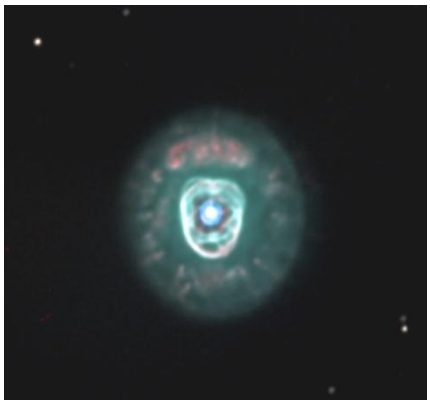
Planetary Nebula: From Messier to Abell

(What are they, and How to Observe Them)

Abell-43

Introduction:

Planetary Nebula,,,,,, when I hear that phrase, I think of a specific type of deep sky object. A type of object that's always interesting and fun to observe or image. They also bring to mind their descriptions: Colorful ephemeral ghosts, luminescent wispy shells of dying stars. Little crystal ball gems in the night sky, delighting amateur astronomers using small or large telescopes. They run from large easily located extended disks showing great detail to tiny almost point-like, challenging to find. Interstellar graveyards giving up secrets of stellar evolution while spreading their wealth of star forged elements across space, swept up by gravity to enrich the next cycle of star birth. Pretty heavy stuff!!



NGC2392

NGC6302

NGC7009

So today, I would like to bring these ethereal objects 'down to Earth' by discussing what they are, why we call them that, some of the people, both historical and modern, behind these objects, and how to go about observing them. Along the way, we'll also review a number of my personal observations of planetary nebula.
Hopefully, when we are done, some of the mystery around these objects will have been lifted, and you will find them as interesting to hunt as I do.

Outline:

- What are Planetary Nebulae:
- Where are these Nebulae Located:
- How Planetaries got their name:
- How to Observe Planetary Nebulae:
- Historical and Modern Astronomers and their Planetary Nebula Catalogs:
  - Charles Messier:
  - William Herschel:
  - Rudolph Minkowski:
  - George Abell:
- Conclusion:

What are Planetary Nebulae?

Planetary Nebulae are clouds of interstellar matter, thin shells of ionized gas and dust. They mark where a star is slowly dying, or has ended its life in a violent explosion. These nebulae come in a wide variety of shapes and appearances.

The central star that creates a planetary nebula is a red giant star in an advanced state of stellar evolution, at or just beyond, the end of its nuclear life cycle. When a star similar in size to our sun has used up all its central nuclear fuel, it first expands into a red giant star. But eventually the force of gravity causes it to contract, and during that process it ejects a significant portion of its mass in a gaseous shell.

Ultraviolet radiation and light from the dying star then energizes the shell of expanding nebulous gas, causing it to appear as a brightly colored nebula. These shells are called ***planetary nebula,*** because they resemble a planetary disk. Most planetary nebula are just a few light-years or less in diameter, and are heated by UV radiation to temperatures of about 10,000 K. About one-fifth of all planetaries are roughly spherical, but the majority are not symmetric. Professional images show that many planetary nebulae have extremely complex and varied shapes. Planetaries are generally classified into three types: spherical, elliptical and bipolar. Some of these shapes are also due to our line-of-slight angle in how the object is projected. Magnetic fields, stellar winds, and interactions with other nearby stars can produce a wide variety of shells.

Stars which are considerably more massive than our Sun can explode violently, ejecting the greatest part of their stellar matter in a rapidly expanding shell. These are called *supernovae remnants.* Any leftover material from the exploding star may from a central compact remnant called a 'neutron star'. Supernova remnants are not considered to be Planetary Nebula. (*classical novae are considered to be mostly a type of cataclysmic variable star, caused by one star in a binary system drawing off material from the second star, leading to periodic flare-ups lasting for several weeks*).

Planetary Nebulae usually have only a few tens of thousands years before they fade and spread their matter into the interstellar environment, seeding the next round of stellar formation. On cosmic timescales, these nebulae undergo rapid changes and have comparatively short lifetimes, so that those we observe are all fairly young objects.
Over a period of time, the central star cools down to a white dwarf star and the nebula will eventually fade from view.

Where are these Nebulae Located?

Planetary Nebulae can be found scattered throughout all four seasons of the night sky. There are currently about 3000 planetary nebula. Most of these nebulae that we can visually observe are located within the spiral arms of our own home galaxy, and can be found all along the glowing band of light that we call the "Milky-Way". But some are visible thru amateur telescopes in nearby satellite galaxies, and professional observatories with large instruments have imaged planetaries in distant galaxies such as M31. Planetary Nebulae are generally among the most favorite deep-sky objects observed among amateur astronomers, and many are very interesting and worth the effort to find, regardless of the equipment that you use. While some planetary nebulae are fairly easy to find from suburban locations, most planetaries require observing from a dark-sky country location such as Cherry Springs.

How Planetaries got their name:

A lot of amateurs mistakenly credit Charles Messier for naming these types of deep sky objects. But that is not correct. Messier in 1764 discovered what would become the first planetary nebula, M27 (the Dumbbell Nebula) in the constellation of Vulpecula, and listed it in his catalogue of nebulous objects for comet hunters to avoid. Messier, with help from fellow French astronomer and comet hunter Pierre Mechain , went on to add three more of these objects to his catalog, (M57, M76, M97) but he never described them as resembling planets.

In 1779, another French astronomer Antoine Darquier, who is today co-credited with Messier for the discovery of M57, "the Ring Nebula", described his observations of it as: "...*a very dull but perfectly outlined; it is as large as Jupiter and resembles a fading planet*". But Darquier's observation of M57 wasn't widely published as Messier's and with credit for finding M57 going mostly to Messier; Darquier's description of M57 was soon forgotten.

But it wasn't until a few years later and by another astronomer that these types of objects were begun to be described as 'planetary nebula'. With the discovery in the constellation of Aquarius of what is now known as NGC7009 – (the Saturn Nebula) in 1782, William Herschel, (discover of the planet Uranus a year earlier in 1781), first used the term "planet" in his description of these objects: "*These bodies appear to have a disk that is rather like a planet, that is to say, of equal brightness all over, round or somewhat oval, and about as well defined in outline as the disk of the planets,,,,".* While it's possible that Herschel had read Darquier's previous description of M57, it could very well be that Herschel had 'planets' on his mind from his discovery of Uranus, as he always kept an eye out for finding additional solar system members. Herschel went on to use the term "planetary" in his publications for 15 separate objects whose characteristics were a well defined round or oval shape with equal brightness across the disk. An example of which was his description of NGC7662 in Andromeda, Herschel calls it: "*a wonderful bright, round planetary, pretty well defined disk,,,"*

Herschel even named one of his deep-sky catalog classification categories (Class-IV) after these objects – "Planetary Nebula". But it wasn't until years later upon the persistence of his son John in using the term "planetary" in publications of his new discoveries from his southern sky cataloging trip to South Africa, that it really caught on and astronomers began actually calling these objects planetary nebula. John Herschel described these objects as: "*exactly the appearance of planets*", or "*perfectly round, very planetary,,, very like Uranus,,",* and "*just like a small planet*". This last quote was regarding NGC2867 in Carina, which for a few days John actually thought "*was so perfectly planetary in appearance,,"* that it took several observations over a period of days after he discovered it in 1834 before he was convinced that it wasn't moving and he didn't actually discover a new 8th planet of the solar system!

From the mid 19th century onwards, astronomers and observers now commonly described these objects as 'Planetary'. For example, the most famous discovery by 'grand amateur' Rev. T. W. Webb is the planetary nebula NGC7027 in Cygnus, which he made in November 1879. (Webb is the author of the popular Victorian era guidebook – "*Celestial Objects for Common Telescopes*"). Webb noted in his observing log that the nebula "*reminded me somewhat of the appearance of Uranus on an extremely bad night*". If you would like to learn more about Rev T.W. Webb, you can read about him on my website on my PDF download page at: http://stellar-journeys.org/Father of Amateur Astronomy.pdf So the credit for popularizing the term 'planetary nebula' goes to the team of William and John Herschel.

During Herschel's time, no one understood what nebula were, so Herschel devised a theory that ran opposite of what we know today, that stars formed in isolation and were drawn together by gravity, first into loose star-cluster, then as they became more dense into globular clusters, and finally were drawn in to "*very aged*" planetary nebula. He felt that most nebulae could be resolved into stars with the right telescope. Herschel also believed that there were some types of true nebulosity, what he called an "*interstellar aether*". He came to this viewpoint from his observation of NGC1514 in 1790. This was William Herschel's first observation of a gaseous planetary shell with an obvious central star that convinced him that "*true nebulosity*" existed. Herschel went on to state in his observation of NGC1514 that it was "*A most singular phenomenon! A star of about 8th magnitude, with a faint luminous atmosphere of a circular form,,, the star is perfectly in the center,,, nor can there be a doubt of the evident connection between the atmosphere and the star*". But it wasn't until 1864 when William Huggins with his 8" Clark refractor first used a spectroscope on NGC6543 (Cats Eye Nebula) seeing a continuous monochromatic emission spectrum, that the true nature of planetary nebula was finally determined. That planetary nebula was not an irresolvable cluster of stars, but a "*luminous gas*".

How to Observe Planetary Nebulae:

Unlike the irregular shaped glow of diffuse emission nebula, planetary nebula live up to their name in that they are generally circular shaped objects somewhat resemble a planet. Some are evenly bright or illuminated across their disk, while others have a darker central region giving them a ring shape. And in some planetaries, the central star that created the nebula can still be seen. Several good examples of planetary nebula with bright prominent central stars that are easily visible are NGC40 in Cepheus, NGC1514 in Taurus, NGC6826 in Cygnus, NGC2392 in Gemini, Abell43 in Ophiuchus, and M27 in Vulpecula.

Visually, if the planetary nebula's surface brightness is high enough, you may be able to see color. While most of the dimmer planetary nebula will have a grayish color, the brighter planetaries will show variations of green and blue colors. Easiest to see colors in are M27 (Dumbbell) in Vulpecula, M57 (Ring) in Lyra, NGC7027 (Magic Carpet) in Cygnus, NGC6543 (Cats Eye) in Draco, NGC7662 (Blue Snowball) in Andromeda, NGC6905 (Blue Flash) in Delphinus, NGC6818 (Little Gem) in Sagittarius, NGC2392 (Eskimo) in Gemini, and Abell50 in Draco. Using H-a narrowband filters, Imagers will be able to pickup planetaries with reddish colors such as NGC6781 in Aquila, Abell70 (Diamond Ring) in Aquila, and the previously mentioned M57 and NGC7027. These colors are from double & triple ionized oxygen and hydrogen caused by the intense UV radiation of the central star. When these atoms drop down to a less excited state, they emit either a greenish or reddish light, depending on the wavelength. To see colors in planetary nebula, look directly at them and do not use your adverted vision. Your eye's color receptor cones are located at the center of your eye and not on the sides.

Even though there's over 3000 planetary nebula, the majority are stellar in appearance, (especially the Minkowski's), or exceedingly faint, (Abell's), needing a specialized line-filter such as an OIII filter or spectroscope to be able to even identify them. Other narrowband filters, such as Lumicon's UHC or Orion's UltraBlock will help to visually enhance viewing planetary nebulas. General broadband 'light-pollution' filters that you can get from Orion also will enhance planetary nebulas, though not as much as the others.

