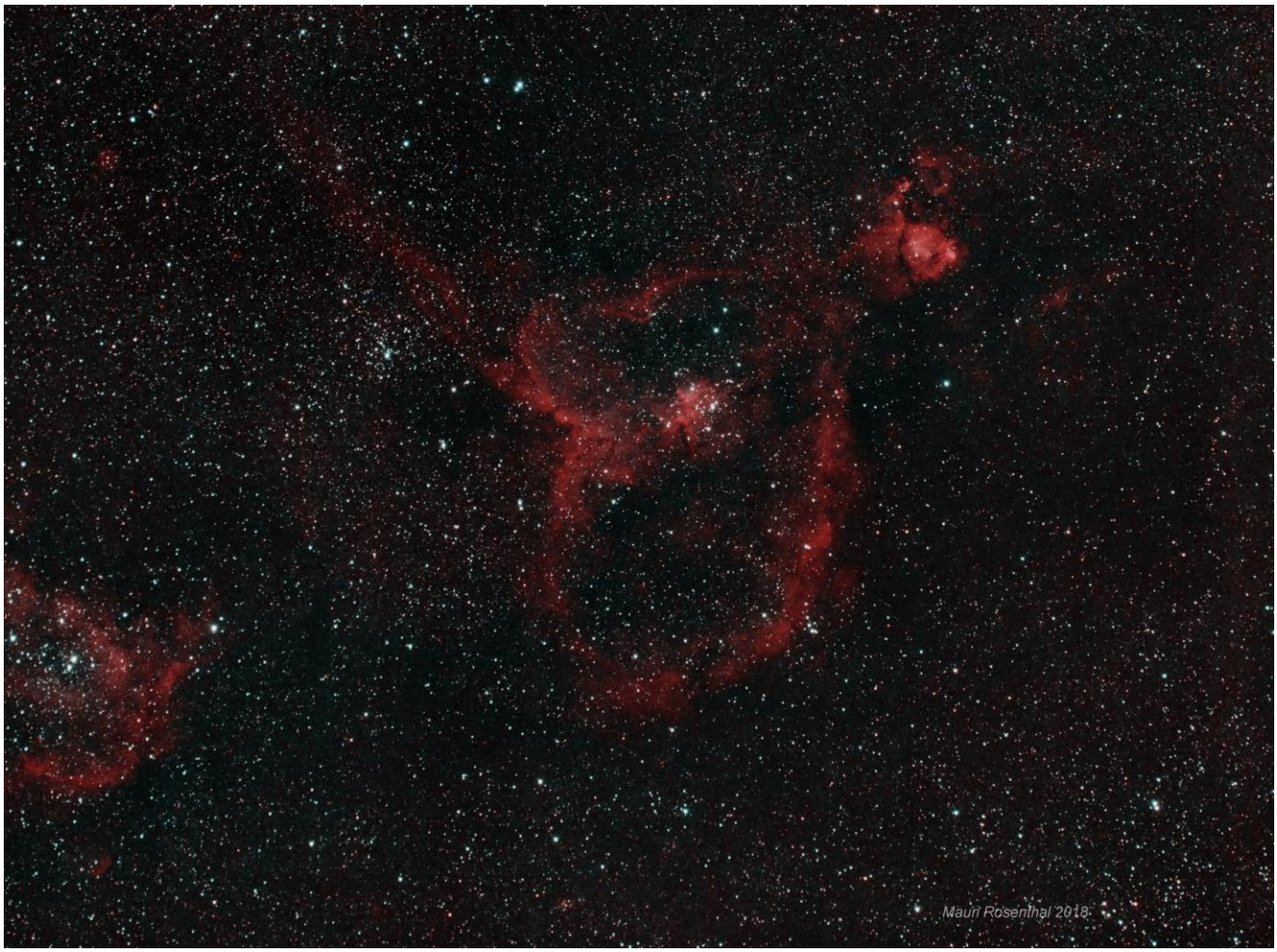
SkyWAAtch



From the Heart

Mauri Rosenthal captured the Heart Nebula – and a fraction of its neighbor the Soul Nebula – from his driveway in Yonkers. Spanning 200 light years, the heart-shaped emission nebula lies some 7500 light years distant in the Perseus spiral arm of the Milky Way, appearing to us in the constellation Cassiopeia. The bright cluster of newborn stars at the center – Melotte 15 – is said to be providing the energy which illuminates the broader structure. Mauri used his Borg 55FL astrograph, a ZWO ASO1600 MC astro cam, an IDAS LPS-V4 filter, and guided iOptron CubePro 8200 mount to shoot 70 minutes of 8 second exposures which were processed in PixInsight. Please see Mauri's interview in this newsletter with Robin Glover, in which Robin describes some new features of his software SharpCap which Mauri put right to work in capturing this image.

Events for November

WAA November Lecture

"Prospects for Lunar-Based Telescopes"
Friday November 2nd, 7:30pm
Lienhard Hall, 3rd floor
Pace University, Pleasantville, NY

The increased interest by NASA, international space agencies and private sector companies in returning to the Moon with robotic and crewed missions during the next decade and beyond opens up new possibilities for conducting scientific investigations from the lunar surface. Our speaker is Dr. Jon Morse, the CEO of the BoldlyGo Institute, who will discuss the pros and cons of establishing lunar-based observatories to study the cosmos and how such facilities might work in concert with future ground-based and free-flying space-based telescopes.

Dr. Jon Morse has more than 20 years of leadership experience in space missions, space-focused organizations, and science and innovation policy. His academic appointments include Professor of Physics at RPI and Associate Professor of Physics & Astronomy at ASU. He served as Director of the Astrophysics Division at NASA HQ from 2007-2011, overseeing the launches of Fermi, Kepler, WISE, Hubble Space Telescope (HST) SM4 and other missions. Prior to that he served as a Senior Policy Analyst in the White House Office of Science & Technology Policy with a portfolio encompassing physical sciences and engineering at NSF, DOE, NASA and NIST. Before moving to ASU in 2003, he served as Project Scientist for the HST Cosmic Origins Spectrograph while at the University of Colorado. He is a Harvard graduate and earned his PhD from the Department of Physics & Astronomy at the University of North Carolina at Chapel Hill. Free and open to the public. Directions and Map.

Upcoming Lectures

Leinhard Lecture Hall
Pace University, Pleasantville, NY

Our December 7th speaker will be Dr. Andrew MacFayden of NYU. He will present on Gravitational Waves.

Call: 1-877-456-5778 (toll free) for announcements, weather cancellations, or questions. Also, don't forget to visit the WAA website.

Starway to Heaven

Saturday November 3rd, Dusk.
Ward Pound Ridge Reservation,
Cross River, NY

This is our scheduled Starway to Heaven observing date for November, weather permitting. Free and open to the public. The rain/cloud date is November 10th. **Important Note**: By attending our star parties you are subject to our rules and expectations as described here. Directions and Map.

New Members. . .

Robert Lewis - Sleepy Hollow
Greg McAlpin - New York
Leah Heiss - Chappaqua

Renewing Members. . .

Kevin Mathisson - Millwood
Peter Germann - Katonah
Claudia & Kevin Parrington – North Salem
Cliff Wattley - Danbury
Richard Rubin - Somers
Kevin Shea - Ossining
Elaine Miller - Pound Ridge
Emmanouil Makrakis - Scarsdale
Samantha Castellano and Family - Hawthorne
Daniel R. Poccia - Cortlandt Manor

Also In This Issue . . .

Westchester Amateur Astronomers

ALMANAC
For November 2018 by Bob Kelly


Nov 7 Nov 15 Nov 23 Nov 30

First things first. Until the abrupt transition from Daylight Time hits us on Sunday, November 4th; we have a few mornings when the morning darkness stays around to greet us when we awake. It's a good thing. In addition to the preview of the winter constellations, we get the see the crescent moon sliding straight down the ecliptic toward the horizon. After the moon's last quarter stand high in the dawn sky during the last few days of October, its path to new moon has a large angle with the horizon.

Venus rises to meet the Moon on Election Day, the 6th, but at only 17 degrees from the Sun, we are hard pressed to see them rising just after 5:15am EST. If you can find Venus with binoculars, you might see Spica just above, closest on the 14th. But Venus leaps into the dark sky. Near the end of the month, Venus is more than 30 degrees from the Sun and almost minus fifth magnitude in brightness. Ironically, Venus will look smaller over time but more of the planet is in sunlight as seen from Earth; so overall, it gets brighter.

The evening sky keeps its sweep of planets low in the southwestern sky. Mercury and Jupiter are equally low and hard to see on the 4th, joined by the Moon on the 8th, as Jupiter departs the evening sky. Mercury's greatest elongation from the Sun is 23 degrees on the 6th but the planet doesn't get high in northern hemisphere skies.

