THE

FLINT RIVER OBSERVER

NEWSLETTER OF THE FLINT RIVER ASTRONOMY CLUB

An Affiliate of the Astronomical League

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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., Aug. 10: FRAC meeting (7:30 p.m., The Garden in Griffin); **Sat., Aug. 12:** High Falls State Park observing (8:30 p.m.); **Fri.-Sat., Aug. 18-19:** JKWMA observings (at dark); **Mon., Aug. 21:** public solar eclipse observing (The Garden, 1-4 p.m.).

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President's Message. We usually think of astronomy outreach and education as doing public observings or indoor presentations. But with the total solar eclipse coming on Aug. 21st, you can do some real astronomy education before then: not telling people about the eclipse – they already know about it -- but *warning* them about it.

Here's the problem.

Those of us who are planning to travel to see totality know how to protect our eyes from the Sun's harmful effects. But our area isn't in the path of totality, and most people don't understand the danger they will face in looking at the partially eclipsed Sun. They think that, since most of the Sun will be blocked from their view during the eclipse, it won't be bright enough to hurt their eyes. You and I know better than that – *but they don't!*

Here are the things you need to warn them about:

1. *Do NOT look directly at the Sun unless you're wearing special solar sunglasses.* Regular sunglasses offer no more protection than not wearing sunglasses at all. If people ask where they can buy solar sunglasses, tell them to Google "solar sunglasses" – and do it *now*, not a day or two before the eclipse. They cost about $2.50 a pair.
2. *Or use pinhole projection to show the eclipsed Sun on the sidewalk or a piece of paper.* Bill told how to do it in last month's newsletter. You don't have to wait until eclipse day to see if this method works: you can do it on any sunshiny day, and then tell other people how to do it.
3. *Do NOT use binoculars to look at the eclipse.* Binoculars magnify the Sun's brightness, which is already intense. Even a momentary glance at the Sun in binoculars can cause permanent blindness.
4. *Do NOT try to photograph the eclipse with your iPhone, camera or anything else.*

Remember, this isn't Show and Tell. You don't need to show anybody the Sun during the eclipse unless you want to. But you DO need to warn people about it, *now!* It's the most important thing you'll ever do in astronomy.

Finally, I know you'll want to join me in welcoming our two newest members, **Chuck Davis** and **Tricia Lopez**. They joined FRAC at our July meeting.

-Dwight Harness

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Last Month's Meeting/Activities. Our June JKWMA observings were clouded out.

We had 15 members – **Felix Luciano, Elaine Stachowiak, Aaron Calhoun, Tom Moore, Carlos Flores, Cindy Barton, Jeremy Milligan, Steve Benton, Steve Hollander, Dwight Harness**, **Kenneth Olson, Truman Boyle, Erik Erikson, David Haire** & **yr. editor** – and three visitors (**Tricia Lopez, Chuch Davis & Steve McMinn**) at our July meeting. Tricia and Chuck joined the club that night. Instead of our scheduled program, we talked about the Aug. 21st solar eclipse.

Here's the way Murphy's Law works.

Fri., July 21st. Weather forecast for our JKWMA observing: mostly clear all evening. Ten people showed up: **Sean & Gianna Neckel; Steve Hollander; Elaine Stachowiak; Jeremy Milligan; Marla Smith; Aaron Calhoun; Tricia Lopez** & her grandson; and **yr. editor**. Due to an oversight on yr. editor's part, Tricia arrived after everyone else had left. (Sorry, Tricia.) Cloud cover: 100%. Total amount of observing done by everyone combined: none.

Sat., July 22nd. Weather forecast: cloudy all night. Everyone stayed home except **Aaron Calhoun** and **yr. editor.** The sky was mostly clear throughout. We watched the Hubble Space Telescope pass over, and Aaron found about 20 objects in various observing programs.

Wouldn't it be nice if Murphy were wrong about things going wrong as often as the meteorologists are wrong about the weather?

