Audio file

Connecting_Classrooms_Ep2_Final

Transcript

00:00:00 Kimberly Inman (host)

Have you ever found yourself in a remote location on a clear dark night? One look to the sky above and you likely experienced the same wonder of countless generations as they too observed the stars and planets.

00:00:13

From ancient times, people have developed a knowledge of astronomy that aided navigation, time keeping and agricultural practices, and much more. Along the way, our view has expanded from observations with the naked eye to what powerful telescopes can detect. With this long history of looking to and learning from the night skyy, what questions remain and how are we finding answers?

00:00:38 Kimberly Inman (host)

Welcome to connecting classrooms, a podcast for educators and their students that brings experts at Shawnee State University directly to your classroom. I'm your host, Kimberly Inman, Dean of the College of Arts and Sciences at SSU. In this series, you will hear from my colleagues who love to share their passion for teaching and research.

00:01:00

We seek to support teachers with supplemental resources for their lessons and to inspire their students to want to learn more in this episode. The first year of science with the James Webb Space Telescope, we will meet Doctor Tim Hamilton, Professor of Physics and director of the Clark Planetarium at SSU. From our campus in Portsmouth, Ohio, Tim works with the Hubble and the James Webb Space Telescopes to study what are called active galaxies, like quasars. These are galaxies whose central black holes are actively sucking in gas heating it up and making it glow so brightly it can outshine the whole rest of the galaxy. Most recently, Tim and his research students at SSU have been studying how microbes can survive space-like conditions by flying the microbes on high altitude balloons into the stratosphere. Now let's connect with Tim and learn about the first year of science with the James Webb Space Telescope.

Telescopes have been placed high up on mountains, and for the last few decades we've had several in space. The Hubble Space Telescope has been orbiting Earth for 33 years, and now the James Webb Space Telescope has been in space for a year and a half.

00:02:10 Kimberly Inman (host)

So, Tim, why do we put telescopes in space in the 1st place? Why don't we just keep them on the ground, where they're easier to get to?

00:02:19 Tim Hamilton

The first telescopes we built certainly were down at ground level. You think about maybe the US Naval Observatory or the oldest operating observatory in the United States, The Cincinnati Observatory and those are not up on mountains. But the trouble is that when you're down that low, you wind up with all that thick atmosphere above you. You certainly get clouds and all the weather that blocks your view of the sky, but you also have the shimmering of the atmosphere. The same thing that makes the stars twinkle when we look at them causes them to dance around through the telescope much, much more, because we're magnifying all of that motion and all of that squiggly nature there. So, we want to get above as much of the atmosphere as we can to reduce what we call the “seeing.” And that “seeing” is the shimmering, the twinkling, and even much more subtle effects that you can't see with the naked eye. So, we put them up on tall mountains now. That gets you above, oh let's say you're going up to

the Hawaiian Mountains, for example, or in Chile, or in the Rocky Mountains, and you can get up 10 - 15 thousand feet above sea level. Now you're above a large fraction of the atmosphere. Many cases you're above the clouds, but you're above a lot of that shimmering of the air. So,

00:03:39 Tim Hamilton

the next logical step was put them in space. When we get them in space, we get rid of all of the atmospheric effects entirely, and we open up new kinds of astronomy that simply weren't possible before. For example, the atmosphere not only does it distort our views,

00:03:59 Tim Hamilton

but it also winds up blocking some kinds of light entirely. Think about the light that we can't see with our own eyes. We can see from red, orange, yellow, green, blue, indigo and red, orange, green.

00:04:14 Tim Hamilton

Ah, red - ROY G. BIV, red, orange, yellow, green, blue, indigo, violet there. I've got to remember my colors in order and, but beyond the Violet is the ultraviolet. Down below the red is the infrared, and the atmosphere blocks most of the ultraviolet light and most of the infrared on top of it. And very useful for us, it blocks

00:04:34 Tim Hamilton

absolutely all of the X-rays and the gamma rays from reaching the earth which is good because otherwise we'd be getting this dose of radiation just from the sun. And it blocks most of that ultraviolet light as well. I mean, think about how bad it is when you get a sunburn, but it would be so much worse if the atmosphere were not opaque

00:04:52 Tim Hamilton

to most of those UV rays. So, if we want to take a look at what's going on in space with ultraviolet light, with X-rays, with gamma rays, with mid, mid-range, infrared and so on, then we have to go up into space in order to see that light at all.