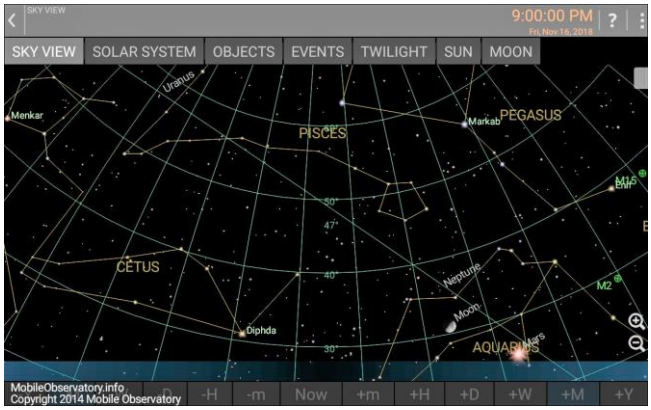
Saturn still stays up after the end of twilight until early December, but also suffers from 'low ecliptic syndrome'. The Moon faces Saturn on the 11th as Luna seemingly struggles to get out of the twilight's last gleaming. Iapetus is brightest around mid-month, 2.9 Titan-orbit widths ahead of Saturn, but harder to find though our thick atmosphere. Brighter Titan is on the same side of Saturn as Iapetus from the 12th to 15th.

Mars is getting smaller and smaller in the telescope, but is high in the south and actually getting higher and easier to find, especially in comparison to the other planets. The reddish planet will be even higher in our sky at the next closest approach in October 2020. The Moon saunters past on the 15th. People who haven't noticed Mars lately will be surprised by the red 'spacecraft' soaring over the Moon's north pole.

Uranus and Neptune provide useful targets for the planet-starved astronomer. Both are up in the middle of the evening, but need a bit of hunting to find. Uranus is near the Ares/Pisces border. Neptune is in Aquarius.

If you want to know where Pluto is this month, the Moon crosses in front of the Kuiper belt object during the afternoon of the 12th.

The constellations Eridanus and Fornax don't usually get much press, but an asteroid and a comet, respectively make noticeable appearances there in the November. Asteroid 3Juno is closest to Earth on the 17th, at magnitude plus 7.5 all month in Eridanus. Follow Orion's bow westward to get to Eridanus and Fornax.



We may be able to see Comet46P Wirtanen in Fornax in binoculars in the second half of November. 46P will be only 7 million miles away from Earth in mid-December. The comet may flare to magnitude plus 7½ or more compared to its more likely maximum at +8½ in December, so it's worth keeping an eye on. Could be a pretty picture with the Pleiades December 17th and 18th.

This loopy comet could be an article all by itself: see November's *Sky and Telescope* (pg. 50).

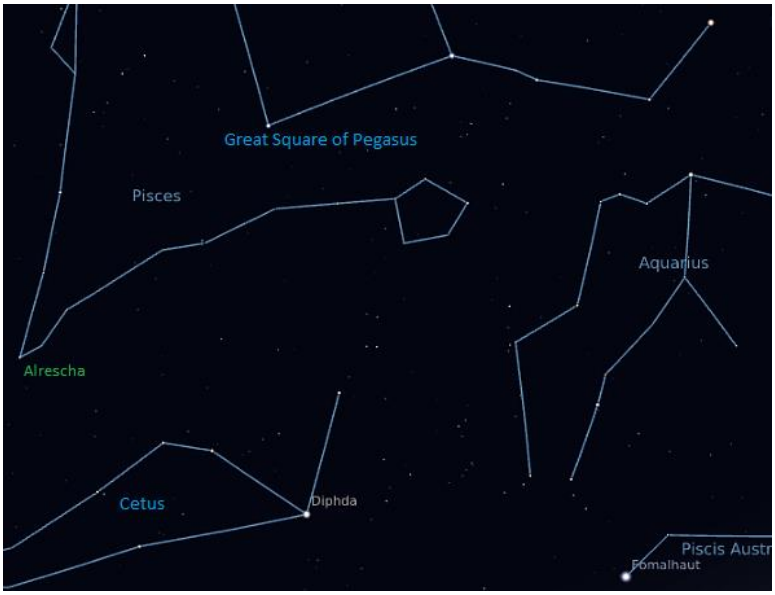
The Leonid meteor shower peaks on the evening of the 16th. Because the Earth plows through the shower, leading with our sunrise side, the peak of a dozen or two meteors an hour will be after midnight, but pieces of Comet 55P/Tempel-Tuttle might show up anytime that night. They often leave persistent trails behind.

The Sun is deep in solar minimum. If solar observatories report any sizable sunspot groups, check them out while you can (with the proper solar filter). There still can be solar eruptions, and strong aurora produced by them, but less frequently during solar minimum.

Prime satellite-spotting time for the brightest satellites is after 4am in morning twilight and until 7pm in evening twilight. The ISS, with only three souls aboard at this writing, is visible in morning skies through the 16th and evening skies starting on the 21st.

In The Naked Eye Sky
November 2018: The Frog, the Fish, and the Whale's Mouth
by Scott Levine.

If you've had the time to look at the skies toward the northeast lately, you might have noticed some familiar friends creeping into the night. Every year toward the end of October, we start to see the **Pleiades** (Messier 45) waving silently from above the houses across the street. It always startles me, kind of like flipping on the light in a dark bathroom and seeing a giant spider on the wall. I like spiders, but they're always much cooler about the whole thing than I am.



Before the Pleiades and the bright lights of the Winter Hexagon file into the northeast, November's southeast sky lets us challenge ourselves a little.

As mid-fall rolls in, most of the east is taken up by the enormous Great Square of **Pegasus**, sitting like a diamond in the early dark. The area below looks vast and empty, a forbidding ocean in Westchester's bright and imprecise sky. These are the watery constellations, Aquarius, **Cetus**, **Piscis Austrinus**, Pisces, Eridanus, the river splashing at Orion's feet, and Capricornus, the weird half fish-half goat thing, where Mars has been doing a bad job of hiding lately.

The brightest stars, shining like distant oases, are second-magnitude **Diphda** (β Cet), whose name means "frog," and **Fomalhaut** (α PsA). The whale's mouth is the southern-most first magnitude star visible in Westchester's nights. Neither of these stars ever get very high off the horizon, so, you'll need to hunt them down a bit. Because they are that low, though, they appear to twinkle more than others, and are stunning on these chilly nights.

Tucked between the Great Square above and Cetus below, **Pisces** is the most distinct of these constellations, and it kind of looks like what it's describing. Sure, I'd buy that there are a couple of fish there, hooked and bound by fishing line. Its most famous part is the **Circlet**; the asterism of five third- and fourth-magnitude stars in a rough circular shape that represent the western fish.

See if you can spot it on a clear night with no Moon. These stars can be tough to see, but when you do, you get an "Oh yeah" feeling. "The teapot of Sagittarius? Oh, yeah!" "The kite of Boötes? Oh, yeah!" From there, the rest of the constellation seems to fill in behind it; always there, hidden right before your eyes. "Oh,

yeah, there's Pisces!" you can say to your neighbors as they hurry across the street. Its brightest star, **Alrescha**, (α Psc) which represents the knot that ties the lines, is the last to join the fun.

Together with the more triangular eastern fish and the bigger V-shaped asterism, these stars almost seem like a handle pulling the entire Winter Circle into the night and bringing us toward the colder weather, and good things to come.

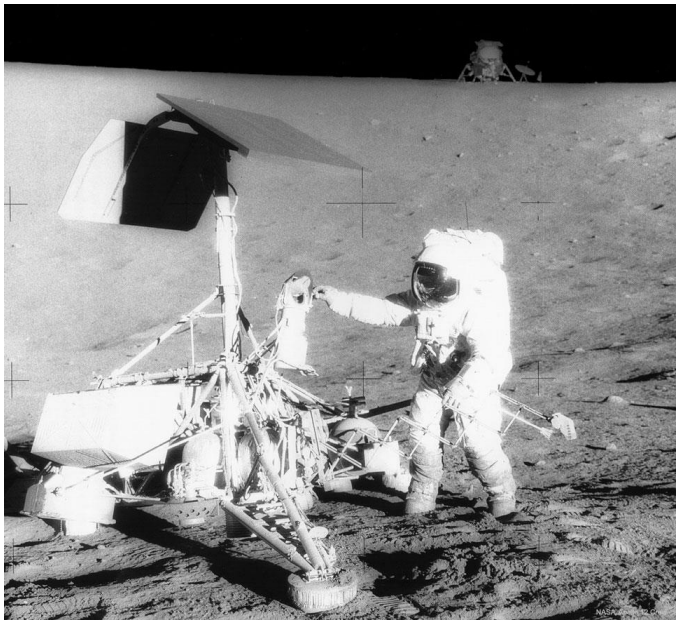
This entire patch of the sky makes me wonder what it must have been like long before light pollution. Imagine starring up at an infinitely starry night and still being to pick out patterns among the endless stars all around you.

While we wait for our old friends of winter to come back, why not try to spot some of the sky's dimmer, wetter constellations. I hope you'll have a look this month.

Lunar Photos

◀12 Day Old Moon

Courtesy of Bob Kelly is this picture of an almost full moon. Bob took the image with an iPhone camera through his 8" dobsonian at the Our Lady of Mount Carmel outreach event.



◀ Lunar Close-Up

Apollo 12 was the second mission to land humans on the Moon. The landing site was picked to be near the location of Surveyor 3, a robot spacecraft that had landed on the Moon three years earlier. In the photograph, taken by lunar module pilot Alan Bean, mission commander Pete Conrad jiggles the Surveyor spacecraft to see how firmly it is situated.

Credit APOD.