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This 'n That. Trivia Question*: How did astronomers determine that Earth is not the center of the solar system?*

Answer: When the ancients saw the **Sun, Moon**, planets and stars move across the sky, they naturally assumed that Earth was the center of the universe and everything overhead revolved around it. Certain biblical passages reinforced that notion, and it was vigorously defended by the Church during the Middle Ages in a brutally unforgiving trial process known as the Inquisition.

(Those passages referring to a stationary Earth included: "The world also is firmly established, It shall not be moved." [I Chronicles 16:30]; "You [God] who laid the foundations of the earth, So that it shall not be moved forever." [Psalms 104:5]; "The sun also rises, and the sun goes down, And hastens to the place where it arose." [Ecclesiastes 1:5]); and "The sun stood still, and the moon stayed, until the people had avenged themselves upon their enemies." [Joshua 10:13]).

When the Italian astronomer **Galileo Galilei** looked at the night sky in his telescope in 1608, he found that two of the planets – **Mercury** and **Venus** — exhibited Moon-like phases that changed periodically, while **Mars, Jupiter** and **Saturn** never changed. Galileo surmised correctly that Venus and Mercury must be closer to the Sun than Earth and the other planets are. The changing phases indicated to him that sunlight was striking them at different angles, which could occur only if they were orbiting the Sun, not the Earth. Since the other planets did not undergo phases, they must be farther from the Sun than Mercury, Venus and Earth.

Galileo also discovered four celestial bodies near Jupiter that changed positions every night relative to Jupiter and each other. He surmised –again, correctly – that they must be moons orbiting the planet, the same way that our Moon orbits the Earth. That discovery supported the heliocentric theory by showing that objects other than Earth could have objects orbiting them. Jupiter's innermost moons soon became known as the "Galilean moons," and later they were named **Ganymede, Io, Europa** and **Callisto.**

In 1610, Galileo published *The Starry Messenger*, a book that made him one of the most widely known and popular figures in the medieval world. For the first time, people read about what it was like to look at the night sky through a telescope. Galileo described such fascinating things as: his discoveries of Jupiter's moons; the unevenness of the Moon's surface (it had mountains, valleys and creaters); stars that could not be seen without a telescope (particularly the **Milky Way**, which appeared as a cloud to the unaided eye); and the difference in appearance between the planets (which were seen telescopically as tiny disks) and stars (which appeared as points of light). People were understandably fascinated with Galileo's revelations: like **Elvis** and **Madonna** in a later day and age, he became known by his first name alone.

Galileo was not the first person to theorize that the Sun, not Earth, was the center of the solar system, nor was he the only prominent astronomer in the Middle Ages to hold that belief.

The heliocentric theory was first proposed by **Aristarchus of Samos** in the 3rd century b.c. After that, it was largely ignored for more than 1,700 years until the great Polish astronomer **Nicolas Copernicus** wrote about it in his book *On the Revolution of the Heavenly Spheres*. Yet Copernicus avoided the Inquisitors' wrath. He died shortly before the book was published in 1543, but Church leaders already knew about it; in fact, he dedicated his book to **Pope Paul III**, and in the Preface he wrote that it "should be useful for mathematical computations even if its hypothesis is not necessarily true." So the Inquisition overlooked his book, on the grounds that Copernicus was not committing heresy (i.e., challenging established Church doctrine) because he offered no proof to substantiate his theory. It was not until 60 yrs. after Copernicus's death that the pope ruled that he had in fact been guilty of heresy.

Galileo, on the other hand, was afforded no such luxury. In 1632, he published a book, *Dialogue Concerning the Two Chief World Systems,* in which three fictional characters discussed the heliocentric theory: one favored it, one was opposed to it, and one had no opinion. Galileo later claimed that he gave equal treatment to both sides, but it was clearly biased in favor of the pro-heliocentric view, because it offered scientific evidence based on what Galileo's telescope had shown him.

Years earlier, Galileo had taken his telescope to the Vatican and showed **Pope Urban VIII** the Moon, Milky Way and planets, and they had in fact become friends. But when the pope read Galileo's book, he was incensed: he regarded it as a personal attack on him. The result was Galileo being brought before the Inquisition in late 1632.

