Stellafane: Visual Observing Olympics - 2018

"The Hidden Gems of Stellafane"

Observe – Any 15 Objects in Any Telescope – Receive a Pin

Name:	2nd Name	Coordinates J2000	Type	Const.	Mag.	Size
□NGC5894	MCG 10-22-4	15 11 41.0 + 59 48 32	Gal.	Dra	12.8	3.0' x 0.4'
□NGC6217	Arp 185	16 32 39.4 + 78 11 54	Gal.	UMi	11.9	2.6' x 2.1'
□Vesta	4 Vesta	~17 25 35.7 – 23 17 33	Ast	Oph	6.5	Stellar
□NGC6535		18 03 51.0 – 00 17 51	G.C.	Ser	9.3	3.4' x 3.4'
□NGC6539		18 04 50.0 – 07 35 10	G.C.	Ser	8.9	7.9' x 7.9'
□Barnard 92	LDN 323	18 15 27.9 – 18 13 19	Neb.	Sgr	--	15.0' x 9.0'
□Berkeley 82		19 11 20.3 + 13 06 49	O.C.	Aql	--	4.0' x 4.0'
□NGC6791	Berkeley 46	19 20 53.7 + 37 46 09	O.C.	Lyr	9.5	10.0' x 10.0'
□NGC6857	Sh2-100	20 01 48.7 + 33 31 32	Neb.	Cyg	11.4	38" x 38"
□Roslund 4	IC 4954	20 04 50.4 + 29 12 38	O.C.	Vul	10.0	6.0' x 6.0'
□NGC6888	Crescent Neb	20 12 01.0 + 38 23 00	Neb.	Cyg	--	18.0' x 8.0'
□IC4996	Cr 418	20 16 32.0 + 37 38 40	O.C.	Cyg	7.3	5.0' x 5.0'
□NGC6934		20 34 11.6 + 07 24 15	G.C.	Del	8.9	7.1' x 7.1'
□NGC7006		21 01 29.5 + 16 11 16	G.C.	Del	10.6	3.6' x 3.6'
□NGC7023	Iris Nebula	21 01 36.0 + 68 10 00	Neb.	Cep	--	14.0' x 14.0'
□NGC7026		21 06 18.5 + 47 51 08	P.N.	Cyg	12.7p	40.0"
□NGC7354	PK 107+2.3	22 40 20.1 + 61 17 08	P.N.	Cep	12.9	22" x 22"
□Basel 3	Biurakan 3	23 15 12.0 + 60 28 00	O.C.	Cep	8.5	5.0' x 5.0'
□NGC274	Arp 140	00 51 01.8 – 07 03 22	Gal.	Cet	13.3	1.5' x 1.4'
NGC275		00 51 04.4 – 07 03 56	Gal.	Cet	13.2	1.5' x 1.1'
□NGC281	Pacman	00 53 00.0 + 56 38 00	Neb	Cas	--	28.0' x 21.0'
□Trumpler 1	Cr 15	01 35 40.0 + 61 17 12	O.C.	Cas	8.1	4.5' x 4.5'
□NGC1023	Arp 135	02 40 24.1 + 39 03 46	Gal.	Per	9.6	7.6' x 2.8'
□NGC1501	PK 144+6.1	04 06 59.6 + 60 55 14	P.N.	Cam	12.0	56" x 56"
□NGC1514	Crystal Ball	04 09 16.9 + 30 46 33	P.N.	Tau	10.8	2.0' x 2.0'
□NGC1569	Arp 210	04 30 49.7 + 64 50 53	Gal.	Cam	11.8	3.3' x 1.7'

Good Luck
Larry Mitchell – Eileen Myers

Vesta coordinates for 9 Aug. 2018 - Approximate

Gal. – Galaxy
G.C.—Globular Cluster
Neb. – Nebula
O.C.- Open Cluster
P.N.- Planetary Nebula
Ast. - Asteroid

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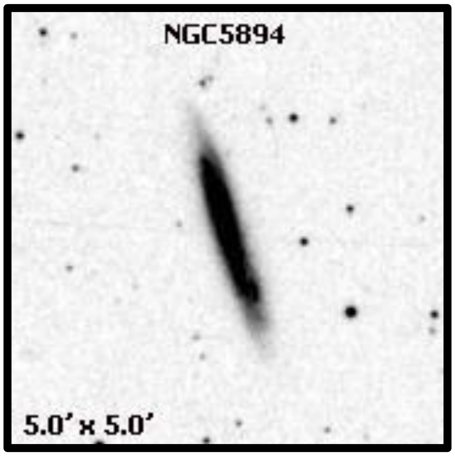
"The Hidden Gems of Stellafane" – Technical Information



NGC5894, Galaxy

Other: UGC 9768, CGCG 297-6, MCG +10-22-4, PGC 54234
J2000: 15 11 40.8 + 59 48 24
Const.: Draco
Mag. 13.4p
Size: 3.0′ x 0.4′
Class: SBdm?
Radial Velocity: +1170
Distance: 54.5 million light years (H$_o$ = 70)

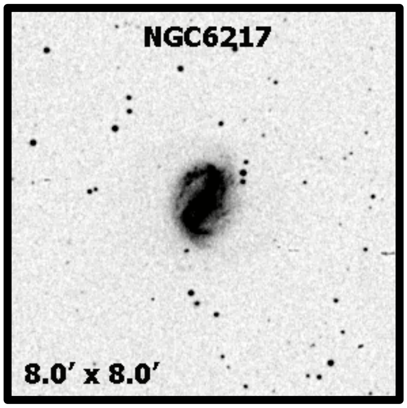
NGC5894 is an edge-on bright spiral type galaxy with slightly warped wings, located in Draco. It was discovered by William Herschel on May 25, 2016. Being an edge-on system it emits a high level of surface brightness, rendering it fairly easily seen in moderate sized telescopes. In the center of the galaxy the HII regions appear linear which indicates the presence of a bar which is hidden by the edge-on orientation. A bar can be detected in edge-on systems by a sudden decrease in the HI intensity at some point along the radius of the edge-on galaxy. The bar in NGC5894 is very small in both distance and height at 0.5′ x 0.05′ in size. A large HII region can be seen toward the southern end of the galaxy. Its distance has been listed from 54.5 to 120 million light years, with the nearer distance being the more recent.

NGC5894 is listed in the 2MASS Flat Galaxy Catalog, an all-sky catalog of 18,020 disc-like galaxies. Flat galaxies are in a category by themselves, and do not show a central bulge. They tend to have a low metallicity, exhibit a low star formation rate, and in general give the appearance of galaxies that just never quite got around to evolving. There are many possible reasons for this, but in general there are two basic requirements for galactic evolution, and those are sufficient gas and sufficient dust for stars to form. Dust grains condense in the cold envelopes of evolved stars and in the ejecta of supernova. These dust grains promote the formation of molecular hydrogen and shield the newly formed molecules from ultraviolet radiation. Additionally the dust grains participate in the formation and cooling of molecular clouds, which eventually collapse to form new stars. As galaxies form stars their interstellar medium becomes enriched with dust, while the subsequent decrease in gas makes the overall star formation rate decrease. Interstellar dust and star formation are strongly linked in galaxy formation and evolution.

NGC5894 is an isolated galaxy with no nearby neighbors influencing the shape of the galaxy. The outer parts of the rotation curve of isolated galaxies tend to be flatter than in interacting galaxies, and the outer regions of NGC5894 appear undisturbed. Most of the nearby galaxies, about 60%, are members of galaxy pairs or groups with at least three members. This leaves 40% of galaxies as isolated field galaxies, of which NGC5894 is a member. Isolated galaxies tend to be of later types and lower luminosity than their interacting counterparts, as less fireworks are going off inside.

Observation, 20 inch F5 Telescope:

A faint elongated glowing streak is seen which is typical of edge on flat spiral galaxies. We see only the central brightest region which is elongated, but not the extended wings. There is no hint of the dust lane and one cannot see a stellar or semi-stellar nucleus. NGC5894 appears fainter than one would expect from a 12th magnitude edge on galaxy, but there is a reasons for this. Flat or Superthin galaxies require special observational skills. These objects appear as hair-like thin faintly glowing streaks that one sees without immediately recognizing they see it…..almost subliminally. Hint – find the field, know exactly where to look, and give it time for the sky bring it to you.



NGC6217 - Galaxy

Other: UGC10470, CGCG 3555-14, Arp 185, MCG+13-12-8, Kaz 73, IRAS 16350+7818, PGC58477
J2000: 16 32 38.7 + 78 11 56
Const.: Ursa Major
Mag.: 11.8b
Surface Brightness: 12.9
Size: 3.0′ x 2.4′
Class: (R)SB(rs)bc
Radial Velocity: +1368
Distance: 63.71 light years (H_o = 70)

A prominent bar, 48” in length, dominates this galaxy which shows up in red light better than blue, indicating the bar is composed of older stellar members. The s-type spiral arms originate from the ends of the bar giving the galaxy a ring-like appearance. A third arm emanates from the core region of the galaxy and is more prevalent on blue plates indicating youth. There is also the resemblance of a straight dust lane in one of the legs of the bar, which is a characteristic of type SBb and SBbc galaxies. The largest HII star formation region is about 2 arc-seconds in diameter and is located 10” southeast of the core and at the location where the bar ends and the spiral arm begins. The distance to NGC6217 is about 63 million light years and it has a diameter of approximately 30,000 light years, meaning it is about a third of the size of the Milky Way. The galaxy is considered to be a starburst galaxy, meaning that compared to normal galaxies it is undergoing a high rate of stellar birth. Its spectrum is dominated by young hot stars that formed only 10 million years ago, so it follows that the nucleus of NGC6217 is considered to be an Active Galactic Nucleus (AGN). Its spectrum shows strong emission lines, indicative of violent outflows of material from the center, possibly powered by a massive black hole and numerous supernovae explosions. A group of smaller galaxies is found 15.0 arc-minutes to the southeast of NGC6217 and may be responsible for the irregularity of the spiral arms and the activity found in the central regions. Supernova 2018gi was discovered in NGC6217 by Patrick Wiggins and was a Type II supernova. Type II supernova are the result of the rapid collapse then violet rebound or explosion of a massive star.

A one sided jet extends from NGC6217, but it is visible only in X-ray and radio images, and completely invisible at optical wavelengths, even when observed in the largest telescopes and the Hubble Space Telescope. The jet emanates from the starburst nucleus and extends 2.7 arc-minutes or 60,000 light years to the southwest of the galaxy. The total luminosity is $\sim 1.7\times10^{39}$ ergs^{-1}. A total of 91 X-ray sources are found within a 38.0′ x 38.0′ nearby field so this is an extremely active area.

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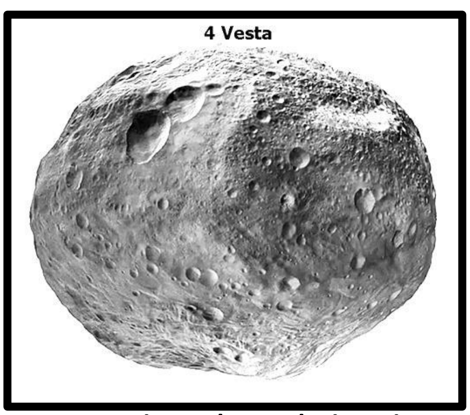


Vesta – Asteroid

Other: 4 Vesta
J2000: 17 25 35.7 – 23 17 33
Const.: Ophiuchus
Mag.: 6.5

Vesta, or minor-planet designation 4 Vesta was discovered by the German astronomer Heinrich Wilhelm Olbers on 29 March 1807, who named it after Vesta, the virgin goddess of home and hearth from Roman mythology. Vesta is the second largest body in the asteroid belt after the dwarf planet Ceres, with a diameter of 329 miles, and it is also the second most massive object, contributing about 9% of the total mass of the asteroid belt. Vesta is the brightest asteroid visible from Earth and this month, August, 2018, it shines at a magnitude of 6,5, which means people with keen eyesight can see it naked eye in the southern part of the constellation Ophiuchus. It was the first of the four largest asteroids (Ceres, Vesta, Pallas and Hygiea) to be visited by a spacecraft. The Dawn mission orbited Vesta on 16 July 2011 for a one year exploration and left orbit on 5 Sept. 2012 for its final destination Ceres. Vesta is unique among asteroids in that it has both light and dark patches on the surface giving an appearance much like the moon. Ground-based observations have determined that the asteroid has basaltic regions, meaning that lava once flowed across its surface. It has an

irregular shape, roughly that of an oblate spheroid. Vesta is also unique in that it is the only known remaining rocky proto-planet to have a differentiated interior which is similar to that of the terrestrial planets. It has a crust of cooled lava covering a rocky mantle and an iron and nickel core. It is thought that Vesta's core accreted rapidly within the first 10 million years after the formation of the solar system. The basaltic crust of Vesta also formed quickly, over a few million years and was the result of volcanic eruptions bringing up material from the mantle, with eruptions lasting an estimated 8 to 60 hours. The lava flows themselves ranged from a few hundred feet to several miles, with a thickness between 15 and 65 feet. The lava itself cooled rapidly, only to be buried again by more lava until the crust was completely covered in basalt.

