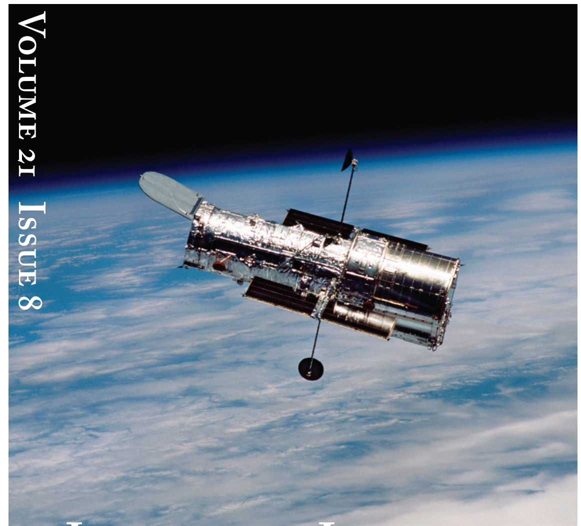
August 2007

The Observer

East Valley Astronomy Club

Volume 21 Issue 8



From the Desk of the President
by Claude Haynes

The website www.cloudynights.com gets a workout this time of year. With the monsoons it seems there are few good observing nights, so I enjoy logging on and reading equipment reviews and comments from all sorts of amateur astronomers. It was on a Cloudy Nights forum where the idea of a memorial to Robert Burnham Jr. was born. EVAC is serving as fiscal agent for the project, and it received a ringing endorsement in the latest edition of Sky and Telescope magazine. Jack Horkheimer has agreed to serve as honorary chairman for the fund drive, and has pledged $1,000 also. Please check the EVAC website or www.rbjm.org for more information.

Hopefully the clouds will be gone for the All Arizona Star Party coming on the weekend of October 12-14. We do need some volunteers to help set things up. More information soon on the website.

I'm sorry that I was out of town during the last meeting, but heard great reports on Steve Coe's talk. This month we have another Steve as speaker; Steve Aggas will fill us in on what he's been doing since his term as EVAC President ended – which includes building a ginormous 36" dob. Even if you never think you will ever personally build a telescope, it should be great fun to understand the effort needed to create one.

Until then, keep looking up – and then go back to looking at your computer monitors till October.
Claude

Inside this Issue:

The Backyard Astronomer
Tracking Down the Mystery Meteorite *by Bill Dellinges*

It all began with the January 1998 issue of Astronomy magazine. There was a story on page 50 about Robert Burnham Jr. (1931-1993) by Tony Ortega. I inhaled the article, asI was eager to learn more about this iconic (and eccentric) man, author of the venerable Burnham's Celestial Handbook.

Photo courtesy of Tony Ortega & New Times

The photograph of him on the first page of the piece struck me as being somehow familiar. It showed him as a young man kneeling at a meteorite on display outdoors. An adjacent sign read, "Meteorite found near Canyon Diablo. Weight 535 lbs." I thought, "Wait a minute, I have a picture of me at that very same meteorite –I'm sure of it!" There the matter rested until the May 2007 EVAC meeting when Tom Polakis announced an effort to establish a memorial to Burnham at Lowell Observatory, where he worked from 1958 to 1979. This got me thinking about Burnham again. I dug out a copy I made of the 1998 article. Looking again at

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Upcoming Events:

Local Star Party at Boyce Thompson – August 4

Public Star Party in Gilbert – August 10

Deep Sky Star Party at Vekol Road – August 11

General Meeting at Southeast Regional Library – August 17

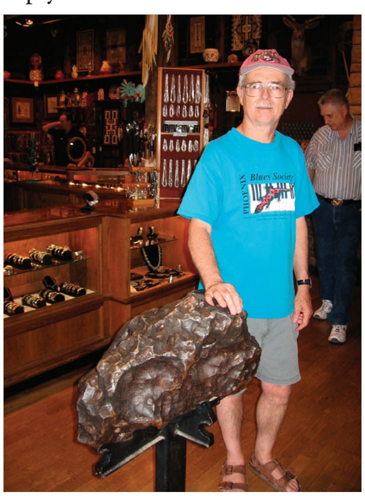
The Backyard Astronomer

Continued from page 1

the picture of him and the meteorite, I decided to find my meteorite picture and compare the two. Combing through my family albums, I found it. There was no doubt it was the same meteorite. Even the background appeared to be similar. There were two things different in my photo. The rock from space was sitting chained to a small cement slab whereas Burnham's photo showed it sitting in dirt. Also, the sign is newer and "242.6 kilo" had been added next to "535 lbs." I noted the back of my photo showed a date of January, 1985. OK, now I knew it was the same specimen, same location. But I couldn't for the life of me remember where this photograph was taken. My first guess was Meteor Crater. But the background bushes and trees didn't look like the terrain at Meteor Crater. Could it have been at Lowell Observatory? I couldn't recall seeing a huge meteorite at Lowell. This was driving me nuts. Maybe I should contact the PBS History Detectives?!

Putting what's left of my gray matter into gear, I somehow remembered I had the print made from a slide – I was sure of that. It took me a week to locate the slide. It was hiding in my astronomy slide collection under "meteors". I checked the date on the slide - ah-ha! October, 1982. That was when the shot was actually taken. Where was I at that time? I was hiking down the Kaibab Trail to Phantom Ranch in the Grand Canyon. But it didn't seem right to me that this meteorite would be on display at the Canyon. Could I have made a side excursion to Meteor Crater or Lowell on that trip?

I sent an email to Meteor Crater with the picture attached. No reply. I sent an email to the EVAC User's Group asking if anyone



knew where this rock sits. A.J. Crayon replied that he thought he saw it years ago outside a gift shop on the South Rim. Well, now that's VERY interesting!

I could smell blood. I emailed the Grand Canyon Association asking if their staff had any knowledge of a large meteorite on display at the South Rim. Mike Buchheit of the G.C.A. replied that he thought he saw it at Verkamp's Store (a souvenir shop) located just east of the El Tovar Hotel. Holy cow, it was beginning to look like the mystery meteorite WAS at the Grand Canyon after all!

A few days later, my wife and I were dining with our niece and her husband. I was proud to tell them how good a detective I had been in tracking down "my rock." I told them I was now pretty sure it's at the Grand Canyon and I planned on stopping there to verify it on my way to the North Rim Star party. Fred listened attentively and calmly said, "Oh yeah, I saw a large meteorite on display inside a gift shop on the South Rim a few months ago, I think the sign read it weighed about 500 pounds. (WHAT?). After I picked myself up off the floor, I uttered three words: TELL

ME MORE! His description of the shop's location jibed with Verkamp's. That's all I needed to know. On June 9th I would home in on that establishment like a heat seeking missile.