These filters work by blocking certain wavelengths of light and/or only transmitting certain specific angstrom lines. The idea is reject as much background skyglow as possible, while enhancing the nebula.
Planetary nebulae emit most of their light in the 4800A to 5300A range, which is the light from ionized oxygen, so a filter than passes these wavelengths work best. The OIII filter passes only the 4959A and 5007A lines, rejecting everything else, including most starlight, and leaving only the planetary nebula visible. These ionized lines are called "*Forbidden lines*" because it is not technically possible to create these types of emission lines in laboratories.

A good rule of thumb is that any planetary nebula that is identified as an NGC# are observable extended objects with disks or shell structures, while most of the IC#'s are stellar objects or have very small diameter disks, nearly indistinguishable from field stars.

The largest planetary nebula visible is NGC7293, "the Helix Nebula", in the fall constellation of Aquarius. Due to its large dim ring-shape size, (about half the apparent diameter of the Moon), the Helix is best observed with wide-field small aperture telescopes from a dark sky. The brightest planetary is NGC7009, "the Saturn Nebula", also located in Aquarius. Due to its small size, a medium to large aperture sized telescope is required to observe any of its interior structure or the two 'ansae' that gives the nebula its Saturn appearance.

While planetaries can be classified into three generic types: spherical, elliptical and bipolar, a more detailed classification system was created by Boris Vorontsov-Velyaminov in 1934 that is still in use today.
Boris was a Russian astronomer best known for his co-discovery of the absorption of light by interstellar dust and his catalog titled: "*Atlas of Interacting Galaxies".* But he also studied planetary nebula and in 1934 devised the classification system still in use today, denoted as "VV"

Class	**Description**
I.	Stellar Image (star like) (these can be very hard to identify)
II.	Smooth disk (*a*, brighter toward center; *b*, uniform brightness; *c*, traces of a ring structure)
III.	Irregular disk (*a*, very irregular brightness distribution; *b*, traces of ring structure)
IV.	Ring or Annular structure
V.	Irregular form (similar to a diffuse nebula)

These classes will give you a good idea of what to expect from the nebula.
The four Messier planetary nebulae are classified "VV" types of: "IIIa" (M27), "IV " (M57), "V" (M76), and "IIIa" (M97).

In general, for visual observers, it's best to hunt planetaries starting off with low-power, wide-field eyepieces and filters to identify the target area. Once the planetary is centered, you can then switch to higher magnifications to try and pull out details in the nebula shells, along with the central star.
Messier's four planetaries, (with the exception of M97), are high-surface brightness objects and are easily visible in most telescopes, even under suburban skies. The twenty planetary nebula from the Herschel catalog are also generally visible in medium size telescopes, though some will require larger size reflectors in the 15 to 20" range and a dark country sky. But the planetaries listed in the Abell catalog are generally very old, extended, and faint, which makes these objects very challenging to observe. The Minkowski planetary nebulae are even more difficult, most appearing star-like and embedded in crowed Milky-Way star fields, showing little to no disk nebulosity.
You'll need a 17" or larger reflector or some type of imaging setup to pull these in.

Observing Guides:
There are a number of good Planetary Nebula related observing guides available to the amateur astronomer.
Here's a few of my favorites:

"*The Night Sky Observers Guide – Glories of the Milky-Way*", by George Kepple:
This is the 4th in the series of handbooks written by George Kepple and Glen Sanner, each chapter covering a specific constellation, with finder charts, sketches, images, and visual descriptions of various deep sky objects.
New Volume 4 focuses specifically on constellations and their objects that lie along the path of our Milky-Way galaxy. Each constellation 'chapter' list all planetary nebulae visible within its boundaries in a very convenient layout.

"*Planetary Nebulae, A Practical Guide and Handbook for Amateur Astronomers*", by Steve Hynes
Having been published in 1992, this book is a little hard to find and a bit pricy, but lists over 1,340 amateur observations of planetary nebula, including some sketches, along with 253 finder charts. Also sections on the historical discovery of, and astrophysics of planetary nebula. Well worth it if you can find one.

Another good guidebook to have, though somewhat 'dated', is the Webb Society's Deep-Sky Observers Handbook series. With volume-two of the handbook – "*Planetary and Gaseous Nebula",* it lists a number of bright planetary nebula visible with small to medium size amateur telescopes. There are a total of 80 planetary nebula listed in the Webb Society handbook, with detailed descriptions and sketches.

Finally, on the internet, there are a number of good sites:

Amateur astronomer Alvin Huey has a number of great observing handbooks on his website:
http://www.faintfuzzies.com/ The first one is called "*Planetary Nebula and Supernova Remnants*", which list over 300 planetaries with finder charts and DSS images. It's a mixture of easy and hard to find, so useful to both beginners and advanced amateurs. Alvin also has a handbook called "*The Abell Planetary Observers Guide*", also containing finder charts, DSS images, and visual eyepiece sketches made with 22" & 30" telescopes. Due to the difficulty of most of the Abell planetaries, this handbook is more for the advanced amateur looking for a visual or imaging observing project.

"*The Brightest Planetary Nebulae Observing Atlas*", by Massimo Zecchin. A downloadable PDF list of the 35 best planetaries across the sky, many that have a high surface brightness observable with small telescopes from a suburban location. Comes in either a black or white version. Includes a finder chart, object info, and a sketch by the author.
http://www.pnebulae.altervista.org/contenuti/primipassi/ObservingAtlas/ObservingAtlas.html

Steve Gottlieb's Adventures In Space - http://www.astronomy-mall.com/Adventures.In.Deep.Space/abellpn.htm

Uwe Glahn http://www.deepsky-visuell.de/Projekte/AbellPN_E.htm website with visual descriptions made thru various medium and large telescopes using an OIII filter, along with DSS images.

Reiner Vogel http://www.reinervogel.net/pdf/Large_PN.pdf download observing guide - a list of 38 large planetary nebula with finder charts, DSS images and visual descriptions using a 22" reflector.

Historical and Modern Astronomers and their Planetary Nebula Catalogs:

So far we've covered what are planetary nebula, how they got named as such, and general tips on how to observe this type of deep sky objects. But who are these people that have been mentioned along the way: Messier? Herschel? Minkowski? and Abell? Let's spend some time digging a little deeper into the background of some of the historical and modern astronomers associated with catalogs of planetary nebula, and we'll look at a few examples of my observations, both visual and video capture, of their planetary nebulae.

Charles Messier:

In July of 1764, while out comet hunting with his 6" speculum mirror reflector, Charles Messier ran across a bright nebula that would become the 27th object on his list to avoid while comet hunting. Messier referred to M27 as a "*nebula without a star,,, it appears of oval shape*". This was to become the first planetary nebula to be discovered, though it took another 20 years before it was categorized as one.

So, who was Charles Messier?

The 18th century French Astronomer Charles Messier is best known for his catalog of nebulae and star clusters, first published in 1771. This list of 110 deep-sky objects is known to today's astronomers as the 'Messier Catalog'.
As an astronomer, Messier's primary job was to hunt for comets. During his comet searches, he kept running into these diffuse non-comet objects that would frustrate him. So Messier began a list to help comet hunters avoid these false comets. Over the centuries, Messier's list became popular targets for amateurs because these 'M-objects' could be easily visually observed with small-aperture telescopes.

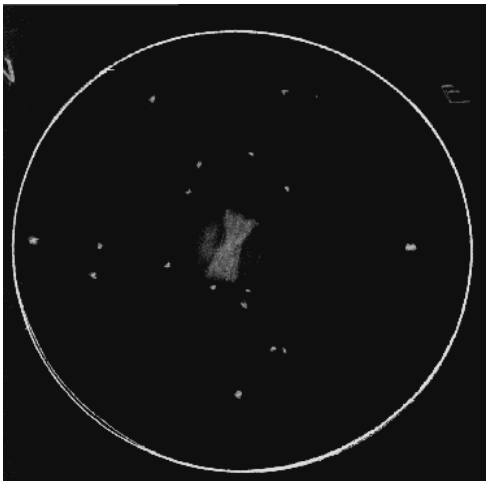
Messier worked as an astronomer for the French Navy. His observatory was located within the city of Paris at the Hôtel de Cluny which was originally a medieval town house built in 1334. The observatory was built on top of a tower attached to the townhouse and was a pyramidal structure with large side windows that could be opened. Inside was kept the portable observatory telescopes that could be positioned to point out of whichever window the observer preferred. For the majority of his observing work, Messier used a small 100mm (4 inch) refractor.
The concept of interchangeable telescope eyepieces was not yet common in Messier's time; most of his telescopes have a fixed eyepiece lens and magnification. While some of Messier's reflecting telescopes had large apertures for the time, up to 8 inches, as they were made of speculum metal, which was the standard of the day, their light gathering ability was only about 70% when newly polished and generally the mirrors would tarnish quickly from the moist night air. Today's modern small refractor or reflector will easily outperform the best of Messier's telescopes.

Of the 110 Messier objects, today we know that 40 are galaxies, 29 globular clusters, 27 open star clusters, 6 diffuse nebulae, 4 planetary nebulae, 1 supernova remnant, and 3 'misc' objects of the star cloud M24, double star M40, and the asterism of 4 stars M73. Over the course of his lifetime Charles Messier discovered 21 new comets, including the Great Comets of 1769 & 1770. Charles is also credited with the first recovery observations of many previously found comets, including being one of the first to recover Halley's Comet in 1759. But it is his list of fixed diffuse objects to avoid while comet hunting, his '*Catalog of Nebulae and Star Clusters',* that today's modern amateur astronomer seeks out as bright showcase galaxies, nebula, and star clusters of the night sky.
That is what Charles Messier, the "Ferret of Comets", is renowned for in the 21st century.

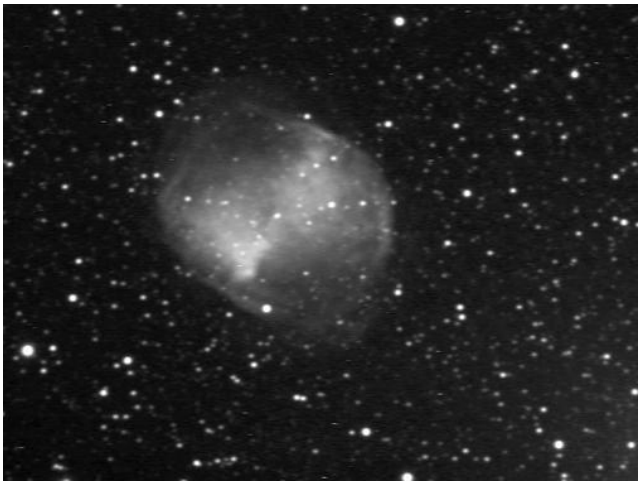
If you would like to learn more about Charles Messier, you can read about him on my website on my PDF download page at: http://stellar-journeys.org/The Ferret of Comets.pdf

Messier Planetary Nebulae:

M27 known as the “Dumbbell Nebula”, (also later called the “Hourglass” by John Herschel), is located in the summer constellation of Vulpecula, 'The Fox'. Discovered in 1764, it was first planetary nebula ever observed, and is one of the brightest and most impressive, easily visible in binoculars. M27 is about 1360 light years distant, and is estimated to be close to 14,600 years old, and about 3 light-years in size. On summer evenings, it is well placed, almost directly overhead, and can be naked-eye from a dark sky location. Due to its high surface brightness, M27 can even be observable thru a small telescope or binoculars during Full Moon. Its central white dwarf star shines at 12.9+ magnitude and is easily visible at the center of the dumbbell shaped nebula in small telescopes. Distinct structural features can be observed within M27, including bright, sharply defined arcs coming off of either end of the dumbbell, along with striations between the main arcs and the center of the nebula. UHC and OIII filters will enhance the contrast of internal features of the nebula.