00:05:08 Tim Hamilton

So, space telescopes have a great advantage, but at the same time there are disadvantages because they make it much more expensive. We can put a telescope on the ground, we just mount it, and whenever we want to fix it, we just go in there with a screwdriver or whatever. But in space, that's a much more expensive proposition. It costs millions of dollars.

00:05:30 Tim Hamilton

Tens, hundreds of millions of dollars to put them in space. And then it costs you every time the astronauts would go to repair the Hubble Space Telescope, that was half a billion dollars more. So, ground based telescopes still have their role and space based telescopes have theirs. So we have this.

mix of both of them.

00:05:51 Kimberly Inman (host)

Why launch the James Webb when we still have the Hubble? What can it do that the Hubble can't?

00:05:56 Tim Hamilton

The James Webb is an infrared telescope, while the Hubble Space Telescope is looking only with visible light. Well, a little bit of the ultraviolet and a little bit of the infrared.

00:06:07 Tim Hamilton

But the James Webb goes from the deep red bands of the visible spectrum all the way down through the near-infrared and the mid-infrared. Wavelengths that simply cannot be seen with the Hubble. And really, for the most part, can't be done from the Earth.

00:06:22 Tim Hamilton

So the James Webb is a is letting us look at the kinds of things that glow with this infrared light. That can be dust, it can be other kinds of molecules that put out infrared light. But also it allows us to see farther away because the universe is expanding as galaxies move away from us with the expansion of space itself, they are being red shifted. The Doppler shift of their light

00:06:52 Tim Hamilton

caused by relativity means that the faster way they move, the redder they get and therefore light that could have been emitted in, say, blue light might be shifted all the way to the infrared by the time that we see it.

00:07:07 Tim Hamilton

The farther away a Galaxy is, the faster away it's moving, and the more it's red shifted. Therefore, if we want to look at, say, starlight for a galaxy, that's way, way far away we need to look in the infrared. Furthermore, the James Webb is a much larger telescope than the Hubble is. The Hubble is about has a mirror, which is about 3 yards across and the James Webb's mirror is about 20 - actually, 20 feet across there. And so we're able to gather much more light with the James Webb, which means it can see things which are much fainter. We get a brighter image out of it, and we also get a sharper view out of it than we do with the Hubble.

00:07:52 Kimberly Inman (host)

So, what has the James Webb found in its first year?

00:07:53 Tim Hamilton

We've already got a long list of discoveries under its belt.

00:07:57 Tim Hamilton

I've put together and now this is – I know podcast is just audio, but because astronomy is such a visual science, I've put together a little slideshow PDF file that the listeners can follow along with when you want to take a look at the pictures and I will refer to the page numbers on each one of these as we go. Page one is simply my title slide there, but let's flip over to Page 2. Now, here, we're taking a look at a Hubble Space Telescope photograph of a supernova that went off in 1987. Now the Hubble wasn't launched until 1990.

00:08:29 Tim Hamilton

Then we had a bad problem with the mirror that distorted the images. That wasn't fixed until the end of 1993, but in 1994 the Hubble turned its gaze over to the supernova - what was left after this star exploded. This is the closest exploding star supernova explosion that had been seen for hundreds of years.

00:08:52 Tim Hamilton

And when the Hubble looked at it, they saw this remarkable interlocking ring picture there. And what you're seeing at the very center is the remnant of the explosion itself. That that bright kind of orangish reddish glow in the middle, surrounded by a brighter ring.

00:09:13 Tim Hamilton

And then that is surrounded by two fainter interlocking rings. Now let's head on and I'll explain what those are in a moment, let's head on to slide #3.

00:09:22 Tim Hamilton

In Page 3 here you see the James Webb view from 2023, so here we are. We're separated by what, almost 30 years of this and we're looking at the same scene. I've got them exactly lined up here, but now we're looking with one, with infrared light two, we're able to see much fainter details. You can tell that easily.

