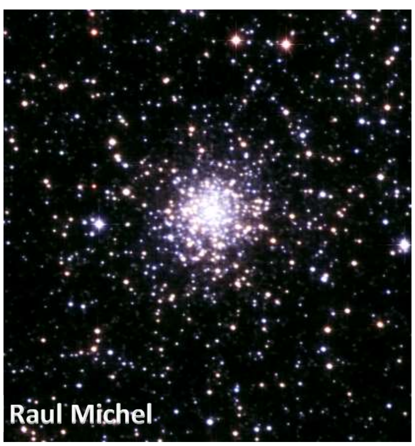
Stellafane Observing Olympics – 2017
"The Hidden Gems of Stellafane"

NGC5248 (UGC8616, Caldwell 45), "Ox-eyed galaxy":

NGC5248 is a "Grand Design" "intermediate" 11.0(B) magnitude spiral galaxy located relatively nearby at 41 million light years away in the constellation of Bootes. A Grand Design galaxy is a spiral galaxy with well-defined spiral arms, extending clearly around the galaxy. An intermediate spiral galaxy is a galaxy that by its appearance is between the classification of a normal spiral galaxy and a barred spiral galaxy. Such galaxies typically have a designation of SAB in the galaxy morphological classification scheme and NGC5248 is classified as an SAB(rs)bc galaxy. In the catalog of "Named Galaxies", NGC5248 is called the "Boöps Boötis", or the "Ox-eyed Galaxy". It is the headliner of the galaxy group known as the "NGC5248 group" which is part of the larger Virgo III galaxy group. Virgo III is a spur of galaxies strung out to the east (our perspective) of the huge Virgo Supercluster. Distance measurements for NGC5248 have ranged from 41.5 million light years to 74.0 million light years, with 58.7 million light years being the average. Visually the galaxy is 6.6' x 5.3' in size and is rotating in a clockwise manner, with the south-western part of NGC5248 being the near side of the galaxy. In galaxies, the large influx of gas and the subsequent star formation keep the central regions constantly changing. However, the ability of gas to reach the nucleus proper to fuel the central region or an active nucleus (AGN) is not guaranteed under all conditions. A bar will drive gas inwards from the two spiral arms along the leading sides of the bar. When gas is kinematically warm and moves at a high speed, the pitch angle of the spiral arms will be large, resulting in a nuclear spiral with arms which extend all the way to the nucleus. When gas is kinematically cold with a low speed, the pitch angle is small, and the spiral arms often end in a circumnuclear ring. These rings act as reservoirs of gas from larger radii, and, as a result, form stars at a high rate, but the ring also becomes an effective barrier to further gas inflow. When spiral arms end at a circumnuclear ring before reaching the nucleus proper, another mechanism may take over to funnel gas further inward. This is a nested stellar bar system, where one stellar bar exists within another. Nested bars are present in approximately 25% to 40% of the population of nearby barred galaxies, and the Milky Way is thought to contain one. These secondary bars are much smaller, with sizes no more than ∼12% of the primary bar. NGC5248 is especially interesting because it contains two circumnuclear star forming rings at 326 (1.5") and 1,200 light years (6.0") out from its nucleus where very little emission is detected. The youngest star clusters are less than 10 million years old and are found in the larger ring in the east and west quadrants, with older star clusters being scattered uniformly throughout the larger ring. Only seven star clusters have been identified in the inner ring, with ages beginning in the 10 to 20 million age range and increasing in age along a clockwise gradient. Spiraling dust lanes are found between 1,200 and 18,000 light years from the core, and a large scale stellar bar with a semi-major axis of 19,000 light years is present. Also found is an embedded bar 4,600 light years in length, dominated by neutral hydrogen (H_I). In NGC5248 both atomic (H I) and molecular (CO) gas has been detected inside of the inner ring structure, so if there are two effective ring structure gas barriers, how did it get there? The embedded bar is credited with transporting gas past the double ring structures. The two circumnuclear star forming rings are detected in Hα emission with the inner ring being narrow and sharply defined. The molecular gas in the inner stellar ring is resolved into a gas ring, however, the outer ring shows no molecular gas, with the spiral arms emanating from here. A void separates the two structures, but there is radial gas motion between the rings. In the inner region of the galaxy all Hα emission arises from these two rings. The ratio [NI]/Hβ is an indicator of the intensity of the excitation of HII regions. The ratio value for the southern half of the inner ring (∼0.1) indicates the site of recent intense star formation, while the outer ring ratio (∼0.03) indicates less intense activity. A total of 507 star cluster candidates have been found in an around the two ring structures with their ages ranging from 6 to 122 million years. When gas is driven onto a circumnuclear ring by a stellar bar, two star formation scenarios are proposed. They are called "**popcorn**" and "**pearls-on-a string**" (van der Laan et al, 2013). The difference between the two lies in the assumed time between gas inflow and the onset of star formation. The "popcorn" scenario holds that the gas density in the ring builds up throughout the ring to some critical density, at which point star formation starts uniformly throughout the ring. The second scenario assumes that star formation will occur predominantly close to the two "inflow" or over-density points of gas onto the ring. The argument is that the gas density will be higher where the gas spiral arms and ring connect than elsewhere in the ring and thus that star formation will mainly occur there. As the new stars are moving slowly out of the over-density regions, a string of aging stellar populations would be formed in the ring. Evidence for the "pearls-on-a-string" scenario in one or both rings is thus an indication for the origin of that ring to be due to gravitational torques from a stellar bar. In NGC5248 it seems the pearls-on-a-string theory works best as both rings show sites of preferred star formation with the youngest stellar populations being found in two locations.

XI Bootes (ξ Boo, ξ Boötis):

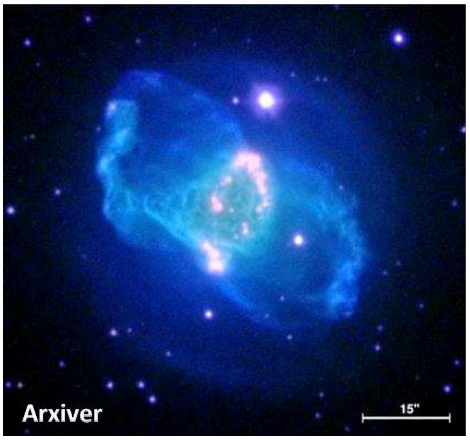
This is a well-studied and attractive binary star which was discovered by William Herschel in 1780. At only 22 light years distance it is one of the nearer double stars and is the nearest visible star in the constellation Bootes. Its orbital period is 151.1 years and its closest approach or periastron last occurred in 1909. The true separation of the two stars is about 33 Astronomical Units (AUs), while from Earth, the apparent separation varies from 1.8" to 7.3". Currently the separation is narrowing with the next periastron occurring in 2061. Visually the two stars show a very nice color contrast, with one appearing yellow and the other a reddish-violet color. The primary star in the system is a BY Draconis variable star with an apparent magnitude which varies only from +4.52 to +4.67 with a period of just over 10 days. It is a spectral type G8 V (main sequence) star with 87% of the mass of the Sun, a temperature of 5,551 K, and a radius of 83% of the Sun. In spite of all of its "sun-like" qualities, it shines at only 60% of the Sun's luminosity. It is a stellar baby at only 200 million years of age and it rotates in only 6.2 Earth days. This results in a Kuiper-like disk of dust material (based on infrared observations), with an estimated minimum mass of 2.4 times the mass of the Earth's Moon. Our Sun's Kuiper belt mass is 8.2 lunar masses by comparison. The companion star is a spectral K4 V star which appears as a reddish-violet color, with a mass 66% that of the sun and luminosity 0.76 of the Sun. Its radius is 0.61% of the Sun, its temperature is 4,350 K and it rotates in only 11.5 Earth days. Both stars are located on the main sequence, so they are still fusing hydrogen into helium. The radial velocities of the two objects is 2.5 and 4.0 miles per second in recession, and there are indications there is a third unseen component in the system which revolves around one of the visible stars in a period of about 2.2 years. It has a computed mass of only 10% that of the Sun.



NGC6284:

NGC 6284 is a globular cluster located in Ophiuchus. It was discovered by the German-born British astronomer William Herschel on 22 May 1784. It has been is designated as classification IX in the Shapley–Sawyer Concentration Class, meaning it is a somewhat loosely concentrated globular cluster, with XII being the most loosely concentrated. The Shapley–Sawyer Concentration Class is a classification system on a scale of one to twelve using Roman numerals for globular clusters according to their concentration. The most highly concentrated clusters such as M75 are classified as Class I, with successively diminishing concentrations ranging to Class XII, such as Palomar 12. (The class is sometimes given with numbers [Class 1–12] rather than with Roman numerals.) NGC6284 is located at a relative distant 49,900 light years away from Earth and 24,400 light years from the center of the Galaxy. Its visual magnitude is 8.9 and its apparent visual diameter is 6.2 arc minutes. The magnitude of the horizontal branch is 16.6, so the stars in this cluster are fairly faint. It is located in a rich starfield along with three other clusters, NGC6273, NGC6287 and NGC6291. Individual star magnitudes within the cluster range from 15 to 17th magnitude. 15 variable stars have been identified, with nine of these being RR Lyrae variables, two are Population II Cepheids, and two are Mira type variables. Four RR Lyrae variables lie within 190" from the center of the cluster. It is always difficult to establish cluster membership for Mira type variables as the absolute blue magnitude for Mira variables is not well known. The two Mira variables considered actual cluster members are located within close proximity of NGC6284. Even though NGC6284 is considered a class IX globular, it has a very dense center, thought to be the product of a "gravothermal catastrophe", more commonly known as a "core collapse." When a fast moving star escapes the gravitational pull of the cluster core, it takes with it some of the kinetic energy, so the core shrinks a little. The remaining stars have to move a bit faster to compensate for the increase in gravitational binding energy of a now denser core. As more and more escape, this eventually leads to a rapidly shrinking cluster core. What stops the collapse from becoming a black hole are binary stars, as they become increasingly more gravitationally bound, providing a huge reservoir of energy. Blue straggler stars are thought to contribute to this contraction reversal, as they are very dense objects that gravitationally sink towards the center of the cluster. The cluster core itself may never settle down completely, but rather collapses and bounces in a cycle called "gravothermal oscillation" which may take tens or hundreds of millions of years to complete. What happens inside a core collapse globular cluster – Stays inside the core collapse globular.

