`"The Southern Cross"

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HERMANUS ASTRONOMY CENTRE NEWSLETTER

JUNE2020

Monthly meeting There will be no meeting in June, due to the coronavirus pandemic.

2020 meeting dates For your diaries. Remaining meeting dates are: 20 July, 17 August, 21 September, 19 October and 16 November.

WHAT'S UP?

Leo The eponymous crouching lion (upside down from the southern hemisphere) can be seen towards the north this month, its body's shape formed by its brightest three stars. The question-mark shaped pattern of stars which marks the animals head is called the Sickle. This area is the source of the Leonid meteor shower which occurs every November. The 12th largest of the 88 constellations, Leo is an ancient constellation. In Greek mythology, it represented the lion with the impenetrable hide which was killed by Hercules in the first of his twelve labours. Leo's brightest star, Alpha (α) Leonis (Regulus), is located at the lower front corner of the lion's body. It is 39 light years away from Earth. The second brightest star Beta (β) Leonis (Denebola) is closer, at 39 light years distance. It is located at the rear, lower corner of the animal. At the base of the head, marking another corner, is Gamma (γ) Leonis (Algieba). All are easily seen with the naked eye.

LAST MONTH'S ACTIVITIES

Monthly centre meeting No meeting took place in May, due to the coronavirus pandemic.

Interest groups

Cosmology No meeting took place in May, due to the coronavirus pandemic.

Astro-photography No meeting took place in May due to the coronavirus pandemic.

Other activities

Educational outreach

Analemmatic sundials at schools When possible, work will continue on these at several Overstrand schools.

THIS MONTH'S ACTIVITIES

Monthly centre meeting The presentation scheduled for 22 June has been cancelled, due to the coronavirus pandemic.

Interest group meetings

The **Cosmology** group meets on the first Monday of each month. There will be no meeting in June, due to the coronavirus pandemic.

There is an entrance fee of R10 per person for members, R25 per person for non-members, and R10 for children, students and U3A members. For further information on these meetings, or any of the group's activities, please contact Derek Duckitt at derek.duckitt@gmail.com

Astro-photography This group meets on the second Monday of each month. There will be no meeting in June, due to the coronavirus pandemic.

To find out more about the group's activities and the venue for particular meetings, please contact Deon Krige at astronomy.hermanus@gmail.com

Hermanus Youth Robotic Telescope Interest Group There is no update.

For further information, please contact Deon Krige at deonk@telkomsa.net

Other activities

Stargazing No events will take place during the coronavirus pandic.

FUTURE TRIPS

No outings are being planned, at present.

2019 MONTHLY MEETINGS

Unless stated otherwise, meetings take place on the **third Monday** of each month at the **Catholic Church Hall**, beginning at **19.00**. Details for the first part of the year are:

22 June	Cancelled
20 July	'Designing and building a mobile home observatory." Presenter: Pierre de Villiers, Centre chariman
17 Aug	'Further unusual curvaceous geographical wonders of Earth." Presenter: Jenny Morris, Centre member
21 Sept	Topic: TBA. Presenter: Eddy Nijeboer, Cape Centre, CT
19 Oct	'Cosmic ray astronomy.' Presenter: Dr Pieter Kotze, SANSA
16 Nov	'1820 and all that: Establishment of the observatory, and scientific connections with the Cape' Presenter: Jenny Morris, Centre member

ASTRONOMY SELF-GUIDED EDUCATION CENTRE (ASEC)

Work continues on planning and administrative requirements for work to begin on the proposed Astronomy Self-guided Education Centre, to be located within the existing whale-watching area at Gearing's Point.

The **Friends of the Observatory campaign** was launched several years ago when preliminary work began on plans to construct an astronomical observatory in Hermanus. Over the years, members have been very generous, for which we are deeply grateful. It may seem logical to assume that, now money has been awarded by the National Lotteries Board, pledge monies are no longer needed. Unfortunately, that is not the case. NLC funds can only be used once the plans have been formally approved by the Municipality.

We would, therefore, be very grateful if members could either continue to contribute to the campaign or start becoming a contributor. Both single donations and small, regular monthly donations, of any amount, are welcome. Contributions can take the form of cash (paid at meetings), or online transfer, The Standard Bank details are as follows:

Account name – Hermanus Astronomy Centre
Account number – 185 562 531
Branch code – 051001

If you make an online donation, please include the word 'pledge', and your name, unless you wish to remain anonymous.

ASTRONOMY NEWS\

Fast radio bursts could be distant magnetars, new evidence suggests 4 May: In recent years, enigmatic events called fast radio bursts (FRBs) have captivated radio astronomers. These brief but incredibly bright radio pulses last only a fraction of a second, yet they have been found in distant galaxies across the universe. Although the discovery of the first FRB in 2007 caught researchers somewhat flat-footed, it ultimately led to many theories about what drives these strange pulses. There is a problem, however: Astronomers have only seen FRB-like events in distant galaxies, which makes them hard to study in detail. That seems to have changed last week.

On 28 April, two radio telescopes spotted a new FRB-like pulse originating from a flaring magnetar located some 30,000 light-years away, putting it firmly within the Milky Way. Just a few days later, they detected another burst from the same nearby object. With the detection of these events, astronomers are optimistic they have spotted a nearby example of a possible source of distant FRBs, namely, highly magnetic neutron stars. A neutron star is the compact core left over after the death of a once-massive star. Because neutron stars have no internal fusion, their uncontested gravity causes them to collapse until a mass a few times that of the Sun is compressed into a ball of neutrons about 20 km wide. Sometimes, neutron stars also sport prodigious magnetic fields. Aastronomers call these stars magnetars.