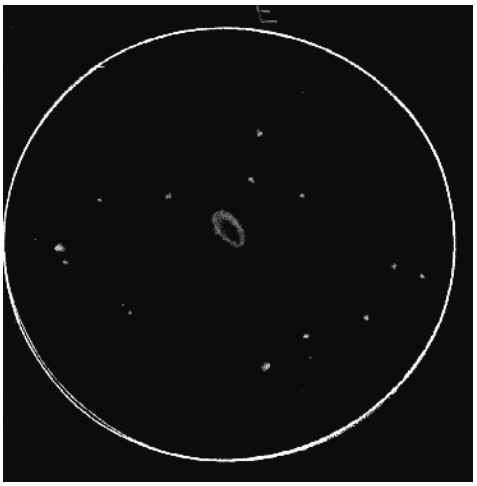


10" f5.6 Dob Reflector 27mm (52x)

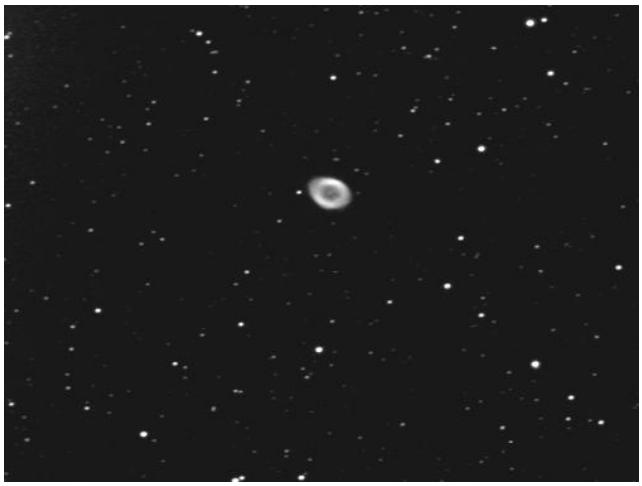


8" SCT f6.3, StellaCam-3 @ 120 seconds

M57 Located in the summer constellation of Lyra, 'The Lyre (Harp)', and is known as the ‘Ring Nebula’.
It was second planetary nebula discovered by Messier (in 1779, about 15 yrs after M27), and is easy to locate and can be observed with small telescopes, even in suburban skies. It is about 2300 light years distant, and about 6000 years old, and is estimated to have a diameter of about a half-light year, and is expanding at about 12 miles per second.
With its high surface brightness, the Ring is one of the best celestial showpieces of the summer sky! While the nebula itself is easy to observe, the central star at 15.4+ magnitude, can be quite difficult to glimpse.
Interestingly, 3-D modeling of the structure of M57 shows that it actually is similar in shape to M27. The differences in shape are a matter of viewing angle perspective. For the Ring, we are looking down the axis of one of its ends. For M27, we are looking at it toward the side, about a 90 degrees rotation.

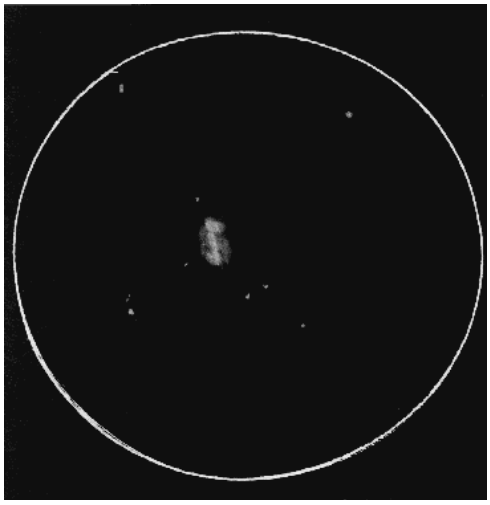


10" f5.6 Dob Reflector 8mm (79x)



8" SCT f6.3, StellaCam-3 @ 30 seconds

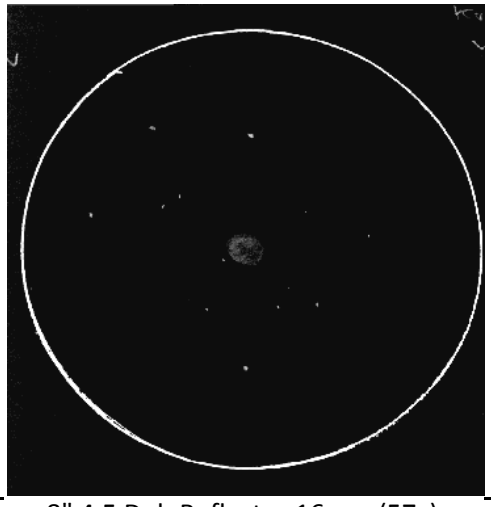
M76 Located in the fall constellation of Perseus, 'The Hero', and is known as the 'Little Dumbbell Nebula'.
Discovered in 1780 by Messier's observing partner, Pierre Mechain, it is about 2500 light years distant, and about 6000 years old, and about 1.5 light-years in size. Before it was determined that M76 was a planetary nebula (in 1918), it was once considered to be two separate emission nebula and given two NGC numbers - 650 & 651. Visually, it is not difficult to find, and resembles its larger namesake in medium size telescopes.



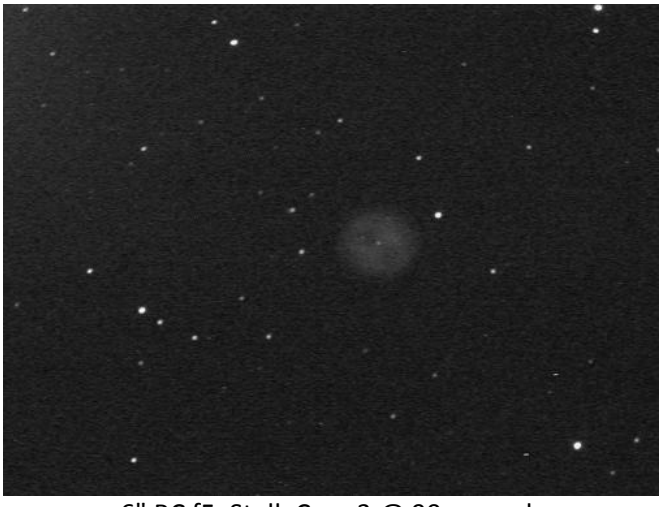
8" 4.5 Dob Reflector 12.5mm (91x)

8" SCT f6.3, StellaCam-3 @ 120 seconds

M97 Located in the circumpolar constellation of Ursa Major 'The Great Bear', and is known as the 'Owl Nebula'.
The last planetary nebula on Messier's "Not a Comet" list was discovered in 1781 by Pierre Mechain. The 'Owl' got its name based on a sketch made in 1848 by the 3rd Earl of Rosse, William Parsons, using his 72" reflector.
It is about 2000 light years distant, and about 8000 years old. M97 is located near the bright dipper bowel star - Merak (Beta Ursa Majoris), would normally make this planetary easy to find, but the nebula is fairly faint and requires a medium sized telescope to see visually.



8" 4.5 Dob Reflector 16mm (57x)



6" RC f5, StellaCam-3 @ 90 seconds

William Herschel:

In William Herschel's deep-sky catalog, one of the major classification categories (Class-IV) is called "Planetary Nebula". There are a total of 77 objects listed, but interestingly, only 20 of these objects are true planetary nebula. Herschel was known for dropping objects that he wasn't quite sure on how to classify into this category. The majority are actually small galaxies (39), a dozen emission/reflection nebula, four star clusters, and several other objects that were not resolvable with Herschel's telescope.

So, who was William Herschel?

After the Messier List, the Herschel's are the next most observed deep-sky objects. Most amateur astronomers know them by their NGC, but they started out as a list created by British astronomer William Herschel and his sister Caroline. For his discovery of the planet Uranus, King George III of England in 1782, knighted Herschel as the "Kings Personal Astronomer" and gave William an annual pension. This allowed William to retire from his profession as a music teacher and devote himself fulltime to astronomy. Using his new wealth, Herschel relocated to a small village in the countryside within a mile of Windsor Castle and built a new permanently installed giant telescope, the "20-foot Reflector". (which had an 18.5" speculum-metal mirror). As the telescope stayed outdoors, unprotected from the elements, Herschel made two mirrors to use with it. When the first metal mirror would tarnish to the point of being unusable, Herschel would swap it out with the second mirror that was kept dry indoors, and then during the day, they would work on polishing the first mirror, readying it to be swapped back when the second mirror tarnished.

From 1782 to 1790, using the "20-foot Reflector", the Herschel's conducted systematic surveys of the night sky, in search of "deep sky" objects, and discovered over 2400. In 1834, John Herschel, (Williams son) , restored the 20-foot telescope and took it to Cape Town South Africa where he added another 1700+ entries to the list. Eventually, all of the Herschel objects, along with discoveries from other astronomers were combined and published in 1888 as the New General Catalogue (abbreviated NGC). In addition to his deep-sky surveys, William Herschel also discovered two of Uranus's moons - Titania and Oberon, along with Saturn's moons Mimas and Enceladus. He also discovered over 800 double & multiple stars. Caroline discovered 8 comets and was honored by the Royal Astronomical Society.

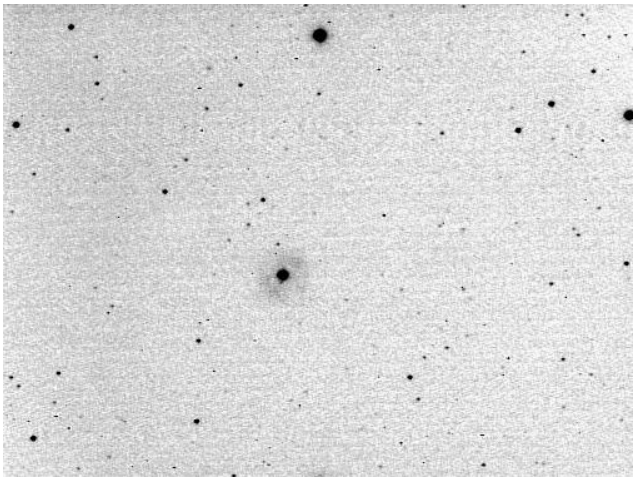
Herschel classified his deep-sky list into eight sub-categories or classes:
Class I - Bright Nebulae,
Class II - Faint Nebulae,
Class III - Very Faint Nebulae,
Class IV - Planetary Nebulae,
Class V - Very Large Nebulae,
Class VI - Very Compressed and Rich Clusters of Stars,
Class VII - Compressed Clusters of Small and Large Stars,
Class VIII - Coarsely Scattered Clusters of Stars.

William Herschel was one of the most notable observers in the history of astronomy, and is often referred to as the 'father of observational astronomy'. And as most stargazers do today, all of his observations were made outside in the open, exposed to the elements, and not from inside an observatory building.

If you would like to learn more about William Herschel and his sister Caroline, you can read about him on my website on my PDF download page at: http://stellar-journeys.org/Herschels and their Catalog.pdf

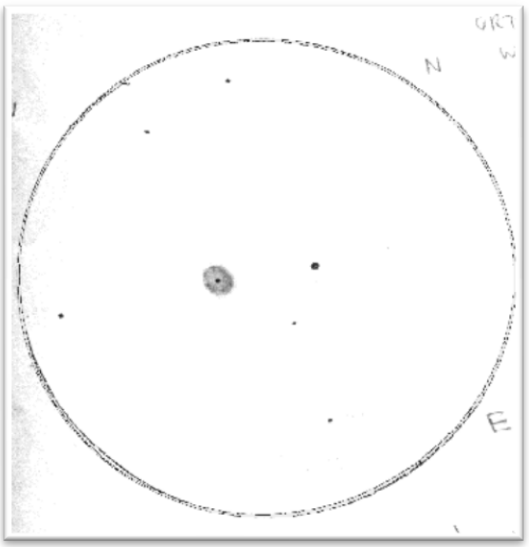
Herschel Planetary Nebula Examples:

NGC1514 "Crystal Ball Nebula" **-** Located in the winter constellation of Taurus, discovered by William Herschel in 1790. This was William Herschel's first observation of a planetary gaseous shell with an obvious central star that convinced him that "true nebulosity" existed. A fairly easy 9th magnitude planetary to observe, it has a bright central star surrounded by a mottled haze. It is about 1960 light years distant.