00:09:44 Tim Hamilton

But also three, were looking 30 years later. Now you might think that the night sky doesn't really change from one year to the next. Aside from the wandering of the planets and the occasional eclipse, but out in out in deep space in places like this, we really are able to look at changes over time.

00:10:02 Tim Hamilton

Where in this case the exploding shockwave from that supernova explosion, we've been able to watch it as it has torn through the image here. Now the center spot and you might want to switch back and forth between picture two and picture three. That center spot is the debris from the exploding star. It's a dust cloud and glowing gas and all of that.

00:10:27 Tim Hamilton

That bright ring surrounding it and you can see in picture three, you notice that it's got little rings of bright dots in that now that weren't there in 1994. That is a ring of gas that was thrown out by the star just before it died, about 10 or a few 10s of thousands of years ago.

00:10:46 Tim Hamilton

So that ring is out there was already there before the supernova went off, and then the 2 outer locking outer interlocking rings are spots that are lit up in kind of an hourglass formation above and below the axis of this this formation here. So we're going to take a look at that inner ring. As the shockwave expanded outward through space, it's invisible until it hits something, and when it slammed into the gas of that inner ring there it started lighting it up like lights on the Christmas tree. And we watched across the late 1990s and early 2000s as one and another and more and more of these spots started glowing as the gas and dust in them was torn apart by the expanding shock wave. Now 30 years later, we're able to see all of that in much more detail and with the infrared, we can see parts of the gas that are glowing much more faintly as well.

00:11:46 Tim Hamilton

That are not not as hot but are but are cooler and are glowing with the infrared light. Now the really interesting thing about this though is what this is telling us about the structure of the supernova. Take a look at slide four, in this case here we've got a diagram superimposed on top of it and look at that inner part there that it labels the keyhole.

00:12:08 Tim Hamilton

Because it's got a little keyhole shape in the middle.

00:12:10 Tim Hamilton

That bluish turquoise colored spot? That's the debris field and you can see that it's expanded from how it was back in 1994. And so as this expansion of the gas is going on, we should be getting a look at whatever is left over after a supernova. You can get two things. You can either get a neutron star.

00:12:32 Tim Hamilton

Which is the densest possible kind of star where all of the material has been compressed into a ball of neutrons. Or you can get a Black Hole. I reckon a black hole is even denser than a neutron star, but it's a special kind of thing then and we don't know which of these it is. Most astronomers think it's probably going to be a neutron star, but we don't know for sure until we can get a look at it. And the problem is here that that dust debris surrounding the remnant is blocking our view.

00:13:00 Tim Hamilton

Now, with the infrared light, the James Webb can see deeper through the dust than the Hubble can. But in this case there's still too much of it to make.

00:13:08 Tim Hamilton

Take a look at picture 5. We've got a nice schematic put out by the people at the Space Telescope Science Institute, which runs both the Hubble and the James Webb, showing you what we believe is going on with each of these there. This is really labeling the parts that I've already shown you here, and hopefully over the next several years - maybe it will take decades - we'll be able to get deeper and deeper views into that inner spot there and see what kind of neutron star or black hole we've got.

00:13:38 Tim Hamilton

Let's take a look over at Picture 6 now. This is a weird object. It's called a Herbig- Haro object named after the two astronomers who had discovered these back decades ago. Back early on Herbig and Haro had seen these bright spots in certain places in the Milky Way - pairs of spots.

00:13:57 Tim Hamilton

in the infrared. And think of infrared light as heat raised basically. So, they knew that these were hot spots, and they were arranged kind of like dumbbells.

00:14:08 Tim Hamilton

But that what was in between them? And it turned out that there are stars in between them. What we're looking at in this case now with the Hubble Space Telescope and finally with the James Webb Space Telescope, is we can see that these are high speed jets of gas, ionized gas called plasma, super-heated, electrically charged gas.

00:14:28 Tim Hamilton

And young stars as they're forming cast off this gas at high speeds through jets from their north and their South poles.