NGC6309, PK 9+14.1, the Box Nebula:

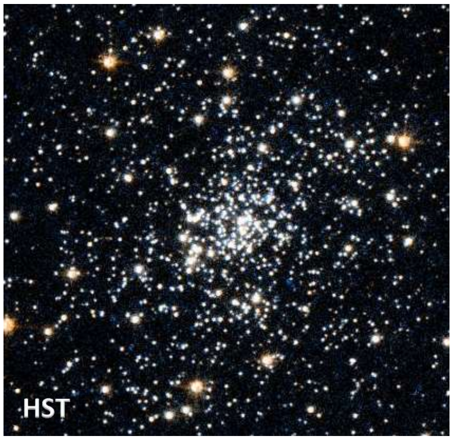


NGC6309 is a quadrupolar planetary nebula located in the constellation of Ophiuchus, and was discovered by the German astronomer Wilhelm Tempel in 1876. Visually it is bright with a photographic magnitude of 10.8 and a size of 16.0 arc seconds. It has been proclaimed a high excitation class 10 nebula with a luminosity 1,800 times that of the Sun. The lobes are excited by the UV flux from the central star. There are two diffuse lobes, one of which is approximately 55" from the central star located in the NE direction. The other lobe is about 78" out in the SW direction. These structures do not share the same symmetry axes as the inner bipolar outflows. Present also is a spherical halo 60" in diameter which encircles the entire nebula. The expansion velocity of this shell is low, ≤ 3.7 miles/sec, which sets a lower age limit of 46,000 years for the nebula. The expansion of the lobes when compared to the overall expansion suggests they are part of a larger structure corresponding to a mass ejection that took place ~ 150,000 years ago. In NGC 6309, we have direct evidence of a change in the geometry of mass-loss, from a spherical structure in the halo to axially symmetric in the two pairs of bipolar lobes. The radio continuum emission indicates a mean electron density of ≃1900 cm^{-3}. Long slit high-dispersion spectra reveal complex kinematics in the central region, with internal expansion velocities ranging from ≃12 to 20 miles/sec. In addition, the spectral line profiles from the external regions of NGC6309 indicate expanding lobes (≃25 miles/sec) typical of what are generally found in bipolar nebulae. There is also a central distorted ring or torus that is expanding at 16 miles/sec. Assuming the ring is a circle and the diameter is ∼20" then the inclination angle of the axis with respect to the line of sight is 72°. Two sets of lobes are present. One is oriented at ∼20" to the line of sight, is expanding at 53 miles / second and is ∼4,000 years old. The other lobe is oriented at 76°, is expanding at 47 miles/second and is ∼3,700 years old. NGC6309 was formed by a set of well-collimated bipolar outflows (jets), which were ejected in the initial stages of its formation as a planetary nebula. These jets carved the bipolar lobes in the fading star's previous asymptotic giant branch (AGB) wind and their remnants are now observed as the point-symmetric knots tracing the edges of the lobes.

δ Hercules, 65 Her, "Sarin":

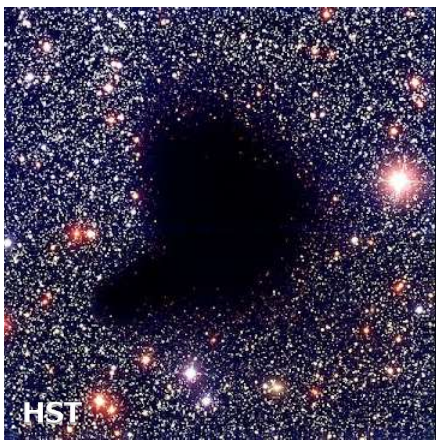
Delta Hercules is a controversial object as it has been described as an optical double (not gravitationally bound), and also as a complex multiple star system consisting of at least two stars and possibly as many as five. It is located 75 - 79 light years away. The primary star, Sarin, is an A-type main sequence subgiant star with a stellar classification of A31V, a blue class A3 subgiant star. This normally means the star is at the beginning of its stellar death as it begins its ascent up the red giant branch. However the main star is not a dying subgiant at all, but rather is composed of two vibrant and fairly youthful hydrogen fusing dwarf stars. This pair is called Delta Her Aa and Ab, and they are a mere 0.06 arc seconds apart. The brighter member, Delta Her Aa has an apparent magnitude of 3.49, and radiates the light of 18.5 Suns from its 8,626 Kelvin surface. Its radius is 2.39 times that of the Sun and it rotates with an equatorial velocity of 270 kilometers per second resulting in a rotation period under only nine hours. Its mass is estimated at 2.0 times that of the Sun and its age is only 370 million years which means only about a third of its hydrogen fusing lifetime has passed. The companion Delta Her Ab is probably a class F (F0) dwarf with a temperature of 7,500 Kelvins, a luminosity of 6.8 Suns and a radius of 1.5 solar and mass 1.6 solar. The physical separation between Aa and Ab is at least 1.45 Astronomical Units, which gives a period of at least 355 days. In a telescope the combined Her A object appears as a white colored star although it has been described as greenish colored. The companion Her B is described as a pale violet or yellow star and shines at 8^{th} magnitude. There is a Delta Her C which is a 10^{th} magnitude object and a Delta D which shines at 10.6 mag. However Her B, C and D do not match the proper motion of Delta A showing they are most probably just line of sight coincidences. In 1830 F.G.W. Struve measured the separation of Her A and B at 25.8" while in 1960 this had decreased to only 9" with Her A moving due south and Her B moves west.

NGC6342:

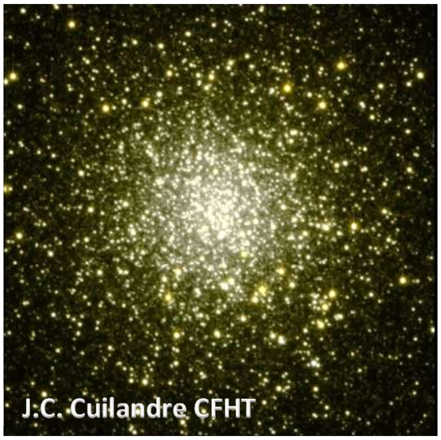


NGC 6342 is a metal rich globular cluster located within the Galactic bulge and in the constellation Ophiuchus. It was discovered by the German-born British astronomer William Herschel on 28 May 1786. It is designated a classification IV in the Shapley–Sawyer Concentration Class meaning it is a rather tightly structured globular cluster. NGC6342 is located at a distance of 28,000 light years away from Earth, but only 5,500 light years from the center of the Galaxy. It metallicity is [Fe/H] = -0.55 to -0.60 ± 0.01 which makes it a metal rich globular cluster when compared to other similar objects. Its interstellar reddening is calculated at a modest E(B-V) = 0.46 to 0.57 considering its galactic central location. The largest stars in the cluster have effective temperatures of only 4,000 to 4,500 K indicating they are low density objects with many years left fusing hydrogen on their main sequences. NGC6342 typically displays alpha and iron peak element abundance patterns that are typical of other metal rich ([Fe/H] > −1) inner Galaxy clusters. NGC6342 is thought to be as old as the bulge, which is surprising given it metal rich status. The globular cluster (GC) system of the Milky Way has long been used to learn about the evolution of the Galaxy. As the Galactic globular clusters (GGCs) constitute some of the oldest systems in the Milky Way, the study of the stellar populations of these fossils can give us important clues of the early stages of the Galaxy's formation. The tool most extensively used in this task has been the analysis of the color–magnitude diagrams (CMDs). However, the presence of significant differential extinction in low-latitude fields, particularly near the Galactic center, greatly complicates traditional CMD analyses. As a result, the study of many GGCs located toward the inner Galaxy has been historically neglected. NGC6342 is one of these poorly studied objects located toward the Galactic center.

Barnard 68:

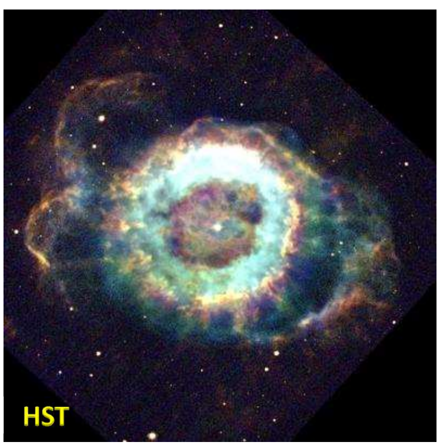


Barnard 68 is a molecular cloud known as a dark absorption nebula or a Bok globule. It is located towards Ophiuchus at a distance of about 400 light-years, which is so close that not a single star can be seen shining between it and the Sun. The American astronomer Edward Emerson Barnard added this nebula to his catalog of dark nebulae in 1919, which was published in 1927, and included some 350 objects. The overall diameter of B86 is about half a light-year across. Because of its opacity, its interior is extremely cold, with temperatures of only 16 K (−257 °C) above absolute freezing. The total mass of the dust component has been calculated at 0.03 solar mass, but if the gas-to-dust ratio in B68 is what is normally assumed, about 97% gas, then the total mass of this cloud is about 3 solar masses, so only a few stars will eventually form from this cloud. Its well-defined edges and other features show that it is in the very early stage of gravitational collapse, eventually becoming a star within the next 100,000 - 200,000 years. Despite being opaque at visible-light wavelengths, B86 blocks out the light of about 3,700 background Milky Way stars. About 1,000 of these stars are visible at longer wavelengths of infrared light. The total amount of obscuration at the center of the cloud is a whopping 35 magnitudes in the Visual band. If a sheet of dust with this high degree of obscuration were placed in front of the Sun, there would be eternal darkness on the Earth. Our central star would then only shine at 9th magnitude, meaning it would be about 15 times too faint to be observable with the naked eye. We are fortunate we can now see the interior of this cloud in IR light. If the collapse had been going on for a little longer, it would not have been possible to see through this cloud today, since the obscuration would then have been much higher, on the order of hundreds of magnitudes. Dark clouds are dark because they contain many forms of submicron-sized solid particles - the *interstellar dust grains*. They also harbor many kinds of molecules. These clouds are responsible for the obscuration of light at visible wavelengths which astronomers refer to as "dust extinction" and it is much higher at shorter wavelengths than at longer ones. These dark clouds are the coolest objects in the known universe with temperatures around -263 °C, just ten degrees above absolute zero, and they are the nurseries of stars and planets. Unfortunately, because they are mostly composed of molecular hydrogen (H_2) and also because they are so cold, 99% of a molecular cloud's mass is virtually undetectable by means of direct observations. A traditional way to study such clouds is by means of observations with radio telescopes of molecules (such as CO, CS and NH_3) that "trace" molecular hydrogen, however, the analysis of such data is rarely straightforward. Imaging techniques at infrared and submillimeter wavelengths are providing new information about these elusive objects. If not disrupted by external forces, the stability of these dust clouds represents a fine balance between outward pressure caused by the heat or pressure of the cloud's pre-stellar contents, and the inward gravitational forces generated by the same particles. This causes the cloud to wobble or oscillate in a manner not unlike that of a large soap bubble or a water-filled balloon. In order for the cloud to become a star, gravity must gain the upper hand long enough to cause the collapse of the cloud resulting in a temperature and density where fusion can be initiated and sustained. When this happens, the much smaller size of the star's envelope signals a new balance between greatly increased gravity and radiation pressure.



