

THE FLINT RIVER OBSERVER

NEWSLETTER OF THE FLINT
RIVER ASTRONOMY CLUB

An Affiliate of the Astronomical League

Vol. 20, No. 11 **January, 2018**

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Please notify **Bill Warren** promptly if you have a change of home address, telephone no. or e-mail address, or if you fail to receive your monthly *Observer* or quarterly *Reflector* from the A. L.

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Club Calendar. Thurs., Jan. 11: FRAC meeting (7:30 p.m., The Garden in Griffin); **Fri.-Sat., Jan. 19-20:** JKWMA observings (at dark); **Mon., Jan. 22:** Sun City Peachtree indoor presentation, 7 p.m.); **Thurs., Jan. 25:** Sun City Peachtree observing (6 p.m. at the softball field); **Fri., Jan. 26:** Sun City Peachtree observing rainout date.

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Vice President's Message. Another year has come and gone, and a new year is poised to yield its surprises, challenges and blessings. As I looked around the room at our Christmas party, I recalled the words of the French writer **Francois de La Rochefoucauld**: "The more things change, the more they stay the same."

FRAC will be 21 years old this February. That's not bad for a club whose first president, **Larry Higgins**, was told that it wouldn't last six months. We persevered because (a) our founders – Larry, **Ken Walburn** and I – had a dream of what our club could become, (b) our early members bought into that dream and worked hard to make it a reality; and (c) the club attracted new members who were equally friendly and outgoing.

Re-enter La Rochefoucauld.

Over two decades, the times and the club's composition have changed – or have they? Not really. The faces have changed, but not the character of our members. We're still friendly and outgoing, we still enjoy getting together, and we still go out of our way to make visitors and new members feel at home.

We're not getting older, baby, we're getting better! Our membership has grown considerably in the past year. Attendance at meetings has skyrocketed, and despite needing fishing licenses attendance is up at our JKWMA observings, too. This year's Christmas party attracted ten more members and guests than last year's.

The latter was a pleasant surprise, of course. But what was even more pleasing to me was how many of those in attendance expressed their disappointment that other members were unable to attend and partake in the festivities.

That's why I've often said that *You are more important to FRAC than you think you are*. If you were at the Christmas party, your fellow club members enjoyed their time spent with you. And if you weren't there, you were missed.

Finally, I would be remiss if I overlooked the role that **Dwight** has played in FRAC's growth. He prefers to deflect praise toward me, but I'm just one of the mules pulling the plow. Dwight is the man steering the plow, the one who keeps the furrows

straight and gets the job done. Thanks, Dwight, for your capable leadership and all that you do for us.

-Bill Warren

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Last Month's Meeting/Activities. We had a record crowd of 36 at our Christmas party at Brian's: **Joe & Martha Auriemma; Dan Pillatzki; Mike & Danielle Stuart; Aaron Calhoun; Marla & Donnie Smith; Sean, Chelsea, Gianna & Isabelle Neckel; Elaine Stachowiak; Alan Rutter; Cindy & Lucy Barton; David, Cherrie & Sarah O'Keefe; Dwight & Betty Harness; Steve Hollander; Dr. Richard Schmude; Truman Boyle; Larry & Linda Higgins; Erik & Mason Erikson; Phil Sacco, Courtney Seabolt & Vicky Walters; Jeremy, Sarah, Emily & Delilah Milligan; and yr. editor.** The food, fun and fellowship was fabulous; some of the attendees stayed until 9:30 p.m. The waitresses thought we'd never leave.

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This 'n That. Here's an early reminder that your 2018 FRAC dues are up for renewal in February. They are still \$15 a year, which qualifies as one of the biggest bargains you'll ever see, considering what you get for it. If you joined last year and paid a pro-rated fee for 2017, remember that this time around you'll need to pay the full \$15 for 2018.

Checks should be made out to FRAC. You can mail in your check c/o **Dwight Harness** (1770 Hollonville Rd., Brooks, GA 30205) or **Bill Warren** (1212 Everee Inn Rd., Griffin, GA 30224). Or you can give it to one of them at a meeting or observing.