(8" SCT f6.3, StellaCam-3 @ 60 seconds)

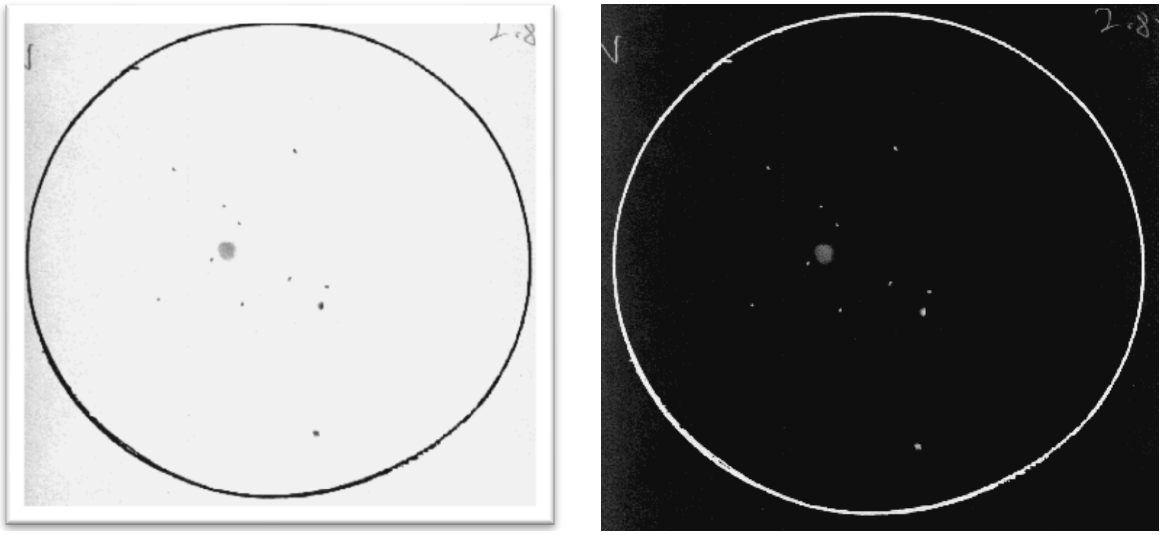
NGC2392 Located in the winter constellation of Gemini the Twins, the "Eskimo Nebula" was discovered by Herschel in 1787. It is about 2930 light years distant. NGC2362 is a bright planetary nebula, in which even small to medium size telescopes will show the 10.5th magnitude central star and multiple shells of dark and light mottled zones.



13" f4.5 Dob Reflector 28mm & 2.8x barlow (102x)

8" SCT f6.3, StellaCam-3 @ 45 seconds

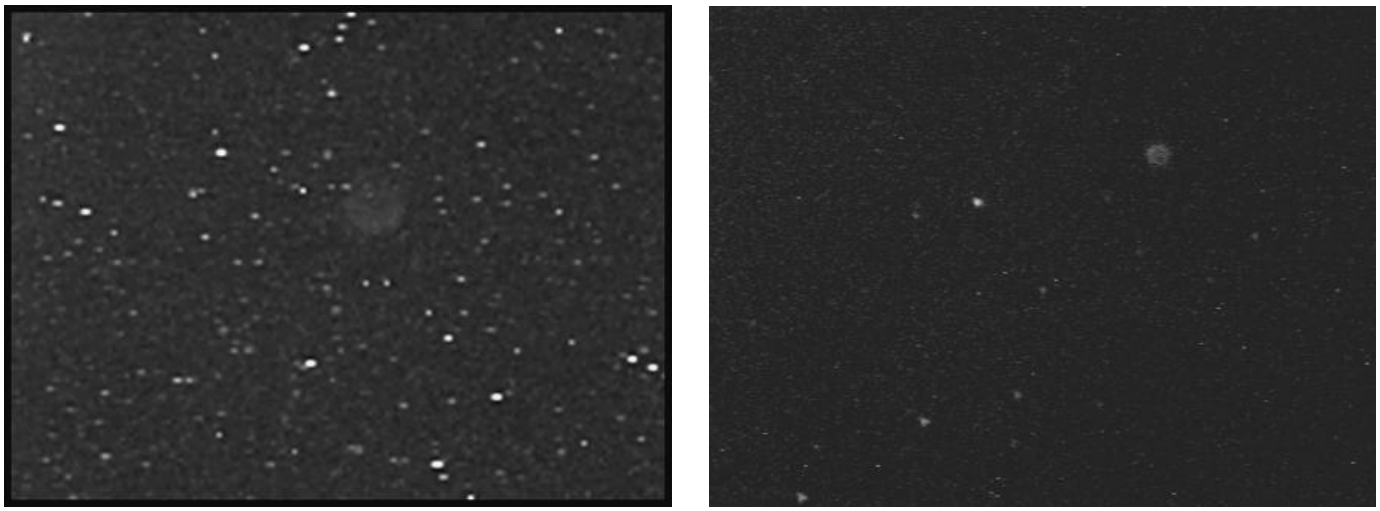
NGC6445 Located in the summer constellation of Sagittarius, discovered by Herschel in 1786. Nicknamed the "Little Gem" or "Box Nebula", NGC6445 is about 3200 light years distant and a diameter of almost 4 light years across. Visually, it's a small faint nebula with a rectangular disk, best suited for medium to large aperture telescopes, and a very, very faint 19th mag+ central star visible only in the large >24" telescopes.



8" f4.5 Dob Reflector 16mm & 2.8x barlow (160x)

NGC6781 Located in the summer constellation of Aquila. Discovered in 1788 by John Herschel. The 10th magnitude planetary has a large somewhat faint featureless disk. NGC6781 is about 3100 light years distant with a 16th Mag+ central star.

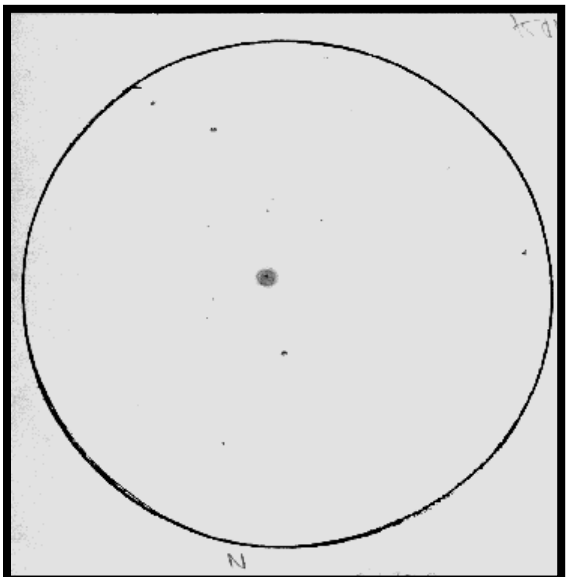
NGC6369 "Little Ghost Nebula" Located in the summer constellation of Ophiuchus, discovered in 1784 by Herschel. The planetary is ring shaped with a dark center where a 15.5th Mag+ central star is visible. In larger telescopes, the ring has an uneven bluish tint. NGC6369 is about 3900 light years distant and a diameter of about 1/3 of a light year across.



NGC6781 - 8" SCT f6.3, StellaCam-II @ 8 seconds

NGC6369 - 6" RC f9 StellaCam-3 @ 15 seconds

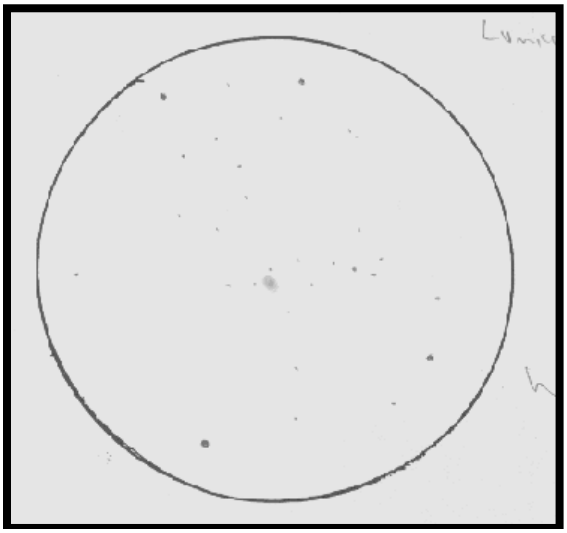
NGC6826 Located in the summer constellation of Cygnus, the "Blinking Planetary" was discovered by Herschel in 1793. The 10th mag+ planetary is located about 3200 light-years with a bright central star of 8.9th mag+, making it an easy target for small telescopes. Visually, when observing the bright central star directly, the nebula tend to vanish, but using averted vision causes the nebula to blink into view.



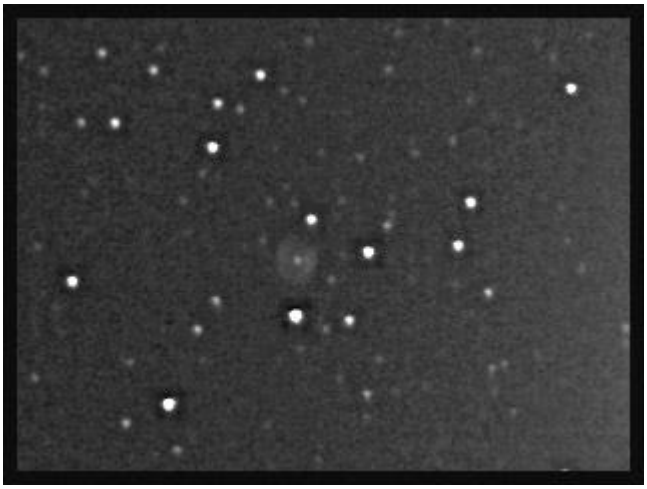
13" f4.5 Dob Reflector 8mm (143x)

8" SCT f6.3, StellaCam-3 @ 8 seconds

NGC6905 Located in the summer constellation of Delphinus, was discovered by Herschel in 1784. The "Blue Flash Nebula" is an oval shaped 11th mag+ planetary, with a 13.5 mag+ central star at a distance of about 4200 light-years. Visually, the planetary is fairly bright in small to medium telescopes, and shows bluish color in larger telescopes.