00:14:39 Tim Hamilton

As these jets of gas slam into the surrounding gas and dust that that formed the star to begin with, it sheds that gas out, kind of like a cocoon, like a butterfly emerging from the cocoon. As it plows through that surrounding gas and dust, the shockwave caused by the high speed.

00:14:58 Tim Hamilton

motion of the jet heats up very hot and causes these hotspots, called the Herbig-Haro objects. This one is the 211th Herbig-Haro object that was discovered.

00:15:10 Tim Hamilton

And with the James Webb, we're able to see in great detail looking at the structure of those jets. In particular, we can look in this one and we can see how

00:15:22 Tim Hamilton

the the two jets coming out the bottom left and the upper right, they kind of Corkscrew around in a while from from time to time and they get they get make these parallel wiggle motions with a mirror symmetry on either side of that first generation of star called a protostar.

00:15:40 Tim Hamilton

This is giving us a clue that what's down at the core, we can't see the star because you see that brown smudge in the middle. That's the dust that blocks our view of it, even in the infrared right here. But it looks like it may be a binary star. And you see most stars are not like the sun that are by themselves. Most stars

00:16:00 Tim Hamilton

are members of a pair. We call them binary stars. Some, in fact, are parts of triple star systems. And then there are even others that are two pairs, so 2 binaries orbiting each other. So a quadruple star system. So.

00:16:14 Tim Hamilton

If it's a binary star, then you've got one star orbiting the other and vice versa. And as they go around each other, those jets are going to wobble around and make a corkscrew pattern, which we can see in the inner regions close to the middle here.

00:16:30 Tim Hamilton

Earlier observations of this Herbig-Haro 211 from the ground had shown the shock waves coming out there. The upper left and the lower. Sorry the upper right.

00:16:40 Tim Hamilton

And the lower left.

00:16:43 Tim Hamilton

But now we can actually see that the flow rate coming out with the James Webb, we can see it's actually slower than we expected from other kinds of protostars with similar kinds of outflows. So this is actually a little bit unusual then. So we can measure the speeds.

00:17:01 Tim Hamilton

Of these outflows, by taking pictures periodically, time after time, year after year, then and you can watch it and play a movie of that stuff moving out.

00:17:10 Tim Hamilton

Let's move on to picture 7. Now, this again, going back to a Hubble image taken almost 30 years ago. And I always like to put these together because it shows you the improvement that we've got with the James Webb over the Hubble and how much more sensitive the light is when the picture is with the James Webb

00:17:30 Tim Hamilton

with its much larger mirror, and it's much more sensitive cameras, much more modern cameras now, so here's a Galaxy called the Cartwheel Galaxy. That's the well, the one that looks like a wagon wheel at the center, right.

00:17:44 Tim Hamilton

You see that it's got that orange to yellow looking center - the hub, and then it has blue spokes going out to a bright blue ring around it. What you're looking at is different colors of stars. The yellow to orange colors are what we might call older, more evolved stars that are cooler in temperature. Now the bright blue comes from very hot stars.

00:18:09 Tim Hamilton

You think about

00:18:10 Tim Hamilton

the blue flame in a furnace, whereas you've got kind of the red coals of just a very dull bit of coals left over after a campfire. So that's the difference. We're looking at its temperature.

00:18:21 Tim Hamilton

So we've got cool temperatures at the center of the cartwheel Galaxy, and then that outer ring is bright and blue - so much hotter. What's going on here is that we're looking at new star formation. New stars include a mix of very hot stars and very cool stars. That means bright blue ones are

00:18:41 Tim Hamilton

the hot stars, cool dim red ones or yellowish orange here for the cool stars.

00:18:48 Tim Hamilton

Now it's got a lot more of those cool stars there, because those are made out of very small bits of mass. They never really get all that hot, and they don't live - they don't burn their fuel very quickly. They live for long, long times. On the other hand, the very massive stars, and only a few of them that are made

00:19:07 Tim Hamilton

are extremely hot and they burn through that fuel very, very quickly, so they burn out in just a few million years, whereas those fainter, dimmer, cool, red stars -those can live for 10s or hundreds of billions of years, maybe even a trillion years in some cases.