***Dwight Harness** is the proud owner of a new boat, a 25-ft. O'Day that sleeps five. Here's our open letter to Dwight about his new purchase:

Now that you've bought a new boat, you're likely to gain a new appreciation for the constellations. Consider:

You could name your boat *Aquarius* (the Water Bearer): It will bear you across the water when you Sail (*Vela*) on the River (*Eridanus*);

We hope you won't have a close encounter with the Water Snake (*Hydrus*), the Sea Serpent (*Hydra*),

or the Whale (*Cetus*). But maybe you'll catch some fish (*Pisces*) -- say, a dolphin (*Delphinus*), a swordfish (*Dorado*) or a flying fish (*Volans*);

You'll appreciate the Poop Deck (*Puppis*) when the girls occupy the head for hours at critical times;

Be sure to steer your keel (*Carina*) clear of sandbars, shoals, reefs, etc. If you don't, your survival may depend on the Air Pump (*Antlia*); and finally,

If your compass (*Pyxis*) and sextant (*Sextans*) don't work and you get lost at sea, do like **Moses** and look for *Columba* (the Dove).

*An open letter from our favorite Bulgarian FRAC member, **Vencislav Krumov**:

"Hello, folks. I want to make a small statement. I'm back in my home country, Bulgaria, and I'm delighted to announce that I started studying astronomy in the physics department of Sofia University. It's a master's-level course designed specifically for "non-specialists" – people with other educational backgrounds like me who need to start from the very basics.

"About 15 years ago, when I was finishing high school and choosing law as my career path, I made a promise to myself sooner or later to get back to physics and astronomy. So this is a realization of a dream for me. I do it only for my personal betterment and enjoyment. I just wanted to put all my amateur astronomy knowledge on a solid science foundation.

"I thank all of you in FRAC for inspiring me to rediscover my high school hobby to such an extent that I decided to make it professional.

"Best regards from snowy Bulgaria. -Venci."

*A. L. Outreach Coordinator **Maynard Pittendreigh** recently earned his 49th observing pin, the 2017 Solar Eclipse Special Observing Award. In case you think it was easy and you should have done it too, consider Maynard's comments: "The challenge was in finding evidence to support **Albert Einstein's** general theory of relativity, which treats gravity as a bending of space in the vicinity of objects containing mass.

"Massive objects like the **Sun** cause a curvature of space, and therefore bend the path of photons (light rays) passing nearby. The task was to photograph the area of the eclipse months before the event and then photograph not only the eclipse but

stars that appeared nearby. The challenge was to measure the deflection of starlight.”

Still...49 pins? **Phil Sacco** and **yr. editor** thought we were hot stuff because we've earned 16 pins!

***Question:** What is *gravitational lensing*?

Answer: When **Isaac Newton** formulated his laws of gravity in 1687, astronomers believed that they applied to everything in the universe. As time went by, however, they found things happening that couldn't be explained by those laws.

In 1915, the German-born physicist **Albert Einstein** published his general theory of relativity, which combined gravity with his earlier special theory of relativity (1905). Einstein theorized that (a) Space and time do not act independently of each other; rather, they operate together as a single entity, *space-time*; (b) When an object containing mass is small and traveling slowly (like me and you and a dog named Boo), it obeys Newton's laws of gravity; but (c) When an object is very large and traveling extremely fast (e.g., a distant galaxy), it can distort the fabric of space-time and bend the light from more distant objects.

Astronomers were slow to accept Einstein's theory that light doesn't always travel in a straight line. They accept it now, though, because it explains phenomena that couldn't be explained earlier.

Dr. Pittendreigh's 2017 Total Solar Eclipse project studied this phenomenon, using the **Sun** and nearby stars. Another example was “**Einstein's Cross**.”



Above: Einstein's Cross

When astronomers used the 200-in. Palomar Telescope to photograph a galaxy 400 million light-years away, they saw not one, but *five* objects in the photo: the galaxy, surrounded by four images of another object – a quasar lying 8 billion l.y. away

behind the galaxy. Gravity bent the quasar's light around the galaxy in four directions, creating a multiple image that resembles a cross or + sign.

That cross was not the first evidence to support Einstein's theory of general relativity, nor was it the only example of gravity serving as a lens to bend light. For example, on Sept. 5, 2016 astronomers using the Hubble Space Telescope photographed a supernova explosion that occurred directly behind a galaxy that is 2 billion l.y. away. As with Einstein's Cross, the galaxy bent the background light, producing four images of the supernova.

In case you still don't quite understand the concept of gravitational lensing, here's another way to look at it: Put a straw in a glass of water, and the straw will appear to bend. Gravitational lensing doesn't change what's there, it changes the way we see it.

*By definition, trivia questions deal with unimportant, little-known facts. Sometimes **yr. editor** uses brief trivia Q&A (or poetry) to fill gaps in the newsletter.