Image Credit: Apollo 12 Crew, NASA

A Discussion with Robin Glover about SharpCap and the Electronic Revolution in Amateur Astronomy

Mauri Rosenthal

I discovered it hiding in the software itself!"

- Robin Glover regarding the origin of the EAA capabilities in his software, SharpCap, which are now transforming amateur astronomy

This is an edited version of a conversation I recently had with Robin Glover, the developer of SharpCap and SharpCap Pro (http://www.sharpcap.co.uk). The purpose of our discussion was to generate this write-up to share with the readers of AAA.org's *Eyepiece* and the Westchester Amateur Astronomers newsletter, *Sky-WAAtch*.

Figure 1 Robin Glover (left) and Mauri Rosenthal Skyping

Mauri: Let's start by hearing your take on the extent to which the combination of the newer CMOS cameras and your software, SharpCap, has been kind of revolutionary, making astrophotography very different today than it was just three years ago before those products really came on board. So tell us, do *you* see it as revolutionary?

Robin: I think that's a very interesting question… CMOS has changed an awful lot of things and is still changing. When I first got into Astrophotography, maybe eight or nine years ago when people were taking webcams to pieces and using them to take lunar and planetary images, CMOS was very much the poor cousin of the CCD images. But since then there's been this fantastic investment by companies all over the world in CMOS technology because those cameras go into mobile phones, they go into cars that detect pedestrians in front of them, and they go into industrial processes. This vast amount of money has been spent not really for the benefit of amateur astronomers at all but it has made the CMOS sensors vastly improved over the ones we were looking at ten years ago. They have much less noise and are much more sensitive. Some companies have now been taking those sensors and putting them into astronomy cameras for us, and we can take advantage of all of those advances in CMOS technology that puts us in a great place to use some much lower priced cameras than we could see some years ago.

But what's very interesting about CMOS is that they challenge some of the long-held beliefs about astrophotography. For a long time people have been getting fabulous CCD images by using very long sub exposures, by stacking up the sub exposures of 10-15 minutes, and there's a very good reason for people doing that with CCD cameras. It's kind of become ingrained in the astrophotography mindset that you have to use those long sub exposures and people have perhaps forgotten the science and the reasons behind it for CCD cameras. It's tricky really because our own intuition says that when we use a photography camera outside, we take a short exposure, and when we use it inside where the lights are dim we take a longer exposure. It's kind of logical to us then that when we try and take photos of the night sky, where it's really, really dark, we take really, really long exposures. Further, when we're taking images of the night sky, we start to stack exposures -- which you don't do when you're taking images of your friend's wedding or your kid's birthday -- and that changes things. So, your intuition about length of exposure from photography doesn't really apply to this question: if I'm going to be taking an hour's images tonight of M42, would I be better off taking six ten-minute images or sixty one-minute images?

Now when you dig into the mathematics of this you discover that the important thing for how long an image you should expose is the *read noise* of the sensor. CCD sensors typically have a read noise of seven or eight electrons, so that means every time we read an image off one of those sensors there's an error added to every single pixel that is equivalent to seven or eight

electrons of noise. In certain CMOS sensors, depending on the gain you've set, you can have read noise between one and two electrons -- so that's an awful lot lower. It turns out that it's important to try and keep the contribution of read noise down because you don't want to be paying the price of that noise every single frame. If you took a 60 one-minute frames you're paying that eight electrons cost of noise every single frame: if you've got a CMOS camera that noise is much less of a cost to pay every frame. When you work through the math you discover that a roughly four times reduction in read noise on a CMOS sensor means that you can get away with reducing your sub exposure time by a factor of sixteen. So suddenly, you look at a case where instead of taking for fifteen minutes up to say over that one hour of imaging you get similar results with the CMOS sensor by taking one-minute subs. Now one-minute subs are very different from 15-minute subs because you can start asking yourself questions like: Hey, how bad could my tracking be if I'm only going to be taking a one-minute sub? What happens if an airplane comes across? Hey, cool I only lose one sub out of sixty not one out of four. Does it matter if I'm using an Alt/Az mount? I mean it's going to field rotate a little bit during a minute but maybe that's not going to be noticeable in a one-minute exposure. Once we've asked all of those questions maybe we discover that by letting the software do the fix-ups for slight drifts in your mount tracking or rotation you're suddenly making astronomy and astrophotography a much more accessible subject.

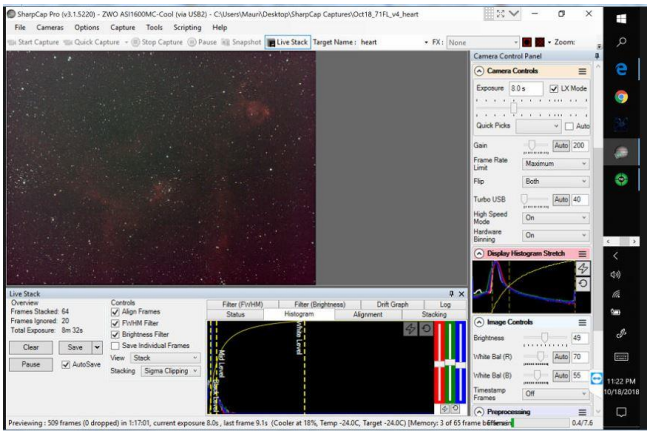


Figure 2 Screen cap of SharpCap in use for imaging or EAA

M: Robin, to me it's interesting that your illustration is using one-minute exposures with CMOS cameras. I've gone maybe to a crazy extreme which is that I am stacking 4-second or 8-second exposures which have a lot of the benefits that you just rattled off. I get away with terrible tracking using fairly flimsy mounts on lightweight tripods that contribute to my ability to do what I call ultra-portable urban astrophotography. It actually transforms my work dramatically from just trying to get five-to-ten minute subs into getting ten minute stacks in SharpCap by using literally four or eight second exposures. Did you have that in mind? Because in my mind that's where it's truly revolutionary.

R: So sure, there are plenty of people who use incredibly short exposures – there are fabulous pictures you can find out there of galaxies by people who've done one-second exposures and that's pretty much taking it to an extreme. There's a sweet spot in the middle where you're not stretching your mount too far but you're getting the best you can out of your camera. The position of that sweet spot depends on the actual sensor in your camera; it depends also on what gain you set; and it depends on the brightness of your sky. Actually, that sweet spot is a lower exposure for astronomers who are in highly light polluted areas where they've got a strong sky background and is a longer exposure if you are lucky enough to live out in some nice dark area.

It's actually quite complicated to calculate that accurately. This is one of the things that I've built into the recent versions of SharpCap Pro. There's a tool called the Smart Histogram and it comes in two stages: First of all it guides you through measuring the characteristics of your sensor. For a lot of the common ones, they're build-in so you don't have to do that, but if you've got a new camera you may have to measure it and that creates a data file on your computer that SharpCap can use every time you open your camera. Thus, it knows the read noise and a lot of other characteristics of your camera, and it means that when you open up the histogram you get some guidelines as to what exposure you need to take. To use it to its full extent you actually tell SharpCap to take a measurement of the background sky brightness in your area. Of course, that might vary -- the moon's coming around again, you'll have a much brighter sky tonight than you would on a new moon evening. Once SharpCap knows about the sensor in your camera and it knows about the sky brightness it can actually run through all those complicated calculations that I've alluded to without you having to worry about them at all. It will say, hey, you'll get best results by setting a gain of 220 and using 16 second exposures.

M: I might still go through all of that and still think that my tracking is really only going to allow for 8 second

exposures so I'll trade-off shorter exposures for more noise because of higher gain.

R: That's exactly one of the things you can do if you think you're tracking only runs two-to-five seconds you can just put a bounds on it and say I don't want my exposures to be longer than that and it will then find you the best combination subject to that limitation.

M: Great!

R: It's that fabulous ability to take short exposures and not worry about your tracking, and then just see an image grow on the screen all at once. I mean most of us are impatient people. You know it's hard when you go out and do astrophotography the old way because you really don't see very much on the screen to begin with. You take all of these sub exposures; you save them to disk; you come back indoors and then you stack them; and sometime later you finally start to see an image. But it's much more involving to see that image grow in front of you on the screen as each 4-second or 15-second exposure is added to the stack.

M: Exactly, and that and that brings us to the other revolution which is EAA (Electronic Assisted Astronomy). I use this regularly at outreach in New York. SharpCap live stacking and those short exposures with filtered optics enable me to show some deep sky stuff in real time to people at outreach events. Now I think the epitome of EAA is to get an almost instantaneous view on a screen and mine build a little bit more slowly than that, but my sense is that this is something that simply couldn't have been done five years ago at all -- or it could have been done in a very kludgy fashion. But you've enabled people to use astrophotography equipment plus any kind of optics and mount combination and dramatically improve the reach for a casual night of visual observing (now electronically) rather than for creating a processed astro image. Was that part of what you had in mind or is that just a side benefit that we get?