00:19:26 Tim Hamilton

So the bright blue phase only occurs while stars are being formed, because very quickly those bright blue stars burn out and they turn into cool red stars as well. And then you're just left with a cool red ones, “red and dead”, as we say.

00:19:41 Tim Hamilton

In the case of the cartwheel Galaxy, what happened is that another Galaxy slammed through the middle of the Cartwheel, which was originally just sort of a normal pinwheel spiral Galaxy like our Milky Way, and slammed through it and kept

00:19:57 Tim Hamilton

on going and then that slamming through created a shockwave that rippled outward through the Galaxy, and as that Shockwave expanded through the dust and gas of that cartwheel Galaxy, it compressed the gas very quickly, forming a lot of new stars at rapid speed, much faster than they would have formed if they were just left.

00:20:18 Tim Hamilton

for the slow drift of gas collapsing under the its own weight of gravity and its own slow time. This is called a starburst event, and that's a starburst Galaxy because that that burst of star form.

00:20:32 Tim Hamilton

Now if we turn over the picture 8.

00:20:35 Tim Hamilton

What we're looking at here is a combination of near infrared light. So it's almost like the visible as well as the mid infrared light with two different cameras on the James Webb, the near infrared camera or near-Cam and the Mid infrared Imager called - Mid Infrared Imager, Miri, M-I-R-I.

00:20:55 Tim Hamilton

Now in the mid part of the infrared, much longer, redder wavelengths than the visible light that we see. We get to look at the heat emitted by warm objects. In this case dust. There really is space dust literally out there in space.

00:21:11 Tim Hamilton

And you can see the spokes going out from the central hub out to the outer ring. That traces in the red here that traces the dust, which we could not see in the Hubble image. I mean we saw little hints of those spoke lines, but that was from new star formation going out there. Here we see the new star formation

00:21:31 Tim Hamilton

in the bluish colors and then the dust

00:21:33 Tim Hamilton

in the red.

00:21:35 Tim Hamilton

Now, where is the Galaxy that slammed through the cartwheel? We used to think it was one of those two on the left. By the way, notice the differences we see on those two, both in the Hubble image and on the the the Webb image. We see that the upper left Galaxy in the Hubble image is very bright and blue. New star formation going on.

00:21:55 Tim Hamilton

While the lower left is, we call it redder in astronomy, but it will look yellow to orange to the eye.

00:22:03 Tim Hamilton

And that's meaning that it doesn't have all that star formation going on. Now when we look with the James Webb, we see that that upper left Galaxy has got all this dust going through it, just like the cartwheel does. So you see dust is actually associated with star formation. Stars produce the dust, they they fuse

00:22:24 Tim Hamilton

Hydrogen into heavier elements going down the periodic table down in their cores with nuclear

00:22:28 Tim Hamilton

Fusion. And then those heavier elements as they swirl around in the star and they're ejected out into space by the strong winds off of the star as it evolves and and goes through its later stages. And then these materials stick together out there in space and form grains of dust, which are combinations of silicates.

00:22:49 Tim Hamilton

Kind of like what you find in sand on the earth, like quartz and so on, as well as hydrocarbons.

00:22:55 Tim Hamilton

Carbon and hydrogen, other other kinds of those elements stick together, and in some combination of this forms that space dust. Now that dust is actually important for life, because without the dust it's very hard to form planets. You can't form solid planets without solid material. Furthermore, that carbon that's in the dust

00:23:16 Tim Hamilton

is also some of the carbon that we get into into the bodies. We need carbon for living things, at least as far as life as we know it. So here you can actually see that process of the dust formation going on, right

00:23:29 Tim Hamilton

Here. Let's go on to picture 9, and here's something entirely different. Here we're looking at Saturn's moon Enceladus, which is a large moon orbiting around Saturn. And in the little insect picture, you see a photograph from the Cassini spacecraft, which orbits around Saturn and has made several close passes to Enceladus.

00:23:51 Tim Hamilton

If you take a look at the bottom, you see those that

00:23:54 Tim Hamilton

spray coming out?