Normally, the answers to such questions are pretty much cut-and-dried: You either know the answer, or you don't. (If we thought you knew the answers, we wouldn't ask the questions.)

The following trivia question is different, though, because most astronomers think they know the answer, but they don't. It involves *escape velocity*.

The question: *If you were in a rocket headed for the Moon, how fast would you have to go to overcome the effects of Earth's gravity?*

Traditional wisdom says you'd have to travel 7 mi. per second, or 25,200 mph, in order to avoid being pulled back to Earth. And that's true, too, for projectiles that are propelled upward in a single, one-time burst like a gunshot or a Fourth of July skyrocket. But moonshots don't work that way. A single thrust of acceleration powerful enough to send a rocket all the way to the Moon would kill the astronauts at liftoff.

Our Apollo astronauts' mighty Saturn V booster rockets accelerated for roughly 17.5 min. in three stages in order to take them above Earth's atmosphere and reach the point where they could coast and let inertia and lunar gravity propel them the rest of the way to the Moon. After that, the

astronauts relied on smaller engines to provide thrust when needed.

The greatest speed ever attained by Apollo astronauts was 24,500 mph during Apollo 10. But here's the point: *They didn't have to go that fast.* As long as their booster rockets provided acceleration and didn't run out of fuel, they could have gone to the Moon at any speed, even a walking pace.

So why didn't NASA do it that way?

The first and most obvious reason is that, traveling at a rate of 3 mph, the trip to the Moon would have taken nine years – and that doesn't include the return trip. A 50-yr.-old astronaut would have been eligible for social security before he returned to Earth.

The Apollo astronauts reached the Moon in three days.

Second, **Pres. Kennedy's** stated goal in 1960 was to land American astronauts on the Moon and return to Earth safely before the end of the decade, not to have them lift off in the '60s and return sometime in the 1980s. It is unlikely that the American public or Congress would have supported the lunar landing program if it meant that we'd get there two decades after the Soviet cosmonauts.

Beyond that, the longer the trip took, the more difficult and perilous it would have been. A trip of such long duration would have required additional food, oxygen, medical supplies, backup equipment to replace vital parts that could malfunction along the way, and larger space capsules to provide additional storage space and give the astronauts room to move around freely and exercise over such a long period. Each of those factors would have increased the weight of the payload, and thus required larger rockets to carry the extra fuel. NASA had neither the time, experience nor funding to accommodate a leisurely trip to the Moon and back, so they wisely opted for the sensible solution.

As you've doubtless guessed by now, the question of how fast you'd need to go in order to escape Earth's gravity is a trick question that has no practical value except as a bar bet.

While technically it is correct that, given constant acceleration and sufficient fuel, you could go to the Moon or anywhere else in the universe at any speed, any approach to space travel other than

getting where you're going as quickly as possible is impractical and unnecessarily hazardous. As **Shakespeare** pointed out, "If it were done when 'tis done, then 'twere well it be done quickly." (*Macbeth*, Act 1, Sc. 7).

Of course, Macbeth was talking about an assassination, not a space flight. But a space flight encompassing more than a decade might have achieved the same result, one way or another.

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Upcoming Meetings/Activities. The Jan. club meeting will be held at 7:30 p.m. on **Thurs., Jan. 11th** at The Garden in Griffin.

Our JKWMA observings will be on **Fri.-Sat., Jan. 19th-20th**.

On **Mon., Jan. 22nd**, we'll conduct an indoor presentation at 7 p.m. at Sun City Peachtree in Griffin.

Three days later, on **Thurs., Jan. 25th**, we'll conduct an observing at the softball field at Sun City Peachtree. The event will begin at 6 p.m. The rainout date will be **Fri., Jan. 26th**, same time, same place.

To get to Sun City Peachtree from Griffin, set your odometer at 0.0 at the McDonald's/Hardee's stoplight north of town on U. S. 19/41. Go N on the 4-lane, and after 3 mi. turn right at the stoplight at Birdie Rd. Go 2.4 mi. to the stoplight at Jordan Hill Rd., and the gated entrance to SCP is directly ahead.

Tell the guard at the gate that you're attending the astronomy talk, and go 1/2 mi. or more to the amenities center; it's the large building where we'll do the indoor presentation.

We'll send out directions to the softball field prior to the observing.

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The Sky in January. We've all heard the phrase *once in a blue moon*; it refers to something that occurs now and then, but not regularly.