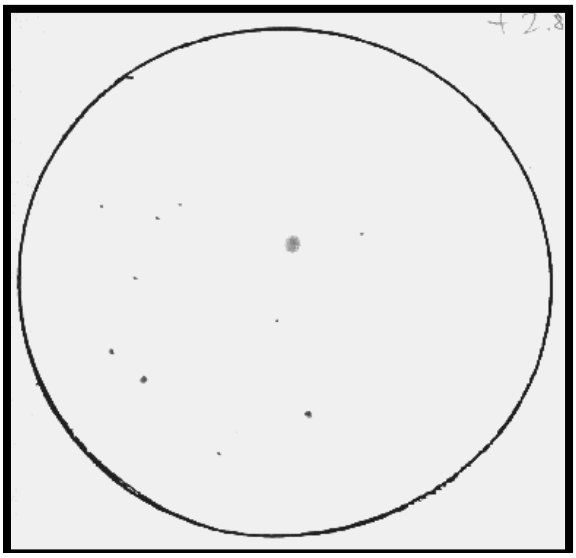


8" SCT f10, 24mm (85x)

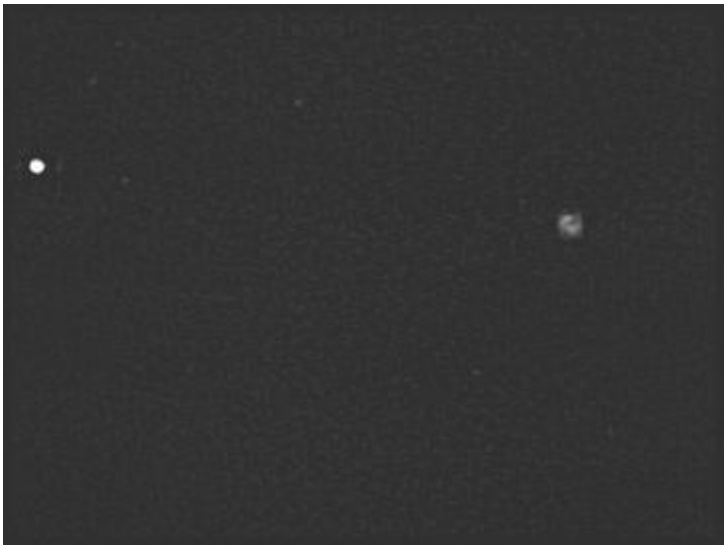


8" SCT f6.3, StellaCam-EX @ 2.5 seconds

NGC7662 Located in the fall constellation of Andromeda, was discovered by Herschel in 1784. Visually, the 8th mag+ "Blue Snowball Nebula" planetary is quite bright in small telescopes and shows a bluish-white color oval. Larger telescopes will show a ring-shape with a mottled interior. NGC7662 is about 3900 light-years distant.



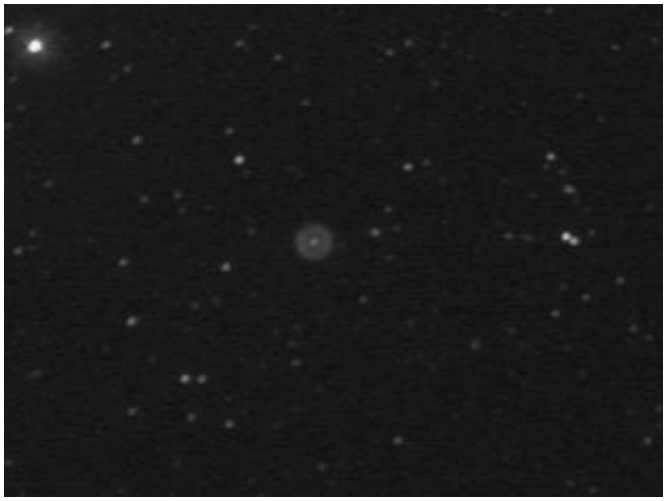
8" f4.5 Dob Reflector 24mm & 2.8x barlow (106x)



8" SCT f6.3, StellaCam-II @ 8 seconds

NGC1501 Located in the fall constellation of Camelopardalis, the Giraffe, the "Oyster Nebula" was discovered by Herschel in 1787. It is about 3600 light years distant. NGC1501 is another bright ring-shaped planetary nebula, in which medium size telescopes will show the 14th magnitude central star and a mottled shell with a central dark zone.

NGC7009 Located in the fall constellation of Aquarius, the Water bearer, the "Saturn Nebula" was discovered by Herschel in 1782. It is about 3900 light years distant and about a ½ light-year in diameter. NGC7009 is bright oval-shaped 8th magnitude planetary nebula, in which medium to large size telescopes will show the two 'ansae' or handles coming off of either side which makes the object resemble the planet Saturn with its rings turned edge-on.

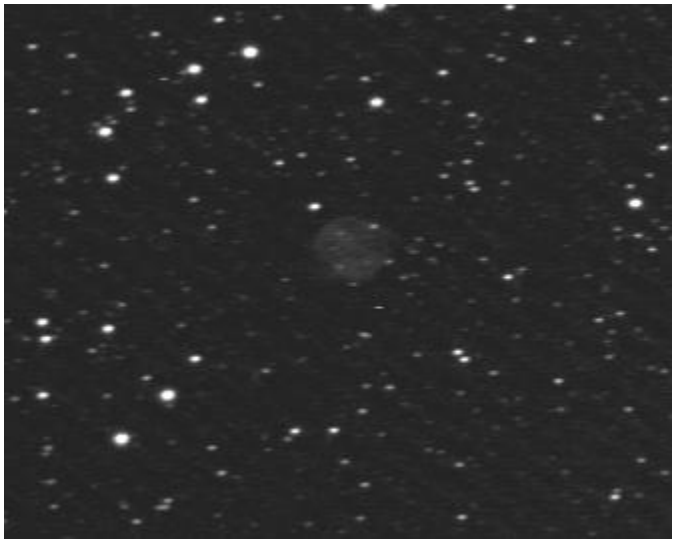


6" RC f5 StellaCam-3 @ 30 seconds

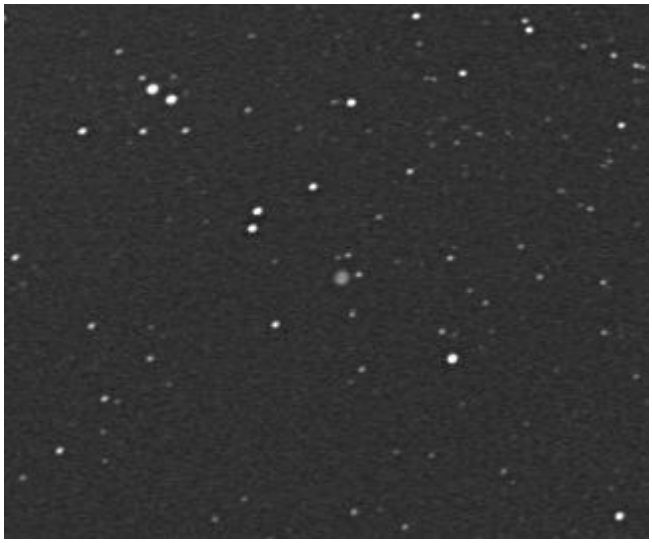
8" SCT f6.3, StellaCam-3 @ 20 seconds

NGC7139 Located in the fall constellation of Cepheus. Discovered in 1787 by Herschel. The 13th magnitude planetary has a large faint featureless disk visible in medium size telescopes from a dark sky location, with several faint embedded stars. NGC7139 is about 4300 light years distant with a 18.7th Mag+ central star.

NGC7354 Located in the fall constellation of Cepheus. Discovered in 1787 by Herschel. This 13th magnitude planetary has a small circular disk visible in larger size telescopes. NGC7354 is about 4200 light years distant.



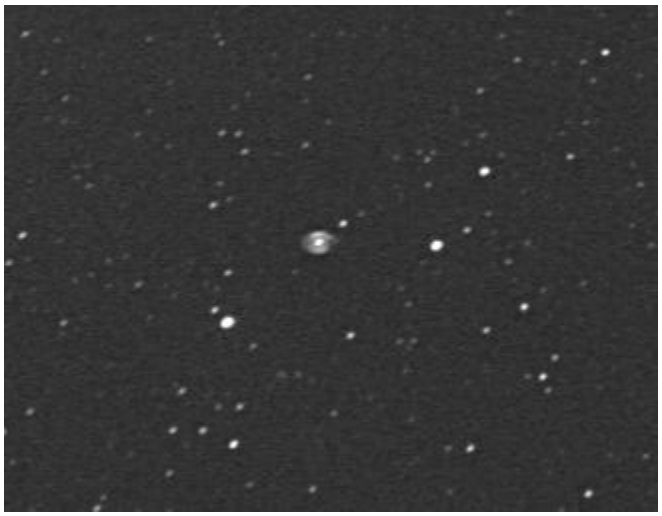
8" SCT f5, StellaCam-3 @ 45 seconds



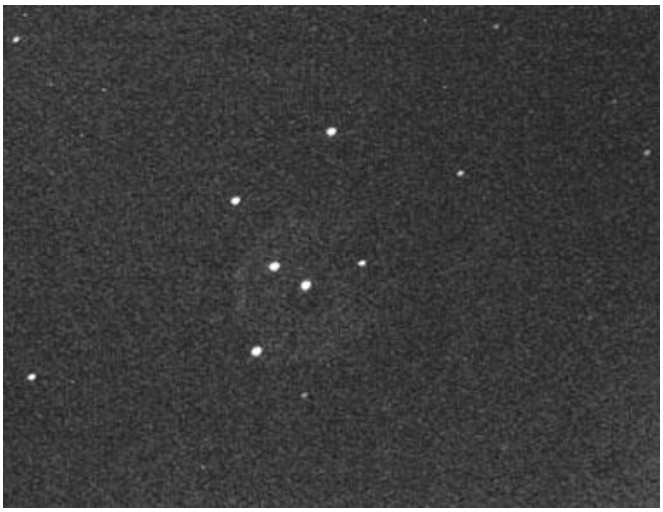
6" RC f5 StellaCam-3 @ 20 seconds

NGC40 Located in the fall constellation of Cepheus, the King, the "Bow-Tie Nebula" was discovered by Herschel in 1788. It is about 3500 light years distant and about 1 light-year in diameter. NGC40 is bright blue-green oval-shaped 10.7th mag+ planetary nebula, in which small to medium telescopes will show the 11th central star, and bright structural arcs.

NGC246 Located in the fall constellation of Cetus, the "Skull or Pac-Man Nebula" was discovered by Herschel in 1785. It is about 1600 light years distant. NGC246 is a large dim mottled planetary nebula, and even though it's listed as 11th Mag+ requires a large telescope and dark skies to observe. The 12th magnitude central star is a binary system.



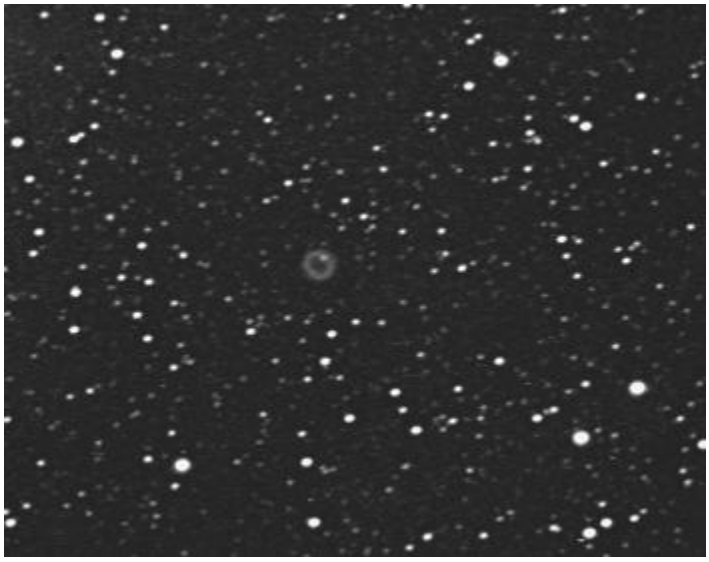
6" RC f5 StellaCam-3 @ 15 seconds



8" SCT f6.3, StellaCam-3 @ 30 seconds

NGC6894 Located in the summer constellation of Cygnus, was discovered by Herschel in 1784.
The 12th mag+ dim ring shaped planetary is located about 5000 light-years with a dim central star of 17.6th mag+.
Best visible in medium to large telescopes from a dark location.