NGC6356:

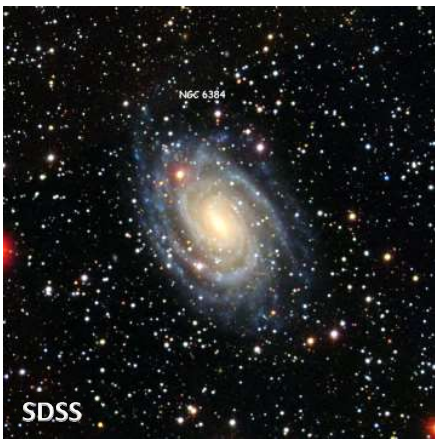
NGC6356 is a globular cluster located in the constellation Ophiuchus and discovered by the German-born British astronomer William Herschel on 18 June 1784. NGC6356 is located 80' north east of the brighter globular Messier 9 (NGC6333). While they may appear to be near each other, NGC6356 is really twice as far distant at 48,900 light years ± 1,300 light years from the Earth and 24,400 light years from the Galactic center. It is designated as a class II in the Shapley–Sawyer Concentration Class, meaning it is a highly concentrated globular cluster, with classification I being the most highly concentrated. The star cluster is more dense and bright towards the middle and becomes difficult to differentiate into separate stars. It's overall diameter is 36 light years, which is small compared to many clusters. This suggests tidal forces in the galactic nuclear bulge have limited this clusters size. Its visual apparent diameter is 10.0 arc minutes and its brightness is 8.25 magnitudes, with stars seen down to the visual limit of V = 19.2. Visually the core appears slightly elongated in a north-south direction, while the outer halo is slightly elongated WSW-ENE. NGC6356 has a well-defined main sequence of stars fusing hydrogen. There is a clear RGB clump at V = 18.00, which results from an evolution of the red giant branch which pauses when the H-burning shell passes through a discontinuity left by the maximum penetration of the convective envelope. The red giant branch is considerably curved in the V versus the (V-I) CMD and flat in I vs. (V-I), which indicates a high metallicity due to blanketing. The horizontal branch (HB) is red and compact and located close to the red giant branch. The HB is relatively flat, beginning & ending at V = 17.50 ± 0.04. It is devoid of stars bluer than the RR Lyrae gap which fits standard metallicity models, as NGC6356 is considered to be a metal-rich ([Fe/H] =−0.4) globular cluster, when compared to other globulars. While it appears to be projected on the Galactic bulge, in actuality it is located on the other side of the Galaxy. However it is still part of the metal rich disk system, being found in an area where globular clusters are considered metal-rich. NGC6356 is one of the most distant of the metal rich globulars located away from the Galactic plane, at 7,800 light years. NGC6356 is unusual in that dust has been detected in the core. The dust mass in the core is small at 4–17 thousandths of a Solar Mass, and this is significantly smaller than the CO-to-dust ratio in the general Galactic interstellar medium, and also in the outflows of evolved stars. The fact that dust is there at all is unusual in a globular cluster consisting of ancient stars too small to manufacture carbon dust and that should have used up any free solid material long ago. The Interstellar Reddening E(B-V)=+0.5 is considered to be minor, especially for so distant an object.



NGC6369, PK 2 + 5.1, The "Little Ghost" Nebula:

NGC 6369 is a planetary nebula in Ophiuchus which was discovered by William Herschel. It is a double-shell planetary nebula consisting of a bright annular inner shell with faint bipolar extensions and a filamentary envelope. The glow from ionized oxygen, hydrogen, and nitrogen atoms are colored blue, green, and red respectively, in the deep HST image of the object. Its distance is estimated to be 2,000 – 5,000 light years but distances to planetary nebulae are poorly known. If 2,000 light years is the true accepted distance, then its large angular diameter of 28 arc seconds works out to a diameter for the nebula of 0.3 light years across. There is little or no twice-ionized helium present so the central star, did not experience the helium flash, and therefore was not a massive progenitor star. It is relatively cool, with a measured value 58,000 Kelvin. Its luminosity is also relatively low, for a dwarf central star, at about 1,000 times that of the Sun (though if you double the distance, it becomes four times brighter). Presently the central star has a modest mass of a bit over a half solar, again indicating the original progenitor star must have been much like the Sun. Even though the star is still heating a bit, it will shortly begin to cool as a white dwarf, as the nebula, expanding at 25 miles per second fades off into interstellar space. The doughnut-shaped blue-green ring represents light from ionised oxygen atoms that have lost two electrons (blue) and from hydrogen atoms that have lost their single electrons (green). Red marks emission from nitrogen atoms that have lost only one electron. Our own Sun may eject a similar nebula, but not for another 5 trillion years. The gas will then expand away from the star dissipating into interstellar space after some 10,000 years. After that, the remnant central star will gradually cool off for millions of years as a tiny white dwarf star, and eventually wink out of existence. The inner shell of NGC 6369 can best be described as a barrel-like structure tilted 50°to the line of sight, with polar bubble-like protrusions, containing H_2 and strong polycyclic aromatic hydrocarbons emission (PAHs), indicating the presence of dust. High-resolution images reveal an intricate excitation structure of the inner shell and a system of outward pointing `cometary' knots. The knotty appearance of the envelope plus other indicators give hints that the envelope of NGC 6369 is not a real shell, but rather a flattened structure at its equatorial regions. Irregular knots and blobs are seen of diffuse emission in low-excitation with molecular line emissions that are located up to 80 arcsec from the central star.

This is well outside the main nebular shells. The filaments associated with the polar protrusions are probably post-shock cooling locations, and likely represent regions of interaction of these structures with surrounding material. Its most unusual features are two extensions of the inner shell along the east and west directions. The west extension appears as a large, filamentary blister or ansae superimposed over the central region, while the eastern extension is a bifurcated or two-branched structure. The H I and He II temperatures are similar, which suggests that the nebula is optically thick to Hydrogen ionizing radiation, and thus significant amounts of molecular material and dust may be present outside the ionization bound optical nebula. This is consistent with indications of emission from polycyclic aromatic hydrocarbons (PAHs) bands that would be produced at a photo-dissociation region (PDR) located outside of the ionized shell. Spectroscopic observations of NGC6369 have shown it to be one of the few evolved planetary nebulae to possess the 21- and 30-μm emission features that are typically observed in Carbon-rich asymptotic giant branch (AGB) stars and some planetary nebulae. According to this model, the kinematical ages of the barrel and bipolar lobes are 2,000 and 3,200 years respectively. The kinematical age of the inner shell is thus less than that of the bipolar lobes. The overall size of this planetary is 38.0 arc seconds and its photographic magnitude is 12.9. Its V-magnitude is a bright and easily seen 12.0. Visually in a telescope this is a beautiful object. It appears as a perfect donut with a moderately bright outer ring and an inner region devoid of any material.



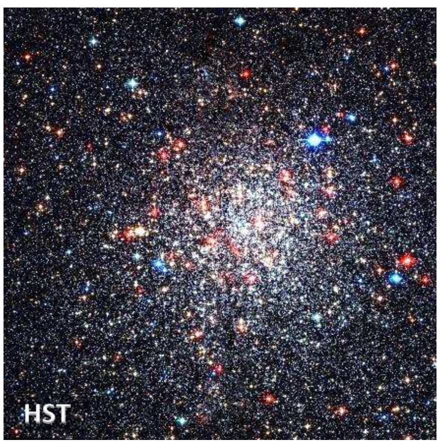
NGC6384, UGC10891, CGCG 55-7:

NGC6384 is an intermediate barred spiral galaxy located approximately 77 million light years away in the northern part of Ophiuchus, and from our perspective, not far from the center of the Milky Way Galaxy. This means we have to observe it through a lot of Galactic interference. The galaxy spans an estimated 150,0000 light years in diameter, slightly larger than our Milky Way. Its morphological classification is SAB(r)bc which indicates it is a weakly barred spiral galaxy (SAB) with an inner ring structure (r) orbiting the bar, and moderate to loosely wound spiral arms (bc). It is thought that galaxy bars funnel gas inwards to the center of the galaxy where it accumulates to form new stars. The estimated mass of the galaxy is 105 billion times the mass of the Sun and it is inclined at an angle of 47° to the line of sight along a position angle of 40°. This galaxy was once considered to be a normal spiral type galaxy with no nuclear activity but now it is classified as a transition type of galaxy known as a Seyfert III galaxy or a LINER-type galaxy. These galaxies have an active nucleus with an emission line spectra which is often contaminated by HII regions in the nucleus. On 24 June 1971, a type Ia supernova was discovered in this galaxy at 27″ east and 20″ north of the nucleus. A type Ia supernova occurs when a compact star that has ceased fusion in its core, called a white dwarf, increases its mass beyond a critical limit by gobbling up matter from a companion star. A runaway nuclear explosion then makes the star suddenly as bright as a whole galaxy. The supernova reached a peak visual magnitude of 12.85 around the end of June and was designated SN 1971L. It was located along a spiral arm, suggesting that the progenitor was not a member of the older, more evolved stellar population of the galaxy. Visually NGC6384 is a rather large galaxy at 7.0 x 4.0 arc minutes and its B-magnitude is 11.1 with a surface brightness of 14.2. Its radial velocity of +1690 in recession places it at a distance of 79 million light years (H_o = 70).