An enormous mountain towers over Vesta's southern pole and reaches up over 65,000 feet or 12 miles in height, making it nearly as tall as Olympus Mons, the largest mountain (and volcano) in the solar system. Olympus Mons reaches nearly 15 miles above the surface of Mars. Like all of the asteroids, Vesta surface is heavily cratered which is the result of bombardments one and two billion years ago that left two particularly enormous craters which occupy much of Vesta's southern hemisphere. The Hubble Space Telescope mapped Vesta in 1996 and found a huge crater at the south-pole named Rheasilvia with a diameter of 310 miles which could have proven catastrophic as the diameter of the asteroid as stated is only 329 miles. The crater is 8 miles deep and material ejected from this collision has resulted in a family of smaller Vestoid asteroids that orbit nearby. Dawn found that it is material from this event that has fallen to Earth as Howardite-Eucrite-Diogenite (HED) meteorites, and these have been very informative. The collision stripped away most of the southern hemisphere's crust, revealing the asteroid's interior. The blow left concentric sets of troughs or fracture lines around Vesta's equator. In 1960 a fireball over Australia landed and the debris matches what was found with the Dawn spacecraft of Vesta. The rocky body had a surprising amount of hydrogen on its surface and it also contained bright, reflective regions.

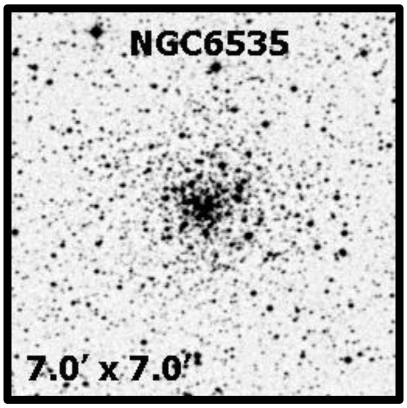
Vesta has an orbital period of 3.63 Earth years, and it rotates on its axis in only 5 hours and 20.5 minutes. At aphelion it is 2.57 AU from the Sun while at Perihelion it is 2.15 AU resulting in a nearly circular orbit with an eccentricity of 0.0886. Its closest approach to the Earth is 106 million miles, and this last occurred around 20 June, 2018 when it reached a Vmag. of 5.3. The estimated surface temperature is -306 to 0.0 degrees F.

One of the most surprising discoveries of the Dawn spacecraft was the there are indications that liquid water once flowed across the asteroid. Images revealed curved gullies and fan-shaped deposits within eight different Vesta impact craters. All eight of the craters are thought to have formed within the last few hundred million years, which is fairly recent in the lifetime of the 4.5-billion-year-old asteroid. With such a cold surface and no atmosphere any water on the surface should evaporate so Vesta is presenting us with an interesting and complex geometry. One possible occurrence is for there to be ice buried beneath the surface, and as meteorites bombard the surface watery debris flows are briefly formed which sculpted the gullies down the crater walls. In 2017, a study found that smooth patches of terrain on the asteroid frequently possessed high concentrations of hydrogen, which is often seen when solar radiation breaks down water molecules. We seem to be finding evidence of water in the strangest places.

Vesta and Ceres are both regarded as proto-planets due to their relatively large size. It is thought the gravitational tug of Jupiter prevented them from forming into a larger body or full sized planet.

Observation:

Vesta is easy to locate in southern Ophiuchus near three bright 4 – 6 V magnitude stars.
Aug 6: 17 25 01.4 – 23 06 00
Aug 7: 17 25 10.8 – 23 09 52
Aug 8: 17 25 23.3 – 23 13 43
Aug 9: 17 25 35.7 – 23 17 33

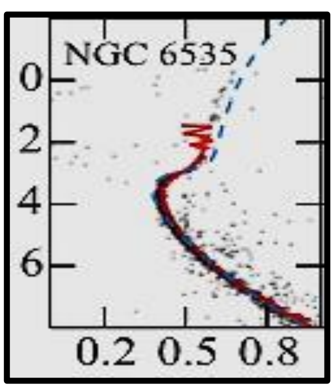


NGC6535, Globular Cluster

J2000: 18 03 50.7 – 00 17 49
Const.: Serpens
Mag.: 9.3
Mag. V-tip = 12.8
Mag V-Horizontal Branch: 15.8
Size: 3.4'
Distance: 22,000 light years

Globular Clusters are like planets in that they are material that did not coalesce into the formation of their parent body. As such they are all ancient objects billions of years old, and composed of more advanced cooler stars, many of which are dwarfs. No new star formation has occurred in these objects for billions of years, and as such they all have relatively low metallicities, when compared to stars that formed later in the more "evolved" universe. The Milky Way contains about 150 globular clusters while some giant elliptical galaxies have in excess of thousands. NGC6535 was discovered in 1852 by the astronomer John Russel Hind with a 7 inch telescope. NGC 6535 is located ～22 000 light-years away from the Sun in the constellation of Serpens. It is only one light-year in diameter, making it a small globular cluster, but it is among the least-condensed globulars in the Galaxy. An HST image of the cluster reveals all ancient yellow stars but no red giant stars are seen. Like most Milky Way globular clusters, NGC6535 has a low metallicity, [Fe/H] = -1.85 ± 0.10 and the 25 brightest stars in the cluster have an average V-magnitude of 15.97. Its Reddening has been found to be E(B-V)=0.36 to E(B-V)=0.44 ± 0.02 mag. The Color Magnitude Diagram (CMD) shows a moderately steep giant branch, and a steeply sloping predominantly blue horizontal branch. It is somewhat unusual in that there is an absence of a red horizontal branch and no RR Lyrae variables are known to be cluster members, although two are located within the area. These have been relegated to field stars status as they are significantly fainter then the horizontal branch stars of NGC6535.

The mean horizontal branch V-magnitude of NGC6535 is 15.73 ± 0.11. A significant population of nine blue stragglers has been detected in NGC6535. Based upon the movement of stellar members near the core region, NGC6535 is one of a few globular clusters in which an intermediate mass black hole (IMBH) is thought to be found in the center of the cluster. NGC6535 is thought to be 10.5 billion years old, relatively young for a Milky Way globular cluster. This is similar to Arp 2 at 10.9 BYrs, NGC6934 at 11.1 BYrs and NGC981 at 10.9 billion years. It has been proposed that younger Milky Way GCs are cannibalized extra-galactic objects that did not originate in the Milky Way.

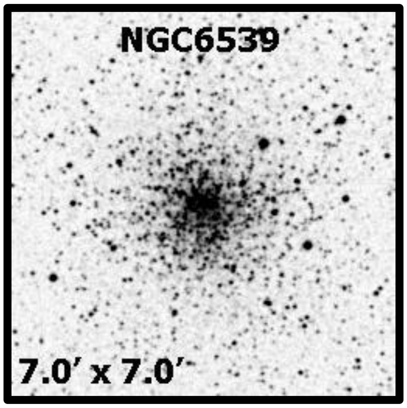


NGC6535, CMD – Isocrone: ApJ, 2015, M. Halford, et al

NGC6535 has an unusual mass to light ratio meaning it is under-luminous for its size. A large number of low-luminosity stars has been ruled out as the reason, nor is the cluster underpopulated in luminous stars. Instead an unusually large mass of dark matter is thought to be the cause, but why this is not seen in other globular clusters is uncertain. Therefore NGC6535 presents us with a large number of unresolved questions that are unique to this cluster.

Observation – 10" f/5 Telescope: Faint but easily seen, large and irregularly round in shape. Some stars can be resolved especially around the edges, and the center does not appear to be brighter than the edges – evenly lit across the cluster. The cluster appears to be fairly loosely structured. A prominent star is located to the immediate west of the object.

Observation – 20" f/5 Telescope: Nice easily seen glowing patch. One brighter star is seen nearby and to the southwest of the main body with three other slightly fainter stars in a line to the north of the brightest member. Many stellerings of stars popping in and out of view. The cluster appears loosely structured and the faint background glow is mottled with slightly unresolved stars.



NGC6539, Globular Cluster

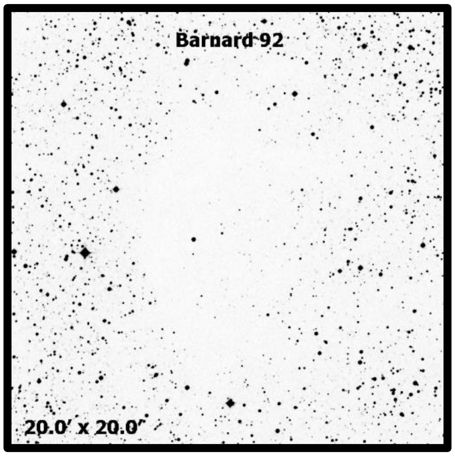
J2000: 18 04 49.8 – 07 35 09
Const.: Serpens
V-Mag.: 8.9
Mag. V-tip: 15.9
Mag. Horizontal Branch: 18.3
Size: 7.9′

NGC6539 was discovered by Theodor Brorsen in 1856 and included in John Herschel's General Catalog as CG No. 4370. It is a metal rich globular cluster located within the galactic bulge and its color magnitude Diagram shows a normal red clump horizontal branch. However there is no extension of blue horizontal branch stars, as seen in NGC6388 and NGC6441, two other globular clusters of comparable metallicity. Thirteen variable stars have been discovered within NGC6539 and 12 of these are long period variables. These long-period variables (LPVs) on the asymptotic giant branch (AGB), including the irregular, semiregular, and Mira classes, can be used in modelling studies of very cool stars. One RR Lyrae variable star has been found but it is unlikely to be a cluster member as it appears to be 0.3 mag. brighter than expected for a RR Lyra variable associated with this cluster.

Within the Milky Way there are two distinct systems of globular clusters, based upon their metallicity. The metal poor group is typically found in the galactic halo, while the metal rich group is confined to the galactic bulge and thick disk. Of the 33 metal rich clusters with [Fe/H] > -0.7, three quarters of them lie within 20 degrees of the Galactic center and half of these lie within 10 degrees of the center. As expected all lie in very crowded fields and all are heavily reddened with the average of the 10° group being E(B-V)= +1.41 which equates to a visual extinction of 4.4 magnitudes. For these reasons much of the comparison between observation and theory of globular cluster stars has therefore focused on lower metallicity systems as they are easier to study. NGC6539 is a metal rich globular cluster that has received little attention in the past. It is located 27,000 light years from the Sun and about 10,000 light years from the Galactic center. It has a relatively high metallicity [Fe/H] = -0.76 to -0.79 dex, and exhibits no blue horizontal branch members, as expected of objects of similar metal abundances. A milli-second binary pulsar has been discovered within NGC6539 which has a period of 23.10 ms, a mass function of M = 0.0097 $M_\odot$ and orbits in a period pf 2.62 days. A large dark cloud lies in the foreground causing a high reddening, E(B-V)= +1.00, and impaired visibility. The prototype metal rich cluster is 47 Tucanae, or NGC104 ([Fe/H]=-0.78), has a cool red giant branch, with the horizontal branch stars concentrated into a "red clump" and the horizontal branch stars are all cooler than the pulsation instability strip. Therefore 47 Tuccanae has no blue horizontal branch stars and most of the metal rich globulars follow this trend of having little or no blue horizontal branch stars. However, two other metal rich globular clusters, NGC6388 and NGC6441, do not follow this trend and possess large numbers of RR Lyrae variable stars which are found in these clusters and they do exhibit a blue horizontal branch. This has been termed the "Second Parameter Effect" and the cause is unclear.

Observation – 10" f/5 Telescope: A faint object appearing as a faintly glowing patch barely above the sky background. Evenly lit throughput and no individual stars or mottling was seen.