R: SharpCap has largely evolved as I've become interested in different aspects of astronomy. So, it all started about eight or nine years ago with webcams and trying to photograph the Moon and the planets with those and realizing just how dreadful the software was that you had to use at the time. I'd be spending an evening outside with the laptop and gloves on in the cold trying to focus on Jupiter and make the laptop do what it was supposed to but making so many mistakes because the software was fighting against me too. So SharpCap started off with a focus on lunar and planetary imaging via webcams, and then as I've become interested in different parts of astronomy different features have been added to SharpCap. About three or four years ago we started getting EAA tools appearing. Often in those days they were tied to a particular brand of camera. Some of the results that were being got were particularly impressive and I realized that I already had a piece of software that did at least one of the hard tasks, which was talking to five or six different brands of cameras quite reliably -- cameras that could easily do these longer exposures, the 5 or 10 or 20 seconds required for EAA. The only part of the problem left to solve was adding up the frames -- aligning them and adding them up -- and that was not a desperately hard part of the solution. It was like a light bulb moment for me: all I've got to do is add this alignment feature and suddenly SharpCap can be an EAA tool. So it was almost that I discovered it hiding in the software itself. It was there, almost ready to be done and I thought wow I can do this! So it was literally two or three weeks of work over the summer of 2015 to go from no EAA to having a workable live stack in SharpCap and being outside testing it out under the stars. It's been fabulously popular since then.

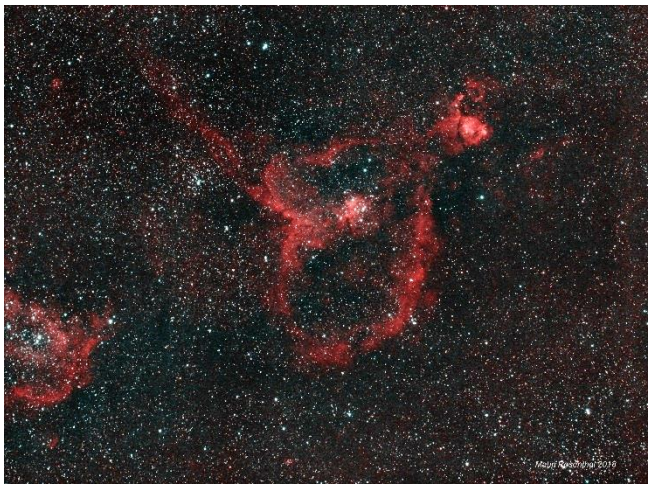


Figure 3 Author's image of IC1805, Heart Nebula, using SharpCap Pro techniques discussed in article including 8 second exposures, dithering, and flat and dark subtraction

M: Yeah, well I think it's remarkable. I think you're understating it. When using it in outreach I will describe what's happening. I'll say that your brilliant software (because people are looking at SharpCap on my laptop which has a tablet configuration so they're looking at the entire interface along with the image display) every 4 seconds or 8 seconds is taking an image off the

camera; it's doing a flat subtraction; it's doing a dark subtraction; and then it's registering the stars and averaging into the stack – and it's doing this in 1.3 seconds. I think you clearly did something extremely creative to get that on-the-fly stacking. Did you use existing algorithms, or did you actually come up with a completely new algorithm for such fast stacking?

R: So the stacking breaks down into sort of three or four different stages. First of all you've got to find some stars and you know I use an existing algorithm for that. That one's been well solved and there's no point in going out there and re-writing it. Then you've got to match up the patterns of stars in the stack with the patterns of stars in the latest frame that have come in so you can work out the alignment. That one I wrote myself. There are algorithms out there to do it but it was a nice interesting challenge to write one myself that was definitely going to be fast enough. It's a little bit like plate solving. Then finally you've got to transform the frame so maybe move it 3 pixels to the left, 2 down and rotate it 1.2 degrees. Again this is already well solved in software and there's no need to reinvent that wheel. And then it's just adding it on which is pretty much simple once you've done all those slightly harder bits of finding the stars, aligning, and transforming.

M: Well I am very grateful for your figuring that out because it's given me a very cool hobby!

R: It certainly brought more targets within reach of outreach because you know before you'd have been showing the moon, you'd have been showing any planets that happen to be within reach, but for the deep sky stuff as you say you would have been constrained by time to get anything meaningful before somebody who's never seen astronomy perhaps loses interest and wanders away.

M: You've already covered this in part of your answer, but I just want to confirm that by way of background you have a day job and you're a software developer and in effect you kind of wanted to solve these problems for your own account and that's what led you down that path of building the software. Is that a fair summary?

R: Yeah pretty much. You know I've been a software developer for many years; I have a day job where I write software in a completely different area. My software ends up being used by law firms and it's completely different from SharpCap but both of them are interesting. But it was just struggling to use the capture tools that were available several years ago and I think you know people who were into the scene then will remember things like *AmCap* and *WXAstroCapture* which were just trickier to use and I used to go outside and try and capture the moon and I take one video and then press snapshot and capture or capture again and I'd realize I just wiped over my previous file with a new one. It was little things like that that made me realize that this software that we had was not designed to be used by people struggling with focusing and tracking at the same time, using a laptop in the dark. It needed to be something that was more foolproof.

M: Yeah I think there's a lot of that in amateur astrophotography. I was very impressed when I first started tracking with PHD to read Craig Stark's description of very similar phenomena -- that he was so tired of being eaten alive by mosquitoes that he felt a need to use his programming skills to build a more robust and easier to use tool to get tracking up and running on any computer with any guide camera and so on. So there's a big parallel. I don't know if you've met him…

R: No, I've never met him, but talked a couple of times over email – he's a great guy.

M: …but I think these are two amazing stories of two guys who we're all very grateful to for providing these tools. Let's move on to one last topic which is the future. What do you envision as the next best things? I can give you my wish list for what I'd like to see next in SharpCap, some of which are probably impossible. Things like, can you image through clouds, please?

R: (Laughs) No! That cloud dispersal feature never works! I keep trying to write one and it never works properly either.

M: Well fix that and you'll get a Nobel Prize. But what do you see as the most important next steps and then I'll bounce my ideas off you.

R: Things that I'm definitely aiming to improve: One thing is I want to have a sequencer in SharpCap so that people who do more complicated imaging runs, perhaps with filter wheels and so on, could build a sequence to take a hundred frames, change the filter wheel to the red position, take another hundred, move the filter wheel to the blue position etc., etc., etc. This is a fairly frequently asked for feature by the power users of SharpCap so that's one way that I want to expand things.

Another is I'm always looking into ways that the image can be improved by the software. The CMOS cameras that we use now are not designed with astrophotography in mind -- they're designed for industrial processes and small format cameras. So the guys who

build them, don't go out and take two or four minute exposures in in the dark and then stretch them almost to the point that they're ripping apart the levels to see what the output looks like, because that's not what the cameras are designed for. But that's what we astrophotographers do, and so we typically expose flaws in the cameras and some of these flaws we correct with dark subtraction, like amp glow. Another flaw that's become prevalent in some of these CMOS cameras is that you see a slight variation in brightness between different lines in the image creating a sort of horizontal banding in the image. The latest version of sharp cap has a tool that's helped to suppress that in the individual frames as they're captured so it looks for that sort of pattern in the image. If you've turned this tool on it tries to wipe it out for you. So, I'm looking at ways that the software can find these individual flaws and then seeing if I can write something that will correct them and hopefully correct them without doing any other damage to the image – like reducing the sharpness or clarity of the image if at all possible.

Figure 4 Detail from astrophoto emphasizing "walking noise". Robin's suggestion for dithering via the latest version of SharpCap Pro enabled me to eliminate this problem on my subsequent attempt.

M: Those sound great!

R: Besides the horizontal banding there are other things. If I work out a way to remove the raining noise or walking noise that is common in images where you see what looks like the streaks of raindrops on a window, running diagonally …

M: My Heart Nebula image from last night is filled with that –

R: Yeah so that's quite a common issue, caused by dark subtraction not being entirely perfect. You know dithering can help with that sort of thing and the latest SharpCap has dithering in it via PHD but if I can find a way to do that in software, I'd love to be able to do something about that. So that's another sort of future direction that SharpCap might help.

Figure 5 Similar detail to Figure 4, captured using new features in SharpCap Pro to eliminate "walking" noise

M: Okay though we should wrap this up so that you can go and write code because those sound extremely valuable! Let me just tell you the few things that I thought of. One is that people seem to love your polar alignment utility. I can never use it because I never have a view to the north whether I'm at home or in a lot of the outreach that I've done. Is it even possible to do a polar alignment utility with only a view, say to the south? Or the big win would be anywhere in the sky? Or do I really have to have the North Celestial Pole?

R: It's actually unfortunately hard to do it without the view to the north. One of the reasons that SharpCap's polar alignment is successful is it doesn't use GOTOs. Every time you do a GOTO that doesn't land bang on the position you expect -- if it's a few arc seconds out, or maybe an arc minute out, then those imperfect GOTOs that you're doing on consumer-grade mounts mean that the results can be very variable. You can use the same tool two or three times in a row without making any adjustments to your mount and get different results, so I avoided that in SharpCap's polar alignment because I didn't like the inaccurate results. Another thing that you can do is something like drift alignment but where you move the mount in RA to speed up the drift. There are some tools that do this, and they're quite

handy and I tried some experiments about that…But the Meridian flip throws that out because you can only do ninety degrees or so before you have to flip, and then on the other side of the flip you don't know that your measurements are valid. So, I have yet to find a way to make that work although I have spent -- as you can see -- some time trying to work out a way. I'm afraid SharpCap Polar Alignment is "if you see the pole only" at the moment so I'm sorry about that.

M: I understand because it seems that if it was easy to do somebody would have figured it out by now. A simple thing: For those outreach settings, a one touch full screen display button – that would be cool.