Barnard's Star:

This runaway star is a very low mass red dwarf of spectral type M4, located about 6 light years from Earth and in the constellation of Ophiuchus. It is the fourth closest star after the three components of the Alpha Centauri system, and the closest star in the northern hemisphere. In visual light it shines at 9.5 magnitude, but it is much brighter in infrared light. The star is named after the American astronomer E.E. Barnard, who was not the first to observe the star (it appeared on Harvard University plates in 1888 and 1890), but in 1916 he measured its proper motion as 10.3 arcseconds per year, which remains the largest proper motion of any star relative to the Sun. This rapid movement in a due north trajectory is a function of its close proximity to earth, and not of its actual space velocity. Barnard's star is 7–12 billion years old, so it is considerably older than the Sun at 4.5 billion years old. It has lost a great deal of rotational energy, and the periodic slight changes in its brightness indicate that it rotates once in 130 days (the Sun rotates in 25). Given its age, Barnard's Star was long assumed to be quiet in terms of stellar activity, but in 1998, astronomers observed an intense stellar flare, indicating that Barnard's Star is a flare star. Four years passed before the flare was fully analyzed, at which point it was suggested that the flare's temperature was 8,000 K, more than twice the normal temperature of the star. The flare was surprising because intense stellar activity is not expected in stars of such age. Flares are not completely understood, but are believed to be caused by strong magnetic fields, which suppress plasma convection and lead to sudden outbursts. Strong magnetic fields occur in rapidly rotating stars, while old stars tend to rotate slowly. For Barnard's Star to undergo an event of such magnitude is a rarity, but it has been given the variable star designation V2500 Ophiuchi. In 2003, Barnard's Star presented the first detectable change in the radial velocity (line of sight movement) of a star caused by its motion and further variability was attributed to its stellar activity. The stars moves 10.3 seconds of arc annually which amount to a quarter of a degree in a human lifetime, roughly half the angular diameter of the full Moon. The proper motion of Barnard's Star corresponds to a relative lateral speed of 56 miles per second. The radial velocity of Barnard's Star towards the Sun is measured from its blue shift to be 63 miles/second. Combined with its proper motion, this gives a space velocity (actual velocity relative to the Sun) of 88.6 miles per second. Barnard's Star will make its closest approach to the Sun around AD 11,800, when it will approach to within about 3.75 light-years. It has a mass of only 0.14 solar masses ($M_\odot$), and a radius 15% to 20% of that of the Sun. Thus, although Barnard's Star has roughly 150 times the mass of Jupiter, its radius is only 1.5 to 2.0 times larger, due to its much higher density. Its effective temperature is 3,100 kelvins, and it has a visual luminosity of 0.0004 solar luminosities. Barnard's Star is so faint that if it were at the same distance from Earth as the Sun, it would appear only 100 times brighter than a full moon, comparable to the brightness of the Sun at 80 astronomical units. Barnard's Star's has 10–32% of the solar metallicity. Metallicity is the proportion of stellar mass made up of elements heavier than helium and helps classify stars relative to the galactic population. Barnard's Star seems to be typical of the old, red dwarf population II stars, yet these are also generally metal-poor halo stars. While sub-solar, Barnard's Star's metallicity is higher than that of a halo star and is in keeping with the low end of the metal-rich disk star range. This, plus its high space motion, have led to the designation "intermediate population II star", between a halo and a disk star. Research has showed weak evidence for periodic variation in the star's brightness, noting only one possible star-spot over 130 days.

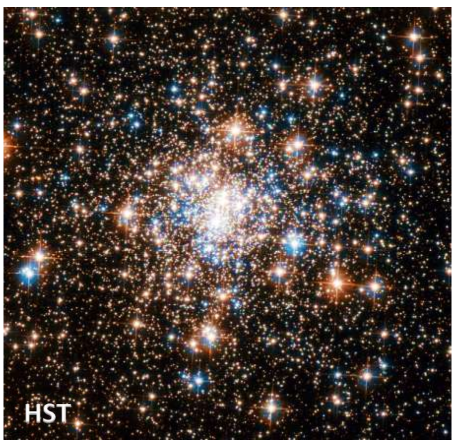
NGC6553:



NGC6553 is a globular cluster located in the constellation Sagittarius, just over a degree southeast of Messier 8, the Lagoon Nebula. It has an apparent magnitude of 8.3 with an apparent diameter of 9.2 arcminutes, and it contains stars fainter than 20th magnitude. The stars at the “V-tip”, the stars at the tip of the red giant branch, and therefore some of the brightest stars in the cluster, have a magnitude of 15.3. The horizontal branch has a magnitude of 16.9, so visually individual stars are difficult to resolve. Its Shapley–Sawyer Concentration Class is XI, meaning the star concentration is very loose even at the center. NGC 6553 follows the mean rotation of both the disk and bulge stars at a Galactocentric distance of 8,800 light years, and appears to be on a nearly circular orbit with a velocity of ∼ 145 miles per second, and a small inclination with respect to the Galactic plane. The kinematics of the cluster is consistent with either a bulge or a disk membership, but the virtual identity of its stellar population with that of its “twin” bulge cluster NGC6528 makes its bulge membership more likely. The globular cluster system of the Milky Way can be grouped into two separate metallicity distributions. The metal poor clusters are located in the Galactic halo, while the metal rich group ([Fe/H]> −0.8) constitute a population of “disk” globular clusters. These clusters are actually strongly concentrated towards the Galactic center, with most of them being physically inside the Galactic bulge, at a galactocentric distance < 10,000 light years. The Sub Giant Branch and turnoff region at V ∼ 21.5 in the CMD, indicates an old age for the cluster at ∼13 billion years, the same age as the inner halo globular cluster 47 Tucana (within a 1 billion year certainty). NGC6553’s metallicity is high, although the exact value is still a matter of debate, with findings ranging from [Fe/H]=−0.5 to [Fe/H]=−0.16. The old age of the object coupled with the unusually high metallicity indicates that the bulge underwent a rapid chemical enrichment to solar and beyond some 13 Billion years ago. This would also indicate an early and rapid assembly of the Galactic Bulge, while it was being built in the early Universe. There is a very high contamination by background stars around the cluster main sequence turnoff, leaving some uncertainty on the value of the turnoff, and luminosity. An additional interesting feature of the cluster color-magnitude diagram is a significant number of blue stragglers stars, whose membership in the cluster is firmly established from their common proper motions. Blue straggler stars are very massive stars that are actually old, but they masquerade as young stars. They are found on the CMD above the turnoff point in many globular clusters, in a place where no cluster stars should be. These are controversial objects, but many astronomers feel they are the product of close binary stars merging into one massive star, however the blue straggler population of NGC 6553 does not appear concentrated towards the center of the cluster. Usually these stars will end up near the center of a star cluster due to their exceptional high mass and in many globular clusters their lack of central locations results in their being tagged “field stars”. NGC6553’s accurate proper motion studies, coupled with the fact that it is already a high density cluster, results in the blue straggler population being found throughout the cluster. The “twin” clusters NGC 6553 and NGC 6528 have virtually identical color-magnitude diagrams. The most populated branches in CMDs are the cluster Main Sequence (MS), Red Giant Branch (RGB), and the Horizontal Branch (HB). The Horizontal Branch for NGC6553 includes a “red clump” of stars at V ∼ 16.6. A narrow sequence of RGB “red bump” stars is located at V ∼ 17.5, and is almost parallel to the RGB sequence. The Red Giant Branch, ”red bump” of stars as predicted by theory, is prominent in this metal-rich globular cluster.

NGC6643, UGC11218:

NGC6643 is a spiral type galaxy 3.8 x 1.9 arc minutes in size with a B-magnitude of 11.7. It is approximately 78 million light years away (H_0=70) in the constellation of Draco, which gives an overall diameter of around 86,000 light years. It classification is SA(rs)c and it has a high surface brightness at 12. 8. NGC6543 contains a very small nucleus that is separated from the broken remnants of an inner ring structure that extends into a complex irregular spiral arm pattern. The galaxy is very rich in ionized gas, and Hα regions prominently trace the tortured spiral arm structure. The rotation curve is perfectly regular and symmetric and reaches a plateau at around 112 miles per second at 30 arc seconds from the center or 9,500 light years. The neutral hydrogen velocities are in good agreement with the Hα ones. Hydrogen alpha images show regions of active star formation throughout the disk, while the radio images show only two point sources. The surface brightness of the inner parts of the arms is very bright and neutral hydrogen is found throughout the arms. The inner arms fragment together with their associated fragmented dust lanes. A couple of supernova have been spotted in this galaxy, SN 2008ij (Type IIP) and SN 2008bo.



NGC6642:

NGC 6642 is a globular cluster located in the bulge of the Milky Way, 26,400 light years from Earth, and seen in the constellation Sagittarius. It is just 5,500 light-years away from the galactic center, and is moving toward the solar system at approximately 35.5 miles per second. It contains RR Lyrae variable stars and many "blue stragglers" (stars which seemingly lag behind in their rate of aging) have been spotted in this globular. Blue stragglers are relatively common in globular clusters and are thought to be the end product of binary stars merging to form one massive object which gives spectral appearances of youth. NGC6642 is known to be lacking in low-mass stars, and the core of NGC 6642, shown here in this Hubble Space Telescope image, is particularly dense, possibly a core collapse object, making this globular a difficult observational target to totally resolve for most telescopes. Furthermore, it occupies a very central position in our galaxy (Sagittarius), which means that images inadvertently capture many stars that don't belong to the cluster — these "field stars" are sometimes difficult to differentiate from the cluster members. NGC6642 has a mass of 110,000 solar masses and it is a very old, highly evolved globular star cluster, at 10.6 – 13.0 billion years, making it one of the oldest fossils in our galaxy. To be so old, individual star in this cluster contain only a fraction of the mass of the Sun. NGC 6642 is one of the more genuine metal-poor clusters, which means that the cluster has almost no other elements than hydrogen and helium, and therefore is very primitive. The overall cluster magnitude is 8.9 while the sub-giant branch consists of stars of V-mag. 18 – 19, and is considerably contaminaed by field stars. The horizontal branch at V-mag. of 16.3. The reddening is E(B-V)= 0.42± 0.03 with a globular cluster typical low metallicity of [Fe/H]= -1.3, meaning few elements heavier than Helium are present.