The magnetic field of a magnetar is about a hundred million times stronger than any human-made magnet. That is strong enough that a magnetar would horrifically kill you if you got within about 1,000 km of it. There, its insanely strong magnetic field would pluck electrons from your body's atoms, essentially dissolving you. Though much about magnetars remains unknown, astronomers do know they are capable of releasing occasional giant flares - strong bursts of radiation across the electromagnetic spectrum. As such, astronomers have theorised that FRBs could simply be flaring magnetars located in distant galaxies, even though they had never before detected an FRB from any known nearby magnetars.

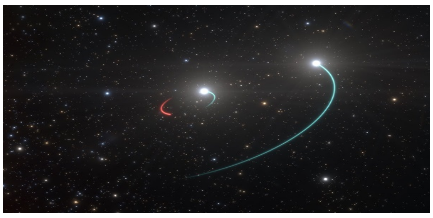
Shortly after the initial detection of a possible FRB-like flare from a nearby magnetar last week, researchers sent two telegrams via *The Astronomer's Telegram* (ATel), a web-based bulletin board where astronomers can post about pressing observations. The ATels outlined that a bright radio burst was spotted in the direction of a magnetar in our Milky Way called SGR 1935+2154, located in the constellation Vulpecula. It' i important to note, however, that ATels are not published papers. They instead serve as a way for astronomers to announce time-critical discoveries to the larger astronomical community. Both of the telescopes involved in the initial detection - the Canadian Hydrogen Intensity Mapping Experiment (CHIME) and the Survey for Transient Astronomical Radio Emission 2 (STARE2) in California - are designed to monitor large areas of the sky for FRBs or FRB-like radio signals. The first radio burst, which lasted just 30 milliseconds, had several FRB-like properties. It was also the very first time this magnetar had ever been detected in radio frequencies.

There was one key difference between this flare and more distant FRBs, though. If this burst happened at the distance of the closest-known FRB beyond the Milky Way, it would be about 1/1,000 as bright. (X-ray telescopes also reported via ATels the detection of a "burst forest" of radiation at the same time as the radio burst, albeit about a hundred times weaker than a typical giant flare from a magnetar). A few days later, the Five-hundred-meter Aperture Spherical radio Telescope (FAST) in China detected another burst from the magnetar, which indicates it is entering an active radio phase.

Although much fainter than distant FRBs, spotting nearby bursts with FRB-like properties is a startling discovery for astronomers who have long wondered whether fainter versions of FRBs exist close to Earth, even if they rarely flare. "We can imagine FRB intensities occur on a range of luminosities, and we are only detecting the brightest ones now," says Shri Kulkarni, an astronomer at the Caltech and investigator for STARE2. This assumption, combined with their data, led the STARE2 group to go as far as stating in their bulletin that "we conclude active magnetars are a source of FRBs at extragalactic distances."

The CHIME radio telescope team has not yet drawn such a strong conclusion, but they are nonetheless also excited about the new nearby burst. "It's certainly not as bright as the FRBs coming from far away," says Paul Scholz, an astronomer at the University of Toronto and lead author of the CHIME bulletin. "But it's definitely a tempting connection to make." It is far too early to draw a firm conclusion about whether this relatively faint FRB-like signal is the first example of a galactic fast radio burst - making it the smoking gun to unlocking the entire FRB mystery. There are also still many preliminary questions left to answer. How often do these fainter bursts happen? Are they beamed so not all radiation is equally bright in all directions? Do they fall on a spectrum of FRBs with varying intensities, or are they something new? How are the X-ray data connected? By: Yvette Cendes

Astronomers find the closest (known) black hole to Earth 6 May: Astronomers have discovered a black hole that is closer to Earth than any found before. Located about 1,000 light-years away in the southern constellation Telescopium, the black hole weighs in at some four times the mass of our Sun, which means it's only about 12 km wide.



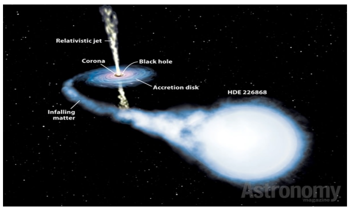
This system HR 6819, contains two stars that orbit a hidden black hole several times larger than our sun. ESO/L. Calçada

The researchers found the hidden beast while tracking binary stars using at telescope at La Silla Observatory in Chile. When they looked at the double star system HR 6819, they noticed that the inner star orbits quickly, while the outer star slowly chugs along. This meant the stars are not just circling each other. Some unseen third object has to be located near the centre of the system. The hidden object and the inner star dance around each other every 40 days. Meanwhile, the outer star slowly circles the pair much farther out Because the invisible object is at least four times the mass of the Sun, it can only be a black hole, the astronomers say.

Because black holes try not to betray themselves, finding a quiet one that is not actively devouring a neighbour is difficult. However, even without emitting light themselves, the gravitational effects black holes have on other visible objects can be very revealing. For instance, on a dark, clear night in the Southern Hemisphere, you can actually see the two stars that orbit the black hole in HR 6819 with your naked eye. "We were totally surprised when we realised that this is the first stellar system with a black hole that can be seen with the unaided eye," study co-author Petr Hadrava said.