R: There's a new option in SharpCap 3.2 where you can use two monitors. If you have a second monitor plugged in (which might be less easy perhaps in outreach events) then you can push the actual display of the image onto the second monitor -- and that's full screen on that monitor. Then all your controls for live stacking stay on your main monitor or your laptop, so you can be adjusting the settings, and everybody can see a nice big picture of the of the image. But yes, something to go full screen for the full image, I can take that on board -- that makes sense.

M: Okay. Well let me go for just one last question, the big future: Do you do you think there will be a role for effectively completely automated systems? I'm thinking that it took me a while to get up all these different learning curves: for navigating the sky; learning how to track; learning how to image; learning how to process. I'm aware of a couple of ventures that aim to get, let's call it EAA, in a very user-friendly configuration. I don't know how much fun it will be for people to be able to just sort of press a button on the telescope and then have magically appear an image of M33 or some colorful nebula. Do you think there will be a role for almost push-button astrophotography?

R: I think there's already that sort of astrophotography happening but it's happening exactly at the opposite end of the price spectrum by people who perhaps live somewhere like Britain, where the weather is dreadful on average, and want to do more imaging than they get to do during British night times. So they may rent an astronomy site, typically in Spain, which is quite common for people who do that sort of thing here. They put their equipment there and they have a remote access to a computer there that runs the equipment. But it's very much at the other end of the price range with very expensive mounts and very expensive kit because in order to make that sort of thing that you're describing work -- the fully push-button automated stuff -- it has to be so very reliable. Because if you want to do the push-button thing but it keeps falling over because something again tonight is not quite working and it's a different thing from last night, it's going to get people very frustrated. Maybe we get to the point that the price that you have to pay for the reliability is too much. Buying a camera from a manufacturer who has been through all the hoops to make sure that it never loses contact with your computer and is a hundred percent reliable is not going to be as cheap as buying your camera from manufacturer who just wants to ship a camera that works. They accept the fact that maybe once in a night's imaging it might have a bit of a wobble and you unplug it and plug it back in again. There the quality implies cost. Sadly, I don't know if that one will fly at this end.

M: I also think of the user experience. A lot of people who are doing this love solving the problems – it's part of the challenge.

R: It's actually *doing it* that's interesting!

M: So, I'll leave you with this one last question: if the weather was good tonight would you rather be taking pictures or writing code?

R: (laughing) I think I'd rather be taking pictures but often I end up writing code.

M: Ok, we all benefit from that, so I'm going to wrap this up. Once again, thank you very much Robin!

You can view the complete version of our discussion on the AAA.org's Astrophotography group's YouTube channel at https://youtu.be/JcRNnS5coi8

Note: This article is appearing simultaneously in *Eyepiece*, the newsletter of NYC based Amateur Astronomers Association of New York and *SkyWAAtch*, the newsletter of Westchester Amateur Astronomers. I'm a member and supporter of both organizations.

Westchester Amateur Astronomers

Miss Expanding Universe

Larry Faltz

The day after our visit to the Adler Planetarium (October 2018 SkyWAAtch) Elyse and I went to the Art Institute of Chicago, a museum I have always considered to be one of the best in the world. Among its many treasures, it holds three of the most recognizable (and most often caricatured) paintings on the planet: Grant Wood's *American Gothic*, Edward Hopper's *Nighthawks* and Georges Seurat's *Sunday Afternoon on the Island of the Grande Jatte*.

Isamu Noguchi (1904-1988), Miss Expanding Universe, Art Institute of Chicago. Aluminum, 113.9 x 88.6 x 15.2 cm (40 7/8 x 34 7/8 x 9 in.)

As we were ambling through one of the American galleries, we looked up to see a figure hanging from the ceiling. It was Isamu Noguchi's 1932 aluminum sculpture *Miss Expanding Universe*. We are great fans of this artist for his vast and brilliant output that includes such diverse works as portrait sculptures, furniture (we have the Noguchi-designed coffee table our living room), fountains, monumental abstract sculptures and vast gardens. Any time we're near Rockefeller Center we stop to marvel at the epic bas relief *News* over the entrance of 50 Rockefeller Plaza, made for the Associated Press in 1940 when the building was its headquarters. The Isamu Noguchi Museum on Vernon Boulevard in Long Island City is well worth a visit. It's one of New York City's lesser-known artistic treasures. Noguchi made quite a few costumes and sets for dance productions, most notably for Martha Graham and for George Balanchine's *Orpheus*, still in the repertoire of the New York City Ballet.

Coffee Table (1947). Bas reflief "News", 50 Rockefeller Plaza, New York (1940)

Noguchi made *Miss Expanding Universe* in 1932 after he, Chinese artist Qi Baishi and Noguchi's very close friend, futurist and designer Buckminster Fuller heard a series of lectures on Edwin Hubble's recent discovery of the expansion of the universe. The work's title was suggested by Fuller. How did this rather arcane topic reach these three artists?

There has always been public interest in progress in physics and astronomy, reflected in newspaper and magazine articles of the time. Readers of the *New York Times* were frequently exposed to scientific news and brought up to date about controversial theories. This was most famously evident in the "Heavens All Askew" headline on the front page of the November 10, 1919 *Times*, reporting the confirmation of Einstein's general relativity by Arthur Eddington, who observed star positions during the total solar eclipse of May 29, 1919. The *Times* had already published a number of stories about Einstein and relativity and followed the "Heavens All Askew" article with two more over the next month.

Until Hubble's work, many astronomers, perhaps most, thought that the Milky Way was the entire universe and the faint spiral-like or homogeneous patches scattered among the stars were either planetary systems in formation or collections of gas. In 1917 Harlow Shapley measured RR Lyrae variables in globular clusters to determine the distance to globular clusters. He calculated that the Milky Way's diameter was 300,000 light years, far greater than anyone had previously suspected (prior values were from 7,000 to 30,000 light years; the current value is about 120,000 light years). He also established the Sun's position within the galaxy, showing it was about halfway between the center and the edge. But he did not think that the spiral nebulas, so called,

were extra-galactic. In the famous Great Debate between Shapley and Heber Curtis at the Smithsonian in 1920 (formally titled "The Distance Scale of the Universe"), he argued

> It seems to me that the evidence…is opposed to the view that the spirals are galaxies of stars comparable with our own. In fact, there appears as yet no reason for modifying the tentative hypothesis that the spirals are not composed of typical stars at all, but are truly nebulous objects.

Shapley hedged his bets a bit, concluding his presentation with

> But even if spirals fail as galactic systems, there may be elsewhere in space stellar systems equal to or greater than ours - as yet unrecognized and possibly quite beyond the power of existing optical devices and preset measuring scales. The modern telescope, however, with such accessories as high-power spectroscopes and photographic intensifiers, is destined to extend the inquiries relative to the size of the universe much deeper into space, and contribute further to the problem of other galaxies.

Curtis, on the other hand, was more certain:

> I hold, therefore, to the belief that the galaxy is probably not more than 30,000 light-years in diameter; that the spirals are not intra-galactic objects but island universes, like our own galaxy, and that the spirals, as external galaxies, indicate to us a greater universe into which we may penetrate to distances of ten million to a hundred million light-years.

If you're interested in the state of observational Astronomy at the time, you should read the debate transcript.[1] The arguments of both astronomers are substantially technical. As Virginia Trimble noted in an article[2] written to commemorate the 75th anniversary of the Great Debate, "the two men's reactions to Hubble's discovery of Cepheids in the Andromeda galaxy [by Hubble in 1924] make clear that both felt the issue of existence of external galaxies (on which Curtis had been more nearly correct) was of greater long-term importance than the size of the Milky Way (on which Shapley had been more nearly correct)."

In 1924, Hubble estimated the distance to the Andromeda nebula to be 930,000 light years. Although short of the modern day distance of 2,500,000 light years (because of unappreciated dust extinction), this measurement proved that the spiral nebulas were indeed external "island universes," something that was first proposed by Thomas Wright in 1750 and independently shortly thereafter by Immanuel Kant. Remarkably, Hubble's result seems to have first been presented to the public not in a scientific paper, or a report about one, but in a story in the *Times* on November 23, 1924. The *Times* had published brief articles on the island universe controversy since the early 1920's. In his excellent 1995 biography *Edwin Hubble: Mariner of the Nebulae*, Gale Christianson seems to have missed the *Times* story, ascribing the public release of the information to a letter Hubble wrote to Shapley on Aug. 25, 1924, with subsequent leakage of this exciting discovery among the astronomical community. Only in late December did Hubble receive an invitation to present a paper about it at the January 1925 joint meeting of the American Astronomical Society and the American Association for the Advancement of Science. The paper was given on Jan. 1, 1925, and for it he received a $500 prize. Here's the *Times* story as published (available on the *Times'* on-line archive), which appears to me to be an almost verbatim transcription of a press release, suggesting that the Carnegie Institution, owner of Mt. Wilson, had a strong desire to see the information before the public and not have it be confined to astronomic academia:

FINDS SPIRAL NEBULAE
ARE STELLAR SYSTEMS

Dr. Hubble Confirms View That They Are 'Island Universes' Similar to Our Own

> WASHINGTON, Nov. 22—Confirmation of the view that the spiral nebulae, which appear in the heavens as whirling clouds, are in reality distant stellar systems, or "island universes," has been obtained by Dr. Edwin Hubble of the Carnegie Institution's Mount Wilson observatory, through investigations carefully carried out with the observatory's powerful telescopes.
>
> The number of spiral nebulae, the observatory officials have reported to the institution, is very great, amounting to hundreds of thousands, and their apparent sizes range from small objects, almost star-like in character, to the great nebulae (*sic*) in Andromeda, which extends across an angle some 3 degrees in the heavens, about six times the diameter of the full moon.
>
> "The investigations of Dr. Hubble were made photographically with the 60-inch and 100-inch reflectors

[1] https://apod.nasa.gov/diamond_jubilee/1920/cs_nrc.html

[2] Publications of the Astronomical Society of the Pacific 107: 1133-1144, 1995 December, available at https://apod.nasa.gov/diamond_jubilee/debate20.html

> of the Mount Wilson observatory," the report said, "the extreme faintness of the stars under examination making necessary the use of these great telescopes. The resolving power of these instruments breaks up the outer portions of the nebulae into swarms of stars, which may be studied individually and compared with those in our own system.
>
> "From an investigation of the photographs thirty-six variable stars of the type referred to, known as Cepheid variables, were discovered in the two spirals, Andromeda and No. 33, of Messier's great catalogue of nebulae. The study of the periods of these stars and the application of the relationship between length of period and intrinsic brightness at once provided the means of determining the distances of these objects.
>
> "The results are striking in their confirmation of the view that these spiral nebulae are distant stellar systems. They are found to be about ten times as far away as the small Magellanic cloud or at a distance of the order of 1,000,000 light years. This means that light traveling at the rate of 186,000 miles a second has required a million years to reach us from these nebulae and that we are observing them by light which left them in the Pilocene ages upon the earth.
>
> "With a knowledge of the distances of these nebulae we find for their diameters 45,000 light years for the Andromeda nebulae (*sic*) and 15,000 light years for Messier 33. These quantities, as well as the masses and densities of the systems, are quite comparable with the corresponding values for our local system of stars."

In fact, Hubble had used more than just M31 and M33. He also looked at NGC 6822 (Barnard's Galaxy in Sagittarius), M81 and M101, commenting in his letter to Shapley that he had some trouble picking out Cepheids in the latter two galaxies.

It's interesting that Hubble concluded that there were "hundreds of thousands" of galaxies, some of which appeared "star-like." He could not have resolved the Cepheids in those galaxies (and there were probably not hundreds of thousands of galaxies catalogued at that time), so he obviously extrapolated from their brightness and the fact that they were not *exactly* star-like. It was an astute and essentially correct conclusion, although we now know that it vastly underestimated the number of galaxies in the universe

It would be difficult to detect or measure Cepheid variables in fainter, more distant galaxies even with telescopes of 60 and 100 inch apertures, so Hubble made the further assumption that galaxies in clusters were relatively similar and that he could simply compare the brightness of their brightest stars or even just their total brightness to estimate their relative distance, and then extrapolate to absolute distances that he found with Cepheids in Andromeda and M33, serving as galactic "standard candles."

Over the next few years, Hubble was able to capture spectra and measure the brightness of 22 "extragalactic nebulae" and the two Magellanic Clouds. In his paper "A Relation Between Distance And Radial Velocity Among Extra-Galactic Nebulae,"[3] Hubble wrote

> …where considerable numbers are involved, and especially in the various clusters of nebulae, mean apparent luminosities of the nebulae themselves offer reliable estimates of the mean distances.

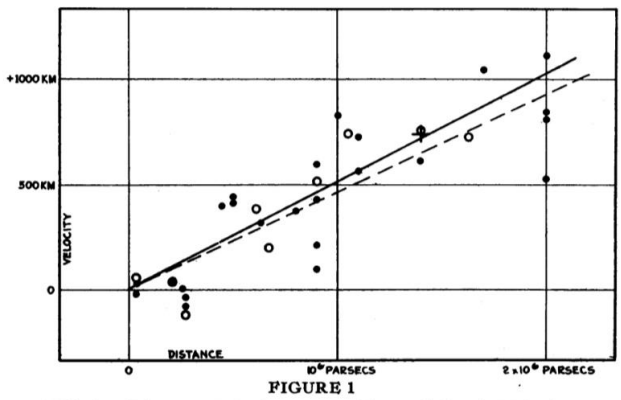


FIGURE 1
Velocity-Distance Relation among Extra-Galactic Nebulae.

Hubble's 1929 velocity-distance diagram. Two curves are shown, based on whether galaxies were plotted individually or in groups

The cautious Hubble noted that

> New data to be expected in the near future may modify the significance of the present investigation or, if confirmatory, will lead to a solution having many times the weight. For this reason it is thought premature to discuss in detail the obvious consequences of the present results.

The issue of whether space had a curvature, of great interest to astronomers and physicists studying general relativity, was potentially addressed by this work.

> The outstanding feature, however, is the possibility that the velocity-distance relation may represent the

[3] Proceedings of the National Academy of Sciences 1929; 15: 168-173, available at http://www.pnas.org/content/pnas/15/3/168.full.pdf

> de Sitter effect, and hence that numerical data may be introduced into discussions of the general curvature of space. In the de Sitter cosmology, displacements of the spectra arise from two sources, an apparent slowing down of atomic vibrations and a general tendency of material particles to scatter.

In a letter to Shapley shortly after the paper was published, Hubble acknowledged that he wanted to hold up the paper to obtain more data but was worried that he would be beaten to priority by other astronomers working on the same problem.

Photo on the wall inside the 150-foot solar telescope at Mt. Wilson showing Einstein visiting in January 1931 (LF).

Hubble submitted his paper to PNAS in January 1929 and it was published in the March issue. Nothing was mentioned about this work in the *Times* until a report in June about a paper presented by Milton Humason (Hubble's assistant) and Francis Pease (designer of the 100-inch telescope at Mt. Wilson) at the annual meeting of the American Astronomical Society in Berkeley. They presented the "greatest known" velocities for 3 "nebulae," determined from red shifts. ("Closed Universe Data Read in New Sky Test," June 22, 1929, p. 19)

> The significance of the work is thought to lie in the curious relation that where bodies are moving away from the earth, the more distant they are the faster they appear to be moving…. The theory is that velocities are illusory and the displacements seen in the spectrum are not actual motions but distortions in light waves…due to a curvature of space, predicted by Einstein…. Thus it is thought, further study may show that the universe is closed, exhibiting a finite volume with no boundaries, just as the surface of the earth is closed in two dimensions.

Three days later the *Times* reported comments by Shapely and Eddington on this work, explaining the belief that the red shifts were gravitational and not due to actual recession of the nebulae ("Speeds of Nebulae Aid Einstein Belief," June 25, 1929, p. 11):

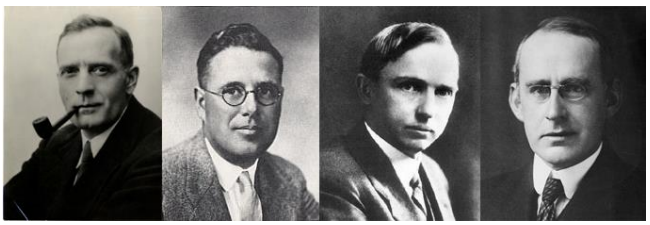
> The measured velocity is probably not a measure of actual motion but more likely a measure of crumpling space, a relativity effect" in the opinion of Dr. Harlow Shapley. "One of the deductions from the general theory of relativity is that the space-time universe is finite but unbounded and that very distant objects should show a spurious velocity of recession."
>
> Eddington agrees. "In such a space, light which has traveled an appreciable part of the way around the world is slowed down in its vibrations, with the result that all spectral lines are displaced toward the red. Ordinarily we interpret such a red displacement as signifying receding velocity in the light of sight."

This, as we know now, is an incorrect explanation, but it shows how focused everyone was on the geometric implications of general relativity. It took a bit of time for astronomers to accept that the universe was actually expanding, so fixated were they on the idea of an eternal, static cosmos.

I could find only one mention of Hubble's name in the *Times* in 1929, and that was in relation to a peculiar article on May 12 entitled "The Size of the Universe."

> Dr. Ludwik Silberstein announced before the American Physical Society that the radius of space is but a paltry five million light years, smaller than most Einsteinians insist. Dr. Hubble of Mount Wilson and Professor Shapley of Harvard estimate that some of them [faint nebulae] are 140 million light years distant.

Silberstein, a Polish physicist, was well-known in his day and was an early enthusiast for relativity, but he differed with Einstein on important details of the theory, and being wrong about those he is now forgotten. It turns out there were a large number of physicists in the 1920's who disdained Einstein's theory in spite of the 2 solid pieces of evidence for it at the time: the precession of Mercury's orbit and the deflection of starlight by the eclipsed sun ("Einstein's Theories Raked By Americans," Oct. 26, 1929, p. 19).