The phrase has its roots in astronomy: any month that has two **Full Moons** is a blue Moon. With Full Moons on Jan. 1st and 31st, January qualifies as a blue moon month. The lunar disk won't be blue, of course – but you can see it that way if you use a blue filter.

The only evening planets visible in Jan. will be **Uranus** (mag. 5.8) in *Pisces* and **Neptune** (mag. 7.9) in *Aquarius*. Although both appear as colorful

stars in binoculars, a telescope will reveal their tiny blue-green (Uranus) and blue-gray (Neptune) disks.

Comet PanStarrs will be visible all night in Jan. as it glides through *Taurus*. On Jan. 1st it will be 2° SW of the **Hyades**, and on the 31st it will be 2-1/2° E of the **Pleiades**. It will appear as a small, fuzzy, compact ball of light, visible in a small 'scope at JKWMA and in a 10-in. 'scope under light-polluted skies. *Astronomy* (Jan. 2018, p. 42) contains a finder chart for the comet in January.

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Three Comets For the Ages

by Bill Warren

Throughout mankind's early history, humans regarded comets with wonder, awe – and dread. Until the mid-1700s when **Edmund Halley** correctly predicted the return of the comet that now bears his name, these mysterious, fuzzy objects were thought to be omens of impending doom. (It was a logical conclusion, since bad news is always lurking around the corner. Comets gave people something to blame it on.)

Now that we know what comets are – “dirty snowballs,” or icy debris left over from the formation of the solar system – the appearance of a bright comet, especially one that is visible to the naked eye, is one of the most eagerly anticipated events in astronomy. We're always disappointed when a comet doesn't live up to its expectations.

At any given time, there are about a dozen comets in the sky, but most of them are too faint to be seen except in large telescopes. However, in the brief span of four years – from 1994 to 1997 – no less than *three* comets earned worldwide attention. Their appearances brought thousands of new astronomers into our fascinating hobby. The last two were bright enough to be seen without a telescope or binoculars, and the first one literally had a major impact on astronomy.



Above: The Shoemaker-Levy 9 Jupiter fragments

1. Comet Shoemaker-Levy 9. On March 24, 1993 the comet-hunting team of **Eugene & Carolyn Shoemaker** and **David Levy** discovered a new and very unusual comet. Officially designated as **C/1993 F2** but better known as **Comet Shoemaker-Levy 9** (it was their ninth joint discovery), the comet never made it to the **Sun**. During its inward journey some 20-30 years earlier, it passed too close to **Jupiter** and was captured by its gravity. Thus, Shoemaker-Levy 9 became the first – and *only*, to my knowledge -- comet to be observed orbiting a planet.

Stranger still, Shoemaker-Levy 9 was no longer a single body when it was discovered; rather, it was a string of fragments that had formed a year earlier when, in 1992, the comet swung close enough to Jupiter to be torn apart by the planet's immense tidal forces. Further calculations showed that those fragments would collide with Jupiter in July, 1994, giving professional and amateur astronomers a year to get ready for the event.

And what an event it was!

On July 16, 1994 the first fragment entered the Jovian atmosphere and was quickly incinerated, leaving behind a dark smudge on the surface that was clearly visible in amateur telescopes. Over the next six days, nearly two dozen more fragments impacted Jupiter like a series of jet planes waiting their turn to land, creating a string of dark stains that were more easily visible than the Great Red Spot and lasted for several months.

FRAC's formation was still 2-1/2 years in the future when that took place, but **Larry Higgins, Ken Walburn, Smitty, Phil Sacco** and I were members of the Atlanta Astronomy Club. We didn't see any of the impacts occur – they appeared as fireballs in photographs -- but we had no trouble seeing the results. It looked like the King of the Planets had developed a bad case of acne.

Question: Since Comet Shoemaker-Levy 9 was already fragmented when it was discovered – and since the largest fragment was only 1.2 mi. in dia. – how did the Shoemakers and David Levy see those fragments from 500 million miles away? They saw them in photographs they made while using the 48-in. Samuel Oschin Telescope on Mt. Palomar to search for potentially deadly Near-Earth Objects, not comets.

2. Comet Hyakutake (pronounced: HY uh kuh TAHK ee). On Jan. 31, 1996 Japanese amateur



Above: Comet Hyakutake

astronomer **Yuji Hyakutake** discovered the second of two comets that bear his name. But this one turned out to be so spectacular that the other one, discovered two months earlier, was quickly forgotten.