Black holes form when very large stars collapse at the ends of their lives. And while they may seem exotic to us, cosmically speaking, these stellar-mass black holes should be extremely commonplace. Scientists expect our Milky Way Galaxy should hold hundreds of millions of them. Yet, so far, just dozens have been discovered. The stellar-mass black holes that astronomers have discovered were only found because they are acting like cosmic lighthouses, shooting off X-rays as they violently consume things like gas and stars. However, these extreme objects are actually not representative of what astronomers expect to be out there. There should be a silent majority of black holes quietly lurking, not eating anything. Though HR 6819 is one of just a few covert black holes ever found, there should be countless more just like it. "This is really only the tip of the iceberg," said Marianne Heida, an astronomer with European Southern Observatory.

And as astronomers seek out more and more hiding black holes, they expect to find them closer and closer to Earth. Hadrava estimates there should be black holes within a few dozen light-years of Earth, which would put them closer than some of the brightest stars in our night sky. In comparison, the previous record holder for closest black hole is V616 Monocerotis, which is nestled in a binary system more than 3,000 light-years away. "Just looking at the number of black holes that we expect in the Milky Way, I would be very surprised if there aren't a few of them still closer by than HR 6819," Heida said.



The third-closest known black hole to Earth is in the Cygnus X-1 system. In this artist's concept, the black hole reveals itself to astronomers as it steals material from blue supergiant star HDE 226868. Astronomy: Roen Kelly after NASA

Discovering these black holes is not just about catalouging objects, either. Researchers need to find them to test their theories of how stars both live and die. "Astronomers have a pretty good idea of stellar evolution in general, but the details are not quite settled yet, especially when it comes to the most massive stars that leave behind black holes," said Heida. Scientists are also still uncertain how living in a system with multiple large members affects the evolution of the stars within. "Those aspects are actually really important because massive stars produce [and release] all the elements in the universe other than hydrogen and helium," she added. "And pretty much all of them are in systems with multiple stars." Another surprising unknown is that astronomers do not understand exactly how supernova explosions work. However, because some supernovae can produce black holes, one way to test competing theories is to compare the number and sizes of known black holes to what various supernova theories predict. So, the more examples they add to the currently small list, the more accurately they can test if they are right.

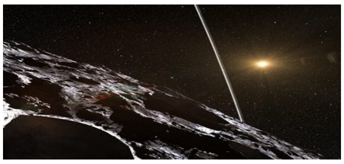
HR 6819 likely started its life as a triple star system before the third star collapsed into the black hole it is today. Though no planets are known in the system, if you were to visit a world circling the inner star, you would be treated to a mysterious sight. On Earth, a solar eclipse happens when the moon passes between us and our home star. On a hypothetical planet orbiting the inner star in HR 6819, the black hole would occasionally eclipse the outermost star. Instead of blocking out the outer star's light, the black hole would act as a magnifying glass. It would create what astronomers call a gravitational lens in the planet's night sky. Viewers of this bizarre eclipse would see a magnified glowing disk surrounded by a pitch-black ring.

The same pattern would appear if the black hole passed in front of a bright background star. The rest of the time, the black hole would only be seen when it consumed some stray bit of gas or a space rock. "Otherwise, the black hole should be black and invisible," said Dietrich Baade, an astronomer at the European Southern Observatory. The awe-inducing arrangement of HR 6819 is not unique, though. Systems with multiple stars account for most of the stars in our galaxy. So, by looking for more peculiar orbits within these systems, astronomers should be able to uncover more hidden black holes.

However, that would still leave a large number of black holes impossible to detect with current methods. Astronomers think that the violent events that give birth to black holes - supernovae - also gives their stellar partners a gravitational kick that flings them into space. Without being able to see how things orbit around it, it is currently impossible to detect a lone black hole. So, for the foreseeable future, astronomers must continue searching multiple star systems to find these muted monsters. "We need to come up with clever ways to search for [black holes] in the vast amount of data that is already available," Heida said. By: Eric Betz

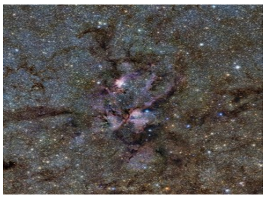
Astronomers think they have found 19 alien objects lurking in the solar system

7 May: Our solar system seems to be hiding a small group of alien objects that began their lives around another star before moving to our cosmic neighbourhood. New research suggests that 19 Centaurs - icy asteroids with occasional cometlike behaviour that usually orbit between Jupiter and Neptune - did not originate in our solar system. Instead, the researchers propose the icy rocks were stripped, individually or en masse, from a nearby star when the Sun was just a newborn in a larger stellar nursery.


New research suggests 19 icy objects trapped in the solar system for billions of years likely came from an alien star. ESO

"Astronomers have known for a long time that there should be asteroids circling the Sun that were not formed in the solar system, but instead were captured early on during the formation of the planets," said Fathi Namouni, an astronomer at the Observatoire de la Côte d'Azur in France. "The difficulty was that we could not tell which are solar system-born and which are extrasolar-born."