On that date I stood before Verkamp's Store. Oh yes, this was the place where my photograph was taken. Though the meteorite is now on display inside the store, I could see in my mind's eye where it was sitting outside in 1982. The ground, rock wall, and pine tree all matched the scene. Currently there is a three foot high historical marker (Verkamp's, Store - 1906) sitting on a slab which might very well be the same one in my photo that the meteorite was chained to. After photographing the store and meteorite, I asked an employee several questions about the meteorite; how did the owners find it and transport it to the store; when it was moved inside; when might the Burnham photo have been taken? She only offered that she thought it was moved indoors in the "late eighties." But if I would email her with my questions, she would try to get answers to my questions from the Verkamps. Later I did email her, but I've not received a response as of this writing.

Well, a few questions remain unanswered but at least I found my meteorite! And it seems to have held up a lot better than I have during the intervening years.

Photo: NASA/LPI/D. Roddy

◑Last Quarter Moon on August 5 at 14:20

○New Moon on August 12 at 16:02

◐First Quarter Moon on August 20 at 16:55

●Full Moon on August 28 at 03:34

Supermassive Black Holes

by Henry De Jonge

Introduction

Black holes by themselves are mysterious and intriguing objects in their own right. They are predicted to form in a variety of sizes from subatomic, (in the early universe) to small, (<10 solar masses) to mid size, (tens to hundreds of solar masses) and to massive, (hundreds or thousands of solar masses). The idea of a supermassive black hole, (SMBH) comprised up of millions to billions of solar masses, is more disconcerting and yet more exciting. Over the years the idea of black holes being purely a destructive force is becoming one where they are viewed as being more creative, (yet still destructive if you get too close). In fact they are now believed to be essential, formative, building blocks of our universe and one of the earliest, basic, structures to be formed after the Big Bang. They are seen as playing a role in star formation, as well as galaxy formation and evolution. It is believed today that they are responsible for about 50% of the radiation produced after the Big Bang and their numbers may be well over 300 million. The closest one is right at the center of our galaxy, about 28,000 light years away and we have excellent evidence for its existence. It is hoped that in the coming years we will actually be able to view the event horizon of this SMBH, thus solidly confirming their existence.

We will look at what is a SMBH, their role in the universe, how they may have formed, how we measure their mass, and what the latest evidence is for their existence.

What is a Supermassive Black Hole?

A SMBH is a simply a black hole of immense mass measured in the millions or billions of solar masses. Recall that a black hole is an object so dense and compact that within a certain radius, (the Schwarzschild radius) not even light can escape. The Schwarzschild radius, (rs) is defined as $rs=2GM/c2$, where G is the gravitational constant, M the mass of the object, and c is the speed of light. Thus any amount of mass or energy confined to a small enough space could conceivably become a black hole, (see figure 1).

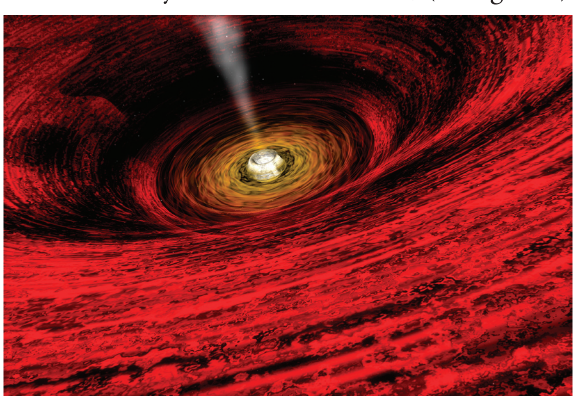


Figure 1: This is a schematic of a black hole with and accretion disk and an emitting jet, (Chandra X-ray observatory)

Quasars, Galaxies, and SMBH's

Quasars were discovered in 1963 by Martin Schmidt while at Mt. Palomar Observatory he discovered a star like object with immense yet variable brightness, confined to a relatively small area, (3C273). At this same time in 1963 Kerr was exploring some solutions to Einstein's field equations which would later describe the space and time about a spinning black hole.

Also about this time astronomer Cyril Hazard used a lunar occultation technique to accurately determine which astronomical objects emitted centimeter radio wavelength radiation. He too discovered 3C273 which appeared to be a star like object in Virgo with very large redshifted lines, (z = 0.15) indicating that it was at a great cosmological distance. In fact the object , (later defined as one of the first quasars) 3C273 had a significant variable optical output that changed over a period of about 10 months, indicating that its size could not have exceeded a few light years. Thus it was a relatively compact object with immense output, which was soon discovered to be an attribute of quasars in general. Donald Lynden-Bell was one of the first to suggest that this quasar phenomenon could be attributed to accretion of matter onto a SMBH residing in the center of a galaxy, (Hobson, et al 2006).

We now have further documented that quasar X-ray luminosity for example can vary in a period of only hours, indicating an even smaller source size, a bit less than the size of our solar system, (Melia, 2007).

Quasars are in general very bright at all wavelengths and show variability on very short timescales, (sometimes hours) yet usually emit far more energy than an entire galaxy of a hundred billion suns, and occupy a space that is smaller than our solar system, (see figure 2). What could be driving this powerful activity?

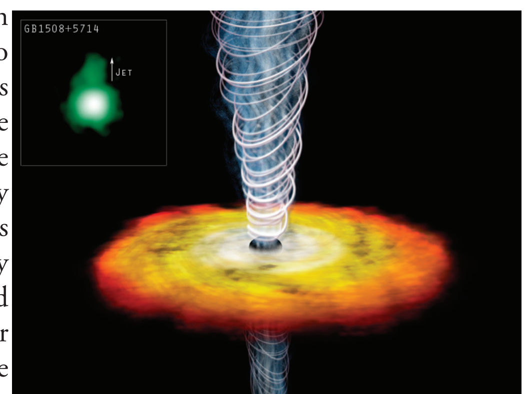


Figure 2: A schematic of a quasar, accretion disk and jet, with an insert photo of a quasar and jet

The best explanation we have to date to explain quasars is that SMBH's are the engines that produce this powerful display of energy. Galaxies that have such highly active nuclei are called active galactic nuclei or AGN. Quasars reside in many different types of galaxies.

Quasars being very distant are also very old. They were generally formed when the universe was quite young, about one billion years after the big bang. Today one of the oldest quasars we know of through the SDSS, (Sloan Digital Sky Survey) has a redshift about 6.3, indicating a time roughly 700 million years after the Big Bang, (Melia, 2007). The SDSS has also confirmed that the number of quasars rises quickly from about a billion years after the Big Bang to a maximum at about 2.5 billion years later and then falls off sharply to the present day, (see figure 3).

A SMBH at the center of such an AGN can convert up to10 solar masses per year into energy when it is feeding, that is when it is accreting nearby stars, gas, and other matter.

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Supermassive Black Holes

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Thus the power emitted depends upon how much matter is nearby and available for consumption. Galactic encounters such as the close passing of other galaxies or even galactic collisions can disturb the environment so that more matter is close enough to begin infalling into the SMBH thereby turning on this central engine. Yet since many quasars reside in relatively quiet or non interacting galaxies, other mechanisms must also be responsible for turning on the central engine. An example of this is our own Milky Way and the nearby galaxy Andromeda, (M31) which both have SMBH's in their centers that are relatively quiet. Our SMBH in the Milky Way has an estimated mass of about 3 million solar masses, making it a relatively low end mass SMBH. Typical quasars have a mass of about 109 solar masses.