A long-period comet that had last visited the inner solar system 17,000 yrs. ago, **Comet Hyakutake (C/1996 B2)** made its presence known in a very big way. Coming within a mere 10 million mi. of Earth – “spittin’ distance,” in south Ga. redneck terms – Hyakutake was visible naked-eye for two months. At its closest, it was traveling so fast across the sky – one **Moon**-width every 30 min. -- that observers could actually see it moving among the background of stationary stars. But what made Hyakutake truly unforgettable was its splendid blue gas tail that stretched more than halfway across the sky – the longest comet tail ever seen.

My 6x30 binoculars had a field of view that spanned 7° of sky. They weren’t powerful enough to show me all of Hyakutake’s tail that was visible in our amateur telescopes – but even so I was able to follow it for *six* binocular-widths away from the fuzzy coma before it dissipated into invisibility against the night sky!

“Hyakutake” was difficult for many people to pronounce; thus, it was also known as “The Great Comet of 1996.”

Question: What kind of telescope was Yuji Hyakutake using when he discovered the comets that bear his name? He wasn’t using a telescope, he was using a very large pair of binoculars with 150mm (6 in.) objective lenses. For three years afterward, the Takahashi firm had a waiting list of buyers for their \$3,000 “binocular telescopes.”

3. Comet Hale-Bopp. On the evening of July 23, 1995 professional astronomer **Alan Hale** and amateur astronomer **Thomas Bopp** independently



Above: Comet Hale-Bopp

discovered a comet (official designation: **C/1995 O1**) that soon reached worldwide fame as **Comet Hale-Bopp**. (It has also been referred to as the “the Great Comet of 1997.”) Hale-Bopp was farther out than **Jupiter** at the time of its discovery, but even then it was unusually bright for such a tiny, distant object, and it had already formed a visible coma.

The comet continued to brighten in amateur telescopes as it slowly made its way toward the inner solar system. By May, 1996 Hale-Bopp was bright enough to be seen naked-eye; in binoculars, it appeared as a small but well defined triangle of light. And by the time of its closest approach to the Sun a year later, it was glowing brighter than any star in the sky except **Sirius**, easily seen without optical aid long before sunset and visible even amid the light pollution of large cities.

Telescopically, Hale-Bopp showed two short tails: a blue gas tail and a thicker, white dust tail. It remained visible naked-eye until Nov., 1997. As a result – and due to a deluge of daily reports and photos on the newly-emerging Internet – Hale-Bopp became one of the most widely observed comets in history. Its 18 months of naked-eye visibility was twice as long as the previous record holder, the **Great Comet of 1811**.

For many astronomers (including me), Hale-Bopp was more than just a comet: its dependability over such a very long period of time made it feel like a friend or family member. For a year and a half, on virtually every clear evening I’d take my binoculars out on the deck of my apartment to spend some time with it, enjoying its beauty or just assuring myself that it was still there.

Question: When will Comet Hale-Bopp return?
Not until around 4385 a.d. If you didn't see it last time, you probably won't see it next time, either.

Comets come and go – silently, and most of them without fanfare. But these three celestial masterpieces never really left us. They remain indelibly etched in the memory of everyone who was fortunate enough to have seen them. When the next Great Comet comes along, you'll consider yourself equally blessed to have seen it. And you won't forget it.

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A Cosmo (But Hardly) Logical Interview With Prof. Stargazer

When **Tom Moore** took a group of new FRAC members to interview **Prof. Stargazer** recently, the professor was hard at work on his latest book, *COSMETOLOGY: Astronomy for Hair Stylists*. Naturally, he wanted their questions to be about cosmology.

John Felbinger: What is the Big Bang?

Prof. Stargazer: Spend some time near **Dwight Harness** and **Bill Warren** at JKWMA when they think no one can hear them and you'll find out.

Ryan Force: What is inflation?

Prof. Stargazer: *Inflation* is the term used to describe the incredibly brief period of time in the universe's history in which cosmologists suddenly realized that they are geniuses and everyone else is a drooling idiot. At that point, their egos inflated faster than the speed of light.

Tricia Lopez: Can you explain **Einstein's** theory of relativity?

Prof. Stargazer: I don't want to get too technical here, Tricia, but basically he said that *Nobody's relatives are as weird as mine*.

Immediately, all around the world astronomers objected to his theory, saying things like "Obviously you haven't met my Uncle Fred!"

Eva Schmidler: Why is the universe expanding in all directions?