Rewinding the solar system's 4.5-billion-year history is a challenge at best. Over such large timescales, small differences in our models can produce dramatically different results. This led Namouni and his colleagues to take a statistical approach. After preselecting a group of Centaurs, they made millions of virtual clones, then rewound the trajectories of those clones back in time. They found the objects seem to have had polar orbits around the Sun, perpendicular to the plane of the solar system. These unusual orbits, the researchers say, indicate the objects initially came from another star. "They've chosen a great problem," says astronomer Kat Volk of the University of Arizona Department of Planetary Sciences. Although not involved with the new research, Volk uses simulations to study objects at the outer edges of the solar system. Regarding the apparent interstellar travellers, she says, "we don't have a great explanation for how you would make these objects."


The Lobster Nebula (NGC 6357), example of a stellar nursery. ESO/VVV Survey/D. Minniti. Acknowledgement: Ignacio Toledo

Nearly 5 billion years ago, the Sun was part of a larger collection of baby stars born in cluster. Following the Sun's formation, the leftover material nearby clumped together, forming a rotating disk that ultimately built the planets. However, the details of how our solar system formed remain uncertain. The current idea is that the ice giants Uranus and Neptune traded places, pushing remaining icy debris farther away from the Sun. A fifth giant planet may also have orbited the Sun, eventually ejected by interactions with our solar siblings. And it's possible that a yet-unseen planet, nicknamed Plant Nine, remains hidden somewhere in the outskirts of the solar system.

All of these problems have made it incredibly complicated to trace back the orbits of objects that emigrated from other stars. However, Namouni and his colleagues soon realizsd that knowing how an object first orbited the Sun could help. In 2018, Namouni and his colleagues revealed the likely interstellar origins of asteroid Ka'epaoka'awela, which roughly means "mischievous, opposite-moving companion of Jupiter" in Hawaiian. Initially spotted in 2014, Ka'epaoka'awela has an unusual, high-inclination orbit, meaning it ventures far above and below the plane of the solar system. Because of the challenge of retracing the path of an individual object, the researchers decided to try a new way of tackling the problem. "We found a way to beat [the chaos] - at a price," Namouni said. "By cloning [an] asteroid's orbit a million times, we can navigate what mathematicians call the chaotic sea and find the stability islands that the centaurs occupy."

The tradeoff of this method is that you still cannot really track precisely where a given Centaur was 4.5 billion years ago. The researchers only know the statistical probability of where a given asteroid was at the beginning of our solar system. The researchers used this method to reveal that Ka'epaoka'awela's orbit - even 4.5 billion years ago - also dipped above and below our solar system's disk of planet-forming material. As mentioned, such an off-kilter orbit suggests that the asteroid initially came from outside the solar system. "One of the important consequences of that work was to point out that there should be more Centaurs on high-inclination orbits that did not belong to the solar system," Namouni says. "So we set out to find them. And we did."

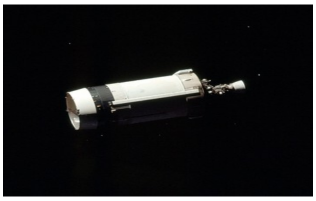
Namouni and his colleagues targeted 19 high-inclination objects with their clone-rich simulation. To their surprise, they found that the tilted orbits of all 19 objects could extend to the beginning of the solar system. In all, this shed doubt on a local origin for the Centaurs When the Sun was born, many of its stellar siblings began their lives at the same time. Since then, the stars have gone their separate ways. However, if planetary formation happened while they were still living under the same cosmic roof, then material could have been traded between the nearby star systems. Did they all swap material at the same time? Or was it more akin to getting hand-me-downs, where the trades came in separate bursts? The researchers hope to answer this question by determining whether the Centaurs came to our solar system as a group or trickled in, one by one.

The presence of extrasolar material in the solar system is not a surprise. "It is entirely possible that we do have populations of small bodies that do originate around other stars," Volk says. Other studies indicate that much of that alien material likely hides in the Oort Cloud - a huge, nebulous sphere of icy material that encases our solar system, beginning a few thousand times farther from the Sun than Earth. "It's possible that the authors of the paper are correct," Volk says. "I just don't think that what they've done in the paper supports that conclusion." Volk's chief concern is the extreme lifetime of the clone model. "I don't buy that you can do that over billion-year timescales," she says. While she thinks rewinding many clones might be an effective strategy over a few tens of millions of years, she doubts the inherent chaos would allow the models to function over 4.5 billion years. "It's just inherently very difficult to do these kinds of backwards integrations and have the results be representative," Volk says.

Another major concern Volk has is that Namouni and his team omitted planetary migration from their calculations. "They are completely neglecting that, and I don't agree with their arguments that that is not important," she says. Namouni says that the large polar orbits of these apparently alien objects means that the Centaurs spend very little time in the region where planetary migration could interfere. That includes the hypothetical Planet Nine, whose influence Volk was also concerned about. Namouni argues that the new method allows researchers to be agnostic about the early solar system conditions that remain uncertain. "Our situation cannot be fine-tuned to change its outcome," Namouni says. "It only has one outcome." That outcome, of course, is that the 19 Centaurs examined were all born around other stars. By: Nola Taylor Redd

How a long-gone Apollo rocket returned to Earth 11 May: On 3 September 2002, amateur astronomer Bill Yeung discovered an object that he believed was a never-before-seen asteroid in a rapid orbit around Earth. While it is easy for massive planets such as Jupiter to frequently capture objects like asteroids and comets, Earth is smaller and has less gravitational oomph with which to influence interplanetary passersby. Yeung's discovery, formally named J002E3, became the focus of an intense analysis with a unique result. The object was not an asteroid captured by Earth in a cosmic game of coincidence. This was a relic of humanity's space race: an Apollo-era rocket that had been placed in orbit around the Sun - and then returned to Earth.