NGC6791, Berkeley 46:

Berkeley 46 - NGC6791 is relatively nearby at 13,000 light years (4 kpc) and one of the most populated open star clusters with a mass of several thousand solar masses. It is officially listed as an Open Star Cluster in Lyra, however it is so unique, it almost is in a category by itself. It was discovered by Friedrich August Theodor Winnecke in 1853. At roughly 8 to 10.2 billion years old, it is recognized as the second oldest open cluster, behind only Berkeley 17. However, it has an Iron to Hydrogen metallicity abundance ratio that is more than twice that of the Sun, at[Fe/H] = +0.30 ± 0.5, and it also contains excess abundances of Calcium and Nickle. It is therefore one of the oldest, yet most metal-rich clusters in the Milky Way. This is very contrary to the typical astronomical theory where older normally means less metals, as these heavier than helium elements have not yet had enough time to form. Berkeley 46's unique combination of old age, high mass, and high metallicity characteristics place it in a bewildering category that is difficult to understand. It has an unusually high population of stars and its highly eccentric orbit, its metal and chemical content, and high number of stellar members, indicate it could be the nucleus of a very tidally disrupted galaxy. It also could be a globular cluster or a transition object between a globular cluster and open cluster. NGC67891 – Berkeley 46 is a very strange and unusual object. Additionally there seems to be three age groupings of stars within this cluster, a feature often found in Globular Clusters but not in Open clusters as open star clusters normally form stars all at approximately the same time. Among the dimmest stars in the cluster are groups of white dwarfs that are 6 billion years old. Another group of stars that appear to be 4 billion years old is found, while a third group of stellar objects are in the 8 – 10.2 billion years old range. This contradiction in age groups for this cluster is very puzzling, if the object really is an open cluster, and how does one explain three generations of stars in one object? The color magnitude diagram shows some more peculiar features, with a large blue straggler population, and both a red clump and an extremely blue horizontal branch. Given the high metallicity of this cluster the extreme blue horizontal branch should not exist and is an excellent example of what has been termed, the "Second Parameter Effect" or "Problem". Normally metal-rich star clusters have only a red horizontal-branch or red clump. However, in some clusters, like Be 46, there is also an unexpected population of blue horizontal branch stars, which should appear only in metal poor clusters. The fact that these metal rich stars are found in the wrong part of the horizontal branch indicates that some other factor, a 2nd parameter, which is unknown, is operating in these clusters. These extreme horizontal branch stars have likely formed due to increased mass loss along the red giant branch and possibly this has to do with the high metallicity of the cluster. Metallicity has been the chief suspect for what is driving the second parameter problem for years, but age and the formation location of the object within the Galaxy are also thought to be causes. The details are still obscure, but it is easy to understand why so much telescope and research time has been devoted to this mysterious object, NGC6791.

NGC6802, Collinder (Cr) 400:

NGC6802 is an open cluster in the constellation of Vulpecula, consisting of about 280 stars. It is relatively bright at an 8.8 visual magnitude. The excess reddening is a moderate E(B-V) = 0.45 - 0.94 and it is located 7,000 light years from the Earth. The cluster has a well-defined main sequence which extends about 4 to 5 magnitudes below the main sequence turn-off at V = 15.0. The red giant branch has a fairly populous red giant bump. NGC6802 is 1.0 to 1.5 billion years old making it a moderately aged open cluster. It has a relatively low metallicity at [Fe/H] = -0.45, which is probably due to the age of the cluster, but it may be the metallicity of the location in the galaxy where the cluster formed. The brightest stars are about 14th magnitude, and most appear in color photographs to be hot blue stars, probably of spectral type A, given the age of the cluster. A W Ursae Majoris star system has been discovered within this cluster. This variable star is an eclipsing binary system, with each star eclipsing the other, resulting in the light curves of the primary and the secondary being about equal. The period is 7.22 hours. There are a lot of foreground stars in the area which contaminates the main sequence data from the cluster.

NGC6819, Melotte 223, Collinder 403:

NGC 6819 is an open cluster in the Cygnus constellation. It was discovered by Caroline Herschel on 12 May 1784 and is a rich cluster consisting of some 929 stellar members. It is situated on the boundary of Cygnus and Lyra and contains roughly two dozen stars of magnitude 10 to 12, with many fainter members down to around 15.5 mag. It is bright and easily seen in a telescope with a published magnitude of 7.3. The age of NGC6819 is estimated to be 1.9 to 2.6 billion years ± 0.5 billion years, making it an old open cluster. The distance is calculated to be 7,000 ± 1,850 light years from Earth. Not many open clusters survive longer than a few hundred million years, so to have one so old and so close makes NGC6819 a valuable and popular study destination. This cluster has received a lot of attention lately as it is one of four clusters located within the Kepler Space Telescope field which is searching for exoplanets by measuring the dimming of light as the planet transits or eclipses the star. When eclipsing binaries occur in star clusters, their importance increases dramatically because they help calibrate the mass and age of all the stars in the cluster. With a well-determined age for a cluster, the color-magnitude diagram (CMD) can be used to test the effects of evolution on an even larger number of stars. Comparisons of the masses and radii of eclipsing stars and the CMD with theoretical stellar models can also lead to deeper understanding about chemical composition variables such as helium abundances. An eclipsing triple-lined binary star WOCS 24009 with a short orbital period of 3.6 days, was discovered in NGC6819, which narrowed the age of the cluster to 2.38 $\pm$ 0.22 billion years. NGC 6819 has metal distribution, [Fe/H]= -0.02, typical of our Sun and the solar metallicity thin disk stars in the solar neighborhood. The excess reddening is a modest E(B-V)= 0.16, but it is variable across the cluster. Twelve blue straggler stars have been found in this cluster by measuring the barium abundance of main and blue straggler stars. Blue stragglers (BSs) are stars that do not follow the pathways laid out by standard stellar evolution. In star clusters they are typically identified as being brighter and/or bluer than the main-sequence (MS) turnoff. BSs have been identified in open and globular clusters, dwarf spheroidal galaxies, and the Galactic field. The barium abundance study has turned out some peculiar objects in NGC6819, including a candidate quiescent low-mass X-ray binary and a puzzling lithium-rich red giant star.

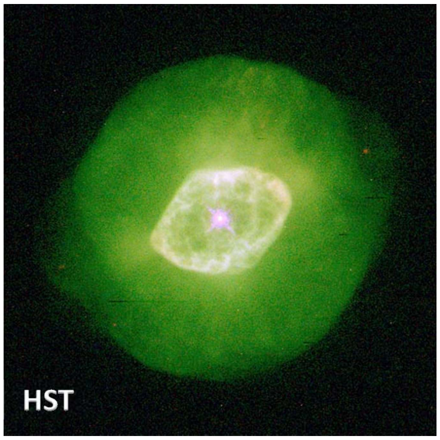
NGC6834, Collinder 407, Melotte 225:

NGC 6834 is a poorly studied open cluster located about 7,002 light years from the Sun in the constellation Vulpecula. It has a visual magnitude of 7.8 and an estimated age of 65 ± 18 million years. It contains approximately 50 stars, some of which are very unusual. Four early type stars with H-alpha in emission have been found, which is surprising as these type of stars are not expected to be found in a cluster of this age. A total of 15 stars have been found to be variable in light output, and also two Be stars have been found, with one being a binary object and the second Be star is a γ Cas-like variable. A classical Be star (CBe) is defined as a non-supergiant spectral B-type star whose spectrum has or has had at some time one or more Balmer lines in emission. The emission lines are produced in a circumstellar disk through a recombination process from reprocessed stellar radiation. They rotate at 70-80% of their critical speed so the formation of the disk is an equatorial mass loss event, and not the natal formation disk the star had during its protostar – pre main-sequence formation period. The formation and structure of circumstellar envelopes and the evolutionary status of CBe stars are some of the unresolved problems being currently studied. Some of these problems can best be tackled through the study of CBe stars in open clusters since we know the age, distance and evolutionary state of these candidates. The planetary nebula NGC6842 is located 38 arc minutes to the east-southeast.

NGC6888, Caldwell 27, Sharp 105, "Crescent Nebula":

The Crescent Nebula is an emission nebula in the constellation Cygnus and located about 5,000 light-years away from Earth. It was discovered by Friedrich Wilhelm Herschel in 1792. The nebula is formed by the fast stellar wind emanating from the Wolf-Rayet star WR 136 (HD 192163) seen in the center of the nebula. This star initially had a mass 25 to 40 times the mass of the Sun. This is a very hot massive star that is blowing off its outer layers at a rate of 1,250 to 2,000 miles per second. This fast wind collides with and energizes the slower moving wind ejected by the star when it initially became a red giant around 250,000 to 400,000 years ago. The result of the collision is a shell and two shock waves, one moving outward and one moving inward. The inward moving shock wave heats the stellar wind to X-ray-emitting temperatures. The electron temperature varies from ~7,700K to ~10,200K. The Crescent is a cosmic bubble about 26 x 16 light-years, blown by winds from its central, bright, massive star. It is shedding its outer envelope in a strong stellar wind, ejecting the equivalent of the Sun's mass every 10,000 years. The nebula's complex structures are the result of this strong wind interacting with material ejected in an earlier phase. Burning fuel at a prodigious rate and near the end of its stellar life this star should ultimately go out with a bang in a spectacular supernova explosion. In the photo, the oxygen atoms produce the blue-green hue that seems to enshroud the detailed folds and filaments. The star and the nebula however are largely nitrogen and carbon while oxygen is depleted and slightly under-abundant with respect to the solar value. It is difficult to explain all of the features seen in this object, but one explanation involves a structure of multiple shells. The inner shell is broken by material from the interaction between the supergiant star and the Wolf Rayet shells, which produces an over-abundance of nitrogen and a slight under-abundance of oxygen. The outer shell is very intense in [OIII] λ5007Å which corresponds to the main sequence bubble that was broken up as a consequence of the collision between the supergiant and the Wolf Rayet shells. Nitrogen and oxygen are not enhanced here but helium appears enriched. Finally there is an external and faint outer shell that surrounds the whole nebula like a thin skin. This represents the early interaction between the winds from the main sequence star with the interstellar medium (ISM) for which typical circumstellar abundances are derived. A number of features are detected far outside the nebula within 1.2° or 100 light years (30 pc) from the star, WR 136. These include extended radial streams of filamentary gas and ultra-compact HII regions (bullets) with high velocity gas motions. These bullets generate cylindrical shocks in the interstellar gas, resulting in the presence of high-velocity gas up 65 – 100 light years (20 - 30 pc) from the star, and far outside the cavity formed by the rarified component of the wind. The Crescent is located about 2 degrees SW of Gamma Cygni (Sadr), the star at the intersection of the cross in Cygnus. It is best seen using a UHC or OIII filter and presents a beautiful view. Under favorable circumstances a telescope as small as 8 cm (with filter) can see its nebulosity.