Prof. Stargazer: It can't decide which way to go, and it's too stubborn to stop and ask for directions.

Marla Smith: What is a quark?

Prof. Stargazer: It's the sound made by an animal that is half-duck and half-poodle: "Quark!"

Tom Moore: A light-year is the distance that light travels in one year. Does that distance change during a leap year? Or during Daylight Savings Time?

Prof. Stargazer: I'm still trying to figure out how to answer the last three questions you asked me, Tom.

Jon Heard: What did he ask you, Sr?

Prof. Stargazer: First, he asked me why light travels at the speed of light.

When I didn't answer that one he said, "Okay, I'll re-phrase the question: How do they know that light travels at the speed of light? Did they time it with a stopwatch?"

I didn't answer that question, either. So Tom said, "I'll try one more time: If light travels at the speed of light, how fast does darkness travel?"

Ken Harris: What did you say?

Prof. Stargazer: I told him to take two aspirin and go to bed.

Does anyone have another cosmology question?

Larry O'Keeffe: I do, Sir. Here's my question: Will the universe ever end?

Prof. Stargazer: I was wondering the same thing about this interview.

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Above: NGC 6914, a combination emission and reflection nebula in *Cygnus*. The blue areas in Alan Pryor's photo are dust clouds that shine by the reflected light from stars within them; without the stars to reflect light off the dust particles, the blue areas would be black (i.e., dark nebulae).

The red areas of the photo are interstellar clouds of ionized gases that emit their own light by simple fluorescence, rather than reflecting the light from other sources.

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Above: The eastern portion of the NGC 383 galaxy group in *Pisces*. The area shown in Alan Pryor's remarkable photo contains at least a dozen galaxies, the eight brightest of which comprise the **Pisces Galaxy Chain**. Those galaxies are, from the lower left to upper right: oval NGC 379; round NGC 380; the brightest member of the group, NGC 383, in the center of the photo with tiny companion NGC 382 just above it like an unfinished snowman; faint NGC 387 to their right, with brighter NGC 386 above it; and still brighter NGC 385 and NGC 384 completing the chain.

The Pisces Galaxy Chain is a target in the A.L.'s Galaxy Groups & Clusters Observing Program. It is visible in small telescopes but best seen in a 10-in. or larger 'scope.

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***Trivia Question** (and space filler): *Will building more powerful telescopes ever permit us to see what the universe looked like just after it began?*

Answer: *No.* In scientific terms, at least, nothing is known to have existed before the Big

Bang, which produced both matter and space. The universe expanded so fast that, in its first 10^{-35} second – which is so brief a period as to be virtually indistinguishable from the Big Bang itself – it grew from the size of a proton to a grapefruit-sized mass. That expansion was faster than the speed of light – a feat so clearly impossible that astronomers use the word *inflation* to distinguish it from everything else that follows the normal rules of physics.

During its early years, the universe was busy, but it was not complex. Rather, it was unimaginably dense, hot and filled with protons, electrons and light particles (*photons*) that couldn't go anywhere because the subatomic protons and electrons were bouncing them around like a pinball machine.

After 380,000 yrs., however, expansion cooled the universe to about 4,600° F, allowing protons and electrons to bond and form neutral hydrogen atoms. That bonding left fewer free particles bouncing around and gave the photons room to travel in the expanding young universe. Those were the first visible light rays, and astronomers have detected them in the form of the Cosmic Microwave Background (CMB), a faint microwave glow that is seen throughout the universe. The CMB preceded the first stars and galaxies by between 10 million and 1 billion years; it is a cosmic echo of the beginning of everything -- “an almost featureless soup of hydrogen and helium,” as Liz Kreusi, *Astronomy*, Dec. 2015, p. 66) put it.

But that's it, the end of the line as far as seeing backward in time goes. No matter what kind of telescope is used or how powerful it is, it won't show what the universe looked like before light was free to travel in space.

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* (Another filler): The **Sun** energizes, heats and lights our solar system; without it, the nearest visible object would be the mag. 0 star **Alpha Centauri**, 4.4 light-years away. The planets still would be there – momentarily, at least – but without the Sun's gravitational anchor they would soon drift away into the depths of interstellar space.

We see the planets, their satellites, asteroids, comets, etc., because they reflect sunlight. Without the Sun, everything in the solar system would be as invisible to us as a black hole.

Jupiter emits slightly more light than it receives from the Sun – but from 500 million mi. away we would be unlikely to see its faint glow.

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