Yeung was already well known in astronomy circles for his prolific discovery of other asteroids - J002E3 was simply one more to add to his collection. astronomers at the Minor Planet Centre quickly realized that J002E3 was not an asteroid. Its unusual orbit made some suspect that it was, in fact, human-made - a leftover piece of space hardware. An analysis of recent launches did not identify any possible candidates for the source of the object. Scientists at the Jet Propulsion Laboratory (JPL) in Pasadena, California, tracing back the object's trajectory, discovered that it had been captured in April 2002 into Earth orbit from an orbit around the Sun that was similar to Earth's. Backtracking even further, the object appeared to have gotten into its Sun-circling orbit after originally escaping Earth orbit all the way back in February 1971. This gave researchers some potential clues as to the origin of J002E3.


S-IVB, seen floating through space, was thought to be an asteroid. NASA

Another team of scientists from the University of Arizona and MIT performed a spectroscopic analysis of J002E3, looking at the light it reflected to search for chemical fingerprints to determine what it was made of. They made a startling discovery: J002E3 appeared to be covered in paint - specifically, white, titaniumoxide (TiO_2) paint. According to Kira Jorgensen Abercromby at California Polytechnic State University, who also studied J002E3 while at the Air Force Maui Optical & Supercomputing observatory, “What we saw were features in the spectral data that matched other upper-stage rocket bodies launched during a similar time frame [to the Apollo missions] and the data also matched typical features found in organic paints that looked like TiO_2.”

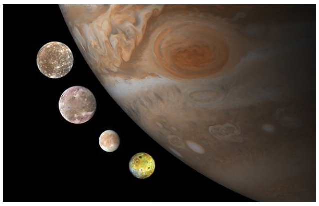
This information pointed toward a very specific object as the identity of J002E3: a spent third stage from an Apollo-era Saturn V rocket, which were historically covered in this specific kind of paint. The massive Saturn V propelled the Apollo astronauts to the Moon and later lofted the Skylab Space Station into orbit around Earth. While 18 complete Saturn V rockets were built, only 13 were ever launched (the rest were built for testing or never used once Apollo’s funding dried up). The Saturn V was a three-stage rocket. The first and second stages of the Saturn V fell back to Earth once they were spent. The third stage, known as the S-IVB, was just under 18 metres in length and, once released, temporarily orbited Earth along with the Apollo spacecraft before being reignited to send its hardware into lunar orbit. Of note, the Apollo 7 mission used the smaller Saturn IB rocket, which also used an S-IVB as a second stage. According to Amy Shira Teitel, host of YouTube’s The Vintage Space, “Without the S-IVB, the Apollo Moon landings couldn't have happened.”

If J002E3 was, in fact, a spent S-IVB, the next question researchers asked was, “Which one was it?” Early test flights with the S-IVB all ended with the third stage splashing into the ocean or disintegrating during re-entry. This was also true for the S-IVBs from the Apollo 4, 5, 6, and 7 missions and the Saturn IB flights that carried astronauts to Skylab. The Apollo lunar landing missions numbered 13 through 17 all intentionally crashed their S-IVBs onto the lunar surface to create artificial moonquakes that could be measured by seismic instruments placed by prior landings. It was the middle Apollo missions (numbered 8 through 12), however, that all intentionally placed their S-IVBs into heliocentric orbits. Any of these missions could have given rise to J002E3. Further analysis of J002E3 suggested it first left Earth orbit in 1969, narrowing things down to Apollo 9 through 12 (Apollo 8 orbited the Moon in December 1968).

Interestingly, while the S-IVB from Apollo 12 was supposed to be placed into a heliocentric orbit, this particular S-IVB instead had ended up in a very distant orbit around Earth. This lent credibility to the idea that J002E3 could have come from Apollo 12, since scientists already knew that J002E3 had left Earth orbit in 1971. The other S-IVBs from Apollo 9, 10, and 11 were confirmed to be in heliocentric orbits. Thus, by process of elimination, J002E3 is almost certainly the S-IVB from Apollo 12.

Many people find the notion of discovering an intact piece of Apollo-era hardware appealing, and these feelings are amplified by the large size of the Apollo S-IVB. "Flown Apollo hardware will always be significant," says Teitel. "We've been to the Moon nine times and most of the hardware that enabled those missions was destroyed - the Saturn V stages crashed into the ocean or were smashed into the Moon, most of the lunar module ascent stages were smashed into the Moon, and the service modules didn't return. That leaves nine command modules, all of which are on display in museums. Flown hardware has an allure simulators and non-flown items just don't have." In the case of J002E3, the hardware is still flying. Shortly after its discovery, the object left Earth orbit in 2003, returning to a heliocentric orbit. Researchers suggest that it may yet be recaptured by our planet, with the first opportunity for this coming up in the mid-2040s. By: Doug Adler

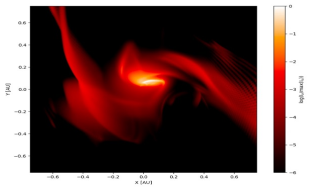
Astronomers re-create the formation of Jupiter's Galilean moons using new theory 18 May: Using insights gleaned from studying exoplanets, astronomers have developed a new theory that explains the formation of all of Jupiter's Galilean moons. The team, led by Konstantin Batygin of Caltech, then went on to use the theory to create computer simulations emulating the moons' formation. The results were promising.