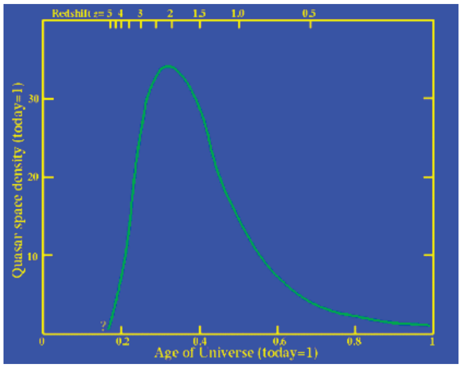

Figure 3: Showing the abundance of quasars as a function of the age of the Universe, (SMBH's 2007)

SMBH's are relatively stable and can power an AGN for a considerable time as long as there is fuel for it to consume. A local star cluster or rich supply of gas and dust is all that would be needed for an AGN. The accretion disk however may not be as stable and we only notice the AGN in their outburst state. The accretion mass fueling most SMBH's is thought to be collected over a long period of time, often during a quiet time for the AGN until the accreted mass begins to fall into the SMBH. Thus we do not necessarily see all the AGN that are in existence but only those that are active. It is calculated that AGN can convert up to about 10% or more of the accretion mass to energy, thus making this process a most efficient energy generating mechanism, (Frank, et al 2002).

Modern evidence seems to suggest that there is a dependence on SMBH, (quasar) mass with time such that it is proportional to (1+z)3 which also parallels the star formation history of the universe, (based upon the UV intensity as a function of redshift), (Melia, 2007).

Figure 4: The Sombrero Galaxy, (M104) which is thought to harbor a SMBH of about 1 billion solar masses. It is an optically quiet galaxy with strong x-ray emissions and very high velocities for the central stars, (SMBH's 2007). Image credit: NASA, ESA and The Hubble Heritage Team (STScI/AURA)

The full answer as to how generally undisturbed galaxies form a quasar is still not known completely, (Melia, 2007). Thus it would appear that all quasars are SMBH's but that not all SMBH's are quasars, many are lying dormant, (see figure 4). To date we know of about 15,000 distant quasars with the number of SMBH's being even larger. It seems that SMBH's may have connections to our Universe in many ways.

How Are They Formed?

A classical question is what came first the galaxy or the central black hole? Since quasars peaked long before most galaxies were formed, (about 2-4 billion years later) it may be safe to assume that at least some SMBH's formed first, although we are not sure if all the quasars and galaxies we see currently represent a fair sample of the universe in time. It is thought that SMBH's can form via SMBH mergers during galactic interactions such as galactic mergers, even without quasars being initially present. This galactic merger theory is one of the three main ideas as to how SMBH's may form.

In NGC 6240 we have an example that may show this process occurring. It is a butterfly shaped galaxy that is thought to be the result of two galaxies colliding about 30 million years ago. Chandra has shown that there are two SMBH's in this structure which appear to be slowly attracting to one another. Currently they are about 3000 light years apart and are expected to merge in about 200 million years. NGC 6240 is about 300 million light years distant and the Keck telescope in Hawaii, using adaptive optics, has shown this dual nature of the clumps of rotating stars about a very large central mass, (International Reporter, 2007), (see figure 5).

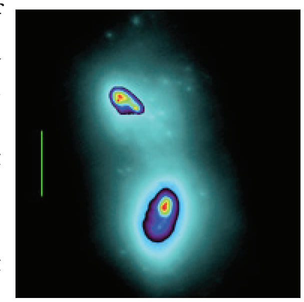

Figure 5: The Keck image of NGC 6240 showing the merger of two galaxies harboring two SMBH's orbiting about each other, slowly in the process of merging, (MIL/UT May 19, 2007).

Recent supercomputer models suggest that gas and dust in merging galaxies plays a major role in SMBH formation. If the merging galaxies contain a lot of gas then their SMBH's will form a binary system in most cases. These SMBH's will eventually merge as the frictional force generated by the stars and gas around them causes the system to lose energy from their orbital motion. The central galactic gas seems to be the main component in determining this evolution. This merging should also produce gravitational waves of immense strength that hopefully will be detectable in the near future, (Levy, 2007).

Evidence and models also suggest a second theory that says as galaxies interact, merge and age, over their lifetimes the gas and dust is herded into the central portions where new stars form and this also may provide food for growing a central SMBH, (or pair of SMBH's) (Melia, 2007). Evidence for this idea comes from a recent discovery that a SMBH suspected to reside in the center of galaxy MCG-06-30-15 is spinning at a relativistic rate, (about 98.7% of what is allowed by GR). This was determined from examining the Fe content of the accretion disk and noting the relativistic bending of the emission light. Astronomers predict that if SMBH's form more slowly from the accreting and condensed matter they

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August Guest Speaker: Steven Aggas

For our August 17, 2007 meeting, we'll have Steven Aggas, a former president of EVAC as our main speaker. Having built several award winning telescopes, recognized at such gatherings as Stellafane in Springfield, Vermont and Astrofest, near Kankakee, Illinois, Steven Aggas will present on telescope construction techniques that should allow just about anyone to build one. Whether you're considering a first scope of 4.5" or 6" diameter to a 20", 25", or beyond, it is possible to build your own thereby allowing for a larger mirror purchase and some 'sweat equity' to turn it into a telescope. Shown in the picture are Elements in Harmony II, the 20"f4.2 built in 1992 and his most recent creation, EiH IV, the 36" f4.5 just completed in May of this year. All components required for an operational telescope, with a Dobsonian mount using Newtonian optics, will be discussed at the upcoming meeting.

Supermassive Black Holes

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would spin at these incredibly fast rates, while if produced by colliding black holes then they would be expected to spin much more slowly, (MIL/UT, 2007).

The third model holds that they may also form via the collapse of super massive gas clouds or through the mergers of smaller black holes. In conjunction with the Big Bang it is thought that dark matter clouds coalesced into dense massive areas that later formed galaxies and black holes, basically a clumping of sorts that happened concurrently. As further evidence for this idea the VLA has recently detected a massive black hole, (about 20,000 solar masses) in a globular cluster around M31. These massive black holes are much harder to locate than SMBH's and are evidence for black holes in between massive and supermassive. Massive black holes like this (and even smaller masses like a few hundred solar masses) are also suspected to reside in the centers of globular clusters around our galaxy, (NRAO, 2007). Another recent discovery by the X-ray satellite Chandra has shown what appears to be a mid sized black hole about 600 light years from the center of galaxy M82 with a mass of about 500 solar masses. This mid sized black hole could possibly "sink" to the center of M82 and continue to grow to become a SMBH without necessarily becoming a quasar, (Melia, 2007). This could be another method of their formation.

Regardless of the method of their formation SMBH's are believed to have a great influence upon the local protogalactic star formation rates due to their energy outflows. This may also be part of the reason that there exists a correlation between the mass of the central SMBH and the stellar velocities further out in the galactic bulges.