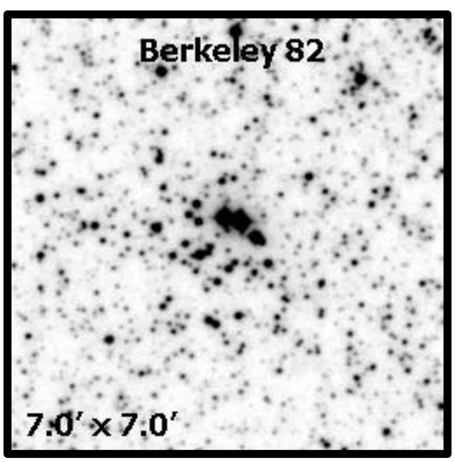
Observation – 20" f/5 Telescope: A faintly glowing round patch with no stellering of stars seen and only a hint of mottling. Appears to be a very compact object. One bright foreground star is located just to the north of the globular but it is not a cluster member. Even though NGC6539 is faint it is a noticeable object.



Barnard 92, Dark Nebula

Other: LDN 323, TGU H135
J2000: 18 15 27.9 – 18 13 19
Const.: Sagittarius
Size: 15.0′ x 9.0′
Radial Velocity: 7.0 km / sec.

Edward Emerson Barnard referred to Barnard 92 as a "black spot." He said, "This black spot known to me in my early days of comet seeking is very sharply defined on its east edge, but less definite on the west. There is a twelfth magnitude star near the middle with several other small stars." Barnard 92 is located on the northern edge of the Great Sagittarius Star Cloud, M24 and is the more conspicuous of two dark nebulae located there, with the other nebula being B93 located just to the north east. These are among the easiest dark nebula to visually detect in a telescope, as they stand out nicely from the rich background of stars found in the Great Sagittarius Star Cloud. William Herschel thought these "dark markings" as they were called were void spaces in the universe where no material existed. Eventually they came to be regarded as holes in the universe, and for most of his career Barnard, due to his tremendous respect for Herschel, adopted this idea as to the composition of these objects. It was not until 1913 when one night Barnard saw small cumulous clouds in the south that appeared inky black and obscured the background. He immediately realized these "dark markings" were really an obscuration of background matter, but he never did understand what was causing the darkness. Robert Trumpler in a landmark paper in 1930 proved the obscuration was simple dust. Today these dark nebulae are also known as 'Bok Globules' and they are known to be centers of stellar formation, composed of objects collectively known as Young Stellar Objects or YSOs. Bart Bok objected to the name and said these objects should be called 'Barnard Globules', after the man who initially discovered them.



Berkeley 82, Open Star Cluster

Other:	MWSC 3065, OCL 103
J2000:	19 11 20.0 + 13 07 06
Class:	O.C. (?)
Const.:	Aquila
Diameter, Overall:	16.8′
Diameter, Actual:	22.4 light years
No. Cluster Stars:	208
V-magnitude:	--
V-Brightest Star:	14.0
Trumpler Class:	III 1 p
Distance:	3,668 light years
Age:	60 - 114.8 Million years

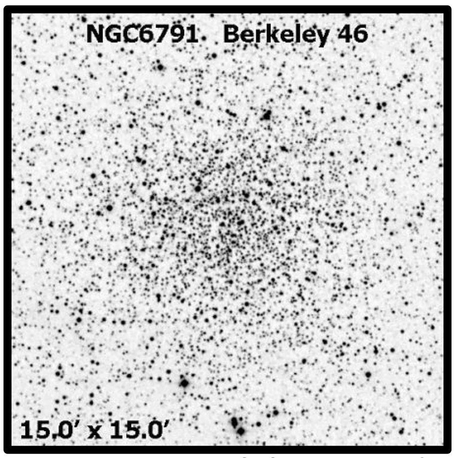
Berkeley 82 is a compact, open cluster which was first identified by Setteducati and Weaver (1962). In 1980 a photoelectric UBV survey found the three brightest stars in the cluster (assuming they are cluster members) are (Left to Right – above):

1.0) Spectral type G2 II/1b Yellow Giant, Vmag. 10.1
2.0) Spectral type K2 II Yellow Giant and Vmag. 11.23.
3.0) B6 III Giant, Vmag. 10.5

Luminous stars in open clusters present many interesting options for stellar evolution and instability. For unknown reasons, it appears that many poorly populated clusters contain Cepheid variable stars, and it is useful to study these sparse clusters to see how they evolve with and without Cepheids. Classic Cepheid Variables are typically massive stars of 4 to 20 solar masses (spectral types F6 – K2), so they potentially can remove material from the cluster needed to form

new stars. Berkeley 82 is located at galactic coordinates 046.8344 + 01.6123, which places it somewhat above the galactic plane and in a region of moderately high extinction. It suffers from a mean reddening E(B-V) = 1.01 ± 0.01 at a distance of 3,668 light years. It is part of a group of clusters with ages ranging 40 – 100 million years. However a cluster age of 60 – 80 million years would be more consistent with the assumed evolutionary status of the two yellow giants. The two stars lie within the blue horizontal branch for core-helium-burning stars. It has been stated that star 3 (above) could possibly be a blue straggler, but its location in the CMD is consistent with the 60 million year age of the cluster so it probably is not a second generation star as has been previously noted. Nearby are other similarly structured clusters of comparable age. The number of total cluster members in Berkeley 82 is around 200. There appears to be a dust lane partially obscuring the southern portions of this open cluster as these stars appears more highly reddened.

Berkeley 82 Observation: 25 inch F/5 Telescope: Overall the cluster looks like a basketball with an arc of three brighter stars on one side of the cluster. These stars range from 7.14 to 8.30 V magnitude so they are easily seen in any telescope. A fainter arc of stars is on the opposite side. The interior of the sphere is filled with resolved and unresolved faint stars ;popping in and out of view.



NGC6791, Berkeley 46 - Open Cluster

Other:	**MWSC 3088, Berkeley 46**
J2000:	**19 20 53.0 +37 46 18**
Class:	**Open Cluster**
Const.:	**Lyra**
Diameter Overall:	**24.0‵**
Diameter, Actual:	**96.3 LYrs**
No. Cluster Stars:	**14,000**
V-magnitude:	**9.5**
V-Brightest Star:	**11.6**
Trumpler Class:	**I 2 r**
Distance:	**16,059 light years**
Age:	**8.0 – 12.0 BILLION Years**

NGC6791, Berkeley 46 was discovered by Friedrich August Theodor Winnecke in 1853 and is located at 13,000 – 16,000 light years distance from the Sun. it is one of the most populated star clusters with a mass of approximately 4,000 solar masses. NGC6791 is one of the most unusual objects in the heavens in that it has several features that just do not fit the current scientific ideas of what is considered normal for stars and for open clusters. It is officially listed as an Open Star Cluster in Lyra, however it may really be a low mass Globular Cluster, or a transitional object between the two, or even the remnant core of a dwarf galaxy. Normally open clusters contain stars that were born out of the same nebulous cloud, at roughly the same time, and most clusters totally dissipate within a few hundred million years due to various gravitational effects. NGC6791 is considered to be the oldest known open cluster in the Galaxy with estimates ranging from 8.0 to over 12.0 BILLION years, an almost unbelievable statistic. However, in spite of its advanced age, NGC6791 is extremely metal-rich with [Fe/H] = ∼+0.3 to +0.4, as determined from its evolved stars. This also is an almost unbelievable statistic and places the metallicity of NGC6791 at more than <u>twice</u> that of the Sun ([Fe/H] = 0.012), while being roughly twice as old as the Sun. NGC6791 therefore ranks as both one of the oldest open clusters and also is one of the most metal-rich objects in our Galaxy. NGC6791 especially contains excess abundances of Calcium and Nickel. This metal abundance is contrary to a basic astronomical concept where older celestial objects are expected to carry fewer metals, as the heavier elements just have not yet had enough time to form. Roughly 10 billion years ago, when NGC6791 came into existence, stars had only been in existence for a relatively short time period of only about 3 billion years. NGC6791's unique combination of old age, high stellar mass, and enhanced metallicity characteristics place NGC 6791 between the physical properties of most Globular and Open clusters, and is a wake-up call for astronomers that we still have a lot to learn. Perhaps one explanation of how this happened is to place the cluster's origin in the inner regions of the Galaxy, in the inner disk close to the bulge which is a very high density region. Here star formation is very efficient and the enrichment of metals occurs rapidly. From here it would have migrated outward, possibly due to the bar and gravitational waves within the arms interacting with the cluster. Additionally, the main sequence for NGC6791 is rather broad, so star formation has been fairly extensive and has occurred over a great period of time. If this truly is NGC6791s origin, and it has since migrated outward, this may help explain its high metallicity and also its unusual orbit. Its orbit is highly eccentric and on closest approach (perigalacticon) it is only about 10,000 light years from the Galactic center, while it is around 30,000 light years when most distant (apogalacticon). Additionally, unlike most open cluster which are found in or near the Galactic plane, NGC6791 orbits about 3,000 light years (～1 kpc) above the Galactic plane (Boesgaard et al, 2009). As of now we simply do not know the true history of this object. Statistically the inward formation – outward migration theory needs some more supporting data to hold up, but we are not yet ready to totally support an external dwarf satellite origin for NGC6791 either.

The color magnitude diagram shows some peculiar features, which includes 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 is an excellent example of what has been termed, the "second parameter effect". Normally metal-rich star clusters have only a red horizontal-branch or red clump. However, in some clusters, like NGC6791, there is also an unexpected population of blue horizontal branch stars, indicating that some 2nd parameter, which is unknown, is operating in these clusters. The extreme blue horizontal branch objects 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 long been the chief suspect for what is driving the second parameter problem for years, but it is still only a theory.

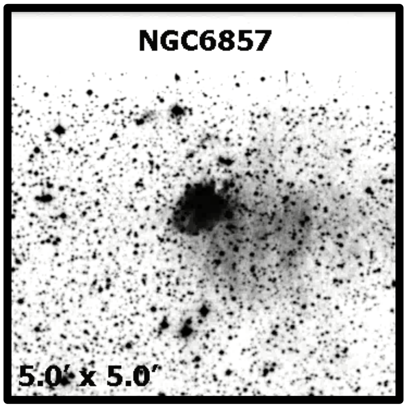
The high metallicity of the cluster likely has led to increased mass loss in the post-main sequence evolutionary phases which have led to about a dozen of the extreme blue horizontal branch stars as seen in the CMD. Most of these blue HB stars are subdwarf B and subdwarf O type stars. Stars lose most of their mass while ascending the red giant branch, or the asymptotic giant branch if massive enough and the planetary nebulae stage during their late evolutionary periods. The amount of the mass loss on the red giant branch depends upon the metallicity of the star and greater mass losses occur in chemically enriched stars. The average mass for the stars in NGC6791 is 1.05 MΘ. Models show a star of this mass which is slightly metal poor at [Fe/H] = -0.7 will lose 41% of its mass through evolution, and 33% on the red giant branch. A solar metallicity star of 1.05 MΘ, will lose 48% of its mass, however ～40% of this loss will occur on the red giant branch. For an extreme metallicity object like NGC6791 of [Fe/H] = +0.4, a star will lose an even larger fraction of its mass on the red giant branch, so a star of 1.05 MΘ with [Fe/H] = +0.4 will form a white dwarf core with a mass of just 0.45 – 0.47 solar masses. Approximately 0.46 MΘ is the threshold at which helium is ignited in the Helium Flash event to produce a carbon-oxygen mixture in the core. These theoretical calculations indicate the amounts of mass loss on the red giant branch which will result in a final mass at the tip of the branch, and it turns out that it is within a few hundredths of the critical mass needed to ignite helium. Given the random nature of the red giant mass loss, some stars had sufficient mass to ignite helium ending up as red clump stars, while others lacked the necessary mass and ended up as extreme blue horizontal branch stars, which is what is seen in NGC6791. The red clump stars are burning helium in their cores while the extreme blue horizontal branch stars are burning up what hydrogen is left in their cores, never having experienced the helium flash event. If a significant fraction of the stellar population is not undergoing the helium flash at the tip of the red giant branch then the luminosity function of the tip of the red branch should be lower when comparing NGC6791 to other open clusters. Not surprisingly this is just what we find. The luminosity at the tip of NGC6791 does not match that of other clusters (Berkeley 17, M67 and NGC188) which suggest there is an absence of red giants near the tip of NGC6791

Normally the Color Magnitude Diagram Turn-off is used for open clusters to determination the age by plotting an Isocrone. However, Bedin et al, 2005, 2008 proposed an alternate way of measuring the age of stellar clusters using the time it takes for a white dwarf star to cool. These stars have no remaining energy source and so they cool down with time, becoming predictably fainter, and therefore they can be used as age determinators. These white dwarfs are cooling due to gravity and becoming fainter as time passes on a fairly regular basis. The Hubble Space Telescope imaged NGC6791 for four orbits and derived some interesting information. The limiting stellar magnitude was 28 and the CMD showed a well developed main sequence and hundreds (～600 WDs) of white dwarf stars. If the white dwarf cooling sequence is considered, then the age of the cluster is only approximately 2.4 billion years, off by a factor of 3. If the cluster were really this young, then it could help explain the high metal content. However, it seems the white dwarfs of NGC6791 are unlike those of many other clusters. As stated, stars with high metallicities will lose more mass when in the post main sequence phase. Therefore if they can expel enough mass on the red giant branch they may never reach the helium flash stage and simply loop over into the blue HB stage quickly followed by the white dwarf phase. These white dwarfs then will have helium cores and not the standard carbon-oxygen cores from which standard white dwarfs, which have experienced the helium flash, will contain. In analyzing 12 white dwarf stars (Kalirai et al, 2007) in NGC6791 this is just what was found, helium dwarf stars. The final mass for these stars analyzed at 0.44 solar masses, just below the critical mass required for Helium fusion in the core of the star. As stated, 0.46 MΘ is the threshold at which helium is ignited to produce a carbon-oxygen mixture in the core. Two thirds of NGC6791's white dwarfs have masses below this 0.46 MΘ threshold suggesting they did not experience the helium flash but rather landed immediately on the while dwarf cooling phase. Models with helium cored white dwarfs cool by a factor of approximately 3 times slower than carbon-oxygen core white dwarfs. This increases the 2.4 billion years age limit up to a cooling age in excess of 7 billion years, which is closer to the expected age.