From bottom to top is Io, Europa, Ganymede, and Callisto. Jupiter is shown to scale on the right. Moons: NASA/JPL/Galileo; Jupiter: NASA/JPL/Space Science Institute; Image data processing and layout: Kevin M. Gill

As Batygin tells Astronomy, the simulations included one run that was so close to reality that he "had to do a double take." It was so jarring, he says, "I went on a run to calm down. Came back. And looked at it again." The researchers tell a story of how the Jovian moons built themselves up - one by one - from tiny motes of icy dust left over from the initial formation of the solar system. Once large enough, each moon then migrated inward, eventually settling into a clockwork-like orbit.

Previous attempts to understand the origin of planets and moons were tailored to explain our own solar system. However, those theories did not work when we tried to apply them to the dizzying array of exoplanetary systems discovered in the last few dozen years. "The exoplanet revolution over the last two decades has completely rewritten the story of how planets form," Batygin says. He compares this to becoming a karate master, but then emerging from your dojo and learning about the many other martial arts practiced around the world. So, based on the most up-to-date exoplanet data, Batygin thinks it might be time to rewrite our understanding of how moons are made."The best model up until now of satellite formation is from two decades ago, and things have advanced since then," he says. "The question of why the icy moons are there is one we know embarrassingly little about." To help shed light on the moon mystery, Batygin, along with Alessandro Morbidelli of the Côte d'Azur Observatory, set out to explain how our solar system's largest planet, Jupiter, got its satellites.

Their new theory paints a picture of a young Jupiter surrounded by an extended disk of gas, called a circumplanetary disk. As material circulated through the solar system in its early years, Batygin says Jupiter's circumplanetary disk served as a 'dust trap' that captured tiny specks of icy matter about 10 mm wide. Over time, the amount of icy dust in the disk continued to grow, leading to more and more collisions and mergers between particles. Eventually, countless 'satellitesimals' - bodies that are about 100 km wide - began to form. These bodies then continued to further clump together until they eventually grew into the embryo of a full-fledged moon.



This beautiful high-resolution simulation shows such a disk around the young exoplanet PDS 70 c.M. Schulik et al.

As this first growing satellite orbited within the dusty disk, it would have left a spiral wake in its path. This wake, as well as increased drag from the remaining gas in the disk, steadily pulled the moon closer to Jupiter. Eventually, the newborn moon reached the inner edge of the disk, exited the feeding zone, and, as the paper describes, halted its 'migratory trek' inward. Finally, this same process repeated, leading to the sequential creation of Jupiter's four Galilean moons, working from inside to out. According to Batygin, Jupiter's innermost moons - Io and Europa, respectively - formed in only about 6,000 years. Ganymede, the next closest, took about 30,000 years. However, according to the theory, by the time icy Callisto started to coalesce, the strengthening Sun had evaporated much of the gas that was initially in Jupiter's disk. So, although Callisto reached about half of its final mass in just 50,000 years, it took nearly 9 million years to accumulate the rest.

While elements of this theory have been suggested before, Batygin says their version includes a new understanding of how dust trap work. This, they claim, resolves the longstanding difficulty of accounting for all, not just some, of the matter needed to form the Galilean moons we see today. The theory also explains how the orbits of Io, Europa, and Ganymede developed their striking orbital resonance, which has fascinated scientists for centuries. For every single orbit outer Ganymede makes, Europa makes two, and innermost Io makes four - returning to their initial setup every 172 hours. According to Batygin, their new theory explains how this relationship could have developed in a stable way: Europa first locks into a pattern with Io, then Ganymede later syncs up with Europa.

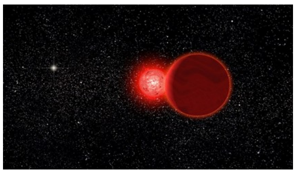
Although the team has been working on the theory since 2018, it was not until last year that observations confirmed their logic and calculations. In 2019, astronomers observing the PDS 70 system, located some 370 light-years away, found the first example of a moon-forming disk circling an exoplanet. And, as Batygin says, "It was far dustier than anyone could have guessed." The theory was further bolstered by additional observations in 2019 that showed signs of gas circulating through the HD 163296 system, much like the new model predicts.

Searching for exoplanets is not just about looking for ET. Another large motivator is that learning about distant worlds can reveal a lot about our own solar system, as well as Earth itself. For instance, Miki Nakajima, an assistant professor at the University of Rochester, tells Astronomy she believes insights from exoplanets also inspired Babygin's well-known predition of Planet Nine, a hypothesised super-Earth lurking in the outer solar system. "Observations of exoplanet systems have provided us windows to observe events that likely happened in the solar system in the past," she says, noting that this is motivating scientists to explore new formation mechanisms. "One of the novel parts of this work is to provide a complete history of the moons," Nakajima says. She doesn't think it would have been possible to test these ideas without the numerical simulations that exist now.