It would appear that SMBH's can grow both slowly and continuously overtime or in larger discrete bits and pieces overtime. Perhaps both growth styles could probably work together as well.

How is their mass measured?

The mass of a black hole can be measured by different methods although all rely upon the gravitational interaction of the black hole with the surrounding matter. Using the Virial Theorem we can estimate the amount of mass contained within a region, (and thus the gravitational field strength) by observing the velocity of objects in the region. If we then can determine the distance from the center of mass we can calculate the spatial extent in which the mass is distributed from the angular diameter.

One actual method is if we know the radiating plasma's distance from the black hole and the force required maintaining it then we can calculate the mass of the black hole required to do so. An example of this method is the AGN, NGC 4258 a spiral galaxy. By using global radio interferometry astronomers measured the speed of the accretion disk out to about 0.5 light years from the center, to be about 650 miles per second. This AGN is unique in that the plasma accretion disk produces enough radiation to excite condensations of water molecules which lead to a maser emission, (at radio wavelengths). The mass calculated from these parameters is about 35-40 million solar masses confined within this 0.5 light year radius. If this represented stars we would see these stars separated on the average by about the distance of our solar system, which would lead to all sorts of gravitational interactions that would be very noticeable. Next to the SMBH in the center of our own galaxy this system offers the most compelling physical evidence for the existence of SMBH's, (Melia, 2007).

In another utilized method if the matter in the accretion disk is irradiated by the black hole it will produce an emission spectrum which will indicate the ionized state of the material, (plasma). By monitoring the light emitted by the black hole, (produced by the infalling matter prior to going beyond the Schwarzschild radius) and the radiation from the ionized plasma in the accretion disk the variation in the radiative output can be determined. There is a time delay depending upon the distance of the emitting material from the black hole and this distance can then be determined. By using this distance from the center and knowing the speed of the accreting matter, (by observing the Doppler shift in the emitting spectrum). One can determine the mass required for this to take place. This method is appropriately known as reverberation. Both of these methods rely on the direct relationship between the SMBH and its accretion disk, (see figure 6). The more massive the black hole the larger and further out the accretion disk can be. These two methods also work well on intermediate sized black holes.

One of the best and most accurate ways to measure the mass of a SMBH is by studying the motions of the close, orbiting, surrounding stars. There is a direct relationship with the mass of the SMBH and the sphere of gravitational influence. High resolution observations are needed for this method. This has been done for the SMBH in the center of the Milky Way know as Sagittarius A*. If we assume Newtonian gravitation, we would expect the stellar velocities to vary according to: v2 ≈ GM/r and that the velocities of the stars would increase as we approach the center. If we calculate the rate of velocity increase with radius we

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10" Deep Space Hunter

A very nice Dobsonian from Hardin Optical. Included in the sale are a finder scope and Telrad. Three eyepieces are also included: 9mm and 25mm (1¼" diameter) and 32mm (2" diameter). Asking price $400.

Peri Cline
480-981-5203 between 6 pm and 9 pm weekdays
peri_cline@cox.net

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A self-guided tour through our solar system, on CD and in book form. Take a scale-modeled tour of our solar system with an introduction to each planet, the dwarf planets, asteroids and much more.

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Cost is $15 plus $4 shipping and handling.

Gary Hyde
480-861-8044
g.n.hyde@att.net

Orion ShortTube 80T Refractor

Telescope features an 80mm objective lens, a 45° erecting prism, and a 6x26 finder scope. Also included in the sale are two eyepieces (10mm and 25mm) and a nice LowePro bag to carry it in. A great 'scope for someone that wants a very portable telescope. Add a tripod and "Have telescope, Will Travel!" Asking price $150.

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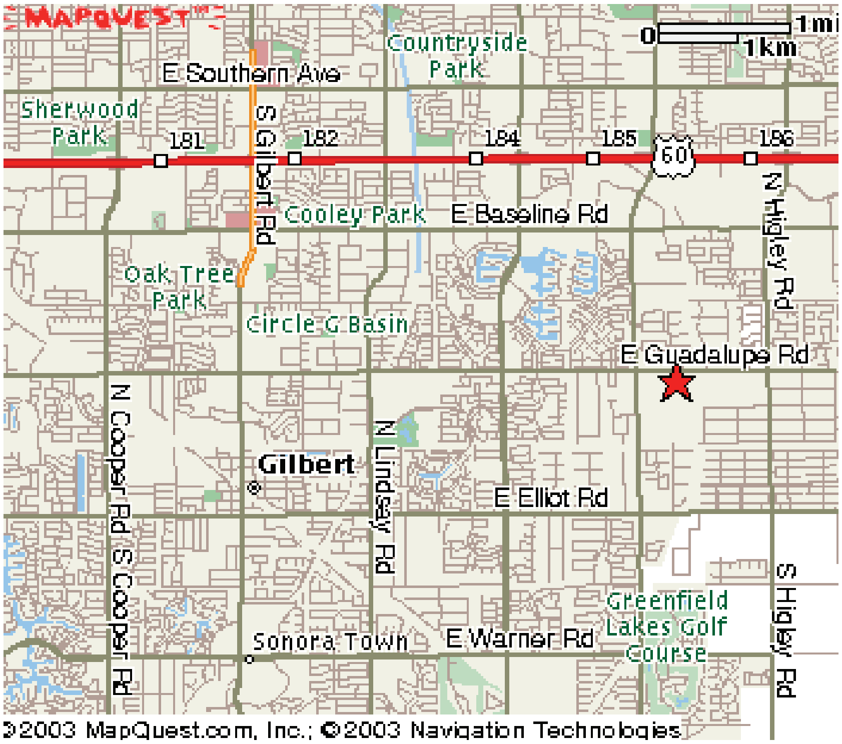
www.eastvalleyastronomy.org/grco/obs.asp

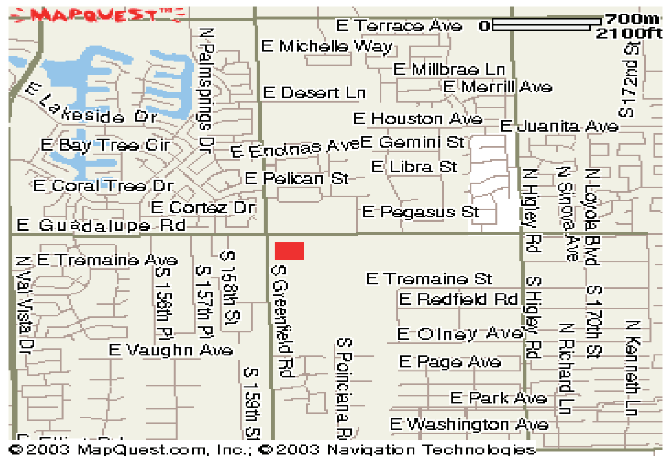


The monthly general meeting is your chance to find out what other club members are up to, learn about upcoming club events and listen to presentations by professional and well-known amateur astronomers.

Our meetings are held on the third Friday of each month at the Southeast Regional Library in Gilbert. The library is located at 775 N. Greenfield Road; on the southeast corner of Greenfield and Guadalupe Roads.