The magnitude of the 12 white dwarfs in NGC6791 runs from Vmag. 21.91 to 24.04, while the temperatures spread is from 12,500K – 34,700 K.

According to our present scientific astronomical expertise level, NGC6791 presents us with a huge riddle, which in the long run is beneficial. We still have gaps in our understanding of the evolutionary processes governing stellar and cluster evolution, and obviously more work needs to be done….NTC6791 is leading the way.

Observation, NGC6791 Visual – 20 inch F/5 Telescope: This is a beautiful very nice open cluster with about 30 brighter members which are loosely scattered. The cluster fades into a background haze of too many stars to count at 212X. It is very large and at 150X seemed to be at its best, showing a faint background glow with sprinkles of brighter stars evenly lit and moderately bright scattered throughout the cluster. This is an extremely beautiful visual object for any aperture telescope, which is very unusual for an open cluster as ancient as NGC6791.

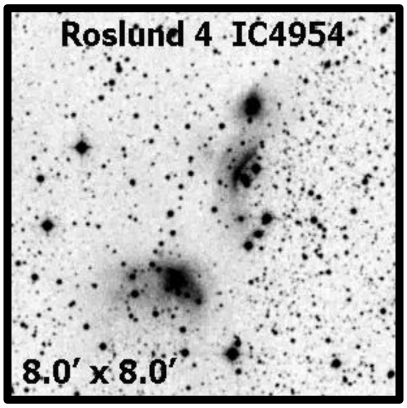


NGC6857, Bright Nebula

Other: PK 70+1.2, Mink 1-98, PN ARO 196, Sh 2-100
J2000: 20 01 48.7 + 33 31 32
Const.: Cygnus
Mag.: 11.4p
Size: 38.0'

NGC6857 is a bright fairly large nebula located in Cygnus. The nebula contains seven HII regions some of which are compact and some are considered ultra-compact in nature. They are powered by massive spectral type mid-O to early B zero aged main sequence stars. Analysis of NGC6857 is important because massive star formation is poorly understood as compared to low-mass stars. This is because their formation takes place in the dense core of a molecular cloud of high visual extinction. This usually is observable only at far-infrared (FIR) to millimeter wavelengths and their evolutionary timescales are much shorter, less than 100,000 years, making them scarce objects. Overall the complex shows a non-uniform distribution of both warm and hot dust which is well mixed with the ionized gas. This contributes to a variation of average visual extinctions of 4.2 to 9.7 magnitudes across the region. The estimated distances range from 25,000 to 30,000 light years. All of the HII regions are in different stages of evolution and the probable ages of the collective regions range from ～0.01 to 2.0 million years for the various ionizing sources. All of the infrared excess stars, and the compact and ultracompact HII regions are located on the periphery of an HI shell which hints at a creation by a Wolf Rayet star. This could indicate that star formation within NGC6857 was induced by an expanding neutral, H I shell. The area of maximum surface brightness is an optically visible compact nebula located 12" to the south of the central star which suggests the existence of a second gas ionization source. This HII region has a gas electron density of ～670 cm^3, and a temperature of ～10,000K. NGC6857 is located only 1.2' to the south of another bright nebula, K3-50. Both objects have been classified from optical data as planetary nebulae, but radio observations raise the possibility that both NGC6857 and K3-50 are separate HII regions. NGC6857 is not nearly as heavily reddened as K3-50 and the excitation of NGC6857 is much greater which indicates that NGC6857 is much closer to the Earth. If so the two objects are not associated with one another.

Observation, 20", F5 Telescope: Very bright nebula, small and slightly elongated in shape with a noticeable but faint star just to the north of center. Looks like a compact HII region. It is located in a rich starfield and it responds very well to nebula filters. Can be seen without a nebula filter as a small glowing patch, but with a nebula filer NGC6857 become a bright obvious object which is twice the size when viewed without the filter. Could not locate K3-50 as nothing reacted to the nebula filter, and all other objects appeared stellar without the filter.

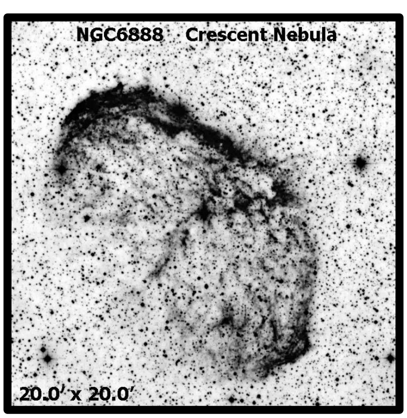


IC4954/55, Roslund 4, Reflection Nebula

Other: IC4955, LBH 153, Ced 175
J2000: 20 04 54.0 + 29 11 00
Const.: Vulpecula
Mag.: --
Size: 3.0′

The open cluster **Roslund 4** and its associated reflection nebulae IC 4954/55 are rarely imaged. This is a small group of stars with nebulosity, located in the Vulpecula constellation and on the outskirts of the Cygnus Super complex. It is possibly associated with a large Carbon Monoxide (CO) cloud of around 100,000 solar masses. A photoelectric study (Racine 1969) resulted in a distance of 9,500 light years (2,900 pc), a minimum reddening of E(B – V) = ～0.91, and an age of 10 million years. However the large amount of molecular gas and the nebula associated with Roslund 4 indicate this probably is an even younger object. As a very young object, there should be present Young Stellar Objects (YSOs), emitting material into the surrounding medium resulting in shocks, known as Herbig Haro Objects. This in turn will result in emission lines of Hα or Sulfur, [S_{II}]. Roslund 4 is full of shock excited gas and these regions do emit emission lines. To look for Herbig Haro objects, compare [S II] images which will show HH objects if present with off-line continuum images where they will not be visible. Roslund 4 has three Herbig Haro candidates, two of which are controversial as to membership. Herbig Haro (HH) objects are small patches of nebulosity that are only found where stars are actively forming and throwing out material at high velocities, which collides with less energetic material resulting in shocks. IC4955 is the northern most nebulous object while IC4954 is located to the south. Both refection nebulae are bright. Emission is detected over a large part of the field, but very strongly around the nebulae, and it is also very strong toward the east of the nebulae (to the left in the photo). To the west the emission is extremely faint or even non-existent. The strongest emission comes from the northern IC4955 area in which an arc shock front is seen.

Roslund 4 Observation: 20 inch F/5 Telescope: This is a very nice and interesting object. The first thing noticed is two nebulous patches, with the northwest one, IC4955, being the smallest and the brightest. The southeast nebula, IC4954, is larger and somewhat fainter. The stars involved total six in number. Three 11.5 to 12.5 stars are readily seen in a row and just to the north of these three stars are two stars of 9.7 and 11.4 magnitude appearing as a double star. These two stars are embedded in nebulosity but I did not notice this. The brightest nebula is located to the north-north west of these two stars. The large somewhat faint nebula to the southeast of the five stars has a star of 8.69 magnitude embedded within. All of the nebulae disappear when an OII filter was used, confirming these are Reflection Nebulae. This is a very interesting object in that the nebulous cloud the star cluster is forming out of is readily seen.

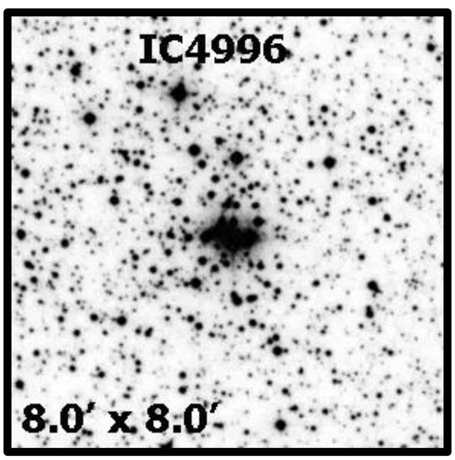


NGC6888, Wolf Rayet Emission Nebula

Other: Crescent Nebula, Sh 2-105, LBN 203, Caldwell 27
J2000: 20 12 01.1 + 38 23 00
Const.: Cygnus
Mag.: --
Size: 18.0′ x 8.0′

Wolf Rayet stars are evolved massive stars that are likely to have gone through several stages of mass loss in the form of both fast and slow moving winds. The stellar environment around stars provides important clues to their evolution, and the history of changing stellar output in the form of winds and ejecta are embedded in the environment of Wolf-Rayet stars. The stellar wind is accelerated from a velocity of around 10 km/sec in the red supergiant phase, to velocities on the order of 2,000 km/sec, which is typical of Wolf Rayet winds. The WR fast-wind interacts with the slower Red Giant wind and sweeps up an accelerating shell, resulting in instabilities and fragments, producing dense knots and filaments. Later on the shock becomes more concentrated in the polar regions of the star where the surrounding density is lower providing a convenient conduit for the wind. In NGC6888 an ellipsoidal filamentary shell is seen at optical wavelengths, but in the X-ray, two lobes are present in opposite zones along the major axis. The nebula is an oblong clumpy shell of emission surrounding a Wolf Rayet, WN6 (Nitrogen) star. The nebula is ~15′ long at the major axis and is located at a distance of about 5,000 light years (1.5 kpc). It is 1.9 million years old and is expanding with a velocity of 85 km/sec. The interaction of the fast wind with the surrounding interstellar medium produces large amounts of hot X-ray emitting gas. The WN6 star is completely surrounded by a cocoon of molecular gas, and the expanding shell is especially prominent in Hα, [NII] and [OIII] emissions. The [OIII] skin appears to consist primarily of wind driven shocks. IRAS images reveal the presence of a larger outer elliptical shell 1.7° x 1.4° in size and not surprisingly, this bubble has a cooler dust temperature than NGC6888. This outer shell has a diameter of 6.2 light years (1.9 pc) that was created in the O-star phase of the Wolf Rayet star, WR 136 (HD 192163). It is thought that a massive O-type star of over 40 Solar Masses evolved through a luminous blue variable phase before becoming the Wolf Rayet star WR 136 that we see today. The nebula responds very well to UHC filters in smaller telescopes and OIII filters in larger ones.

Observation, NGC6888 Visual – 20 inch F/5 Telescope: In a telescope NGC6888 looks pretty much like the photograph. It is oblong in shape and may be seen with or without a nebula filter, but is best seen with a filter in place. Three bright stars of differing luminosities are embedded within the nebula and the brightest star is the illuminating objet. NGC6888 is observable in almost any aperture telescope, but in larger aperture instruments with a nebula filter in place, it becomes a beautiful object, that must be seen.