NGC7008 Located in the summer constellation of Cygnus, the "Fetus Nebula" was discovered by Herschel in 1787.
The 10th mag+ fairly bright broken annual shaped planetary is located about 2800 light-years, with a diameter of about 1 light-year with a central star of 13.2th mag+. Visible in medium to large telescopes from a dark location.

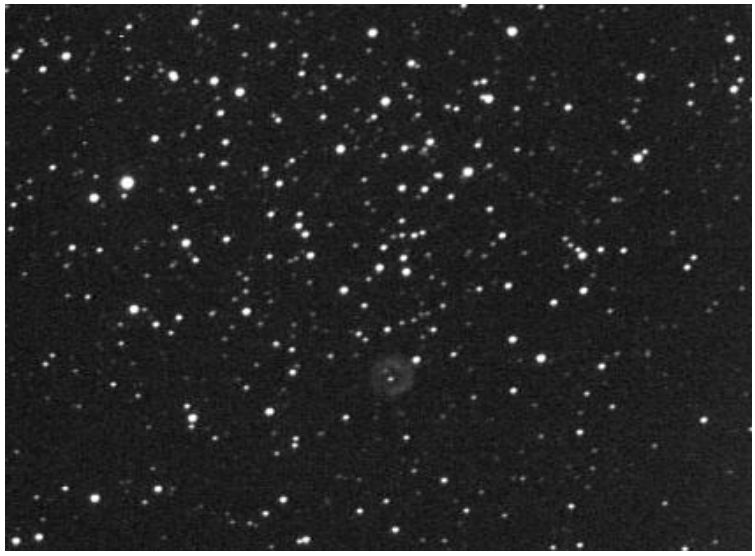


8" SCT f6.3, StellaCam-3 @ 30 seconds

6" RC f5 StellaCam-3 @ 30 seconds

NGC2438 Located in the winter constellation of Puppis, was discovered by Herschel in 1786. Appears as a foreground object in fromt of the open cluster M46. The 11th mag+ ring shaped planetary is located about 2900 light-years, with a diameter of about 1 light-year with a central star of 17.5th mag+. Visible in medium telescopes from suburban.

8" f4.5 Dob Reflector 16mm 57x



8" SCT f6.3, StellaCam-3 @ 20 seconds

Rudolph Minkowski:

German-American astrophysicist Rudolph Leo Minkowski was born on May 28, 1885 in Strasburg, Germany (which is now part of France), to Marie Siegel and Oskar Minkowski. In 1913, Minkowski enrolled at the University of Breslau to study physics, but was drafted into the German Army in 1914 and served thru WWI till it ended in 1918. Afterwards he returned to the university, where he earned his PhD in 1921. In 1922, he went to work for the University of Hamburg, first as an atomic physicist, then later as an observational astronomer. In 1935, Minkowski accepted a research assistant position at Mt Wilson Observatory and immigrated to the US to escape German persecution.

Minkowski is best known for his Mt Wilson research work on supernova remnants with astrophysicist Walter Baade, in which the two of them devised the spectral grouping of 'Type-I' and 'Type-II' still used today to classify these violent explosions, and as a tool in determining cosmological distances to galaxies. In 1942, Minkowski identified the central star of M1, the 'Crab Nebula' by its unusual optical spectra.
But in the late 1940's he published three versions of a paper titled – "New Emission Nebulae" where Minkowski listed over 200 planetary nebula that he had studied for their spectra, galactic distribution, and motion. In his papers, Minkowski didn't formally label his entries, but later when they were collected into a catalog, they were given designations based on which paper they were first referenced in. An example of a Minkowski catalog object designation is: "M 2-9" (Butterfly Nebula) in the constellation Ophiuchus. (the 9th object from the second paper).

In the mid-1950's Rudolph was chosen to lead the newly commissioned 'National Geographic Society – Palomar Observatory Sky Survey', to be created using the Palomar Observatory's 48-inch Schmidt telescope. The survey was to photograph the entire northern sky down to a magnitude of +22 from Palomar. The POSS is still in use today!

Minkowski was also known for designing Schmidt spectrographic cameras used on the larger telescopes, and again with Walter Baade, identified the optical counterparts to some of the early radio sources being discovered at the time, including 'Cygnus A' in 1954.

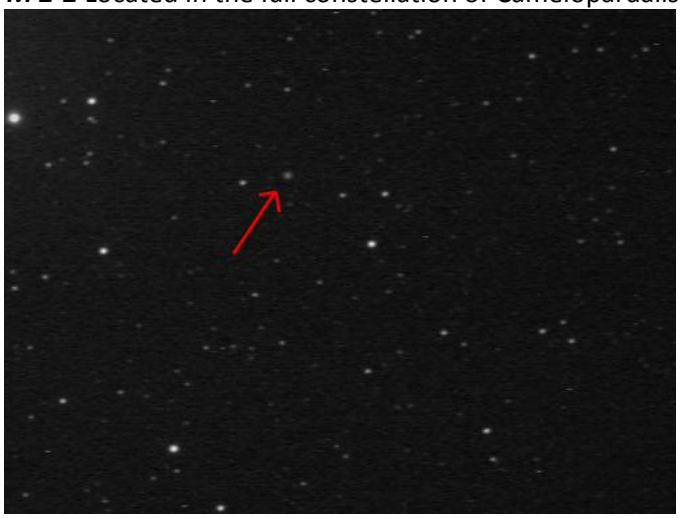
Minkowski retired from his position at Mt Wilson in 1960, but remained active in the research community at the University Of California at Berkeley. A popular story at Berkeley goes that on the night of the very last observing session that Minkowski had on the 200" Hale Reflector at Palomar, before he retired the next day, he captured the spectrum of 3C-295 and determined that it was the highest redshift ever observed, at z=0.46, making it the farthest known object in the universe! (about 5 billion light-years). The astronomers on duty during the observation declared that the rest of the night was officially 'overcast', and celebrated Minkowski's discovery in the observatory's library with a bottle of whiskey.

At the age of 81, on January 4th, 1976, Rudolph Minkowski passed away at his home. In addition to his research legacy in supernovas, planetary nebulae, and colliding galaxies, Minkowski discovered a comet – '1950 B Minkoswki', also is credited with co-discover of NEO asteroid 1620 – 'Geographos', has a lunar created named after him along with a small planetary nebula, and was the 1961 recipient of the Astronomical Society of the Pacific's 'Bruce Medal' for research.

Minkowski Planetary Nebula Examples:

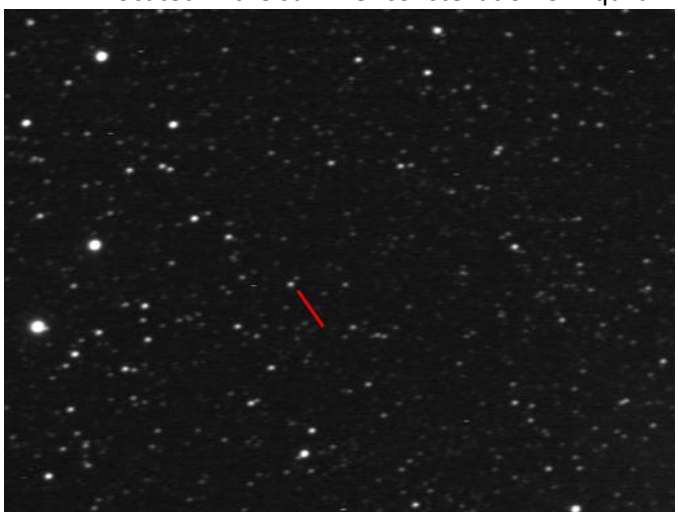
Most of Minkowski's planetary nebula are very small, star-like, (less than 10" in diameter), and very faint, (>13^{+} Mag) and are difficult visual observations. The best way to visually confirm that you have found one is to use your UHC or OIII filter and rapidly pass it back and forth between the eyepiece and you eye, causing the planetary to 'blink' in brightness from the other stars in the field of view. You can do this either by hand-holding the filter or using it in a filter slider or wheel with an open slot to one side of the filter. Imagers will need to have a very accurate polar alignment and calibrated GOTO to ensure that the planetary is centered and then afterwards will need to compare their image to a star chart or another image where the planetary is highlighted. While most of the Minkowski's are star-like, there are a few that do show very small disks or hints of shells in medium to large telescopes under dark skies.
These are: M 1-9 (Minkowski's Footprint) and M 1-79 in Cygnus, M 1-36 (IC4673) in Sagittarius, M 2-51 in Cepheus, M 1-64 and M 1-68 (NGC6765) in Lyra, and M 2-9 (Butterfly Nebula – NGC6302) in Ophiuchus.