Meetings begin at 7:30 pm.

Visitors are always welcome!



2007 Meeting Dates

August 17

September 21

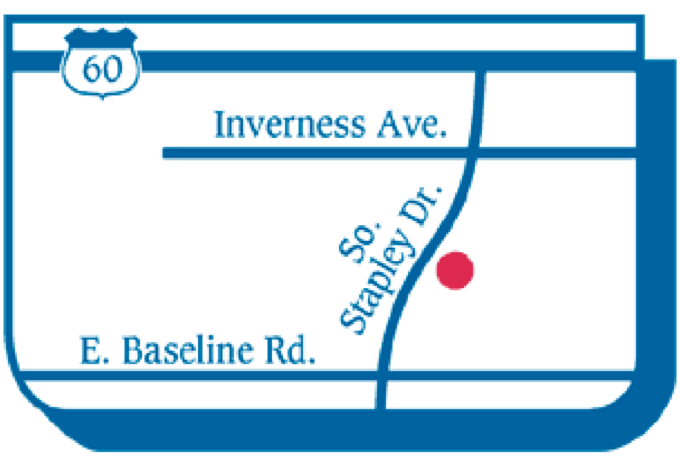
October 19

November 16

December 21

Southeast Regional Library
775 N. Greenfield Road
Gilbert, Az. 85234

All are welcome to attend the pre-meeting dinner at 5:30 pm. We meet at Old Country Buffet, located at 1855 S. Stapley Drive in Mesa. The restaurant is in the plaza on the northeast corner of Stapley and Baseline Roads, just south of US60.



Old Country Buffet
1855 S. Stapley Drive
Mesa, Az. 85204

Likewise, all are invited to meet for coffee and more astro talk after the meeting at the Village Inn restaurant located on the northeast corner of Gilbert and Baseline Roads in Mesa.

Village Inn
2034 E. Southern Avenue
Mesa, Az. 85204

August 2007

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1	2	3	**4**
5	6	7	8	9	**10**	**11**
12	13	14	15	16	**17**	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

August 4 - Local Star Party at

August 10 - Public Star Party at Riparian Preserve in Gilbert

August 11 - Deep Sky Star Party at Vekol Road

August 17 - Monthly Meeting at Southeast Regional Library in Gilbert

July Meeting Minutes

Randy Peterson, filling in for Claude Haynes, called the meeting to order at 7:30 p.m. Following introductions of officers and board members, ten visitors introduced themselves.

Bill Houston gave the treasurer's report:
Income: $412.00
Expenses: $394.69
This gives a positive cash flow of $17.31. The bank balance as of June 30 was $8310.13.

The Burnham Memorial fund has a current balance of $140 with pledges of $1,000. Someone asked if they could donate using PayPal. That method of donating money is being pursued.

Martin Thompson reported that the observatory volunteer schedule was out. It will be the responsibility of the individual volunteer to find a replacement if he or she will be unable to meet the schedule. Martin also announced that since Win Pendleton will be out of town for the November and December second Friday programs, volunteers are needed to cover. Anyone interested should contact either Win Pendleton or Martin Thompson.

Randy Peterson reported on the upcoming events for August. They are as follows:
Local Star Party at Boyce Thompson on Saturday, Aug. 4
Gilbert Public Star Party on Friday, Aug. 10
Deep Sky Star party at Vekol on Saturday, Aug. 11
Perseid Meteor Shower, late night & following morning on Sunday, Aug. 12. If anyone is interested in a group observing session, they should contact Randy Peterson.
Total Lunar Eclipse, the morning of Tuesday, Aug. 28
And into October, the All Arizona Star Party is scheduled for October 12 & 13.

Our guest speaker for the August meeting will be former EVAC President, Steven Aggas, sharing his new telescope. Since it has a 36" diameter mirror, the presentation will most likely be in PowerPoint format and not the actual telescope.

For recognition, Chris Schur's picture of the planetary conjunction of Venus and Saturn on June 30 was featured in Astronomy Picture of the Day for July 4, appropriately titled "Red, White and Blue Sky."

Also shared was APOD's picture for July 9 of the size of our Sun in early July compared to its size in early January. The Sun is noticeably smaller in July than in January, and therefore further from the Earth in July.

Steve Coe announced that SAC would be holding a star party for novices at their Cherry Road site on August 11. This event will be held "monsoon or shine," unless of course the road is closed due to flash flooding. Contact Steve Coe to confirm location, date and time at stevecoe@ngcic.org.

For Show & Tell, Tom Polakis presented a special slide show prepared with the ProShow application – beautifully entertaining.

After the refreshment break, Randy Peterson, filling in for Howard, introduced the speaker, Steve Coe, a distinguished member of the Saguaro Astronomy Club. Steve gave a delightful talk on Nebula – bright and dark, emitting, absorbing and obscuring including many beautiful pictures.

The meeting adjourned to a local eating establishment about 10 pm.

East Valley Astronomy Club -- 2007 Membership Form

Please complete this form and return it to the club Treasurer at the next meeting or mail it to EVAC, PO Box 2202, Mesa, Az, 85214-2202. Please include a check or money order made payable to EVAC for the appropriate amount.

IMPORTANT: All memberships expire on December 31 of each year.

Select one of the following:

☐ New Member ☐ Renewal ☐ Change of Address

New Member Dues (dues are prorated, select according to the month you are joining the club):

☐ **$30.00 Individual** January through March

☐ **$35.00 Family** January through March

☐ **$22.50 Individual** April through June

☐ **$26.25 Family** April through June

☐ **$15.00 Individual** July through September

☐ **$17.50 Family** July through September

☐ **$37.50 Individual** October through December

☐ **$43.75 Family** October through December

Includes dues for the following year

Renewal (current members only):

☐ **$30.00 Individual** ☐ **$35.00 Family**

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NASA's Space Place

Tones from the Deep

by Patrick Barry & Tony Phillips

Now is an exciting time for space enthusiasts. In the history of the Space Age, there have never been so many missions "out there" at once. NASA has, e.g., robots on Mars, satellites orbiting Mars, a spacecraft circling Saturn, probes en route to Pluto and Mercury—and four spacecraft, the Voyagers and Pioneers, are exiting the solar system altogether.

It's wonderful, but it is also creating a challenge.

The Deep Space Network that NASA uses to communicate with distant probes is becoming overtaxed. Status reports and data transmissions are coming in from all over the solar system—and there's only so much time to listen. Expanding the network would be expensive, so it would be nice if these probes could learn to communicate with greater brevity. But how?