Although treated respectfully by the Inquisitors, Galileo was forced to recant his heliocentric theory under the threat of death. Nevertheless, he was convicted of heresy in 1633. But instead of sentencing Galileo to death, the Inquisitors ruled that, since he had confessed his sin, he would be permitted to live out the rest of his life under house arrest. He died nine years later, in 1642.

The heliocentric theory eventually prevailed, of course – but it was not until 1992 -- the 350th anniversary of Gaileo's death -- that **Pope John Paul II** apologized for the Church's error.

Still…Until his trial Galileo had no reason to believe that his pro-heliocentric statements would go unpunished despite his popularity and friendship with the pope. Yet he spoke out anyway, knowing that he might face the Inquisition. It was an act of extreme bravery. But Galileo didn't do it to prove that he was right or the Church was wrong; he did it because it was the only way that the truth would ever be revealed.

*__Taking the Galaxies With a Grain of Sand.__ As **yr. editor** pointed out in his recent evolution special report, the quest for scientific knowledge begins with theories which, when verified, become facts. But facts can change as advances in technology produce new data. For example, consider the question of how many galaxies there are in the universe.

Traditional estimates have been based on the famous Ultra Deep Field photo by astronomer **Robert Williams**, who aimed the 78-in. Hubble Space Telescope (HST) at a tiny, apparently barren area in *Ursa Major* near the **Big Dipper** over a ten day period in 1995. That ultra-long-exposure photo took astronomers far deeper into the universe than they had ever seen before, revealing nearly 3,000 galaxies in an area of sky that was twelve times smaller than the **Full Moon**. By extending those figures to include the entire celestial globe, they arrived at an estimate of between 100-200 billion galaxies.

In 2009, however, astronauts installed a new and radically advanced camera, Wide Field Camera 3, on the HST. That camera produced an even more far-reaching photo, the Ultraviolet Ultra Deep Field, which suggested that, rather than a paltry 100-200 billion galaxies, the early universe contained about *2 trillion* galaxies. Both the Ultra Deep Field and Ultraviolet Ultra Deep Field photos show distant galaxies as they were more than 13 billion years ago, not as they are now. That's what happens when we look backward in time: We see things as they were, not how they have changed since then.

HST's successor, the James Webb Space Telescope, will be launched in 2018. It will probe even farther back in time, showing us galaxies that formed only a few hundred thousand years after the Big Bang. Its photos undoubtedly will increase the universe's galaxy total far beyond Hubble's capability.

You've probably heard somewhere along the way that there are more stars in the universe than grains of sand on all of Earth's beaches. It sounds fantastic, but it may be true. Consider: If there are 2 trillion galaxies with an average of, say, only one billion stars per galaxy, there are roughly 2 sextillion stars in the known universe. (That's a 2 with 21 zeros after it.)

We've done our part in counting the stars; we'll leave it to you to estimate the number of grains of sand.

You won't be the first to take the universe with a grain of sand: In the 3rd century b.c., **Archimedes** – the ancient world's greatest mathematician – estimated that it would take 8 x 10^{63} grains of sand to fill the universe. (Archimedes must have had a *lot* of free time on his hands to count that high.) He was wrong – probably by at least a few trillion powers of ten, because the universe is much larger than Archimedes thought it was – but we're confident that your estimate will be closer to the truth.

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Upcoming Meetings/Activities. Our club meeting will be at 7:30 p.m. on **Thurs., Aug. 10th** at The Garden in Griffin**.**

On **Sat., Aug. 12th**, FRAC will conduct another "Paddle In the Park" kayak- and land-based observing at High Falls State Park. The event will begin at 8:30 p.m. with a kayak tour of the lake, with one or two FRAC members providing commentary regarding the **Moon**, planets and constellations along the way. When the kayakers return to shore, other FRAC members will join them in showing our guests what the sky has to offer in our telescopes.