M 2-2 Located in the fall constellation of Camelopardalis



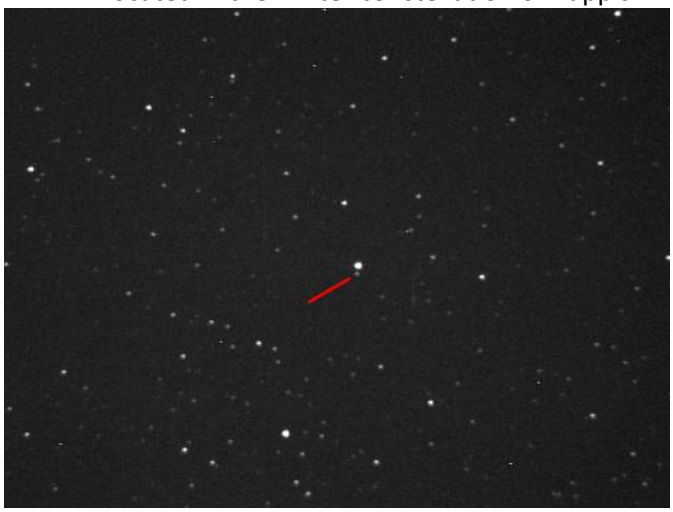
8" SCT f6.3, StellaCam-3 @ 30 seconds

M 1-74 Located in the summer constellation of Aquila



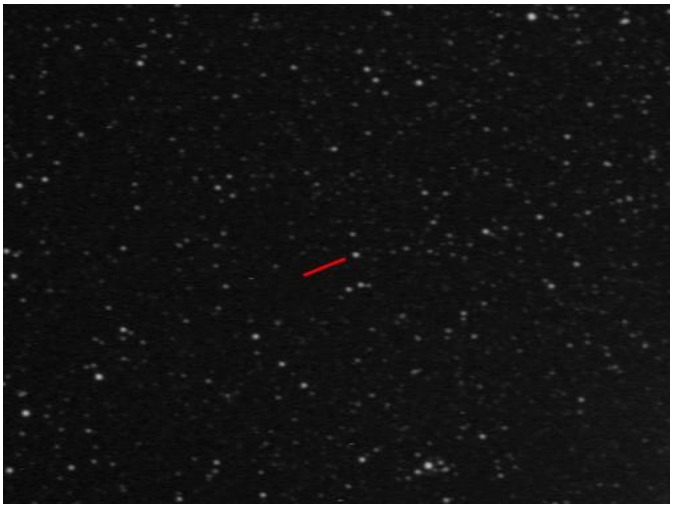
8" SCT f6.3, StellaCam-3 @ 20 seconds

M 1-17 Located in the winter constellation of Puppis



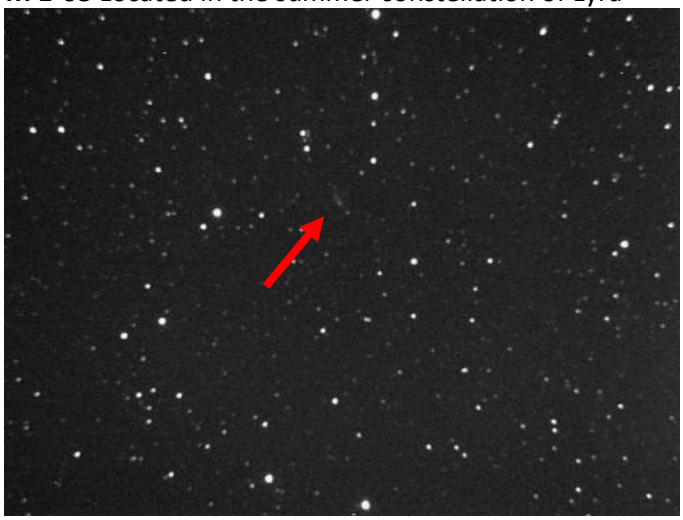
8" SCT f5, StellaCam-3 @ 20 seconds

M 1-59 Located in the summer constellation of Scutum



8" SCT f6.3, StellaCam-3 @ 20 seconds

M 1-68 Located in the summer constellation of Lyra

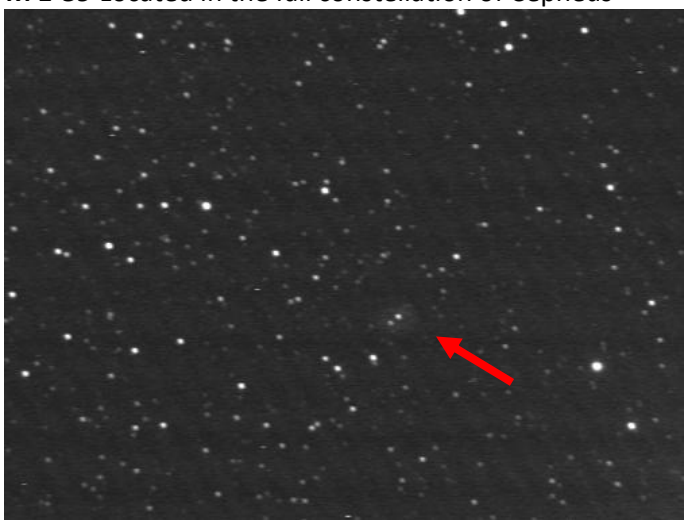


8" SCT f5, StellaCam-3 25 seconds (NGC6765)

M 1-64 Located in the summer constellation of Lyra

8" SCT f5, StellaCam-3 25 seconds

M 1-59 Located in the fall constellation of Cepheus



8" SCT f5, StellaCam-3 @ 25 seconds

M 2-55 Located in the fall constellation of Cepheus

8" SCT f6.3, StellaCam-3 @ 35 seconds

George Abell:

American astrophysicist George Ogden Abell was born on March 27th, 1927 in LA California to Annamarie and Theodore Abell. As a young boy growing up, George's mother, who was a librarian encouraged him in reading, while his father would take him to various Los Angeles museums, including the Griffith Observatory and Planetarium. This led to George developing an interest in science and astronomy, which he excelled at in school. After graduating from high school in 1945, Abell enlisted in the US Army Air Corps, hoping to become a pilot, but with the war winding down, he was instead sent to weather school, and was stationed over in Japan as an Air Corps weatherman. Upon discharge from the service, George enrolled at Caltech where he studied physics and astronomy. During his college years, George was active on the bowling team, drama club, and an editor for the college newspaper. Also during this time, Abell's first semi-professional astronomy related job was as a 'tour guide' at Griffith observatory, and then later as a 'lecturer'. Abell graduated in 1951 from the California Institute of Technology with a B.S. in astronomy, continued on for his masters in 1952, and then his doctorate in 1957.

Abell's first true professional job was as a Caltech astronomer was working on the National Geographic Society – Palomar Observatory Sky Survey, created using the Palomar 48-inch Schmidt telescope. Abell was one of the first to have access to the plates soon after they were taken. George's primary research was reviewing the POSS survey photographic plates looking for the formation of galaxy clusters. From this research, Abell created a catalog of 2,712 galaxy clusters that has since become a valuable tool in cosmological luminosity studies.

But while searching thru the plates for faint galaxies, he ran across a number of unreported planetary nebula. From the new data contained on the plates, Abell compiled a list of 73 very old and faint planetary nebula, which he first published in 1955. Over the next decade, Abell expanded his list with a number of additional finds and in 1966 published his final revised catalog of 86 old and faint planetary nebula in paper titled: "Properties of Some Old Planetary Nebula". Abell, with several other astronomers, also cataloged a number of faint low-surface brightness globular star clusters from the POSS plates, which became known as the Palomar catalog.

After the POSS survey ended, Abell became a professor of astronomy at UCLA, where he spent the next 17 years, during which he became chairman of the UCLA Astronomy Department. Abell was known for his popular classroom style where he believed it was more important to teach the "how and why" of science, rather than just the facts.

Abell carried this philosophy over into his working with the local LA school district's high school summer science program where he taught college level physics, astronomy, and math.

In addition to teaching at UCLA, Abell would also travel to small colleges and give public lectures on astronomy and science, calling out the difference between what is true science versus the popular pseudo-science of the day, such as the belief in the Bermuda Triangle, or ancient astronauts. He wrote a widely used college text book on astronomy titled: "*Exploration of the Universe*", and participated both in-front, and behind the camera for a number of public educational TV programs: "*Understanding Space and Time*", and "*Project Universe*".
Abell was also a founding member of the 'Committee on Scientific Investigation of Claims of the Paranormal' now known as the 'Committee for Skeptical Inquiry'.

At the age of 56, on October 7th, 1983, while at home, George O Abell died from a heart attack. He is survived by his current wife and two sons from a previous marriage. A number of astronomical 'objects' are named in Abell's honor, which includes a 17th magnitude periodic comet 52P/Harrington–Abell, with a 7 year period that he co-discovered in 1955, an asteroid (3449), and an observatory over in England.

For additional interesting information on the life of American astrophysicist George O Abell, visit the American Institute of Physics (AIP) Oral History project at:
https://www.aip.org/history-programs/niels-bohr-library/oral-histories/4475
https://www.aip.org/history-programs/niels-bohr-library/oral-histories/5193

Abell Planetary Nebula Examples:

Abell's catalog is recognized today as an excellent compilation of faint, challenging planetaries for the visual observer with access to larger telescopes and dark skies. These are also challenging to imagers using either video-astronomy or more traditional astrophotography cameras due to their large size and faintness. Over half of the Abell planetary nebula has central stars of 17+ magnitude or fainter!!

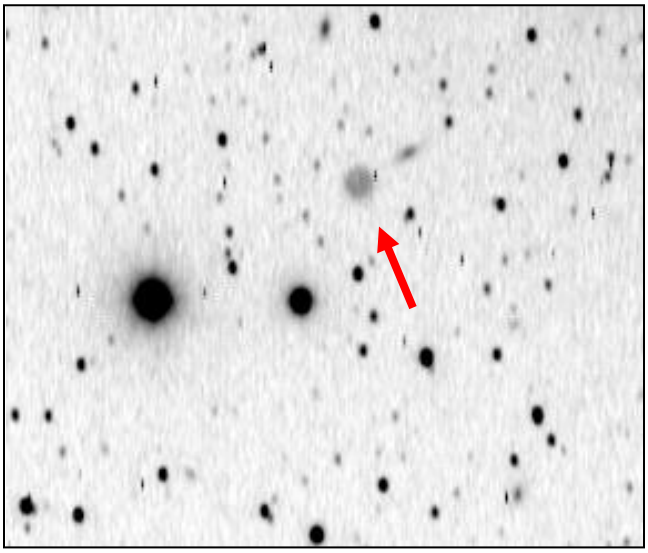
It should be noted that since being published in 1966, four of the members of Abell's catalog have since been determined to be either a faint galaxy, reflection nebula, or a non-existent photographic plate fault, bringing the corrected number of Abell planetary nebula to 82. These rejects are Abell11, 17, 32, & 76.

For the most part, due to being very old, highly evolved, large, and having a very low surface brightness, Abell's can be difficult to observe. O-III filters can be a big help, allowing the nebula to 'pop' from the dimmed field.
(Though due to the faintness of these objects, sometimes using a filter can actually make the nebula harder to see if you don't have sufficient aperture).

Interestingly, back in the early 1980's, before the Dobsonian telescope revolution took hold, which brought about large aperture reflectors becoming available to amateur astronomers, George Abell was once asked by an amateur astronomer about observing his planetaries. Being more of a theorist than an observational astronomer, Abell replied that he doubted that any would ever be visually observable, and that maybe it might be possible to photograph some. Today we know that numerous amateur astronomers, armed with either large reflectors of 20" or greater, or using state-of-the-art imaging telescopes and cameras are routinely observing and imaging his planetary nebula.

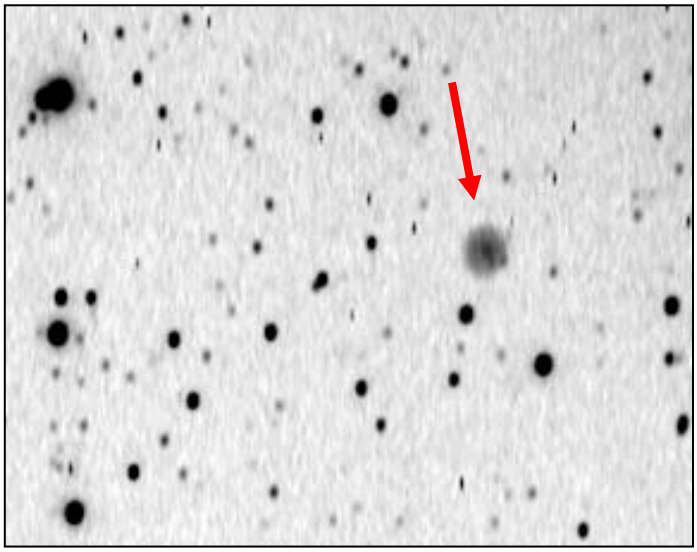
Generally it's best to save hunting for Abell Planetaries for trips to dark sky locations, and on nights of excellent transparency. Visual observers must be completely dark adapted and avoid all lights during observing.
Only use the dimmest of red lights for checking finder charts. While some Abell's can be observed using smaller telescopes in the 8 – 12" range, most of these objects will require large telescopes in the 16" or greater size. For imagers, most of the Abell's can be captured using an 8" SCT in under 5 minutes, though there are some that will require larger optics or deep exposures.