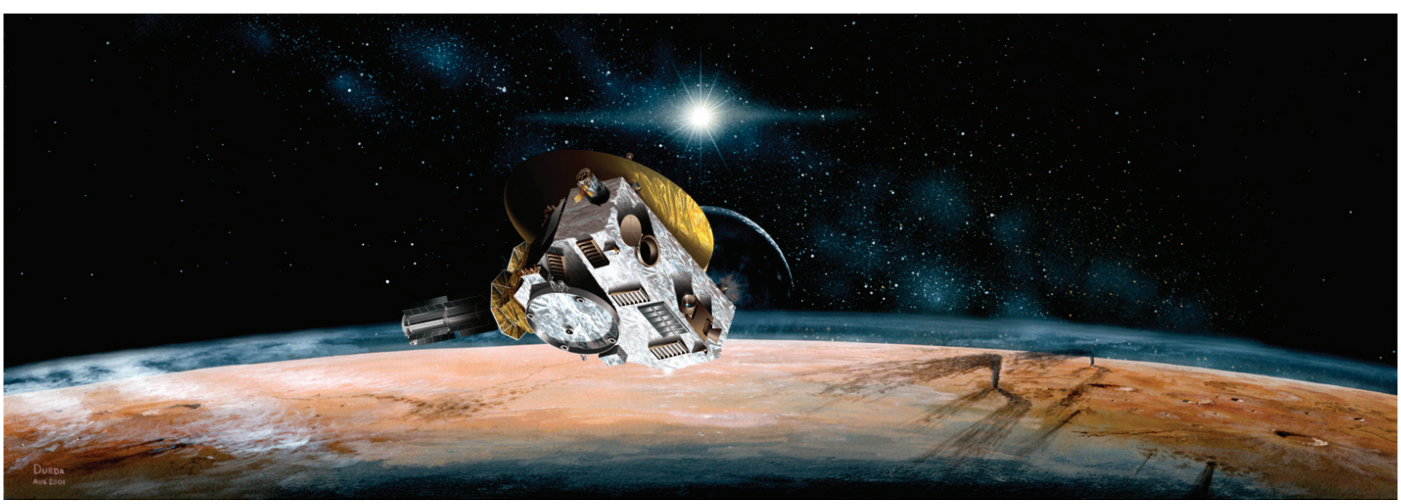
Solving problems like this is why NASA created the New Millennium Program (NMP). The goal of NMP is to flight-test experimental hardware and software for future space missions. In 1998, for instance, NMP launched an experimental spacecraft called Deep Space 1 that carried a suite of new technologies, including a new kind of communication system known as Beacon Monitor.

The system leverages the fact that for most of a probe's long voyage to a distant planet or asteroid or comet, it's not doing very much. There's little to report. During that time, mission scientists usually only need to know whether the spacecraft is in good health.

"If you don't need to transmit a full data stream, if you only need some basic state information, then you can use a much simpler transmission system," notes Henry Hotz, an engineer at NASA's Jet Propulsion Laboratory who worked on Beacon Monitor for Deep Space 1. So instead of beaming back complete data about the spacecraft's operation, Beacon Monitor uses sophisticated software in the probe's onboard computer to boil that data down to a single "diagnosis." It then uses a low-power antenna to transmit that diagnosis as one of four simple radio tones, signifying "all clear," "need some attention whenever you can," "need attention soon," or "I'm in big trouble—need attention right now!"

These simple tones are much easier to detect from Earth than complex data streams, so the mission needs far less of the network's valuable time and bandwidth, Hotz says. After being tested on Deep Space 1, Beacon Monitor was approved for the New Horizons mission, which is currently on its way to Pluto, beaming back a simple beacon as it goes.

This article was provided by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.



This artist's concept shows the New Horizons spacecraft during its planned encounter with Pluto and its moon, Charon. The spacecraft is currently using the beacon monitor system on its way to Pluto. Credit: Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute (JHUAPL/SwRI)

If It's Clear…

by Fulton Wright, Jr.
Prescott Astronomy Club

August 2007

Shamelessly stolen information from Sky & Telescope magazine, Astronomy magazine, and anywhere else I can find info. When gauging distances, remember that the Moon is ½ a degree or 30 arc minutes in diameter. All times are Mountain Standard Time unless otherwise noted.

On Monday, August 6, between 3 and 5 AM, you can see the crater Clavius on the Moon at its best. With a small (3 inch) telescope look fairly high above the east horizon for the nearly half phase Moon. Libration tips the southern part toward us and the terminator is well placed to show off the terrain. This is not a convenient time to be up observing, but you will be rewarded with a great view of a huge (130 mile diameter) crater containing an arc of decreasing sized craters in it. While you are there, check out Rupes Recta (the straight wall) north of it, which will appear as a bright line under this illumination.

On Tuesday, August 7, at 9:11 PM, Europa's shadow falls on Jupiter. 12 minutes later, Europa moves from in front of Jupiter and becomes visible.

On Sunday, August 12, it is new moon, so you can hunt for faint fuzzies all night. As a matter of fact, it is the perfect night for looking for meteors. (See next item.)

On Sunday, August 12, you can see the Perseid meteor shower at its best. You can start observing about 9 PM when the radiant has risen and the sky is dark, and expect the conditions to improve as the radiant rises higher. The radiant is in the northeast, but meteors can appear anywhere in the sky. Lie back, look up, keep warm.

On Tuesday, August 21, at 8:28 PM you can see a third magnitude star occulted by the Moon. With binoculars or a small telescope, look 25 degrees above the south-southwest horizon for the slightly gibbous Moon and Tau Scorpii, about to disappear behind the dark limb of the Moon. The star pops back into view at 9:55 PM from behind the bright limb. While you are waiting for the reappearance, take a look at the crater Plato in the north. Libration tips that part of the Moon toward us. If you have a big (12 inch) telescope and good seeing, you should be able to spot some small craterlets in its flat floor (not an easy observation). If you checked out Rupes Recta (the straight wall) on the morning of August 6, head on south and see it as a dark line with the current illumination.

On Monday, August 27, at 6:50 PM (13 minutes before sunset) the full moon rises spoiling any chance of seeing faint fuzzies for the whole night, except for during the eclipse after midnight. (See the next entry.)

On Tuesday, August 28, between midnight and dawn, you can see a total eclipse of the Moon. Here is the schedule:

12:52 AM Moon enters penumbra (unobservable)
1:20 AM penumbra first visible (time approximate)
1:51 AM partial eclipse starts
2:52 AM total eclipse starts
3:37 AM mid eclipse
4:23 AM total eclipse ends
4:31 AM Astronomical twilight starts
(first light in the east)
5:03 AM Nautical twilight starts
(most stars still visible)
5:24 AM partial eclipse ends
5:34 AM Civil twilight starts
(a few, bright stars still visible)
5:59 AM Sun rises
6:10 AM Moon sets

On Wednesday, August 29, about 9 PM, you can see an asteroid near a planet. With binoculars or a small telescope look 25 degrees above the southwest horizon for Jupiter (mag -2) and, half a degree to the upper right, Vesta (mag 7). For a few days around this date you can watch Vesta move by Jupiter.

Lunar Eclipses in 2003

Photographer: Tom Ruen
Location: New Brighton, Minnesota
Date/time:
May 15, 2003, 10:19 pm CDT (Moon 14 degrees high)
November 8, 2004, 7:11 pm CST, (Moon 24 derees high)
Equipment: Digital camera, 6" Newtonian reflector, 50x.
Exposures: 1.6 and 1.0 seconds.
Processing: Cropped, reduce resolution, rotated north up.