NGC6891, PK51-12.1:



NGC 6891 is found in Delphinus and lies at an estimated distance of 12,400 light years, and this is thought to be an accurate distance. This is unusual for planetaries, making it an ideal laboratory for analysis. NGC6891 can be found two and a half degrees south of the 5th-magnitude star Rho Aquilae. The nebula has a high surface brightness and is a rare Triple shell planetary. The main components are a bright inner shell, that is spindle shaped 9” x 6” in apparent size, and optically thick. It is expanding at 6.2 miles per second at the equator and 1.5 miles per second at the tips. Next out is an intermediate shell which is also elongated in shape and expanding at a higher 17 to 28 miles per second. The large faint halo is slightly distorted and 80” in apparent size which in actual diameter is 4.9 light years. It has a slow expansion velocity of 4.8 miles per second and the edge is unusually sharp. It formed some 28,000 years ago when the progenitor star began losing mass at a tremendous rate when it was at the tip of its Asymptotic Giant Branch (AGB). Material is flowing outward from the inner shell in a collimated flow in two opposite directions along the major axis, roughly 35° in PA. It collides with the outer portion of the intermediate shell, causing material to bunch up deforming the shell outward. This result in a slight brightening of the area, and this type of object is known as a Fast Low-ionization emission region or FLIER. Another name for this is ANSAE. Often these features are located on the outside of the planetary, but in NGC6891 they are internal structures, although the outer halo does exhibit less density in the area farther out. The central star is a white dwarf star with a temperature of 50,000 K and a mass 0.75 that of the Sun. Trying to get an accurate distance using the central stars for planetaries often gives erroneous results. The reason is the central star is not an ordinary star, but rather a very hot stellar object which was once the core of a star, and whose light is being analyzed after it has travelled through a lot of contaminating ionization fields. The Visual-band and the [O III] images of this nebula do not correspond well. In the [O III] line, the halo is of comparable brightness with the inner core and the two regions are distinguished more by their morphologies than by a change in luminosity. At a magnitude of 10.7, NGC6891 can be seen in telescopes as small as 4.5-inch aperture. An 8-inch scope reveals the nebula’s 12.5-magnitude central star, while larger instruments may even show the faint outer halo and the bluish color of the central disk.

NGC6905, PK 61-9.1, “Blue Flash Nebula”:

NGC6905 is a high excitation planetary nebula located in Delphinus and discovered by William Herschel in 1784. The central star emits one of the widest O VI emission lines (λ3811, λ3834Å) among planetary nebulae, and only a couple dozen objects have this emission, with some exhibiting variability. OVIII emission (λ1930, λ1932, and λ2977Å) has also been detected in NGC 6905, making it one of only three known planetaries with such an emission. The distance to the nebula is not well known, as is the case with most planetary nebulae, and estimates vary from 5,500 to 8,475 light years. One of the more recent analysis has settled on 5,900 light years. The shape of the nebula has been carved out by the outward radiation from the central star, which has a brightness of 14 – 14.7 magnitudes. This 14th magnitude white dwarf is a Wolf Rayet type star with an extremely high temperature of 150,000 Kelvins. It was once thought of as being a binary star, but more recent analysis has proven it to be single. Pulsation periods of about 16 minutes for the central star have been reported. The halo is expanding at 32.5 miles per second and consists of an internal shell with angular dimensions of 47” x 34”, and roughly conical extensions with ansae-like formations along the major axis. The ansae and the inner shell are thought to have formed separately. The ansae or FLIERS (fast low-ionization emission regions) are particularly intense in N II emission, but this emission is weak in the halo. FLIERS are small dense regions that appear in pairs along the symmetry axis of planetaries and are moving outward at supersonic velocities. They are formed by the collimation of the fast wind emanating from the central star, and colliding with the previously ejected nonspherical slow wind emitted during the AGB phase on the star’s evolutionary track. A jet or bullet is instrumental in the formation of FLIERS, and these can be significantly slowed down in only a few hundred years and long before being fully ionized. NGC 6905 is bracketed by three 11th and 12th magnitude stars, and with an apparent diameter of 40 arcseconds, NGC 6905 is easily visible through a 4.5-inch telescope. It responds very well to nebula filters.

NGC6960, "Veil" Nebula, "Cygnus Loop"

The Veil Nebula also known as the "Witches Broom" is a cloud of heated and ionized gas and dust in Cygnus, which is a large supernova remnant. It was discovered in 1784 by Sir William Herschel. NGC6960 is only a small part of the overall nebula, located on the western edge of the expanding material. It appears to pass through the bright 4th magnitude star 52 Cygni. The source supernova (Hot massive Type BO star of 15 solar-masses) exploded about 6,000 BC and the remnants have since expanded to cover an area roughly 3 degrees in diameter (about 6 times the diameter of the full moon). Of the original star, only a stellar remnant, either a neutron star or a black hole, is left but its position is unknown, despite many attempts to locate it. For reasons stated below, it may not even exists any longer. The distance to the nebula is not precisely known, but a good approximation is about 1,470 – 2,500 light-years. Spectral analysis indicates the presence of oxygen, sulfur, and hydrogen. The Veil nebula is also one of the largest, brightest features in the X-ray sky. Parts of the nebula appear to be rope-like, which is due to the shock waves that are expanding away from the supernova explosion. They are so thin that the shell is visible only when viewed edge-on, giving the appearance of thin filaments. Irregularities in the shell surface lead to multiple filamentary images which appear to be intertwined. These structures are shaped by an expanding shockwave as the expanding material slams into the surrounding interstellar medium (ISM). Over thousands of years the central part of the nebula has been cleared of dust making background stars here more visible. The Cygnus Loop is not fully understood, although it has been extensively observed in all bandwidths of the electromagnetic spectrum. A particular difficulty is its morphology which has a large northern circular shell and a bubble-like southern part which makes it an unusual object compared to other supernova remnants (SNRs). Some models show that the SNR must have exploded in the southern bubble and the northern part is the outbreak. Substantial differences between the northern and the southern regions have been observed in their radio emission properties as well as in their optical and X-ray emission characteristics. The differences in the north and southern portions of the nebula may be best explained by TWO supernova eruptions which appear to nicely account for the Cygnus loop observations at all wavelengths. Further evidence a SNR existed in the south is due to a recently detected neutron star close to the center of the southern bubble. The southern part of the remnant resembles a crescent whose western part is incomplete and is mixing with weak peripheral emission. The southern crescent is brighter than most of the northern portions of the Cygnus Loop. The shape of the Cygnus Loop is circular in the north and according to the double interaction theory the supernova in the north exploded first creating a complete circular, shell type remnant. A second supernova event took place to the south and not far away from the northern remnant. The northern parts subsequently became governed by a compression of the magnetic fields, whereas the southern portion was formed most likely from shock acceleration. Shortly after the second explosion the shock waves of the two supernovae collided. The younger southern supernova had a higher energy density than the northern component and swept-up the shell of the older remnant bending it inward. Thus the pronounced upper polarized shell of the southern supernova remnant was created. The collision of the two shells also created the X-ray extensions encompassing the polarized emission. The ages of these two supernovas cannot be determined to a high degree of certainty based upon their sizes, because of the interaction, collision and deformation of the expanding winds.

The following are reasons to conclude that two supernova events make up the overall Cygnus Loop and are in interaction.

1) The radio morphology of the Cygnus Loop differs in the south and north.
2) The distribution of polarization intensity differs completely in the south and north.
3) The tangential magnetic field indicates a regular magnetic field in the southern part, but disturbed in the north
4) The radio spectral index changes across the Cygnus Loop indicating a steeper spectrum (less compression) for the south.
5) The northern part has different characteristics of the optical filaments compared with the southern region.
6) There is weak or no X-ray and infrared emission in the south in contrast to the strong radio appearance.
7) X-ray enhancements seen at the superposition of both shell's periphery indicate an interaction of both SNRs.
8) Evidence for the existence of a stellar remnant, probably a neutron star, almost exactly at the center of the southern shell. The northern remnant is centered at ∼(α,δ)= (20h 51. m36, 31◦ 30) and its extent is about 3.0×2.6 degrees. The southern remnant, whose extent is about 1.4×1.8 degrees, is centered at ∼(α,δ) = (20 h 49. m56,29◦ 330).

61 Cygni:

61 Cygni is a binary star system, both of which are also variable stars, in the constellation Cygnus. They consist of a pair of K-type dwarf stars that orbit each other in a period of about 659 years. Both appear to be old-disk stars, with an estimated age that is older than the Sun. They can be seen with binoculars in city skies or with the naked eye in rural areas without light pollution. At a distance of just over 11 light-years, it is the 15th-nearest-known star system to the Earth (not including the Sun). This system will make its closest approach at about 20,000 CE, when the separation from the Sun will be about 9 light-years. 61 Cygni first attracted the attention of astronomers when its large proper motion (67miles/sec) was first demonstrated by Giuseppe Piazzi in 1804. In 1838, Friedrich Bessel measured its distance from Earth at about 10.3 light-years, very close to the actual value of about 11.4 light-years; this was the first distance estimate for any star other than the Sun, and the first star to have its stellar parallax measured. Among all stars or stellar systems listed in the modern Hipparcos Catalogue, 61 Cygni currently has the seventh-highest proper motion, and the highest among all visible stars or systems. William Herschel began systematic observations of 61 Cygni as part of a wider study of binary stars. His observations led to the conclusion that binary stars were separated enough that they would show different movements in parallax over the years, and Herschel hoped to use this as a way to measure the distance to the stars.