00:23:56 Tim Hamilton

That is actually what we call a cryovolcano. Cryo from the Greek word for ice. So what this is this is a cryovolcano. It's so cold out there that ice is a rock. Ice is just treated by the planetary astronomers as a a plain old rock. A mineral like quartz and feldspar and so on

00:24:16 Tim Hamilton

like that. Like we would have on the Earth. But it's so cold out there that it never gets liquid. You don't find liquid water out there unless something else heats it up. Sunlight? Way too faint. Way too cool in order to melt the ice out that far out in the solar system. So.

00:24:33 Tim Hamilton

If ice is like a rock, then when it's heated up and melts, that's lava.

00:24:40 Tim Hamilton

So we have this molten lava. It's somewhere down inside Enceladus, which is like the magma inside the Earth, and when it sprays up through the crust, you get a cryovolcano, which is like a regular volcano on the earth. And it's spewing hot, molten…water. You might also think of it like a geyser, which would also be a pretty good description.

00:25:00 Tim Hamilton

Now what we see here in that wider blue kind of skewed rectangle there.

00:25:07 Tim Hamilton

Is we're looking at

00:25:11 Tim Hamilton

a photograph – a combination photograph and spectrum. Now this is a new, relatively new kind of an instrument which is on the James Webb. We've had them for about 20-30 years for practical purposes. Now they're getting better and it's called an integral field spectrograph or simply an integral

00:25:29 Tim Hamilton

field unit. The idea is you take a picture and every pixel in that picture you've got a spectrum. You shine the light from that pixel through a prism, or more commonly, what we call a diffraction grating. But it does the same thing, and that spreads the light out into its colors.

00:25:47 Tim Hamilton

As it does so, we get the chemical signature of whatever elements and molecules are in there. So this is a great fantastic tool. Now it doesn't look like much on the picture, but you can see that that bright pixel in the middle of that blue image, that whole pixel there is what contains the entire moon of Enceladus.

00:26:08 Tim Hamilton

That's that, that little rectangle showing you it goes down to that pixel.

00:26:12 Tim Hamilton

And what we can see with this web image is that that water is spraying out far into space, and if we take a look at the next picture, we can see how this is a schematic. It's got the photograph of the lower left, but the rest is the schematic. We can see Saturn and its rings there and then we see that Enceladus.

00:26:32 Tim Hamilton

is making a ring of water vapor surrounding it or a little frozen water droplets. So it's kind of like ice crystals orbiting around Saturn, all spewing out of its cryovolcanoes. Now.

00:26:46 Tim Hamilton

By shining that light of each of those pixels through the spectrograph, then we can see the chemical signature of water showing up with bright spikes. Or they show up as spikes in that graph there, and so this is a fantastic tool. We can do both imaging taking pictures and the spectroscopy which gives us the chemistry and the physics

00:27:05 Tim Hamilton

at the same time.

00:27:08 Tim Hamilton

Let’s go on to picture 11 now. This is actually one I'm very excited about because this picture was taken by a team that I'm on is called CEERS, C-E-E-R-S, which stands which stands for Cosmic Evolution, Early Release Science. By the way, when we came to naming the team we had

00:27:27 Tim Hamilton

oh, we had, like, one or two emails going around about the proposal for using the James Webb and then we had 28 emails in one or two days about what the acronym should stand for. Yeah, it shows you what we astronomers get excited about. It's coming up with cutesy acronyms.

00:27:44 Tim Hamilton

This is a big team. We've got like 100 some odd people in it and we all do all different kinds of science, but we're using the James Webb in a large part to take pictures of the very first galaxies that were formed. That's one of our big goals. And so, uh, the head of our team, Steve Finkelstein at the University of Texas.

00:28:03 Tim Hamilton

He was looking at the pictures when they came right off the telescope and in this wide picture here he saw -

00:28:10 Tim Hamilton

this is that little inset box there. This faint little red smudge and that red dot is a Galaxy now, judging from the color, this turns out to be one of the most distant galaxies ever found. And at the time it may have been the most distant one ever found. Now, because the universe is expanding. As I explained before, the farther away a Galaxy is, the faster it's moving away from us.

00:28:33 Tim Hamilton

Now, because of relativity, a Galaxy moving away from us at high speed will have its color look redder than it really is. It's called red shift. The faster it moves, the more the color is red shifted.