Directions to High Falls S. P. will be sent out prior to the event, but you can also find them (complete with G.P.S. coordinates) in the Downloads section of our website.

Our JKWMA observings will take place on **Fri.-Sat., Aug. 18th-19th.** Hunting season should have begun by then, so the gate should be open when you arrive**.** You don't need to close it behind you as you enter or leave.

FRAC will conduct a special public solar eclipse observing at The Garden in Griffin from 1-4 p.m. **Larry Higgins** and **Aaron Calhoun** will be there, and they would appreciate it greatly if you will join them to show the eclipse to area residents.

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The **Moon** shuts off the beams of the **Sun** as it passes across it, and darkens so much of the Earth as the breadth of the blue-eyed Moon amounts to.

-The Greek philosopher **Empedocles**,
describing a solar eclipse in 450 b.c.

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More Facts and Trivia About Solar Eclipses
by Bill Warren

Q. *Why are the **Sun** and the **Moon** the same size in our view?*

The Sun's dia. – 864,000 mi. – is exactly 400 times as great as the Moon's dia. (2,160 mi.). By an amazing coincidence that has nothing to do with science, the Moon is also 400 times closer to Earth than the Sun is, so most of the time the Moon and Sun appear to be the same size, i.e., 1/2° in dia. (As you'll see below, exceptions exist.)

Q. *How many total solar eclipses have there been in the last 10,000 years?*

The one on Aug. 21st will be the 3,342nd.

Q. *How long do they last?*

If you mean *How long can totality last?*, the maximum is 7m 29s, but they are extremely rare. Only ten have lasted that long in recorded history. The next one will be on July 16, 2186.

(On the other hand, the next total solar eclipse to cross the continental U. S. will be on April 8, 2024. The area of totality will carve a narrow path from Texas to the extreme northeastern U. S. With totality lasting between 3m 22s and 4m 27s, it will be about twice as good as the one on Aug. 21st, only the path of totality will be farther away from our area.)

At the other extreme, viewers along the outermost edge of the umbra on Aug. 21st may experience only a few seconds of totality. That's why eclipse observers consider it important to view totality from somewhere near the middle of the umbra's path.

Typically, totality lasts between 3-4 min., but on Aug. 21st it will last between 1m 30s and 2m 40s, depending on where you watch it within the area of totality. (If the sky is clouded over that day, you can still watch it on NASA's live stream. Details are available at www.nasa.gov/eclipselive.)

Everyone in the U. S. will see at least a partial eclipse.

But if you mean *How long does an entire total solar eclipse last?*, the answer is anywhere from 2-4 hrs.

A total solar eclipse consists of five phases.

**First Contact* occurs when the Moon's leading edge begins its slow creep across the Sun's face, producing a partial eclipse;

**Second Contact* is when, in the final seconds before totality, Baily's beads and the diamond ring are all that's left of the Sun's disk;

**Third Contact* is when totality begins;

**Fourth Contact* is when, after a brief period of totality, the diamond ring and Baily's beads reappear; and

**Fifth Contact* is when, after the second period of partial eclipse, the last portion of the Moon's trailing edge moves away from the Sun.

It takes a few hours for all that to happen – but every solar eclipse is different. The path of totality is never the same from one eclipse to another, nor is the duration.

Q. *Why are some solar eclipses longer than others?*

If the Moon and Earth traveled through space in circular orbits, all solar eclipses would last the same amount of time. But since both of them travel in elliptical orbits, sometimes the Moon is closer to Earth than at other times. And sometimes Earth is closer to the Sun than at other times.

At its closest point to us (called *perigee*), the Moon is 225,000 mi. away; at its farthest point, or *apogee*, it is 252,000 mi. away. The Moon can be as much as 12% larger at perigee than at apogee. At such times it is known as a "Super Moon."

Solar eclipses that occur during a Super Moon have longer periods of totality because it takes longer for the enlarged Moon to cross the Sun's face. (Of course, not every Super Moon is accompanied by a solar eclipse; for example, the Super Moon of Nov. 14, 2016 did not eclipse the Sun.)