Continued from page 5

can determine the central mass of the SMBH. Our SMBH is about 28,000 light years distant and by using adaptive optics we can image in the IR, individual stars orbiting about 7-10 light days away from this source. The next closest SMBH is in M31 and we can image stars about 2 light years from the center. The stars we image around Sagittarius A* orbit at speeds up to 5 million kilometers per hour, so fast that we can detect their proper motion over several years. Some of these stars orbit this central engine in about 15 years total time. One particular star known as S2, (about 15 solar masses and about 17 light hours away) has been tracked for over 10 years at speeds of 5000 kps, and defines an elliptical orbit that has one focus on the SMBH. Using this stellar kinematic data the mass of our SMBH can be calculated to be about 3.4 million solar masses, (squeezed into a space of about 17 light hours in diameter). Sagittarius A* is estimated to have an average accretion rate of about 1/100,000 the mass of the sun per year, (Frank, et al 2002).

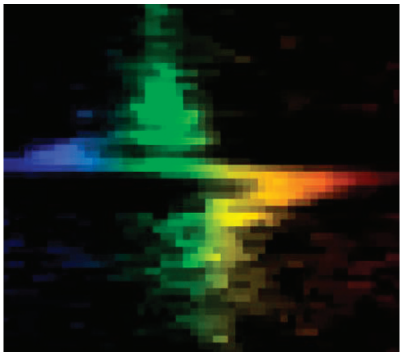


Figure 6: The radial velocities, (about 400 kps) near the nucleus of M84 with the blue shift moving towards us and the red shift receding. The SMBH at the center is estimated to be about 300 million solar masses, (SMBH's 2007).

In the Virgo cluster resides NGC 4486a, a low luminosity elliptical galaxy close to M87. By again using stellar kinematic studies, (analyzing Doppler shifted radiation in the near IR) a central SMBH of about 12.5 million solar masses was calculated, (Nowak et al 2007).

These methods are sometimes used concurrently so that we can establish correlations between them and the physical models we use to describe gravity and space-time. So far the theory and the physical evidence are showing to be fairly well defined so that the calculated masses are believed to be realistic. More physical evidence in the future will help determine better accuracy.

Additional Evidence for SMBH's

One of the best examples of a SMBH existence is M87. It is a giant elliptical galaxy suspected of harboring an SMBH of about 3 billion solar masses at its center in an area the size of our solar system. Its optical image shows a jet of plasma about 6,500 light years long while the stars at the center show a high Doppler shift motion of about 550 kps. This jet and the high velocity central stars indicate a larger gravitational field than can be accounted for by the visible stars, (SMBH's 2007).

Another example of strong circumstantial evidence for the existence of a SMBH comes from NGC 4261 in the Virgo cluster about 45 million light years distant, (see figure 7). It has very large jets shooting out from its core and very strong radio emissions that indicate a SMBH of about 1 billion solar masses. This SMBH would occupy a space about the size of our solar system, (SMBH's 2007).

Chandra took images of relatively dark areas of both the northern and southern sky, which were similar to the Hubble Deep Field, at x-ray energies. These are the longest and most distant x-ray images produced to date. Chandra discovered via the x-ray emissions that the number of suspected SMBH's in the images was in the order of about 500. Extrapolating this area to the universe at large gave a rough estimate of about 300 million SMBH's. Chandra only detected the x-ray emissions that it was able to pick up, which would not have been all that could exist, so that this number is considered a lower estimate. The faint x-ray background in the intergalactic medium has been a problem for years to explain and x-ray photons are too energetic to have been long ago produced like the cosmic background radiation. Since stars and most galaxies do not radiate much in this region the suggestion has been made that perhaps SMBH's are responsible. If this were true than calculations indicate that there would have to be at least 10 times more SMBH's that evidence suggest, implying that the majority of SMBH's are dormant or at least undetectable from Earth, by x-ray, UV, NIR, and optical means, (Melia, 2007).

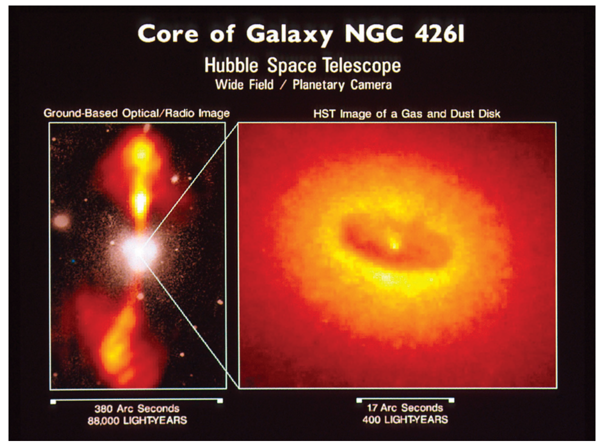


Figure 7: A composite image, (using both radio and optical wavelengths) of NGC 4261 showing the accretion disk, emitting jets and the radio lobes. The SMBH at the center is about 1 billion solar masses, (SMBH's 2007).

In 2000 astronomers reported the discovery of a Type 2 quasar which is invisible to optical telescopes. This AGN was detected by faint x-ray emission and resides in a normal looking galaxy, which may also indicate many more hidden or partially hidden SMBH's in other normal looking galaxies. If we take into account the quasar x-ray radiation as well as the estimated x ray radiation of obscured quasars in normal galaxies we can account for about 50% of the universe's radiation after the Big Bang being produced by SMBH's. It appears that stars may not be the most dominant radiation producers in the universe as earlier thought. The evidence and continuing development of space based observations may be forcing this paradigm change for us.

Closer to Earth, in Centaurus A, in the southern constellation Centaurus, (about 11 million light years distant) the HST discovered a disk of glowing , high speed gas, revolving about a dense core of matter with a mass of a couple of million solar masses, (see figure 8). Since this core of high density mass is not shining brightly it is unlikely to consist of normal stars and is considered to be a black hole. Centaurus A is also emitting, (seen in radio wavelengths) a bipolar mass ejection comprised up of highly