An observer using 7×50 binoculars can find 61 Cygni two binocular fields southeast of the bright star Deneb. The angular separation of the two stars is slightly greater than the angular size of Saturn (16–20”), so, under ideal viewing conditions, the binary system can be resolved by any 7 mm aperture. This is well within the capability of typical binoculars, though to resolve the binary these need a steady mount and 10x magnification. With a separation of 28 arc-seconds between the component stars, 10x magnification would give an apparent separation of 280 arc-seconds, above the generally regarded eye resolution limit of 4 arc-minutes or 240 arc-seconds. 61 Cygni A is a typical BY Draconis variable type star, designated as V1803 Cyg and shining at 5.21 magnitude. 61 Cygni B is a flare type variable star named HD 201092 and is slightly fainter at 6.03 magnitude. The two stars orbit their common barycenter in a period of 659 years, with a mean separation of about 84 AU—84 times the separation between the Earth and the Sun. The relatively large orbital eccentricity of 0.48 means that the two stars are separated by about 44 AU at periapsis and 124 AU at apoapsis. Currently both stars are near their apoapsis, or the greatest extension in their elongated orbits. The leisurely orbit of the pair has made it difficult to pin down their respective masses, and the accuracy of these values remains somewhat controversial. 61 Cygni A has about 11% more mass than 61 Cygni B. 61 Cygni A's long-term stability led to it being selected as an "anchor star" in the Morgan–Keenan (MK) classification system in 1943, serving as the K5 V "anchor point" since that time. Starting in 1953, 61 Cygni B has been considered a K7 V standard star. 61 Cygni has an activity cycle that is much more pronounced than the Sun’s sunspot cycle. This is a complex activity cycle that varies with a period of about 7.5 ± 1.7 years. The combination of star spot activity combined with rotation and chromospheric activity is characteristic of a BY Draconis variable. Because of differential rotation, this star's surface rotation period varies by latitude from 27 to 45 days, with an average period of 35 days. The outflow of the stellar wind from component A produces a bubble within the local interstellar cloud. Along the direction of the star's motion within the Milky Way, this bubble extends out to a distance of 30 AU, or roughly the orbital distance of Neptune from the Sun. This is lower than the separation between the two components of 61 Cygni, and so the two most likely do not share a common atmosphere. The compactness of the astrosphere is likely due to the low mass outflow and the relatively high velocity through the local medium. 61 Cygni B displays a more chaotic pattern of variability than A, with significant short-term flares. There is an 11.7-year periodicity to the overall activity cycle of B. Both stars exhibit stellar flare activity, but the chromosphere of B is 25% more active than for 61 Cygni A. As a result of differential rotation, the period of rotation of 61 Cygni B varies by latitude from 32 to 47 days, with an average period of 38 days. There is some disagreement over the evolutionary age of this system. Age estimates vary from 2 to 10 billion years, with the latest model in 2008 giving an estimate of 6.0 ±1.0 billion years for the pair. On several occasions, it has been claimed that 61 Cygni might have unseen low-mass companions, planets or a brown dwarf. A 2011 study using the Keck Interferometer failed to detect any exoplanets around 61 Cygni.

NGC7128, Collinder 440:

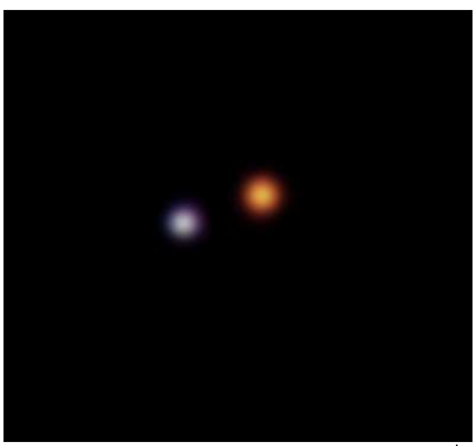
NGC7128 is a medium rich open cluster of about 35 stars, with a visual diameter of 3.1 arc minutes. Like so many other deep sky objects, it was discovered by William Herschel in 1787. It is located close to the Cygnus star formation complex. The main sequence turn-off is V = 12.3 which gives a cluster age of only 10 million years. NGC7128 has an overall brightness of magnitude 9.7, and it is composed of stars varying in individual brightnesses from mag. 11.5 to mag. 17.5. It contains a homogeneous sample of massive B-type stars which are only slightly evolved from the main sequence with the majority of the cluster stars of spectral type B0 – B4. Visually it is a lovely sight with the brighter stars arranged in a small ring with one of them being a beautiful orange color. The distance to the cluster is about 8,150 light years and there is a 3.09 magnitude stellar extinction in front of the cluster. This places it about halfway between the Sun and the Perseus spiral arm of the Galaxy so NGC7128 is considerably reddened at E(B-V)=1.1 mag. A total of 10 variable stars have been noted in NGC7128, of which 3 are eclipsing binaries, 2 are irregular and 3 are periodic variables with uncertain types. Also at least one Be star showing Hα emission is associated with the cluster, plus two other early-type emission stars are found which may be Be stars. Two of the cluster stars are late-type supergiant stars (Spectral type K supergiants), which are at least one magnitude brighter than the brightest cluster B stars. Be stars are spectral type B stars but they have emission lines. Classical Be stars (CBe) are non-supergiant B stars and are often variable in nature. The Be type spectrum is most strongly produced in class B stars, but it is also detected in O and A "shell" stars. A "shell" star has a detached shell of gas surrounding the star which is thought to be the circumstellar disk present around many Be stars. If it is aligned edge-on to us it creates very narrow absorption lines in the spectrum. Be stars are primarily main sequence stars, but a number of subgiants and giant stars are also included. The emission lines come from the circumstellar material which is ejected by the rapid rotation of the star. A gaseous disk formed from material ejected from the star explains all of the Be star characteristics.

NGC7129, Lynds 1181 (Nebula), Collinder 441 (Open Cluster):

NGC 7129 is a bright reflection nebula located 3,750 light years (1.15 kpc) away in Cepheus. A young open cluster, Collinder 441, is embedded in the nebula and is illuminating the surrounding molecular cloud complex, the dark nebula Lynds 1181. The cluster contains a few massive objects and approximately 130 stars ranging in brightness from 11th to 18th magnitude. All are very young objects that have formed out of this molecular cloud, with most members being less than a million years of age. Because of the young age, only a few cluster members of spectral class B are on the main sequence yet, with the majority of the stars on the pre-main sequence evolutionary track. The fraction of stars in the cluster with circumstellar disks (Young Stellar Objects or YSOs of class II) range from 33 to 54%. The young stars have blown a large, oddly shaped bubble in the molecular cloud that once surrounded them at their birth. Its bluish color comes from light filtering through dust that still surrounds the young stars, while ultra-violet and visible light produced is absorbed by the surrounding dust grains. They are heated by this process and re-release the energy at longer infrared wavelengths and were best photographed by the Spitzer Space Telescope. Small red crescent shaped objects located just to the north east of the cluster are Herbig-Haro objects, ionized hydrogen gas compressed by shock waves from energetic jets streaming away from infant pre-stars. Pale extended filaments of reddish emission mingling with the bluish clouds are caused by dust grains effectively converting the invisible shortwave ultraviolet starlight into somewhat visible red light through photoluminescence. A much cooler molecular cloud is located outside the bubble, but it also is mostly invisible to Spitzer. Three very young stars near the center of the nebula are sending jets of supersonic gas into this cloud. The collision of these jets heats carbon monoxide molecules in the cloud which produces the complex nebulosity. Ultimately the natal gas and dust in the region will be dispersed, with the stars drifting apart as the loose cluster orbits the center of the Galaxy. The open cluster NGC7141 is only half a degree away to the southeast, but it is twice as distant as NGC7129 at over 6,000 light years. Megastar incorrectly places NGC7133 where NGC7129 is currently plotted, calling it a "bright nebula". NGC7129 is placed as a separate open cluster object located just to the SW of the present position of NGC7129. SIMBAD clearly states NGC7133 is "not an object, error, artifact", and this has been followed by the astronomical community. The nebula and the star cluster are therefore the same NGC object, NGC7129.

NGC7448, UGC12294, Arp 13:

NGC7448 is a spiral type galaxy 100 - 110 million light years away, and located in the constellation of Pegasus. It is a bright galaxy at V-mag. 11.6, with a surface brightness of 12.1. This is a very bright and obviously active object to be 100 million light years distant and still have such a high luminosity. Its classification is SA(rs)bc, its size is 2.5' x 1.2' and it is considered to be rather blue for its classification. In Arp's classification structure it falls into the "Spiral galaxies with detached segments" category and he included it in his catalog because of its high surface brightness. It has a small very bright nucleus located within a high surface brightness halo of bright knots in the spiral structure. The nucleus is considered "active" and it is very similar to Seyfert type 3 galaxies, which are often called LINERS (Low ionization nuclear emission-line regions). NGC7448 is located within a group of galaxies which are interacting with each other, producing tidal streams and tails. Other members include, NGC7448, NGC7463/64/65 subgroup, UGC12313 and UGC12321. A clear tail that has been drawn out of NGC 7448 and a stream apparently extends from the NGC 7463/4/5 subgroup towards NGC7448. NGC7448 is the largest and the dustiest galaxy in the group and it sits alone off to the west of the other members. The spiral pattern in NGC7448 is composed of two regions of quiet different surface brightnesses. The inner region of the disk has tightly wound high surface brightness spiral fragments, forming a ring 0.37' in diameter formed by the bright inner spiral structure. Individual arms are not easily identified. The surface brightness decreases abruptly at the edge of this inner zone. Outer individual arm fragments and a general inter-arm spiral pattern in weak dust lanes can be somewhat traced over the outer disk. A cluster of unresolved HII regions exists in one of the most conspicuous of the outer arms on the northern side of the core. One bright HII region 35 arc seconds to the northwest portion of the disk is 13 x 11 arcseconds in size and is as bright as the bulge. The neutral hydrogen content of NGC7448 is normal for its morphological classification. It has a regular flat rotation curve at 93 miles per second, meaning the rotation rate of the arms stays constant from the inner core region out to the visible edge. Supernova 1997dt was discovered in NGC7448.