L-R: Edwin Hubble, Milton Humason, Harlow Shapley, Arthur Eddington

There are quite a few articles in the *Times* about Shapley, who was the head of the Harvard Observatory and seemingly the Neil deGrasse Tyson of his time. By then he seems to have completely shed any negative

connotations that might have resulted from being wrong about the distances of spiral nebulas at the Great Debate. I suspect he had a good publicity agent (as does Tyson, no doubt). He wasn't the only scientist in the public eye, and of course the world-famous Albert Einstein was news wherever he went. The *Times* was full of reportage about the great man. It seemed whenever Einstein spoke, a newspaper story appeared. There was a semi-charming story on Dec. 31, 1930 relating the imminent arrival of Einstein to Pasadena for a two-month stay.

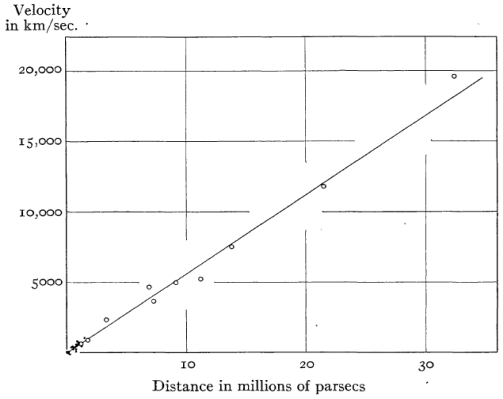
> EINSTEIN TO STUDY SPEEDING NEBULAE
>
> Great stellar systems, like the Milky Way, rushing away from the earth at 7,300 miles a second, offer a problem to Dr. Albert Einstein.
>
> Southern California scientists have this problem ready for the German author of the principle of relativity, who will reach Pasadena tomorrow.
>
> They likewise have a problem for his wife, Frau Elsa Einstein. Frau Einstein will be asked to decide what sort of California bungalow she likes best to house her and her husband here.

This article includes a lengthy quote from Hubble about the data that led to his claim about the expansion of the universe. Einstein's interest in it undoubtedly arose because it challenged his conception of a stable universe, maintained that way with the cosmological constant that opposed gravitational contraction due to the mass of all the matter in the universe.

Einstein was an irresistible subject for the *Times*. "Einstein Explores Far Away Nebulae" (January 24, 1931, p. 5), "Einstein Drops Idea of 'Closed' Universe (Feb. 5, 1931, front page), "Einstein Tells of Advance in His Field Theory In Unifying Gravity and Electromagnetics (June 10, 1931, front page), "Einstein Explains Ideas on Universe" (June 27, 1932, p. 14), even "Einstein Now Enrolled in Ranks of Whistlers" (Oct. 2, 1931, p. 22)[4]. The *Times* reported "Einstein Bids Adieu to Scientist Hosts" (Feb. 28, 1931, p. 12), discussing the great man's return to Berlin after some sightseeing at the Grand Canyon and the Petrified Forest in Arizona. We never did learn about the bungalow, but we did find out that the couple had been bedeviled by the press:

> Frau Elsa Einstein intimated some relief in taking leave of the newspaper men, of whom, she said, so many knew so little about the processes of Professor Einstein's thoughts…. As the train pulled out, Frau Elsa, voicing sentiments which the professor himself in his reticence would not utter, did bid one hearty goodbye. That was to the photographers. The farewell was tinged, it appeared, with no little pleasure so far as the scientist and his wife were concerned.

There is little about Hubble in 1930, but in starting with the Dec. 31, 1930 article his name appears more frequently. By late 1931, Hubble was the featured astronomer in relevant *Times* stories, with articles on 3 consecutive days (Oct. 31-Nov. 2, 1931) reporting on a lecture series he gave at Princeton. This followed the publication, with his assistant Milton Humason, of "The Velocity-Distance Relation Among Extra-Galactic Nebulae" in the July 1931 issue of the Astrophysical Journal.[5] This paper extended his 1929 observations to much fainter galaxies over distances of 30 megaparsecs and showed an even more convincing correlation between recession velocity and distance than the 1929 paper.



The distance-recession velocity graph from Hubble & Humason's 1931 paper

[4] "Asserting that nearly every genius whistles and that he has heard Dr. Albert Einstein whistle, Augustus Lukeman, sculptor of New York and Stockbridge, Mass. stopped off in New York yesterday long enough to defend whistling as the ally of art and to deny the contentions concerning it of Dr. Charles Gray Shaw, New York University Professor of Philosophy. On Monday, Dr. Shaw declared that whistlers were usually morons, but on Wednesday he relented, saying that he objected to 'puckering of the lips' by whistlers, but that 'whistling with the throat is often done by intelligent people.' Pooh-poohing such delicate distinctions, Mr. Lukeman said it made no difference to him how a man whistled, as long as he did. Mr. Lukeman said he had heard Dr. Einstein whistle melodiously on his last trip here, had read only yesterday that Mussolini whistled, and had no doubt that Mr. Hoover and Mr. Edison did."

[5] Astrophysical Journal 1931; 74:43-80, available at http://www.adsabs.harvard.edu/abs/1931ApJ....74...43H

Hubble realized that by assuming that galaxies are more or less the same, a given galaxy's brightness would be proportional to its distance.

> When no stars can be seen, a new criterion is required, necessarily calibrated by the data for the sample collection. This is furnished by the absolute luminosities of the nebulae themselves, which exhibit a restricted range about a well-defined most frequent value. The criterion is statistical, but when it is once calibrated, its application appears to be quite general.

From that time forward, Hubble was credited with discovering the expansion of the universe, although a recollection written in 2011 by Canadian astronomer Sidney van den Bergh points out that Hubble was not the only person working on this problem.[6] Van den Bergh describes how Milton Humason showed him how to use the 48" Schmidt telescope at Mt. Palomar (now known as the Oschin-Schmidt) on the very night before Humason formally retired in 1965. Van den Bergh participated in a new version the Great Debate, also entitled "The Scale of the Universe," on the occasion of the 75th anniversary of Shapley-Curtis, arguing with Gustav A. Tammann about the value of the Hubble Constant.[7] Van den Bergh provides the following time-line for work on the expansion of the universe, seeking to debunk what he called "the myth that Hubble discovered the velocity-distance relation."

- 1922 From radial velocities of only 29 spirals Wirtz concludes that either the nearest or the most massive galaxies have the smallest redshifts.[8]
- 1924 Using observations of 42 galaxies Wirtz (1924) concludes "that there remains no doubt that the positive radial velocities of spiral nebulae grow quite significantly with increasing distance."
- 1925 Lundmark notes that the redshifts of small (presumably distant) spiral galaxies are larger than those of larger nearby ones.
- 1927 Lemaître derives the expansion rate of the Universe and explains its expansion in terms of the General Theory of Relativity.
- 1929 Hubble repeats Lemaître's work with essentially the same data and obtains similar results.
- 1930 de Sitter re-discusses mostly the same data more thoroughly and again finds the same result.
- 1931 Hubble & Humason obtain 40 new radial velocities which extend the determination of redshifts to the Leo cluster at a redshift of 19600 km/s. This places the reality of a linear velocity-distance relationship for galaxies beyond reasonable doubt.

Van den Bergh notes that Hubble read German and would have undoubtedly seen Wirtz' articles. He also pointed out that Hubble and Lundberg were at odds because Hubble accused Lundberg of stealing his schema for galactic morphology. Apparently, Hubble also picked a fight with de Sitter for not acknowledging Hubble's priority, this perhaps at the instigation of Hubble's wife Grace. He also reports that Lemaître claimed priority in a note written in 1950 about his 1927 paper. But "History is written by the victors," or as it was said in John Ford's film *The Man Who Shot Liberty Valence*, "When the legend becomes fact, print the legend." Ultimately, Hubble was right when he decided not to wait to publish. Had he done so, we might be talking about the deSitter Constant or the Lundmark Constant or even the Lemaître Constant, and in that case we'd be constantly having to fish through Windows Character Map to find the "i" with the circumflex on it!

Ruth Page as Miss Expanding Universe, NY Public Library Jerome Robbins Dance Collection

[6] https://arxiv.org/ftp/arxiv/papers/1108/1108.0709.pdf
[7] https://apod.nasa.gov/diamond_jubilee/debate96.html.
[8] Vesto Slipher of Lowell Observatory discovered galactic red shift in 1912, and was able to measure the speed of galactic rotation by comparing the spectra of light from either side of a galaxy. From the speed of rotation, one could estimate a galaxy's mass.

I suspect that Hubble's Princeton lectures in the fall of 1931 were the stimulus for Isamu Noguchi's interest in universal expansion, directly or indirectly. Noguchi had become involved with modern dance by the early 1930's. This led to an interest in abstracting the human body, accounting for the peculiar proportions of the sculpture. He suggested a dance to ballerina and choreographer Ruth Page (1899-1991). Page had a wide range of creative interests, performing and choreographing both classical ballet and modern dance. For *Expanding Universe* Noguchi encased Page in a dark blue wool sack dress, very much like some of his later costumes for Martha Graham. His conception was that the universe was expanding from an amorphous mass, and so the dancer ought to appear rather amorphous. The dance was premiered on November 2, 1932 in Fargo, North Dakota (!). It was apparently later merged into a dance called "Variations on Euclid" and a silent film of the opening few minutes of a 1938 stage performance is available on YouTube. An excerpt from *Expanding Universe* was given at the Noguchi Museum in June 2018, the first time it had been performed in more than half a century, but I was unaware of the existence of the sculpture or the dance and missed it.

