18th century, natural resource exploitation and populations have grown concurrently. In fact, between the year 1800 and 2000, the global population went from 1 billion to 6 billion.

Even more startling than the fact that this represents a sixfold increase in just two centuries (the largest population explosion in history) is the way the rate of increase has accelerated. While it took 120 years for Earth's population to go from 1 to 2 billion (between 1800 and 1920), it took just 33 years to add another billion (by 1960). The next three billion were added 14, 13, and 12 years later, respectively (by 1974, 1987 and 1999).

The same holds true for consumption. Looking at energy usage alone, humanity went from a global consumption of about 5650 terawatt-hours (TWh) in 1800 to over 150,000 TWh in 2017. So in the same amount of time it took for our population to increase by a factor of seven, energy consumption increased by a factor of thirty. Here we see yet another exponential trend, where resource consumption has grown in a way that vastly exceeds population growth.

In the coming decades, it is estimated that an additional 3 to 5 billion lives will be added to Earth's population. This will be happening at a time when the very systems we depend upon to feed, house, clothe and sustain ourselves will be undergoing drastic shifts thanks to climate change. For many, the solution is to look off-world for the necessary resources. But how long will these last?

“The shock of realizing that we could suddenly run up against the physical limits of the Solar System made us wonder how we could devise a warning bell,” Dr. Elvis added. “Sounding a warning that we have used up 1/8 of the resources of the Solar System is about right, we reckon, because then we'll have just 3 doubling times till we are done. How long is a doubling time? Twenty years, at the growth rate we've been on for the past 200 years. That seemed like the minimum time needed to change a vast economy, a million times bigger than the world economy today.”

Another important aspect of this study is the way it emphasizes how measures need to be taken sooner other than later. As Prof. Milligan explained to Universe Today via email, humanity is on the verge of a renaissance in space exploration. When you consider that we are not just considering going back to the Moon or exploring Mars, but actually creating permanent bases there, the need for a discussion on limits becomes much more clear. As Dr. Milligan told Universe Today via email:

"We are not about to go to the Moon or Mars in the next couple of years, but both are on the horizon. In fact, going to Mars and mining asteroids fit neatly together. Mars is an obvious place to operate from if we are going to mine the Main Belt. However, Mars also makes up a large amount of the accessible planetary surface in the Solar System. It makes sense to use some of this Martian surface, but also to ask questions about how much of it we should use, how much planetary surface we will ever be able to access elsewhere.”

Compared to Earth, billions of years of Martian history has been beautifully preserved in its many interesting surface features – alluvial fans, sedimentary deposits, lakebeds, etc. These tell the story of how Mars once had a warmer, wetter climate that changed drastically over the next 3.8 billion years. If humanity were to colonize there and begin altering the terrain (whether we're talking about mining and development or full-scale terraforming), these features could be lost forever.

In response, it has already been suggested that parts of Mars should be set aside as “planetary parks” to protect these characteristic features. However, as Prof. Milligan added, we also need to address the larger picture of overall resource exploitation and consider how certain methods of usage, and the kind of resources being used, could be traded off against each other.

“Interesting questions then arise, e.g. is it more important to protect Vesta or Ceres?” he said. “If we have to, should we sacrifice more of one in order to save more of the other? These are tough choices, so we need some sort of framework to get traction upon them.”
Finally, there are the implications that this study and its recommendations could have. Assuming the various governments and private interests of the world can be compelled to come together in the near-future and hammer out a framework for development in space, then the establishing of “nature preserves” should definitely be factored in.

“We can build a space economy in a way that is geared for the long term, but if we don’t think big and long term then major problems could arise,” said Dr. Milligan. “We won’t face the consequences, but somebody else will. Of course, there are going to be various different proposals about how we get the space economy geared for the long term. Discussions about what we should use, what we should protect from certain kinds of use, and how much we should simply leave alone. This is a contribution to that discussion.”

For those who suspect that Dr. Elvis and Dr. Milligan have an “anti-development” agenda, the authors are clear that sticking to one-eighth of the Solar System will hardly hold anyone back. In the long run, it’s simply a matter of ensuring that we give ourselves enough time to find new resources with which to feed our economy before exhausting the old.

On top of that, the authors make allowances for the possibility that technological advances could alter the situation down the road. However, until we know with some degree of confidence that humanity will not be limited to the Solar System someday, it is best not to be counting on future advances to save us. As Dr. Elvis summarized:

“Our 1/8 principle is no immediate break on making space trillionaires. Even a space economy 10 times bigger than the world’s current economy leaves a lot of room for a bunch of them. Of course, four hundred years from now we may have found new physics that lets us escape the straight-jacket of the speed of light. That would open up potentially endless growth. On the other hand, do we want to become one of those science fiction species that raids world after world for its resources regardless of the locals?”

“We do allow all sorts of ways out of the problem, e.g. growth that stops being exponential with plenty of time left, would not pose the same problems,” added Milligan. “And, of course, we are looking at the Solar System as a closed system. Not much in, not much out. Interstellar capabilities, and the capacity to draw upon materials from elsewhere, or simply to grow elsewhere, would also change matters. But we work with a precautionary principle: we can’t just assume that futuristic technology will always be there when it’s needed.”

Planning for the next 500 years may seem a bit dramatic and excessive. But considering what has taken place in the last 500, it makes sense to come up with a framework for handling what are sure to be some very drastic changes. It is also not farfetched at all to assume that these changes will dwarf anything we’ve experienced in the past. Beyond that, as Milligan said, everything is pretty much the stuff science fiction!
Deep Field: Nebulae of Sagittarius
Image Credit & Copyright: Emilio Rivero Padilla

Explanation: These three bright nebulae are often featured on telescopic tours of the constellation Sagittarius and the crowded starfields of the central Milky Way. In fact, 18th century cosmic tourist Charles Messier cataloged two of them; M8, the large nebula just left of center, and colorful M20 on the top left. The third emission region includes NGC 6559 and can be found to the right of M8. All three are stellar nurseries about five thousand light-years or so distant. Over a hundred light-years across, the expansive M8 is also known as the Lagoon Nebula. M20's popular moniker is the Trifid. Glowing hydrogen gas creates the dominant red color of the emission nebulae. In striking contrast, blue hues in the Trifid are due to dust reflected starlight. Recently formed bright blue stars are visible nearby. The colorful composite skyscape was recorded in 2018 in Teide National Park in the Canary Islands, Spain.

Source: NASA APOD