N Cassiopeia, η Cassiopeiae, "Achird":

Eta Cassiopeiae, is a beautiful binary star system in the circumpolar constellation of Cassiopeia. It was first discovered by William Herschel in August 1779. The pair are orbiting around each other with a period of 480 years. Based upon parallax measurements, the distance to this system is 19.42 $\pm$ 0.06 light years. The primary star, Eta Cas A, has a stellar classification of G0 V, which makes it a G-type main-sequence star much like the Sun that is fusing hydrogen on the main sequence. It therefore resembles what the Sun might look like were humans to observe it from Eta Cassiopeia. The star contains 97% of the Sun's mass and its size is 101% of the Sun's radius. It is of apparent magnitude 3.44 and radiates 129% of the luminosity of the Sun from its outer envelope at an effective temperature of 6,087 K. It appears to be rotating at a leisurely rate, with a projected rotational velocity of only 2 miles per second. What makes the star really stand out however is its 8th magnitude companion. The cooler and dimmer magnitude 7.51 companion is of stellar classification K7 V, and is an orange K-type main sequence dwarf star. It has only 57% of the mass of the Sun and 66% of the Sun's radius. Smaller stars generate energy more slowly, so this component radiates energy at only 6% of the luminosity of the Sun. Its outer atmosphere has an effective temperature of only 4,036 K compared to the Sun's 5,778 K temperature. This star, and the primary component contain only half the abundance of elements heavier than hydrogen and helium—what astronomers term their metallicity. Star colors are subtle. But put two stars of even somewhat different colors together, especially if there is a brightness difference, and the contrast can become quite intense. Eta Cas A and B thus give a beautiful view through even a small telescope, with the pair an easily-resolvable 11 seconds of arc apart. Based on an estimated semi-major axis of 12" and a parallax of 0.168", the two stars are separated by an average distance of 71 AU (1.75 times farther than Pluto is from the Sun or 6.6 billion miles), where one AU is the average distance between the Sun and the Earth. However, the large orbital eccentricity of 0.497 means that their periapsis, or closest approach, is as small as 36 AU, with an apoapsis of about 106 AUs. For comparison, the semi-major axis of Neptune is 30 AU. There are six dimmer optical components listed in the Washington Double Star Catalog, however, none of them are related to the Eta Cassiopeia system and are in reality more distant stars.

There are two necessary conditions for the existence of a planet in this system. One are stable zones where the object can remain in orbit for long intervals. For hypothetical planets in a circular orbit around the individual members of this star system, this maximum orbital radius is computed to be 9.5 AU for the primary and 7.1 AU for the secondary. (Note that the orbit of Mars is 1.5 AU from the Sun.) A planet orbiting outside of both stars would need to be at least 235 AU distant to remain in the system.

The second condition has to do with metallicity. Eta Cas is something of a northern-hemisphere version of the Alpha Centauri system. If the brighter G-type star were to have an Earth-like planet, the dimmer K star would shine in the planet's sky with an orange light of 5 full moons. Stars with planets, however, seem to have metal contents similar to or even greater than that of the Sun. Achird-A (and presumably, since the stars were born from the same interstellar cloud, also Achird-B) is however metal-poor. Its iron (and other elements heavier than Lithium) content relative to dominant hydrogen is only half that found in the Sun, so a planet seems unlikely. To date no exoplanets have been reported in this system.

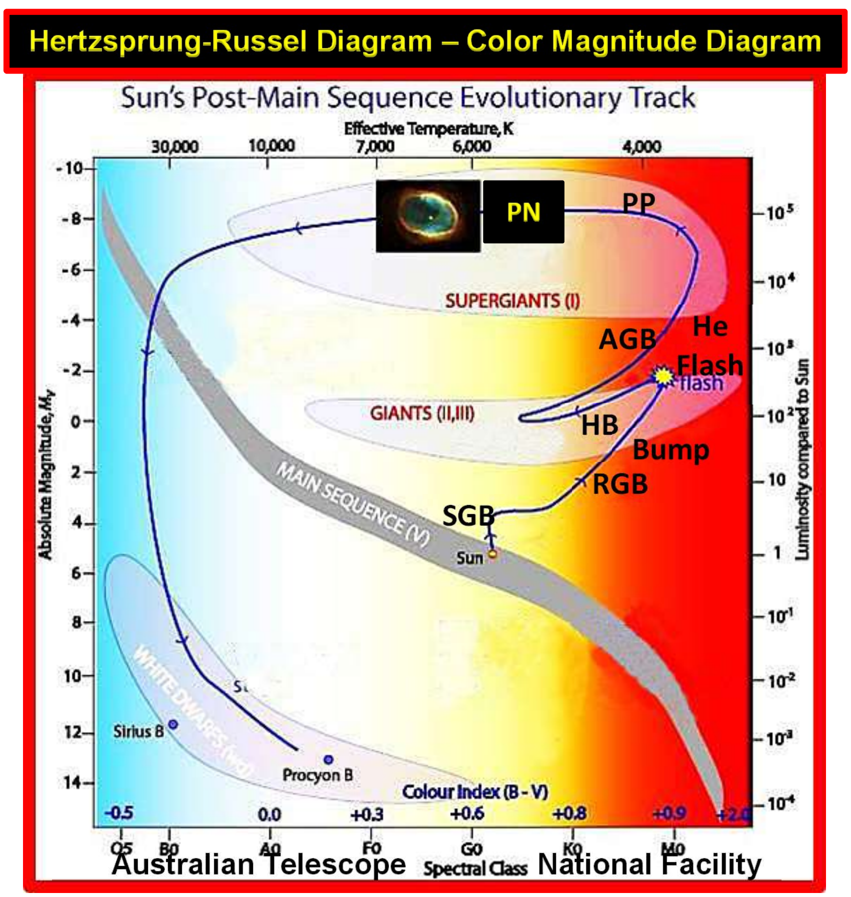
Description	Eta Cassiopeia A	Eta Cassiopeia B
Apparent magnitude	3.44	7.51
Spectral type	G0 V	K7 V
Mass	0.972 ± 0.012 M⊙	0.57 ± 0.07 M⊙
Radius	$1.0386 \pm 0.00.8$ R⊙	0.66 R⊙
Temperature	5973 ± 8 K	4036 ± 150 K
Luminosity	1.23321 ± 0.0074 L⊙	0.06 L⊙

NGC40, PK 120+9.8, Caldwell 2, "Bow Tie Nebula":

NGC 40 is a well-studied planetary nebula discovered by William Herschel on November 25, 1788, who described it as "a 9th magnitude star, surrounded with milky nebulosity" as seen through his 18.7 inch telescope with a speculum (metal) mirror. It is located in the northern constellation Cepheus and consists of hot gas expanding away from a dying star. It is located just over 17 degrees from the North Celestial Pole and therefore circumpolar from most northern latitudes. NGC40 is a well-studied object, classified as a low-excitation PN with a Wolf Rayet, WC8-type central star. Imaging studies reveal a bright slightly elliptical core, a large halo, and filamentary structures. The star has ejected its outer layer leaving behind a smaller layer and a hot star with a temperature on the surface of about 50,000 K. Radiation from the star ionizes the outer halo layer causing it to glow much like a neon light. The mass of the white dwarf central star is 0.567 ± 0.06 MΘ and its age is 5,810 ± 600 years. This ionized halo is about one light-year across and is moving outward at 20 miles per second, but with a turbulent motion of 4 miles/sec. The electron temperature for this halo is calculated to be 7,400 ± 160K. The inner halo line profiles are split by about 30 miles/sec, which is consistent with the splitting seen in the bright core. The initial movement of the pre-nebular circumstellar wind and of the post-ejection wind results in a roundish structure with two lobes. The overall size of the structure is ~61,500 AU wide, with the halo having a complex density structure with nebular peak densities as high as ~3,000 cm^{-3}. The distance to NGC40 is estimated to be 3,750 ± 390 light years, but accurate estimations of planetaries are difficult to ascertain, so distances have varied from 1,050 to 6,750 light years. The main outer clumps seen in narrowband images are kinematically associated with a barrel-shaped core, and thus are not the result of a true jet, typical of Ansae or FLIERS in other planetary nebulae. This barrel-shaped core has been expanding for ~4,000 years at roughly 15 miles per second. Abundance gradients are also present in the nebula as indicated by the discovery of 21 µm and 30 µm emission features in the spectrum which were obtained from the Infrared Space Observatory (ISO). Based on the presence of the 21µm feature, the bulk of the dust in the nebula has been produced during a carbon-rich phase of the star before the atmospheres became hydrogen poor. Based upon this finding an upper estimation of the dynamical age of NGC40 is ~5000 years. About 30,000 years from now, scientists theorize that NGC 40 will fade away, leaving only a white dwarf star approximately the size of Earth. NGC40 can be glimpsed with just a 100mm (4-inch) instrument.

IC1747:

IC1747 is a high surface brightness planetary nebula in Cassiopeia, which was discovered at the Harvard College Observatory in 1908 by Wilhelmina Pickering and published in the Harvard Circular #98 called “Nebulae”. Wilhelmina Pickering was a prolific writer who wrote several books and is also known for studies of several astronomical objects (Campbell’s star, Swings Struve 1, the Horsehead’s Visibility). The first Index Catalog (IC) had been published prior to her discovery of IC1747 so it was included in the second catalog. At first IC1747 was thought to be an emission line star, but by 1918 it was classified as a planetary nebula, where it was mostly analyzed for understanding gas abundances in planetaries. By the 1970s it was used as a beacon for radio research and distance measurements. It is very surprising that so little research has been conducted on this object. IC1747 has an integrated Visual magnitude of 13.6 an apparent visual diameter of 26 arc seconds, with an actual nebula diameter of 1 light year. IC1747 is a bi-polar planetary, but this is often overlooked due to the unusually bright outer halo, which is normally much fainter in most planetary nebulae. Distances to planetaries are always controversial, but distance estimates for IC1747 vary from 6,700 light years to 9,600 light years. Its distance from the center of the Galaxy is 34,556 light years and it is located 218 light years above the plane of the Milky Way. The central star, a Wolf Rayet type star, is shining at 15.4 – 15.8 magnitude. IC1747 belongs to an astrophysical rare but important group of planetary nebulae that exhibit OVI, OVII, and OVIII emission lines. Of the more than 1,700 known Galactic planetary nebulae only 26 objects possess the OVI type emission. Members of the OVI emission doublet sequence, λλ3811, 3831, belong to the highest excitation class of planetary nebulae, and it is only among this group of central stars that non-radial pulsators have been found. For IC1747 terminal wind velocities (highest velocity attainable by an object as it moves through a medium) in the range of 1,550 to 2,360 miles per second have been determined. Due to its high surface brightness IC1747 can be seen in 10 inch telescopes or smaller. Larger telescopes will show a hole in the middle. As with many planetaries it responds extremely well to nebular filters.



I am giving a talk from 4:00 to 5:30 on Saturday July 22, which will cover these objects in more detail, and from a slightly more technical, but understandable nature. Everybody is invited and I hope you can attend.

Larry Mitchell