Earth's solar orbit is elliptical, too. At perihelion, Earth and the Sun are 91.4 million mi. apart, while that distance increases to 94.5 million mi. at aphelion. But since the Sun is so far away from us, its increase in size at perigee is only 3%, so its change in size is not nearly as noticeable as the Moon's. (See below.)

At any rate, those factors combine to determine how long the eclipse will last.

Q. *There are total and partial solar eclipses; are there any other kind*?

As noted earlier, normally the Moon and Sun appear to be the same size. However, if the eclipse occurs when the Moon is near its apogee, its disk will not be large enough to block all of the Sun's larger disk from view. At totality, the dark lunar disk will be surrounded on all sides by a thin, bright ring of sunlight. Such eclipses are known as **annular eclipses**. (Annulus is Latin for "ring.")

The Aug. 21st solar eclipse will be total, not annular.

Few celestial events are as compelling to astronomers as total solar eclipses. They occur an average of once every three years, but sometimes there are none at all in a given year.

When one does occur, the umbra is small – never larger than 167 mi. in dia.. (And even then, the Moon's shadow is barely large enough to reach Earth.) Total solar eclipses are unlikely to be visible from any given location more often than three times in a thousand years.

Given those facts, perhaps you'll understand why eclipse chasers are willing to spend Big Buck$ and travel thousands of miles to other parts of the world to see them.

Still…The possibility always exists that on eclipse day those few precious moments of totality may be rained out or clouded over. That's why tour operators like to schedule week-long solar eclipse sea cruises or trips to exotic places, with well-known astronomers, astronauts, etc., available to help you understand and enjoy the experience. They want to ensure that you'll have fun and consider your trip a success even if you've maxxed out your credit cards and traveled thousands of miles only to find overcast skies or rain during the eclipse.

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Above: NGC 3319, a barred spiral galaxy in *Ursa Major.* (Photo by **Felix Luciano**). Extremely faint visually, **NGC 3319** is a Herschel II target that **yr. editor** saw as "a blotchy, irregularly lighted 3-1/2' 1-1/2' blur of light oriented NE-SW."

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Above: NGCs 4169, 4173, 4174 & 4175 (The Box), a galaxy quartet in *Coma Berenices*. (Photo by **Alan Pryor**.) Lovely in photographs, **The Box** is extremely difficult to find and observe visually.

Elongated **NGC 4169** is a Herschel II target. At mag. 11.7, it is the largest and brightest member of the quartet, and best seen by averted vision. The only other member **yr. editor** saw was the one to the right of 4169, i.e., **NGC 4173** (mag. 13.3). It appeared as an extremely faint erasure smudge on the sky. At mags. 14.3 and 14.5, the other two galaxies may as well not have been there.

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Below: M20 (Trifid Nebula), an emission (pink) and reflection (blue) nebula in *Sagittarius.* (Photo by **Alan Pryor.**) **M20** was discovered by **Charles Messier** in 1764. **John Herschel** – **William Herschel's** son -- gave it its familiar nickname, **Trifid Nebula**.

Along with its equally famous neighbor **M8 (Lagoon Nebula)**, which is located 3/4^{o} to the SW but not shown in Alan's photo, M20 is one of the most popular summertime targets for observers and astrophotographers. Both are easily seen in binoculars, appearing as two **Moon**-sized patches.

Dark lanes trisecting the Trifid give it the visual and photographic appearance of a celestial piece of popcorn. A mag. 7 star and associated open cluster, **NGC 6514,** lies within Trifid Nebula; the blue nebulosity surrounding the mag. 7.5 star to the right is also part of the Trifid.

In 1962, a sci-fi movie, *Day of the Triffids,* involved space aliens arriving on Earth as deadly spores during a meteor shower that came from Trifid Nebula. The aliens eventually were killed off when someone discovered that they would dissolve in salt water; it's about what you might expect from a movie that couldn't even spell *Trifids* correctly.

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