00:28:45 Tim Hamilton

Now, for galaxies that are fairly close by, they're not really moving away all that quickly, and the red shift is pretty small. For those, the Galaxy looks normal to our eyes, and you can really only tell the color shift by using that instrument called a spectrograph. Kind of like what we used in that picture of Enceladus there.

00:29:04 Tim Hamilton

Now that with the spectrograph, we would then look for the distinctive colors emitted by elements like hydrogen, say, and we'd being able to see if that color has shifted just a bit. But when the Galaxy is really, really far away, the red shift is so big that it takes on a very distinctively red color, visible to the naked eye.

00:29:22 Tim Hamilton

Or at least when you're looking at the computer screen. Now, we didn't have a spectrograph to check the red shift on this exactly from this photograph. So Steve had to judge judge it based on how well its color matched what we would expect for a Galaxy that far away. That's not as accurate, but it will do for a first look. And what he found was that

00:29:43 Tim Hamilton

this Galaxy appears to be 13,400,000,000 light years away from us.

00:29:50 Tim Hamilton

That means we're looking at it the way it used to look 13,400,000,000 years ago. Remember, a light year is the distance that light travels in one year. So if something is 10 light years away from us, we see it the way it looked 10 years ago. If it's 13 billion light years away, we see it the way it looked

00:30:10 Tim Hamilton

13 billion years ago.

00:30:12 Tim Hamilton

Now. So we're literally looking backwards that far in time now. It's not a figure of speech. We are literally looking backwards in time when we look out that far in space. Well, the universe itself is only 13,700,000,000 years old. So we're looking at this Galaxy when the universe was only about 300,000,000 years old.

00:30:34 Tim Hamilton

Give or take a bit.

00:30:36 Tim Hamilton

That means that the galaxies were forming very early on after The Big Bang and the creation of the universe to begin with. So when Steve found this Galaxy, it turned out it was his daughter Maisie's birthday, and she asked him if he would name something for her. And so we've named this Maisie's Galaxy, and the name seems to be sticking.

00:30:55 Tim Hamilton

We published- well “we” - I'm I'm on the team, but I wasn't on this paper. We published a paper very quickly after this announcing the most distant Galaxy known.

00:31:04 Tim Hamilton

And then a day later, somebody else published another paper, discovering another Galaxy that was even farther out.

00:31:10 Tim Hamilton

And a day or two after that, there was another paper announcing even a further Galaxy. So it's really tough competition when you're looking back to the beginning of the universe.

00:31:20 Tim Hamilton

Let's go on to 12 and here we get on to our last subject for this podcast. This is for 12 here. This is a Hubble photograph. And then in 13 I'll show

00:31:30 Tim Hamilton

You the Webb view.

00:31:33 Tim Hamilton

This is a picture of a cluster of galaxies, and here we see the Hubble view of it and if you click over onto the next page, page 13, you'll see the Webb view and notice how much brighter everything is. This shows you again how much more sensitive Webbs

00:31:52 Tim Hamilton

cameras are and how much more light we gather with that gigantic 20 foot wide mirror.

00:31:57 Tim Hamilton

This is what we call the first deep field image the Webb took of the Galaxy cluster one called SMACS 723 now SMACS is an acronym. It's called the Southern Massive Cluster Survey, and it's looking at clusters of galaxies all around the southern half of the

00:32:14 Tim Hamilton

sky. Now while some galaxies sit alone

00:32:17 Tim Hamilton

by themselves, others are found in groups like our Milky Way, which is in a group with the Andromeda Galaxy nearby and several small what we call dwarf galaxies orbiting around the pair of them. Still other galaxies form large clusters, which could have even hundreds of large galaxies and many more dwarf galaxies.

00:32:37 Tim Hamilton

The idea of a deep field is that the telescope takes a long exposure of 1 field of view, 1 patch of the sky to look for, very faint and distant galaxies. In this case, astronomers had the Webb stare at this one field of view for over 12 hours.

00:32:56 Tim Hamilton

You can compare that to the fraction of a second you might use to take a photograph of a sunny scene with your phone. As a result, the Webb can see objects that are about 100 fifty, 155 billion times fainter than the faintest stars you can see with the naked eye.