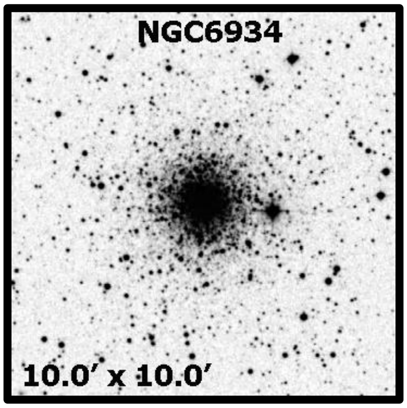
IC 4996, Open Cluster

Other:	**MWSC 3297, OCL 158**
J2000:	**20 16 32.0 + 37 38 40**
Class:	**O.C.**
Const.:	**Cygnus**
Diameter Overall:	**26.4‵**
Diameter, Actual:	**34.8 LYrs**
No. Cluster Stars:	**365**
V-magnitude:	**7.3**
V-Brightest Star:	**10.6**
Trumpler Class:	**II 3 p n**
Distance:	**5,751 LYrs**
Age:	**8.0 - 14.1 million years**

IC4996 Is a very young open cluster located in the Cygnus formation arm and 130 light years (40 pc) above the plane of the Galaxy. Its reddening is a modest 0.673 magnitude and its distance has been listed in various places as 5,646 – 7,817 light years. IC4996 contains 365 stars within an angular diameter of 26.4 arcminutes on the sky. 11 core stars have been identified in an extremely compact central region. Accurate proper motions of stars here are impossible to determine due to the crowding of stars. Four variable stars are known to exist in the cluster. One is probably an RR Lyra type with a period of 0.236 day and amplitude of 0.12 mag. in an infrared filter. The second variable is an eclipsing system with a period of 1.499458 day, and the period of the 3rd star has not been determined yet. The fourth star is V454 Cyg, an eclipsing binary with a period of 2.31689 days. IC4996 contains many massive spectral Type-B stars, and the age of the cluster has been estimated at a young 7.35 to 14 million years. As further proof of the clusters youth, there are Pre Main sequence (PMS) stars still forming within this cluster covering a range in spectral types from A4 to early G. These stars are located at 0.5 and 1 magnitude above the main sequence. Several have been identified as Herbig emission line stars of spectral Type AB and T Tauri Stars which cover the spectrum from Type F to K stars. For determining the temperature of Type O, A, and F spectral type stars, the width of the Calcium (Ca) II K line, 3933 Å is a good indicator. Type B stars are not included as Ca II K line is weak at these spectral types. Medium resolution spectra in the wavelength ranges 3700 – 4800 Å and 6000 - 7100 Å was taken for 16 stars in the field of IC4996 (Delgado et al, 1999). The main conclusions were: A heliocentric radial velocity of -12 ± 5 km s^{-1} was obtained which agrees with other young clusters in the Cygnus star forming complex. Ten stars were found to be cluster members from the radial analysis results. An early

Type G member is a weak lined T Tauri star, based upon photometric properties and the strong Li I λ6708 absorption. An IRAS map of the region shows the presence of a large dusty shell around the open cluster.

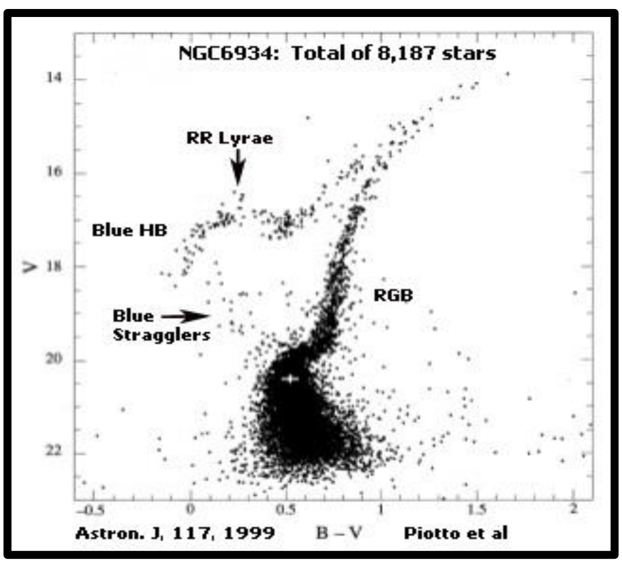
Observation, Visual – 20 inch F/5 Telescope: This is a very Nice and Bright Open cluster – Visual Eye Candy. The brightest star is near the center at 8.0 V-mag. with a slightly fainter but still bright star next to it. A group of somewhat brighter stars near the core form a crooked chain of 8 stars and this dominates the cluster. The overall shape of the cluster is elongated and 21 stars were counted down to the limit of visibility. This is a bright and easy visual object



NGC6934, Globular Cluster

Other: GCI 117, MWSC 3369
J2000: 320 34 11.6 + 07 24 15
Const.: Delphinus
Mag. 9.75
Mag. V(tip): 13.8
Mag V(HB): 17.1
Size: 7.1′
Radial Velocity: -411.4 km/sec

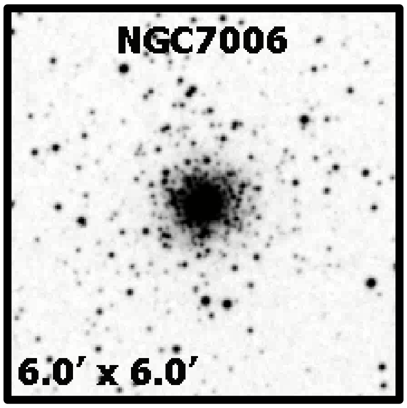
NGC6934 is a halo globular cluster that is in a retrograde orbit around the Milky Way and shares orbital parameters with another cluster, NGC7089 (M2). Isochrone fittings yeild an ancient age for NGC6934 of 13 billion years (as of 1999). Some believe globular clusters in retrograde orbits are extragalactic objects which have been captured by the Milky Way. NGC6934 is one of several globular clusters which have extended tidal tails of co-moving stars as determined by statistical star counts. Studying the extended tidal tails of globular clusters yields important discoveries about the nature of the galactic halo, the disruption rates of the clusters, the orbits of the clusters and the merging of extragalactic objects. The evaporation rate of the cluster and the percentage of former cluster stars which are now in the general Milky Way field are also obtained. NGC6934 is an exceptional candidate for a survey to probe the existence of such tails, because it has a line-of-sight velocity of -411.4 km per second, implying it is moving directly towards the Earth. This is far different from the average halo globular cluster movement. This is importqant because any field stars found in the vacinity of NGC6934 with the same line of sight velocity as NGC6934 are very likely to be members of a co-moving population. The tail extends out to one degree along a northwest tidal extension. Within the tail median range spectroscopy of 1.4Å was sufficient to determine radial velocities to within $\pm$ 10 km per second, and at this radial velocity resolution 303 former stellar members of NGC6934 have been found out to ∼ Vmag. 19.5.



85 variable stars have been found within NGC6934. 29 of these are RR Lyrae stars, two are eclipsing binaries of W Uma type, one SX Phe star and three variables of other types. The SX Phe variable most likely belongs to a group of blue straggler stars, and the eclipsing binaries are probably unrelated foreground stars. The large number of RR Lyrae stars are thought to be typical of most globular clusters, which means that many prior studies for RR Lyrae stars have been incomplete, possibly up to 30% incomplete. The RR Lyrae stars in NGC6934 have a mean mass of M = 0.63M⊙, an effective temperature of 7,300K and a metallicity [Fe/H] = -1.53. They are found in the instability strip on the CMD, and extend both bellow and above the horizontal branch spanning over one V-magnitude. NGC6934 also has a prominent grouping for Blue Straggler stars which range from about 18th to 20th V-magnitude and have a range of color. The horizontal branch of NGC6934 has a mixture of both red and blue horizontal branch stars.

The Hubble Space Telescope/Wide Field Camera 2 imaged NGC6934 and analyzed 8,187 stars within the cluster. It was found that reddening E(B-V) = 0.05 $\pm$ 0.02 with the average stellar Vmag.= 16.37 $\pm$ 0.2. A well-defined sequence of blue straggler stars was noted. These are thought to be former binary stars that have merged into one massive star, giving the false impression they are young objects, when in reality they are not. Many of the known extragalactic captured globulars clusters are on average younger than their Milky Way birthed counterparts, but even though NGC6934 is possibly a captured object, it also is an aged object.

Observation – 10" f/5 Telescope: A very nice visual globular cluster, bright and easily seen, with a very definite brightening towards the central region. Some mottling was seen at higher powers, so some of the brighter stars are just beginning to be resolved in a ten inch telescope. The bright central region is large and the edges seem to fall off rapidly in brightness.



NGC7006, Globular Cluster

Other: GCI 119, GCRV 13202, MWSC 3446, Caldwell 42
J2000: 21 01 29.5 + 16 11 15
Const.: Delphinus
Mag. V10.46
Mag. V(tip): 15.6
Mag V(HB): 18.8
Size: 3.6′
Radial velocity: +215

NGC7006 is a small globular cluster discovered by William Herschel on August 21, 1784 and is located in the constellation of Delphinus. It is possibly the most distant globular cluster, with the exception of NGC2419, in that it is located 137,000 light years away. This places it a whopping 5 times the distance between the Sun and the center of the Galaxy. This is almost as far away as the Magellanic Clouds are from the Solar System. It is also possible that NGC7006 and NGC2419 are the most distant members of the Milky Way Galaxy. Its actual diameter at 110 light years is only slightly smaller than M13 but it is 5 time farther out. Despite its great distance, at V-mag. 10.46 it is easily visible in small telescopes down to about 6 inches in diameter, but it is difficult to resolve into individual stars due to its distance. The luminosity of the cluster is about 130,000 times that of the Sun and it is estimated to contain 259,000 stars. NGC7006 is located in the halo of the Galaxy and is useful in studies to determine how stars formed and assembled within the halo of the Galaxy. Eccentricities in its orbit plus its great distance, hint that it may have formed elsewhere, possibly in a small external galaxy, similar to the Fornax dSph galaxy, which was subsequently captured by the Milky Way. NGC5466, NGC6934, Palomar 13 and NGC7006 all have orbits that are highly eccentric and possess various inclinations to the galactic plane and all are thought to be extragalactic origin objects.

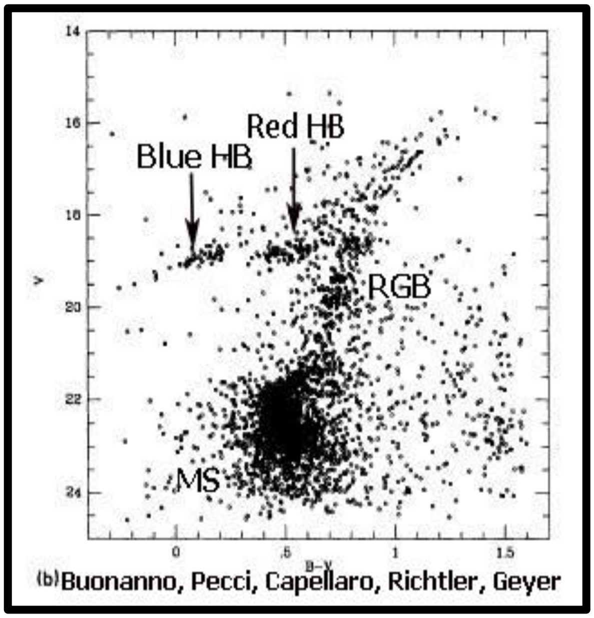
NGC7006 is well known for its variable stars and contains 76 known variable stars, most of which are RR Lyrae variables. RR Lyrae stars are periodic variable stars commonly found in globular clusters. They are pulsating horizontal branch stars of spectral classification A or F and have a mass about half that of the Sun, and are metal poor objects. Before shedding their mass on the Red Giant Branch they were about as massive or the Sun or slightly less so at about 0.8 solar masses.

The horizontal branch of NGC7006 is too red for its metallicity, [Fe/H] ∼-1.6 dex, and NGC7006 is a prominent example of the "Second Parameter Effect". The Vogt-Russell theorem states that the initial condition of a star defines it subsequent evolution. All Milky Way globular clusters have ages in excess of 10 billion years which means that only low mass stars of M < 0.9MΘ are present on the Main Sequence. The post main sequence stars have about the same initial mass for a given metallicity at their turn-off point and are expected to evolve in the same way. However this is not what is observed.