Jonathan Lunine, a planetary scientist at Cornell University who put forward one of the earlier influential models of how Jupiter's moons may have formed, tells Astronomy he is interested in knowing more about the formation of Ganymede and Callisto. Though these two moons are similar in size, they have drastically different geological histories. Lunine says future missions to the moons could take more detailed measurements of their gravitational fields, revealing more about their interiors and providing insights into the differences between the two. Though the new research focuses specifically on spelling out the history of Jupiter's icy moons, Batygin believes its concepts could also apply to Saturn, as well as distant gas giant exoplanets. By: Erica Naone

Wandering stars pass through our solar system surprisingly often 21 May: Every 50,000 years or so, a nomadic star passes near our solar system. Most brush by without incident. However, every once in a while, one comes so close that it gains a prominent place in Earth's night sky, as well as knocks distant comets loose from their orbits.

The most famous of these stellar interlopers is called Scholz's Star. This small binary star system was discovered in 2013. Its orbital path indicated that, about 70,000 years ago, it passed through the Oort Cloud, the extended sphere of icy bodies that surrounds the fringes of our solar system. Some astronomers even think Scholz's Star could have sent some of these objects tumbling into the inner solar system when it passed. However, Scholz's Star is relatively small and rapidly moving, which should have minimized its effect on the solar system. In recent years, scientists have been finding that these kinds of encounters happen far more often than once expected. Scholz's Star was not the first flyby, and it will not be the last. In fact, we are on track for a much more dramatic close encounter in the not-too-distant future. "[Scholz's Star] probably didn't have a huge impact, but there should be many more stars that have passed through that are more massive," said astronomer Eric Mamajek of NASA's Jet Propulsion Laboratory,


Scholz's Star and its binary brown dwarf Michael Osadciw/U of Rochester

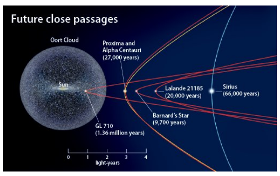
Around Christmas 2013, Mamajek was visiting a friend and fellow astronomer, Valentin Ivanov, at the offices of the European Southern Observatory in Santiago, Chile. While the two chatted, Ivanov was looking at recent observations of a star catalogued as WISE J072003.20–084651.2. The star caught Mamajek's interest because it was just about 20 light-years away, but astronomers had not noticed it thanks to its dim nature and tiny apparent movement (or proper motion) across our night sky. To him, those two things were a clue. Since it did not appear to be moving much side to side, the star was likely moving toward us or away from us at a breathtaking pace.

As the astronomers continued talking, Ivanov measured the star's radial velocity to learn how quickly it was moving toward or away from our Sun. Soon, they had their answer. "Within five or 10 minutes, we had the initial results that this thing came within a parsec

[3.26 light-years] of the Sun," Mamajek says. "It was screaming through the solar neighbourhood." The two astronomers and their colleagues would eventually show that it passed even closer than that. In fact, it passed closer to our Sun than any other known star. This status prompted them to name the cosmic trespasser after its discoverer, astronomer Ralf-Dieter Scholz, who has devoted significant time to finding nearby stars.

Mamajek has since moved on from studying Scholz's Star. In the meantime, other astronomers have also taken up the work. Thanks to a European Space Agency satellite called Gaia, which is built to map the precise locations and movements of over a billion stars, we now know about other close encounters. In 2018, a team of researchers led by Coryn Bailer-Jones of the Max Planck Institute for Astronomy in Germany, used Gaia data to plot our Sun's future meet-ups with other stars. They discovered nearly 700 stars that will pass within 15 light-years of our solar system over just the next 15 million years. However, the vast majority of close encounters have yet to be discovered, the team suggests. They suspect roughly 20 stars should pass within just a couple light-years of us every million years. However, "space is big," Mamajek points out. "Statistically, most of those stars would pass the outer edge of our solar system." That means encounters like the one with Scholz's Star are common, but only a few are close enough to actually dislodge a significant number of comets, Nonetheless, a few stars should still come surprisingly close. If a large, slow-moving star did pass through the edge of the Oort Cloud, it could really shake up the solar system.

A massive star steamrollering through the outer solar system is exactly what Gaia data show will happen less than 1.4 million years from now, according to a 2016 study. A star called Gilese 710 will pass within 10,000 astronomical units - 1 AU is equal to the average Earth-Sun distance of 93 million miles. That is well within the outer edge of the Oort Cloud. At half the mass of the Sun, Gliese 710 is much larger than Scholz's Star, which is just 15 percent the mass of the Sun. This means Gliese 710's hulking gravity could potentially wreak havoc on the orbits of icy bodies in the Oort Cloud. While Scholz's Star was so tiny it would have been barely visible in the night sky - if at all - Gliese 710 is larger than our current closest neighbor, Proxima Centauri. So, when Gliese 710 reaches its closest point to Earth, it will burn as a brilliant orange orb that will outshine every other star in our night sky.



Many stars will pass close to the Oort Cloud, only one will move through it. Astronomy: Roen Kelly

This event could be "the strongest disrupting encounter in the future and history of the solar system," the authors wrote. Fortunately, the inner solar system is a relatively tiny target, and even if Gliese 710 does send comets flying our way, it would take millions of additional years for these icy bodies to reach us. That should give any surviving future humans plenty of time to take action. In the meantime, they can enjoy watching what may be one of the closest stellar flybys in the history of our solar system. By: Eric Betz

Pluto's strange atmosphere just collapsed 22 May: Pluto's atmosphere is hard to observe from Earth. It can only be studied when Pluto passes in front of a distant star, allowing astronomers to see the effect the atmosphere has on starlight. When this happened in 2016, it confirmed that Pluto's atmosphere was growing, a trend that astronomers had observed since 1988, when they noticed it for the first time. Now, all that has changed - Pluto's atmosphere appears to have collapsed. The most recent occultation in July last year was observed by Ko Arimatsu at Kyoto University in Japan and colleagues. They say the atmospheric pressure seems to have dropped by over 20 percent since 2016.