00:33:13 Tim Hamilton

When we look at these clusters of galaxies, we see something remarkable. The gravitational pull of the galaxies warps the fabric of space-time around them, which bends the path of light rays coming from even more distant galaxies, ones that are behind the cluster, And,

00:33:31 Tim Hamilton

the cluster then acts kind of like a wavy, warped limbs that distorts the view of those more distant galaxies behind it, turning them into long, thin arcs and making it look like you're watching them through a round fishbowl.

00:33:46 Tim Hamilton

In many cases, the images of these background galaxies are split into many copies so that we see several distorted versions of each one. This effect is called a gravitational lens, and it really does act like a lens. It magnifies and it brightens the things behind them.

00:34:04 Tim Hamilton

You can see the lensed galaxies, the ones in the distant background. When you look at this cluster, if you look for the long thin arcs and ones which are kind of pulled out like stretching taffy or distorted into weird shapes, and they'll tend to make arcs that sort of ring around the center

00:34:23 Tim Hamilton

of the of the of the cluster, and so you're going to see these arcs making kind of circles going around the picture here.

00:34:32 Tim Hamilton

Now, because the amount of distortion we see depends on the mass of the Galaxy cluster that acts as the lens, we can use the lensing effect to weigh these clusters and find their mass. We now know that most of the mass of the Galaxy is not in the stars or the gas clouds, or the space dust. All those things we can see directly with the telescope.

00:34:52 Tim Hamilton

Instead, the vast majority of that mass is something called dark matter.

00:34:57 Tim Hamilton

In a cluster, this dark matter makes up over 80% of the total mass, while stars are only around 5% and almost all the rest of

00:35:06 Tim Hamilton

it is gas.

00:35:08 Tim Hamilton

So what we can do, we can calculate the total mass with gravitational lensing. Then we can subtract away the mass we see in stars and gas, and then what we're left with is the dark matter.

00:35:23 Tim Hamilton

We don't really know what dark matter is, though. There have been theories that it could be small black holes or even rogue planets flying out between the stars, but there haven't been enough of those found to account for it. The best theory most of us believe, is that it's made-up of some kind of exotic subatomic particles, popularly called WIMPs. W-I-M-P.

00:35:44 Tim Hamilton

That's Weakly Interacting Massive Particles. Again, acronyms. Everything in astronomy is an acronym it seems.

00:35:51 Tim Hamilton

But which kinds of particles are those? Experiments to identify them haven't found any yet, and there are a lot of these particle types that have been predicted by the particle theorists, though, so we may just have to keep trying them one after another and see when we finally find something.

00:36:08 Tim Hamilton

So that's what I've got to show you. And I will say that

00:36:13 Tim Hamilton

because the pictures coming out of these are just so impressive in their own right, I've put together an activity where you can go on to our website and you can download some of these pictures from the Hubble, from the James Webb, and you can experiment with making full color images out of them.

00:36:33 Tim Hamilton

Because all the pictures taken by a telescope, by a professional telescope, are black and white, and in order to make a color image, what we do is we take

00:36:42 Tim Hamilton

a red filter, a green filter, and a blue filter. We take a black and white picture with each one of those colored filters, and then we use some special software to put them together to make the color the full color.

00:36:55 Tim Hamilton

Why do we do this? The reason is is that we don't usually just do

00:36:59 Tim Hamilton

Red, green, and

00:36:59 Tim Hamilton

Blue. In fact, a lot of the colors you see here aren't even visible to the eye. Infrared, ultraviolet in some cases, and so on. So this allows us to use any combination of wavelengths of light, no matter what

00:37:13 Tim Hamilton

it is. And then we can combine them to get that full color image and then comparing where do things look red or bluer, and so on tells us about the physics of what's going on.

00:37:25 Kimberly Inman (host)

You've been listening to Connecting Classrooms brought to you by the College of Arts and Sciences at Shawnee State University. For show notes and extended classroom activities related to this episode, please visit www.shawnee.edu/connecting. For this episode, audio engineering was provided by T.R. Berry.