1. Often globular cluster stars with the same [Fe/H] abundance have very different abundances in light elements, such as C, N, O, Na, and Al on the Red Giant Branch. This hints that other processes govern their evolution.
2. The assumption that the same initial conditions actually exists on the main sequence may be invalid
3. Milky Way globular cluster stars of the same metallicity show very different morphologies on the Horizontal Branch - the "second parameter effect"

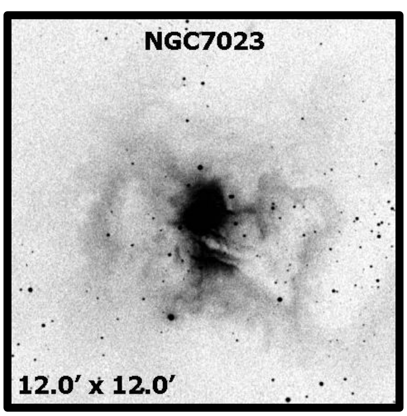
Therefore additional parameters ae required for an accurate description of post main sequence stellar evolution. In the Milky Way there is a general relationship between Horizontal Branch morphology and metallicity. On average, metal poor stars in globular clusters tend to produce Horizontal Branch stars with high temperatures resulting in Blue Horizontal Branch stars. Metal rich globular clusters form cooler red horizontal branch stars. However other unknown parameters affect stellar evolution because globular clusters do not always obey this general rule. NGC7006 is an example as it has an excessive red horizontal branch with a low metallicity. The reason for this is unclear, and age, Helium abundances, CNO abundances and stellar rotation which could induce stellar mixing have all been presented as possible reasons. These are all factors which change the mass of the stellar envelope when ascending the red giant branch, undergoing the Helium flash, if massive enough, and progressing along the horizontal branch. Below is a CMD for NGC7006 showing a lot of field contamination stars, but also a pronounced red horizontal branch which should be diminished for a cluster as metal deficient as NGC7006.

Age is the leading candidate for cause as younger globular clusters would produce a redder horizontal branch than older GCs of the same metallicity. Age differences might be able to reproduce the differences in HB morphologies. For example, the pair NGC288 and NGC362 both have the same metallicity, [Fe/H]= -1.2 dex but NGC288 is 2 billion years older than NGC362. The clusters M3 and M13 both have a metallicity of [Fe/H]= -1.6 dex yet M13 is 1.7 billion year older. Unfortunately no reliable age of NGC7006 exists due to its large distance, and only the tip of the red giant branch has been studied spectroscopically. Increased CNO abundances will lead to redder horizontal branches, but an overabundance of CNO has not been found in NGC7006, implying it is composed of lower mass stars. Increased rotation rates on the red giant branch would delay the helium flash which would cause larger core masses resulting in hotter stars, placing them on the blue horizontal branch. Increased rotation would also cause a lower surface gravity which would produce smaller stellar envelopes, also producing bluer HB stars. Conversely slower rotating stars would have less mass loss and would therefore end up as red horizontal branch stars. However, recent studies of M13 and M15 (Behr et al. 2000; Behr et al. 2000) found just the opposite situation where the red horizontal branch stars had the higher rotational speeds than the blue HB stars. Therefore even though NGC7006 represents an extreme example of the Second Parameter Effect, the confusion as to the true causes are still illusive



NGC7006 CMD, Astron J. vol 102, 1991

Observation – 10" f/5 Telescope: A very nice visual globular cluster, round in overall shape and with a small brighter nucleus, although the central brightening is not obvious – more like a gradual brightening towards the center. Could not see any individual stars or see any mottling.

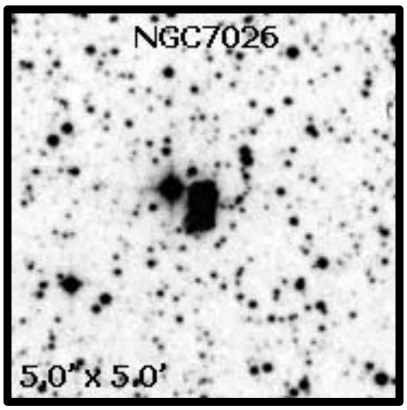


NGC7023, Reflection Nebula

Other: "Iris Nebula", VDB 487, LBN 487, OCI 235, C 2059+679
J2000: 21 01 36.0 + 68 10 00
Const.: Cepheus
Mag.: 7.20b
Size: 14.0'

NGC7023, is also known as the "Iris Nebula" and is a well-studied and bright reflection nebula in Cepheus. Even though NGC7023 is a nearly object, the reported distance has varied significantly from 1,050 to 1,700 $\pm$ 600 light years depending upon the analysts and how the distance was measured. The nebula itself is irradiated by the triple binary star system HD 200775 which consists of two Herbig Be stars with effective temperatures of approximately 19,000K and a third companion star which has received little attention from analysts. The stars are immersed in a cavity which is filled with a low density atomic gas, $\sim$100 cm^{-3}, within the molecular cloud. This cavity is biconal in shape, which is a fancy way of saying butterfly or bipolar shaped, and overall the dimensions are about 5.0 x 2.5 light years. The stars illuminate the walls of the cavity and we see the reflected light in an almost edge-on orientation. At the edge of the cavity, three main Photo Dissociation Regions or PDRs are present. The brightest PDR is located 45" to the northwest of the binary star, and is oriented almost edge on from our perspective. Four Young Stellar Objects (YSOs) or infant stars are found in this area. Other PDRs are located ∼55" to the southwest and ∼155" east of this star. The northwest and the southwest PDRs have similar excitation conditions and contain filaments with a higher average density of 1 million particles per cm^3, while the region between the filaments has a lower density of only 10,000 particles per cm^3. Therefore the interstellar matter is dense within the cavity wall and the star illuminates this matter, forming the reflection nebula that we see. This information was obtained via the Spitzer Infrared Spectrograph.

Gas and dust temperatures are higher close to the star and decrease with increasing temperature from the star, as expected. In general gas temperatures will be larger than dust temperatures at the edge of the PDRs while their temperatures are similar inside the PDRs. Dust temperatures tend to range from 20 – 110K while the gas temperatures are 30 – 50K. Aromatic Infrared Bands (AIBs) are prominent emission bands that are emitted by UV-irradiated interstellar matter such as that found in NGC7023. The strongest AIBs are observed at 3.3, 6.2, 7.7, 8.6, 11.2 µm and these features are produced by a specific class of molecules called Polycyclic Aromatic Hydrocarbons or PAHs as is commonly seen in the literature. PAHs are heated by Ultraviolet radiation and become highly excited, and when the excitation becomes relaxed, they emit photons in the Aromatic Infrared Bands (AIBs). These AIBs reflect the amount of interstellar carbon present, which can be as great as 20%, along with other local physical and chemical evolutionary conditions within the molecular cloud.



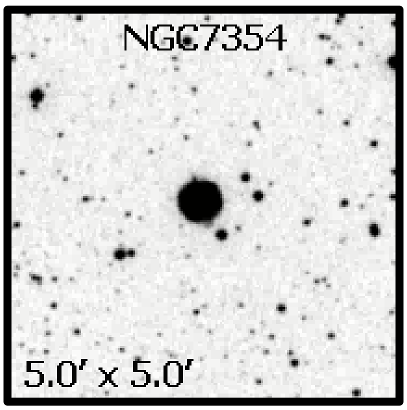
NGC7026, Planetary Nebula

Other: PK 89 + 0.1, PNG 89.0 + 0.3, HD 201192
J2000: 21 06 18.5 + 47 51 08
Const. Cygnus
Mag.: 15.1v, 12.7p
Mag. Central Star: 14.2
Temp. Central Star: 130,000K

NGC7026 is a well studied and complex bipolar planetary nebula located at an estimated distance of 6,800 ± 1,350 light years. The central star is a Wolf Rayet star with strong carbon emission lines (WC3) with a V magnitude of 14.2. The estimated temperature of this star is a very hot 80,000 to 130,000K, with a luminosity 2,100 time that of the Sun. The terminal wind velocity is 3,500 km s^{-1} so this is a highly energetic object. The core mass of the star is 0.56 solar and it is estimated the parent star would have had a mass just over 1.1 times that of the sun. The equatorial toroid is expanding, as are the polar lobes, and the nebula is strongly ionized which represents a moderately evolved planetary nebula. There are four separate outflows of material and a central spherical shell of material. The bipolar structure is still in the early stages of formation. X-ray observations which are confined to the bipolar lobes reveal a plasma temperature of 1.1 million degrees K. As with many planetaries, shock heated gas is produced when the fast wind collides or plows into the dense slow moving wind produced when the star was in the Asymptotic Giant Branch (AGB) stage. HST images of the lobes reveal them to be composed of multiple filamentary loops with cometary knots which are distributed along the inner edges of the lobes and pointing toward the central star. There are also emission knots which are located beyond the lobes. A total of eight knots, are found, four to the south and four knots to the north of the nebula and these reach space velocities of 180 km s^{-1}. It is interesting that these knots lie symmetrically around the central star and consists of four pairs of knots. These knots seem to be high-speed parcels of gas (Ansae or fliers) that were related to the early stages of formation of the poly-polar structure. The knots appear to emanate from the lobes and follow different paths along the conical surface. The main symmetry of NGC7026 is nearly north-south and the northern lobe is slightly more compact and reaches a distance of 27" away from the central star. The northern lobe points away from the Earth, while the southern lobe is tilted this way. However the lobes appear to be split into four major sections, northwest, southwest, northeast, and southeast. There is a gap in the southeast lobe where there is a sharp termination of the X-ray emission, which represents a quick cooling of the hot shocked gas. This southeast lobe is open ended and blown out. The inner region of NGC7026 appears as a tight waist, but the equator is actually expanding rapidly at 57.3 km s^{-1}, nearly one-third as fast as the lobes. The main symmetry axis is tilted 15° to the plane of the sky and the main axis is expanding at a rate of ∼150 km s^{-1}. At this speed and given the mean size of the lobes at 25" the approximate expansion age for NGC7026 is only 1,540 years. The knots and lobes open out from the main axis and each of them presents a different tilt angle.

NGC 7026 is actually a poly-polar nebula, consisting of three entangled bipolar lobes, a fast-expanding equatorial waist, diffuse material outside the waist, and four pairs of high-speed knots of emission. NGC7026 has developed in the recent past the high wind speeds and ionization structures which lead to the complicated shapes, shocks, cometary knots and filamentary lobes. Assuming the lobes are full of material, on average each lobe would contain approximately 0.13 solar masses of material. For this amount of gas outflowing at velocities of 150 km s^{-1} for 1,540 years, a gas kinetic energy of 6.4 × 10^{35} erg s^{-1} is required, a huge amount of energy. This may be overestimated as we are assuming a completely filled volume for the lobes, but it still shows the central star has sufficient power in its outward stellar winds to drive the observed expansion pattern.

Observation – 10" f/5 Telescope: Appears round and diffuse, grey in color and uniform even brightness. Easily seen and located near a fairly bright star. In larger telescope, 20", the planetary appears elongated with two elongated lobes separated by a darkness between them, looking like a hamburger seen edge on. Responds well to nebula filters. A very nice visual Planetary Nebula.



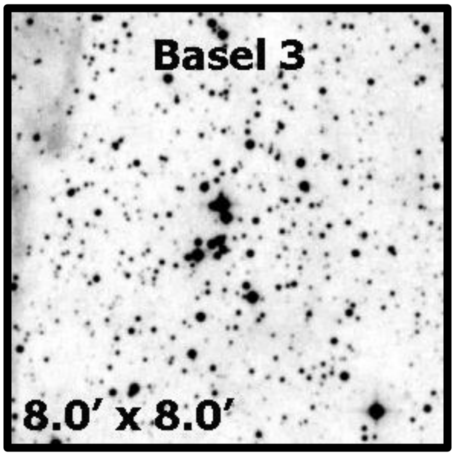
NGC7354, Planetary Nebula

Other: PK 107+2.1, PNG 107.8+2.3, IRAS 22384+6101
J2000: 22 40 20.2 + 61 17 06
Const.: Cepheus
Mag.: 12.9p, 8.6r
Mag. Central Star: 16.2
Radial Velocity: -42.5

The Planetary Nebula NGC7354 consists of a thin bright outer shell, an inner shell with two polar caps, two spike-like tails close to the north and south of the nebula, and low-excitation bright knots that are projected on the equatorial plane. As with all planetary nebulae these structures are carved out by the rapid outflow from what is left of the central star. The outer shell is approximately 33" x 29", nearly circular, and it looks like a round envelope in high contrast images. However it appears as a faintly cylindrical structure in lower contrast images with a position angle (PA) of ～15°. It is brighter in Hα light, which is slightly more energetic than in [NII] light, but several bright knots are seen at the edge of the [NII] image that are not seen in Hα. The outer shell, as expected is the oldest part of the structure at about 2,500 years. This, and all outward velocities below, assumes a steady outward expansion of 60 km s^{-1}. This is probably unrealistic as initial velocities would be expected to be greater. The inner shell has an elliptical shape and its major axis is oriented in PA ～30° with the major and minor axis 21' x 16' in size. It is noticeably fainter in [NII] than in Hα, and is the next oldest structure in the nebula at approximately 1,600 years. The northern knot (seen in the photo abpve) extends 7" while the southern knot extends outward 11" and is narrower than the northern component. HST images of NGC7354 reveal these knots to be jet like features appearing as cometary tails with a bright knot facing the central star and fainter tails pointing outward. These knots formed at the same time as the inner elliptical shell, around 1,600 years ago. Bright equatorial knots are resolved into a series of smaller knots and filaments embedded in diffuse emission. The equatorial knots are denser and contain more dust than the rest of the nebula. Electron density in the central region is ～2,400 cm^{-3} and it decreases to ～1,000 cm^{-3} at the outer shell. The electron temperatures decrease only slightly from ～15,000K at the center of the inner shell to ～13,000K at the walls of the outer shell as expected. Spectra indicate that the inner shjell is expanding with a velocity which is smaller than that of the outer shell. This is somewhat unusual as normally material toward the center of planetary nebulae is ejected at a faster rate. Most of the equatorial knots are moving at velocities that are similar to the outer shell, while the velocities of the two jets are relatively small, which is puzzling.