Abell 4 Located in the fall constellation of Perseus



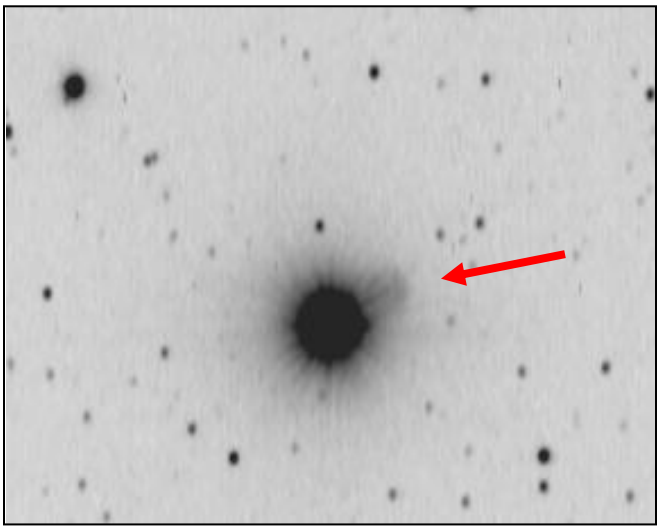
8" SCT f5, StellaCam-3 @ 3 minutes (no filter)

Abell 10 Located in the winter constellation of Orion



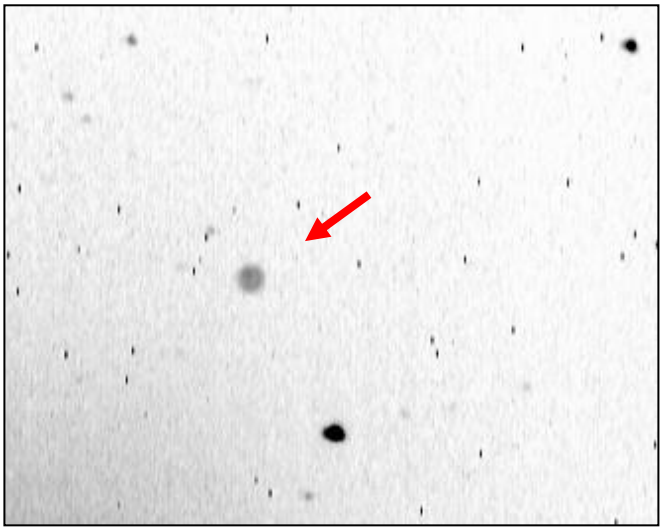
8" SCT f6.3, StellaCam-3 @ 3 minutes (no filter)

Abell 12 Located in the winter constellation of Orion



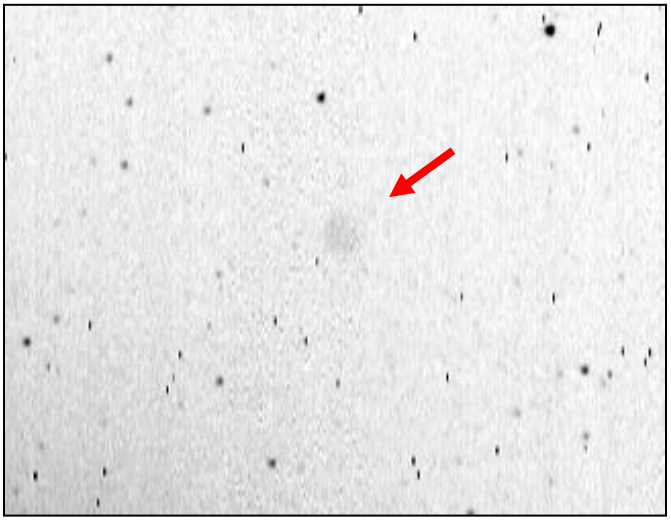
8" SCT f5, StellaCam-3 @ 3 minutes (no filter)

Abell 50 (NGC6742) Located in Fall constellation of Draco



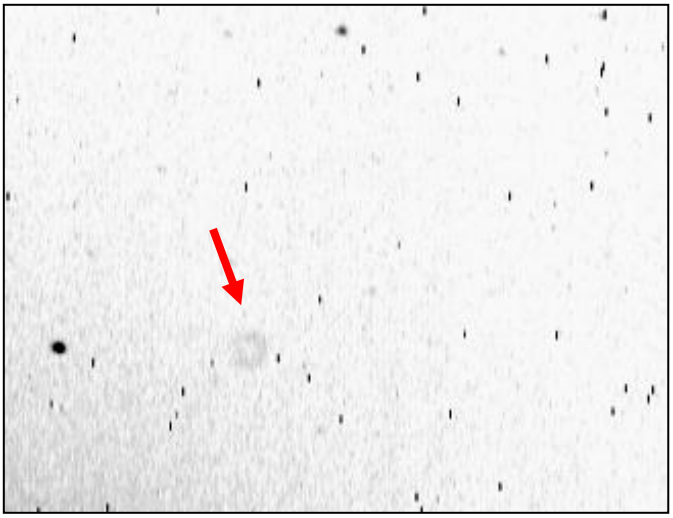
8" SCT f6.3, StellaCam-3 @ 3 minutes (OIII filter)

Abell 55 Located in summer constellation of Aquila



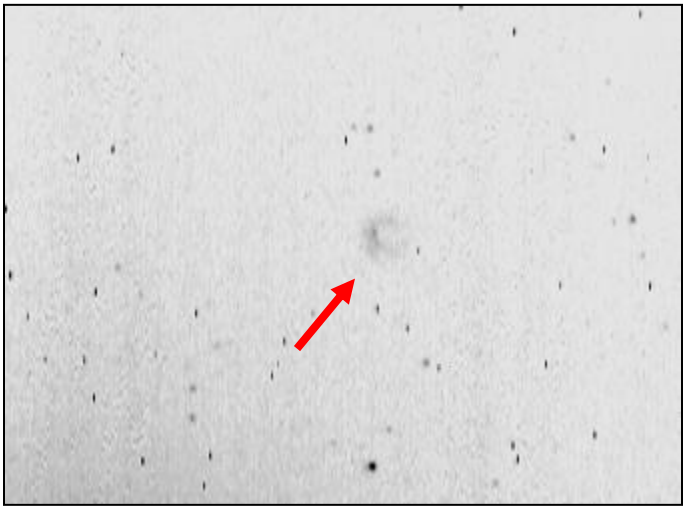
8" SCT f5, StellaCam-3 @ 3 minutes (OIII filter)

Abell 70 Located in the summer constellation of Aquila



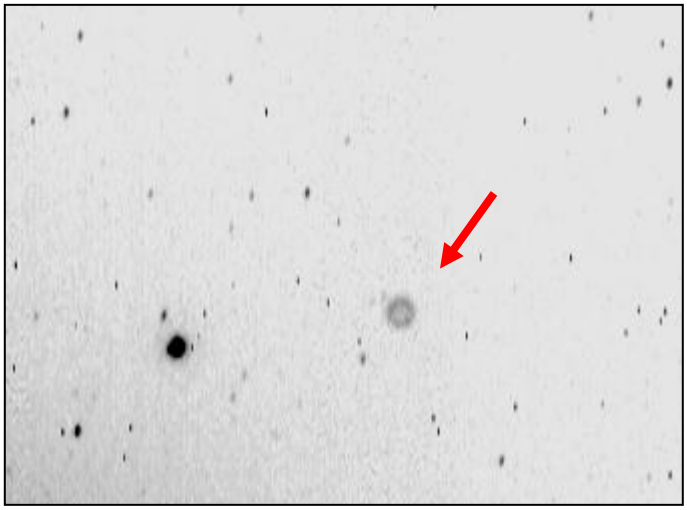
8" SCT f6.3, StellaCam-3 @ 4 minutes (OIII filter)

Abell 75 (NGC7076) Located in Cepheus



8" SCT f5, StellaCam-3 @ 3 minutes (OIII filter)

Abell 81 Located in the fall constellation of Cepheus



8" SCT f6.3, StellaCam-3 @ 3 minutes (OIII filter)

Conclusion:

So today I introduced you to a class of colorful luminescent wispy shells of deep sky objects, and some of their catalogs. We learned a little about the historical and modern individuals behind each catalog, and looked at sketches and video-capture image examples of various members of each catalog. Hopefully this little presentation has inspired you to search-out and explore these very rewarding celestial objects.

So I encourage everyone to get out tonight and try your hand at finding and observing the ghostly disks of these elusive deep-sky objects, the planetary nebula of Charles Messier, William Herschel, Rudolph Minkowski, and George Abell. Thank you.

Larry McHenry http://stellar-journeys.org/

Credits:

Professional Images:

M27 - Fred Calvert/Adam Block/NOAO/AURA/NSF
M57 - Adam Block/NOAO/AURA/
M1 - Adam Block/NOAO/AURA/
NGC2392 - Peter and Suzie Erickson/Adam Block/NOAO/AURA/NSF
NGC7009 - Brad Ehrhorn/Adam Block/NOAO/AURA/NSF
Abell43 - Ed Walendowski/Adam Block/NOAO/AURA/NSF
Abell39 - WIYN/NOAO/NSF
M97 - NOAO/AURA/NSF
M76 - N.A.Sharp, NOAO/AURA/NSF
NGC6369 - Gemini Observatory/Abu Team/NOAO/AURA/NSF
NGC40 - WIYN/NOAO/NSF
Helix - NASA, NOAO, ESA, the Hubble Helix Nebula Team, M. Meixner (STScI), and T.A. Rector (NRAO)
PuWe1 - T.A. Rector (University of Alaska Anchorage) and H. Schweiker (WIYN and NOAO/AURA/NSF)
SoapBubble - T. A. Rector/University of Alaska Anchorage, H. Schweiker/WIYN and NOAO/AURA/NSF
Jones1 - T.A. Rector/University of Alaska Anchorage, H. Schweiker/WIYN and NOAO/AURA/NSF
BD+303639 – Gemini Observatory, NSF, University of Hawaii
NGC6565 - NASA/Hubble/ESA/M. Novack
NGC6302 - NASA/Hubble/ESA
NGC6543 - NASA/Hubble/ESA
NGC6751 - NASA/Hubble/ESA

Amateur Images: Video capture Images and Sketches: Larry McHenry - http://stellar-journeys.org/

Books:

"Webb Society Deep-Sky Observers Handbook, V2: Planetary and Gaseous Nebula ", by Kenneth Glyn Jones
"Messier's Nebulae and Star Clusters", by Kenneth Glyn Jones:
"*The Complete Guide to the Herschel Objects*", by Mark Bratton
"The Abell Planetary Observers Guide", Alvin Huey, www.faintfuzzies.com
"*Observing and Cataloguing Nebula and Star Clusters: From Herschel to Dryer's NGC*", by Wolfgang Stenicke
"*The Night Sky Observers Guide*, Vol1 – 3", by George Kepple & Glen Sanner
"*The Night Sky Observers Guide* - Glories of the Milky-Way, Vol4", by George Kepple

Magazines:

"*Cosmic Catalogs you can use*", by Alan Goldstein, Astronomy Magazine – February 2019
"*Observing Stellar Blowouts*", by Stephen James O'Meara, Astronomy Magazine – February 2019
"*I Love Planetaries*", by Sue French, Sky & Telescope Magazine – October 2018
"*The Eagle's Best Nebula*", by James Dire, Reflector Magazine – September 2018
"*Aquila's Gems*", by Ted Forte, Sky & Telescope Magazine – August 2018
"*The Riddle of the Nebulae*", by Howard Banich, Sky & Telescope Magazine –August 2018
"*M27 – The First Planetary Nebula*", by Howard Banich, Sky & Telescope Magazine – July 2018
"*George Abell's Ethereal Bubbles*", by Steve Gottlieb, Sky & Telescope Magazine – July 2017
"*Meet the Minkowskis*", by Ted Forte, Sky & Telescope Magazine –August 2016
"*Observing Bright Planetary Nebulae*", by Alan Goldstein, Astronomy Magazine – September 1991
"*M57, The Ring Nebula*", by Rick Dilsizian, The Observer's Guide Magazine – Vol-9 July-August 1988
"*Summer's Multitude of Planetaries*", by Jack Marling, Deep Sky Magazine – Summer 1986
"*The Central Stars of Planetary Nebula*", by David Kratz Deep Sky Magazine – Summer 1986
"*Observing Planetaries from the City*", by Alister Ling, Deep Sky Magazine – Summer 1986

Misc:

Google & Wikipedia: various entries
SEDS (Students for the Exploration of Space)
"Earth Centered Universe" planetarium software by David Lane http://www.nova-astro.com/
"DeepSky Planner" – Steve Tuma & Dean Williams