Page used music by little-known composer Robert Ben-Levi Wolf for the dance. I suppose that the proper music for *Expanding Universe* would be the baryon acoustic oscillations that were created after the Big Bang, but although those were actual sound waves, they were not in an audible frequency.

Isamu Noguchi, Ruth Page

Noguchi himself seems to have had only a tangential interest in astronomy. He was however particularly fascinated by the famous Jantar Mantar observatory in India and took many photographs of the site on visits there between 1949 and 1960. The observatory's architecture and instruments (all non-telescopic) inspired many of his subsequent sculptures and installations. His large work *Skygate* in Honolulu is designed to cast a perfect circular shadow on its base twice a year when the sun is directly overhead at noon, and is perhaps his only astronomically functional work.

The whole idea of a sculpture that looks like a flying squirrel and is entitled *Miss Expanding Universe* is obviously peculiar. Astronomy and dance don't seem to have much in common, although there's nothing that precludes someone from having an interest in both, as Elyse and I demonstrate. But there aren't any ballets that I know of that explicitly concern themselves with astronomical objects or events. When Mars and Venus appear in ballets, they are mythological figures, not celestial bodies. The Moon and the Sun are found on the backdrops of many ballet sets, but no choreographer I can recall has sent their dancers to other planets. Only Ruth Page and Isamu Noguchi seem to have taken up the challenge of making a dance that expresses a challenging astronomical idea. Now one wonders if someone will be enthused and creative enough to choreograph a dance about black holes or gravitational waves!

Astronomy in literature:

…Nor when expandingly lifted by your subject, can you fail to trace out great whales in the starry heavens, and boats in pursuit of them; as when long filled with thoughts of war the Eastern nations saw armies locked in battle among the clouds. Thus at the North have I chased Leviathan round and round the Pole with the revolutions of the bright points that first defined him to me. And beneath the effulgent Antarctic skies I have boarded the Argo-Navis, and joined the chase against the starry Cetus far beyond the utmost stretch of Hydrus and the Flying Fish.

With a frigate's anchors for my bridle-bitts and fasces of harpoons for spurs, would I could mount that whale and leap the topmost skies, to see whether the fabled heavens with all their countless tents really lie encamped beyond my mortal sight!

Herman Melville, *Moby Dick*, Chapter 57: Of Whales in Paint; in Teeth; in Wood; in Sheet-Iron; in Stone; in Mountains; in Stars

Results of the WAA Member Survey

Thank you to the nearly one-third of our members who responded in just a few days to our survey, the first time we've ever polled the WAA membership. We were particularly interested in what you wanted to hear at our meetings at Pace University.

We learned quite a bit. 37% of the respondents have attended at least 6 meetings in the past two years, while about the same number have only been to one or two and just 10% have never been to Pace. The survey confirmed that the location, day and time are probably optimal for the greatest number of members. Only 3 respondents said they have a permanent obligation elsewhere on Friday evenings. The main reason that members don't attend is that there are the inevitable conflicts of a busy life (60%). Only a few members say they opt out if the topic is not interesting to them, and 2 responded that the meetings were simply not important to their appreciation of astronomy.

Our club members are interested in the gamut of astronomy. The topic that seems of least interest is astrobiology, with 16% of the respondents saying they were not interested at all, against almost half who were interested or very interested in this topic. Our challenge is to find good speakers to present a spectrum of topics at the right level of understanding for a membership that has a wide range of scientific sophistication and pre-existing knowledge of the material.

Topic	Interested and Very Interested
Objects in the night sky	93.2%
Solar System	87.9%
Cosmology	84.2%
Amateur astronomy equipment	77.2%
Astrophysics	75.7%
History of Astronomy	75.7%
Physics	74.1%
Astrophotography	68.4%
Exoplanets	66.7%
Research astronomy equipment, observatories	66.0%
Earth science and meteorology	61.4%
Astrobiology	45.6%

We asked for free-text input on possible topics and received 82 suggestions. Many related to the broad topic areas in the prior question and suggested specific programs, which we will incorporate into our planning. There were quite a few general comments such as *I think WAA is a terrific group with a fabulous newsletter and great programs, both for members and outreach. I am constantly learning and I enjoy the opportunities (equipment, shared knowledge, conversation) offered at all WAA gatherings*, which we appreciate. This perceptive comment reflects one major challenge to developing our programs, which often utilize our contacts with academic institutions: *Professors 'lecture.' A good speaker 'speaks.' I've heard enough lectures to cover a lifetime. I can never hear enough good talks by speakers who engage their audience with passion and the exuberance of someone fascinated by what they're talking about.* The talks by David Mestre (Discovery Museum) on the Antikythera mechanism and Carter Emmert (Hayden Planetarium) tour of the Earth, the Moon and Mars in real time were singled out by several respondents as models for future events. Another comment lays out probably the most difficult issue we have in trying to choose speakers: *Some lectures are too technical or simply over my head. I try to select which ones I attend based on that possibility and subject.* It's not possible to guarantee that every lecture will be pitched to the level of understanding of every attendee. We have to accept that reality without abusing it.

We need member participation in our planning and operational activities. People are needed to step up to the plate when current leadership turns over, as it must in any organization that wants to have a healthy future. We need to create teams to support our major functions, in particular people to work with VP for Programs Pat Mahon to identify and recruit local lecturers who have interesting astronomy stories to tell, are good speakers, are available, willing to come to us and will accept our honorarium ($150) and maybe our invitation to dinner at Applebee's. We can't afford Neil DeGrasse Tyson, but there are many excellent speakers in the New York area, even some professors who can 'speak.' It may also be time to develop some unique programming on days other than Friday and perhaps at different venues. This would require some significant member enthusiasm, creativity and effort, but it's great when these things are successful. Our members make us "the best astronomy club this side of the Oort cloud."

If you are willing to give just a couple of hours a month to helping out with programming, communications (93% say email blasts are "important or very important"), writing for or editing the Newsletter (90% "important or very important"), outreach, star parties or anything else, please send an email to waa-president@westchesterastronomers.org. Thanks!

Member & Club Equipment for Sale

November 2018

Item	Description	Asking price	Name/Email
Celestron 8" SCT on Advanced VX mount	Purchased in 2016. Equatorial mount, portable power supply, polar scope, AC adaptor, manual, new condition.	$1450	Santian Vataj spvataj@hotmail.com
Celestron CPC800 8" SCT (alt-az mount)	Like new condition, perfect optics. Starizona Hyperstar-ready secondary (allows interchangeable conversion to 8" f/2 astrograph if you get a Hyperstar and wedge). Additional accessories: see August newsletter for details. Donated to WAA.	$1200	WAA ads@westchesterastronomers.org
Celestron StarSense autoalign	New condition. Accurate self-alignment. Works with all recent Celestron telescopes (fork mount or GEM). See info on Celestron web site. Complete with hand control, cable, 2 mounts, original packaging, documentation. List $359. Donated to WAA.	$250	WAA ads@westchesterastronomers.org
Celestron Advanced GT Equatorial Mount	Celestron Nexstar+ hand controller, 2" tripod, counterweight bar with 10 lb. weight , cables	$225	Gary Miller garymiller7@optonline.net
Televue Everbrite Diagonal	1.25", brass compression ring	$95	Gary Miller garymiller7@optonline.net
Illuminated Reticle Eyepiece	Meade, 12mm	$30	Gary Miller garymiller7@optonline.net
SuperView 30mm Eyepiece	Generic, 68 degree AFOV, 2" diameter	$35	Gary Miller garymiller7@optonline.net
Meade 395 90 mm achromatic refractor	Long-tube refractor, f/11 (focal length 1000 mm). Straight-through finder. Rings but no dovetail. 1.25" rack-and-pinion focuser. No eyepiece. Excellent condition. A "planet killer." Donated to WAA.	$100	WAA ads@westchesterastronomers.org
Oberwerk BT-70-45 Binocular Telescope	Excellent condition. Two sets of Oberwerk EPs: 23.9mm (16x) and 8mm (47x). Also include Celestron 13mm (29x) plossls. Metal fitted case. Celestron red dot finder. Phil Harrington says "one of my favorite instruments sold today". Has only been used about 10 times. I like the big bino experience enough that I want to get a 100mm unit. Original cost $1030.	$700	Eugene Lewis genelew1@gmail.com
Televue 55mm 2-inch Plossl.	Televue 55mm 2-inch Plossl. Very lightly used. Excellent condition. Original box.	$175	Eugene Lewis genelew1@gmail.com
Orion 150 Mak-Cass	Orion 150 f/12 Mak-Cassegrain. In excellent condition. Will include heated dew-shield.	$300	bousteadtom@gmail.com

Want to list something for sale in the next issue of the WAA newsletter? Send the description and asking price to ads@westchesterastronomers.org. Member submissions only. Please only submit serous and useful astronomy equipment. WAA reserves the right not to list items we think are not of value to members.

Buying and selling items is at your own risk. WAA is not responsible for the satisfaction of the buyer or seller. Commercial listings are not accepted. Items must be the property of the member or WAA. WAA takes no responsibility for the condition or value of the item or accuracy of any description. We expect, but cannot guarantee, that descriptions are accurate. Items are subject to prior sale. WAA is not a party to any sale unless the equipment belongs to WAA (and will be so identified). Sales of WAA equipment are final. *Caveat emptor*!