Binary star models have successfully explained planetary nebula equatorial density enhancements, and the accretion disks in these binary systems account for the narrow waist bipolar appearance, and even the jets that are sometimes seen. Details vary but all models indicate a jet is launched by the central star or its companion. At first glance it would appear the circular shape of the planetary, NGC7354, would indicate a single star in the center is illuminating the halo and the inner and outer halo shape would support a single central star. However, a single star cannot explain why the inner and outer haloes have different PA's, as this would indicate the direction of the ejection has varied with time. As of now there is no evidence that NGC7354 houses a binary star, but this irregularity in the shells seems to indicate the presence of a binary system. It has been proposed that as the envelope was ejected, the binary became closer and mass transfer began creating an accretion disk. A jet arises from the accretion disk which explains the two jet-like features seen in NGC7354. An expanding dense ring in the equatorial plane would explain the equatorial bright knots. Precessing of the binary system would explain the different PAs on the sky of the inner and outer ring. Therefore, even though we have not discovered a companion to the central star, the morphology of NGC7354 seems to indicate binarity.

Observation – 10" f/5 Telescope: Round in shape and faint, with an even brightness throughout and no central star seen.



Basel 3, Open Cluster

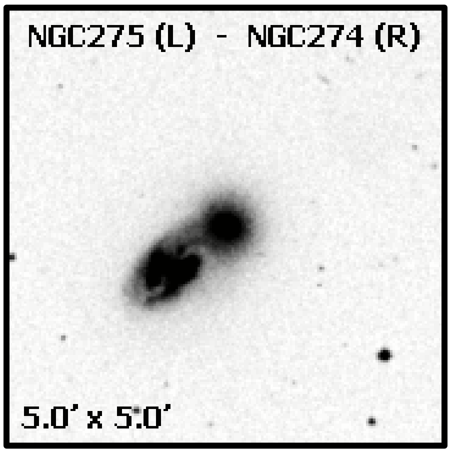
Other:	**Mark 50, Biurakan 3, MWSC 3712**
J2000:	**23 15 15.1 + 60 26 02**
Class:	**O.C.**
Const.:	**Cepheus**
Diameter, Overall:	**9.0′**
Diameter Actual:	**12.0 light years**
No. Cluster Stars:	**59**
V-magnitude:	**8.5**
V-Brightest Star:	**9.8**
Trumpler Class:	**III 1 p n**
Distance:	**7,498 light years**
Age:	**12.6 million years**

Basel 3 is located inside a faint HII nebula complex, Sharpless 157 (SG13), which is a large shell like structure 27 arc minutes in diameter. Basel 3 is only 28′ arc minutes to the east of NGC7510, a rich open cluster. The nebula cloud is illuminated by the brightest stars of Basel 3 and also by the surrounding stellar association Cas OB2. In 1986 Lozinskaya et al proposed an interesting cascade formation scenario in which the Cas OB2 association condensations formed the open clusters NGC7510 (10,400 light years distant) and Basel 3/Markarian 50 (7,500 light years distant) which then formed in the HII region Sh 2-157A. In 1951 Beniemin Markarian, of the Biurakan Observatory in Armenia, noticed the bright star, HD219460, was surrounded by a small and compact grouping of stellar objects. Later on Grubissich in 1965 conducted photographic UBV photometry of 60 stars around HD219460 and determined a distance of 7,330 light years (2.25 kpc) for the cluster. He named the grouping Basel 3, for the Astronomical Observatory of the University of Basel, Switzerland's oldest university, founded in 1460. Basel 3/Mrk 50 is small and poorly populated and located on the inner part of the Perseus arm, with distance measurements ranging from 6,900 to 11,275 light years from the Sun. Its Trumpler classification is III 1 p (very strong concentration; most stars of nearly the same brightness; poorly populated). The core region has an angular diameter of 4.8 arc minutes, which at its distance is almost 6 light years (1.8 pc), and the overall diameter of the cluster is 9 arc minutes or nearly 12 light years (3.6 pc). It is a very young open cluster with an age of only 12.6 million years. As with many open clusters, the outer corona is richer in faint less, massive stars than the central region. In a cluster as young as Basel 3/Mrk 50 this can only be the result of a mass segregation of primordial stars, with the denser members settling toward the center. Gosta Lynga of the Lund Observatory in Sweden recognized only 5 stars as cluster members in his Catalog of Open Clusters published in 1987. However even a casual look at photographs of the cluster show at least ten or more members with the brighter stars forming a crescent shape. The cluster is visually bright with an overall V-magnitude of 8.5.

Most of the information printed about Basel 3/Markarian 50 concerns the visually brightest star in the cluster. This star, HD219460, is considered a true cluster member, with a V-mag. of 9.8, and it is located near the center of the cluster. It is a Wolf Rayet star (WR 157) and its emission may be the source of the surrounding nebula, Sh-157. In 1940 it was also found to be a close binary star of 1 arc-second separation with nearly equal magnitudes. The period of the binary is uncertain and ranges from 1.786 to 2.032 days. Van der Hucht's 2001 Catalog of Wolf Rayet stars classifies the system as WN5 + BIII VB with an absolute magnitude of Mv = -4.07 for the WR star and Mv = -5.67 for the binary system. The Wolf Rayet star has undergone a high rate of mass loss from its original 30 solar mass size, which initially would have made it the most massive star in the cluster. The Wolf-Rayet half of the binary, by itself, is actually the fourth brightest star in the cluster while its companion, plus two other stars, of luminosity class III are more luminous. The luminosity of the WR star indicates that it has evolved off the Main Sequence and is close to the Giant phase of its evolution. The companion star has been classified both as a B0 III-V star and a B1 II star, due to spectroscopic and photometric uncertainties due to the closeness of the two stars. Modern analysis has shown it is slightly brighter than the WR star by 0.14 magnitudes.

Basel 3 Observation - 36" telescope: A beautiful open cluster with two 10th magnitude stars standing out as the brightest. These stars are followed in brightness by 3 slightly fainter members at 11 and 12th magnitude. A total of 9 stars were counted as being members, and the cluster stands out well from the background. These nine stars may be just part of a much larger object as an apparent clustering of fainter stars extends out about 3 arc minutes to the south of these 9 stars, and may or may not be part of this cluster. These stars range from 12.5 to 16.0 magnitude and were not visually noted as being cluster members.

NGC274 – NGC275, Interacting Galaxies



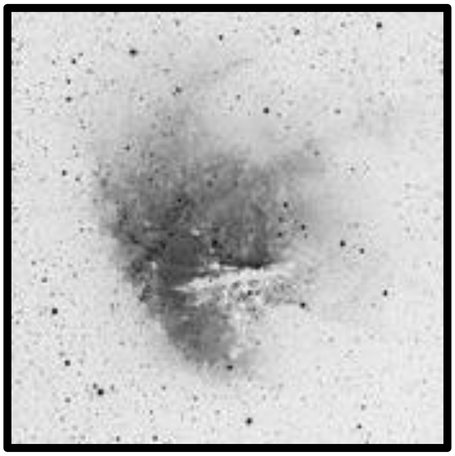
Other: NGC274 - Arp 140, MCG -1-3-21, PGC 2980
MGC275 – MCG-1-3-22, IRAS 485-720, PGC 2984
J2000 NGC274: 00 51 01.8 – 07 03 22
NGC275: 00 51 04.4 – 07 03 56
Const.: Cetus
Mag. NGC274 - 12.8p
NGC275 - 13.2p
Size: NGC274 - 1.5' x 1.4'
NGC275 – 1.5' x 1.0'
Class - NGC274: E/SO D
NGC275: SB(rs)cd pec
Distance: NGC274 – 83.0 million light years
NGC275 – 83.1 million light years

Atomic gas observations of NGC275 (Left in photo) reveal a tidal tail approximately 3.6 arc-minutes long which extends many radii beyond the interacting pair. The HI morphology shows a prograde (Both rotating in the same direction) close encounter between the galaxy pair approximately 150 million years ago. The Hα emission from NGC275 indicates a clumpy irregular star formation, but neither the molecular gas or the star formation is centrally concentrated. NGC275 is close to a merger with NGC274 but it does not show enhanced centrally concentrated star formation due to gas inflow, as would be expected with such an encounter. If the eventual merger is to lead to a significant burst of star formation it must be preceded by a significant conversion of atomic to molecular gas, but at the current rate of star formation all the molecular gas will be exhausted by the time the merger is complete. Kennecutt e al in 1987 found that star formation in the core region is more sensitive to the effects of galactic interactions than is the disk area. NGC275 is a late type weakly barred spiral galaxy, while the other component of Arp 140, NGC274 is an early type elliptical system which is gas-poor with little evidence of any HI being associated with it. This group represents part of a small sample of spiral – elliptical interacting pairs and the pair of galaxies rotate in a counter-clockwise direction. The star formation in NGC275 as determined by Hα and radio continuum emission is irregular and not centrally concentrated. The total atomic mass for the entire Arp 140 system is $3.8 \pm 0.4 \times 10^9$ MΘ. NGC275 is a barred spiral galaxy and the distribution of molecular gas is clearly bar-like, but the molecular gas present is not strictly aligned with the bar. The bar is indistinct and runs along the minor axis with a rotational velocity of NGC275 at ~175 kms^{-1}. Based upon the extent of the tidal tail and the velocity of the gas within the system the two galaxies have been interacting for approximately 150 million years. It is possible that the Hα emission and the molecular gas we now see are the products of an episode of star formation which began around perigalacticon, also about 150 million years ago. The distribution of molecular gas is unusual in that neither the molecular gas distribution nor the recent star formation is centrally located, although there is one star cluster within the nucleus, so a small amount of star formation is happening there. The star formation is patchy and extends outward, although there is no indication of a spiral structure.

One of the semi-unique features of the Arp 140 pair is that only one of the galaxies is a late-type gas rich object. This characteristic distinguishes it from the interacting systems which constitute the Ultra Luminous Infrared Galaxy population (ULIRG), which are believed to result from the merger of two gas rich disks of unequal masses. The brightest emission from the molecular gas and star formation tracers such as Hα regions, are not found in the central location, but rather are offset to the north-west. NGC275 is presently undergoing star formation in a random like manner which is driven by small scale events instead of large-scale dynamical processes. The star formation which was enhanced by the interaction of the two galaxies is likely to have contributed to the depletion of the molecular gas in certain specific regions of the galaxy. The angular separation of the pair is 44 arc-seconds which equates to a small projected linear separation of around 25,000 light years.

Observation: Lauren Herrington, 17 years old, 12 in. telescope

NGC274 and NGC275 are clearly seen as two distinct objects. From a drawing: NGC274 was seen as a round object and the brighter of the two while NGC275 appears slightly elongated.