Pluto NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute/Alex Parker

Astronomers have long known that Pluto's atmosphere expands as it approaches the Sun and contracts as it recedes. When the Sun heats its icy surface, it sublimates, releasing nitrogen, methane and carbon dioxide into the atmosphere. When it moves away, the atmosphere is thought to freeze and fall out of the sky in what must be one of the most spectacular ice storms in the solar system. Pluto reached its point of closest approach to the sun in 1989, and has since been moving away. However, its atmosphere has continued to increase to a level that is about 1/100,000 of Earth's.

Astronomers think they know why, thanks to the images sent back by the New Horizons spacecraft that flew past Pluto in 2015. These revealed an unexpectedly complex surface with widely varying colours. A mysterious reddish cap at the north pole turned out to be coloured by organic molecules. Also, a large, white, ice-covered basin called Sputnik Planitia stretched across a large part of one hemisphere. Planetary geologists think Sputnik Planitia plays an important role in regulating Pluto's atmosphere. That is because, when it faces the Sun, it releases gas into the atmosphere. Simulations suggest that this is why Pluto's atmosphere has continued to grow, even as it has begun to move away from the Sun. The simulations are complicated by Sputnik Planitia's colour, which determines the amount of light it absorbs, and this in turn is influenced by ice formation in ways that are hard to predict. Nevertheless, these same simulations suggest that, since 2015, Sputnik Planitia should have begun to cool, causing the atmosphere to condense into ice. Arimatsu and colleagues say that is probably what is behind their new observation.

There is a problem, however. The models suggest that Pluto's atmosphere ought to have shrunk by less than 1 percent since 2016, not the 20 percent observed by the Japanese team. So there may be some other factor at work that is accelerating Pluto's atmospheric collapse. The result must also be treated with caution. The effect of Pluto's atmosphere on distant starlight is small and hard to observe with the 60-centimetre reflecting telescope that the team used. They say the various sources of error in their measurement make it only marginally significant. Better observations from larger telescopes are desperately needed. However, this is unlikely to happen anytime soon. As well as moving away from the Sun, Pluto is moving out of the galactic plane, making stellar occultations much rarer and with less bright stars. That means the chances to make better observations in the future will be few and far between. The team concludes with a plea for astronomers to observe Pluto with bigger, more sensitive telescopes, By: The Physics Arxiv blog

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DID YOU KNOW?

Zodiac constellations 4 – Zodiac: astrology and astronomy


Babylonian astrology

In the 4th century BCE, Babylonian catalogues entered Greek astronomy. Chaldea became so strongly identified with astrology that 'Chaldean wisdom' became synonymous for Greeks and Romans with divination through the planets and stars. Horoscopic astrology first appeared in Ptolemaic Egypt. Ptolemy was the main Greek whose work laid the foundations for Western astrological tradition. Planets, houses and signs of the zodiac were rationalised and their function set down in a way little changed to present day.

Until the 17th century, astrology was considered a scholarly tradition and helped drive the development of astronomy. It was commonly accepted in political and cultural circles and many astronomers were employed as astrologers for their noble or royal patrons. Renaissance court astrologers would complement their use of horoscopes with astronomical observations and discoveries. Many now credited with having overturned the old astrological order eg Brahe, Galileo, Kepler were themselves practising astrologers.

Astrology was also used in other traditional studies incl alchemy, meteorology and medicine. In medieval Europe, university education was divided into seven distinct areas, each represented by a particular planet and known as the seven liberal arts. Dante linked these arts to the planets. As the arts were seen as operating in ascending order, so were the planets in decreasing order of planetary speed. Grammar was assigned to the Moon, the quickest moving celestial body. Dialectic was assigned to Mercury, rhetoric to Venus, music to the Sun, arithmetic to Mars, geometry to Jupiter and astrology/astronomy to slowest moving Saturn.


Astrology is no longer accepted as a science

By the end of the 17th century, scientific advances leg the telescope and emerging astronomical theories and concepts eg the heliocentric model undermined the theoretical basis of astrology. Astrology lost its academic standing and became regarded as a pseudoscience.

In both astronomy and astrology, although it is a star, the Sun has no constellation. So, a specific system has been devised to describe the Sun's position in relation to other, much more distant, stars. Over the course of a year, as Earth orbits the Sun, the Sun appears to trace a circular path ie the ecliptic. At the same time, the position of the other stars changes as Earth's position, relative to the Sun, changes. This means that, relative to the other stars, the Sun appears to moves in the sky thorough the year, apparently moving through the zodiac constellations. This is why the Sun is described as 'passing through' a particular constellation at certain times of year eg the Sun passes through Sagittarius from late December to late January.

The rest of this series will explore the characteristics and features of the thirteen constellations through which the ecliptic passes. It will start with Sagittarius, the constellation through which the Sun passes at the start of the calendar year.

Sources: Ridpath, I (Ed) 2012 Oxford dictionary or astronomy Oxford, OUP, Ridpath, I (Ed) 2006 Astronomy London, Dorling Kindersley, curious.astro.cornell.edu, en.wikipedia.org, lpi.usra.edu, universetoday.com

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