Continued on page 15

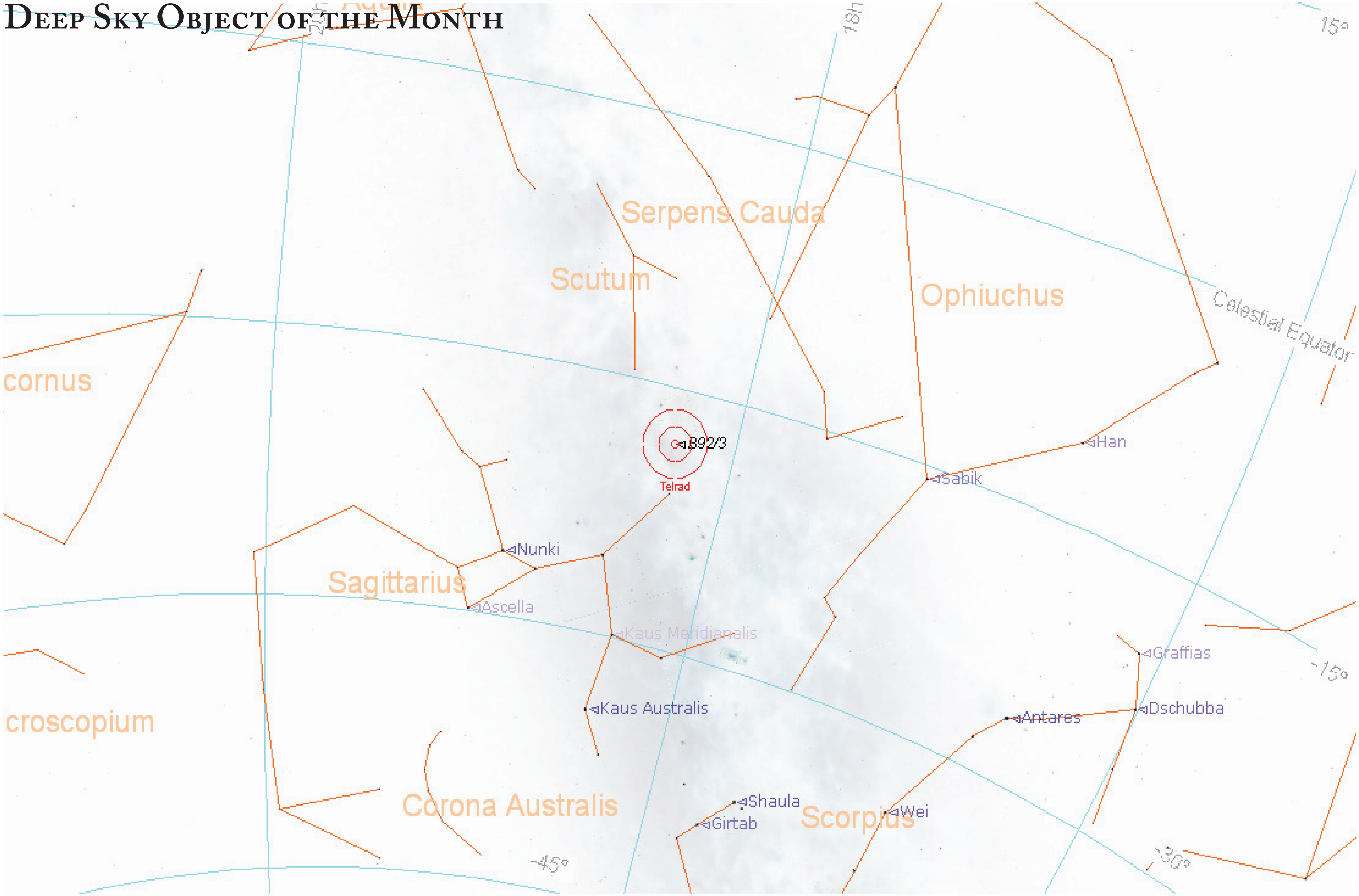


Chart generated with Starry Night Pro

Barnard 92 (LDN 323) Dark Nebula in Sagittarius

RA 18h 15m 31.7s DEC -18° 10’ 59” Magnitude: 6.0 Size: 7.6’ x 7.6’

Continued from page 13 energetic particles, (plasma) perpendicular to the dark bands of dust surrounding it, (Melia, 2007).

Another AGN indicative of a SMBH is Cygnus A with a relativistic plasma ejection jet crashing into the ISM and creating giant radio lobes, spanning over 500,000 light years, (much larger than the diameter of the Milky Way). It is about 600 million light years from earth and is one of the brightest radio sources in the heavens. This long stable span of particle jets also indicates a long stable source which is most likely a very large rotating SMBH. It is speculated that the twisting motion of the magnetized plasma near the SMBH's horizon is causing the jets, although the exact mechanism is still not understood.

Figure 8: Centaurus A showing the bright central region and the emitting jets, (Chandra X-Ray Observatory).

Back in our own galaxy, both x-ray, (from the XMM Newton satellite) and near IR flares have been detected from Sagittarius A* with periods of 17-20 minutes, which would suggest these occur within a few Schwarzschild radii above the event horizon. This information would also indicate via models that the disk is inclined about a 77 degree angle and that the infalling mass interacts with the SMBH in a clumpy fashion rather than in a continuous stream. It may even have more than one spiral arm in the accretion disk. The complete structure of this disk however is not yet fully understood and all the relativistic effects are not well modeled especially in regards to black hole spin effects, (Falanga, et al, 2007).

We see that there exists very strong indirect evidence for the existence of SMBH's in our own galaxy and in far distant ones, as well as in the Universe at large. They may be far more influential than earlier imagined.

Conclusions

Thus we see that SMBH's, (and black holes in general) play many roles in this Universe, from the BB to the present day. They support and drive star formation, galaxy formation and evolution, and may supply much of the existing radiation in the Universe. They are far from the destructive machines so commonly portrayed and are actually quite creative and stimulating. They also seem to be far more common than earlier realized, most likely in a variety, (continuously?) of sizes.

In terms of galaxy evolution we know that there exists a correlation between SMBH mass the mass, (or luminosity) of the central bulge component of galaxies. The mass of the SMBH is about 0.006 times the mass of the central bulge, or roughly that about ½ % of the mass of the bulge material collapses into a SMBH. This infalling of mass and efficient energy conversion is most likely the quasar phase that we see from earth, (Hobson, et al 2006). There appears to also be a correlation between the mass of a SMBH and the velocity dispersion of stars in the bulge component of a galaxy, despite the fact that many of these stars are too far away from the center to really feel the SMBH's gravity to any great degree. These two relationships hint that there may a partnership between the evolution of a galaxy and it's SMBH at some time in the past. It is now believed that very flat disk galaxies that lack a central bulge may lack a SMBH at their center, while every galaxy that does have such a central bulge seems to harbor such a SMBH, (Nowak, et al 2007).

Even in the search for dark matter, (DM) SMBH's may lend a helping hand. Since DM is gravitationally influenced, around a SMBH, (such as in the center of our own galaxy) astronomers expect to have a dense "spike" of dark matter formed around it. The SMBH may even help form stars out of DM or regenerate white dwarfs via dark matter accretion onto such stars. The annihilation of dark matter, (via WIMP pair annihilation) in such cases should be detectable in the gamma ray portion of the spectrum. The flux of gamma rays detected from our galactic center via EGRET, indicates this possibility. In the future more accurate data collection in both the gamma ray and near IR spectrum may validate this idea of "DM burners" near the center of our galaxy, (Moskalenko, et al 2007).

In the future if we can image the event horizon of our galaxy's SMBH via the global mm-VLBA, this will provide the smoking gun of a SMBH to be sure. This may be realized by the strong light bending near the horizon and the resulting detection of this shadow. At the distance of 28,000 light years this would correspond to an angular size of about 30 micro arc seconds.

Despite no direct physical evidence of any black hole to date, it is interesting, (and a bit ironic) that a SMBH in our own galaxy, may be the first provider of such evidence for black hole existence.

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