NGC281, Emission Nebula

Other: Sh2-184, LBN 616
J2000: 00 53 00.0 + 56 38 00
Const. Cassiopeia, Pacman Nebula
Diameter: 28.0′ x 21.0′

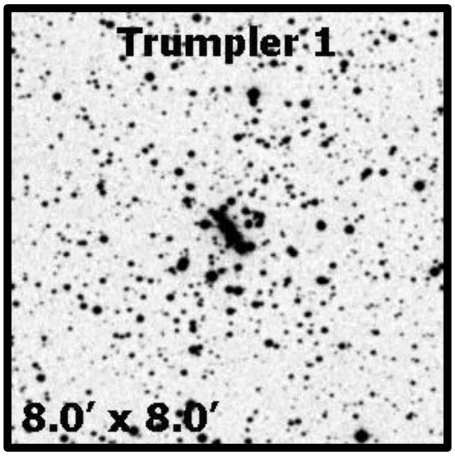
NGC281 is a bright emission nebula in Cassiopeia that was discovered by E.E. Barnard in 1881 with his 5 inch refractor. It is located at a high galactic latitude, 1,000 light years above the Galactic disk, so visually it suffers little from extinction. It is located on the far side of the Perseus spiral arm. NGC281 is surrounded by an extensive HI cloud which is approximately twice as large as the nebula and several dark Bok globules of star formation are seen in front of the cloud. NGC281, the nebula, has a centrally located open cluster, IC1590, discovered later by Guillaume Bigourdan using a 12 inch refractor at the Paris Observatory. The cluster has 63 probable members and is extremely young with an estimated age of only 3.5 million years and with very little evidence for an age spread. The brightest member of IC1590 is an O-type Trapezium like system, HD5005 which is composed of three massive stars of spectral types O6.5V, O8.0V and O9.0V. HD5005 is the principle ionizing source for the cloud and is located in the center of the cluster. IC1590 is an elongated object 5.0 x 20.0 light years in size. NGC281 has been extensively analyzed yet distances vary from 6,500 – 12,000 light years. In 2014 a distance of 9,200 light years was determined by measuring water masers at 22 GHz. The diameter of the nebula is estimated to be a huge 21 light years. The gas and dust material is arranged in a clumpy structure around the central star cluster, consisting of numerous star formation regions.

NGC281 is a typical stellar nursery filled with Young Stellar Objects or YSOs and it offers an excellent laboratory for studying stellar evolution. The majority of the identified YSOs are low mass Pre-Main Sequence (PMS) stars of less than one to two million years of age and masses of 0.5 – 3.5 MΘ. These stars are composed of, Infrared excess stars, X-ray and Hydrogen stars. There are indications that classic T Tauri stars have triggered star formation around the edges of the cluster, IC1590. In stellar evolution there are two modes of star formation that are associated with HII regions, and both are dependent upon the initial density distribution of the molecular cloud. One is called the “cluster mode” which gives birth to open star clusters and forms usually in the centrally condensed massive clouds of the nebula. The other mode is called the “dispersed mode” which forms only loose clusters or aggregates of stars and is thought to form in clumpy scattered clouds within the nebula. Whatever initial star formation scenario takes place, high mass stars formed during the first generation will produce shock fronts from their supernovae and this then will generate the formation of yet a new generation of stars at the edge of the molecular clumps, and NGC281 is full of these clumps. Young Stellar Objects are used to infer the star formation history of NGC 281. The southwestern quadrant of the NGC281 cloud is obscured by an adjoining molecular CO cloud, known as NGC281 West, located in front of it. Ongoing star formation in NGC281 West is indicated by the presence of an H_2O maser emission and Infrared sources within this cloud, which are located near an HII region. Another CO molecular cloud or radio peak, is located in the southeastern quadrant. NGC281 East and West are thought to be part of a 2,000 light year wide HI super-bubble, the origin of which were multiple supernovae. These supernovae create strong stellar winds originating from OB associations and blow the surrounding gas into a halo, carving out extensive cavities in the interstellar medium. The super-bubble is slightly elongated along the disk and is expanding at approximately 12 miles s^{-1} both parallel to and perpendicular to the Galactic disk, and all within the last 20 million years.

Maser is an acronym for "Microwave Amplification by Stimulated Emission of Radiation". Masers work the same was as lasers except they emit microwaves instead of visible light. Masers are simply tightly focused microwaves that stay tightly focused over long distances and emit energy in a very narrow spectrum. Large masers or "water fountains" as they are sometimes called are caused by high mass stars that are either forming or dying, and they throw out material including clouds of water that can travel at recorded speed of up to 220 miles per second.

Observation: Amelia Goldberg, 15 in. telescope

Easily seen object and really responds well to an OIII filter. The nebula appears lumpy throughout and large. The Open cluster is easily seen and the main star HD5005 stands out…..Nice!



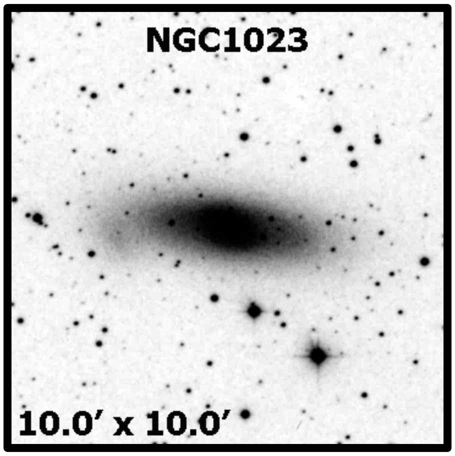
Trumpler 1, Open Cluster

Other: Collinder 15, MWSC 0127
J2000: 01 35 38.4 + 61 16 30
Const.: Cassiopeia
Diameter Overall: 9.6'
Diameter, Actual: 15.3 light years
No. Cluster Stars: 50
V-magnitude: 8.10
V-Brightest Star: 11.3
Trumpler Class: II 2 p
[Fe/H] = -0.71
Distance: 7,821 - 8,400 light years
Age: 12.6 – 27 million years

The brightest star in the central bright chain is STI 237AC a Vmagnitude 9.6 star. A Vmag. 9.97 companion is close by and labelled BD+60 276. Most of the bright stars comprising the central chain of this cluster have never had magnitudes determined however. The cluster is located very near the open cluster Czernik 4. Trumpler 1 is an extremely concentrated open star cluster located within the outer edge of the Perseus spiral arm. The Vmag. of the cluster members range from a bright 8.1 to 19.0. The Color magnitude Diagram (CMD) shows gaps in the main sequence between Vmag. 10.7 and 11.6 and another deficiency of stars between Vmag. 14.0 and 14.8. All studies have shown that these gaps are real, however the cause of these deficiencies is not well understood.

Young clusters like Trumpler 1 provide valuable information about star forming processes. These studies require a knowledge of the cluster distance, age, reddening and stellar content, all of which may be obtained from the Color Magnitude Diagram (CMD). Additionally the distribution of the stellar mass at the time of cluster formation is needed, and this is referred to as the Initial Mass Function or IMF. It is a fossil record enabling us to understand the early evolution of a star cluster and provides a link between the easily observed luminous population and the fainter important low mass stars. Another related problem is the mass segregation of low and high mass stars within star clusters. Trumpler 1 has been used for such studies, as its massive stars are concentrated towards the cluster center as compared with low-mass stars. Trumpler 1 is a dynamically relaxed system and it is quite possible that the low mass stars within the cluster possess the largest random velocities. If so these stars will try to occupy a larger volume of space than the high mass stars. However it is not clear whether the mass segregation is a result of orbital movement (dynamical evolution) or an imprint of the initial star formation process itself. Thus the young open star clusters, like Trumpler 1, are the laboratories in a galaxy which can provide answers to many current questions in astrophysics regarding stellar and cluster evolution.

Trumpler 1 Observation - 36" Telescope : **This is a beautiful visual open cluster which definitely qualifies as a true showpiece object of the heavens. Four very bright stars of approximately 9th magnitude dominate the cluster and form a line of stars northeast – southwest in orientation. The second star down from the most northeast star is a close double star. Four slightly fainter stars were noted. The overall shape of the cluster is round with a total of 15 stars counted as cluster members. It was difficult to tell among the fainter members what was a cluster member and what was not. Trumpler 1 could easily have been included in the Messier listing if only Messier had observed it.**



NGC1023 / NGC1023A, Interacting Galaxy

Other: UGC2154, CGCG 523-83, Arp 135, MCG +6-9-73, VV1039, LEDA10123
J2000, NGC1023: 04 40 24.1 + 39 03 46
Const.: Perseus
Mag., NGC1023: 9.35V, 10.35B
Mag., NGC1023A: 14.5B
Size, NGC1023: 8.7′ x 2.3′
Size NGC1023A: 1.5′ x 1.0′
Class, NGC1023: SB(rs)0
Class, NGC1023A: 1B ?
Radial Velocity, NGC1023: +601
Radial Velocity. NGC1023A +742
Distance, NGC1023: 30.0 – 37.0 million light years (H_o=70)
Distance, NGC1023A: 29.0 - 34.6 light years (H_o=70)

NGC1023 is a member of the Local Supercluster of Galaxies and is an intermediate barred lenticular galaxy. Lenticular's are also known as SO galaxies. It is a nearby object with distances variously posted from 30.0 to 64 million light years, making it an ideal SO galaxy for study. NGC1023 is the brightest in a group of 13 galaxies and has a companion NGC1023A near the eastern edge of the disk at a similar distance of 29 million light years. These systems are closely interacting or even in the act of merging, but it is thought that the companion is too small to cause a significant disruption of the main galaxy, even if the companion is dark matter dominated. NGC1023 is thought to harbor a supermassive black hole in the center with a mass of 40.4 $\pm$ 0.5 million MΘ.

Lenticular galaxies are a cross between spiral galaxies and elliptical galaxies and contain elements of both, with a large irregular shaped central region along with the remnant of a disk structure. Like ellipticals they are largely devoid of gas so stellar formation has ceased leaving them composed largely of old stars. Lenticular galaxies are fairly common and comprise about 25 per cent of all large galaxies in the Local Universe. In Hubble's tuning fork diagram they exist at the apex between the ellipticals and the spiral galaxies sharing qualities of both types. In the near universe SOs are more prevalent in galaxy clusters than in the general interstellar medium. However for some unknown reason, at higher redshifts (more distant and older objects) the SO fraction in galaxy clusters is smaller, while the corresponding spiral fraction is larger. Therefore S0 galaxies are more common in the present epoch than at higher redshifts which raises the possibility that the distant redshifted clusters could possibly be the progenitors of the lenticular galaxies that are observed in the present day universe. It is not known how this transition to the lenticular condition occurs. One theory says it is possible that SOs form when spiral galaxies simply lose their gas and stop forming stars. On the other hand SOs could form from merger events with objects of equal mass merging to form giant elliptical galaxies, while unequal mass mergers result in a mixed system like SOs with both spheroidal and disk like systems which have lost most of their gas through the merger event. How to differentiate between these two theories is not easy. If lenticulars are simply gas stripped spirals then their outer stellar regions would be only modestly affected by the transition and the outer disk would remain similar to that of its progenitor. Most of the effects would be felt in the central regions, while the outer disk regions would remain the same with rotation dominating over random motions. However, if SO galaxies result from mergers, then the systems would have velocity dispersions in the outer regions dominated by random motions. Planetary nebulae may aid in solving this puzzle. These are old low mass stars at the end of their evolutionary lives and they should be able to trace the bulk of stellar dynamics. They possess strong emission features, particularly in the 5007Å [OIII] line meaning they can be reliably identified and identified over great distances. To explore this theory the Planetary Nebula Spectrograph (PNS), has been constructed and mounted at the 4.2-m William Herschel Telescope. NGC1023 was chosen as the target due to its being one of the nearest large lenticular galaxies at a distance of only ∼30 million light years. 204 planetary nebulae were detected and their line-of-sight velocities were measured within NGC1023 to study rotational properties of the galaxy. For NGC1023 the fading, gas stripped spiral scenario best fits the inner radii of the galaxy where gas is non-existent, and a normal rotational disk is found. However, at large radii the motions undergo a gradual but major transition to random motions with little rotation, thus the fading spiral scenario does not work here. The minor merger scenario fits better with the data at large radii, due to the random motions in the outer disk, but it fails to explain the presence of a rotation dominated disk at small radii. Mergers with smaller satellites increase the velocity dispersions by at most a few tens of km s^{-1} which is in stark contrast with the dispersions in the outer parts of NGC 1023 (≈200 kms^{-1}). Additionally the optical image of the companion, NGC1023A, appears relatively undisturbed which is hard to explain if the interaction were in some way significant. It certainly does not explain why star formation in the inner parts of the galaxy has shut down.

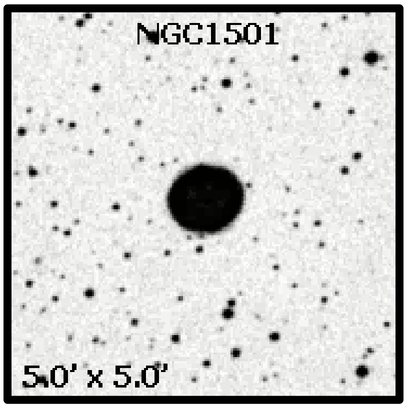
Another possible way of determining the processes leading up the Lenticular stage is to study globular clusters, and NGC1023 as the nearest SO galaxy has proved useful. The past history of a galaxy is best determined in its faint outer regions, which show evidence of minor mergers, traces of accretion or simply fading of material. For early type elliptical galaxies this is difficult due to the absence of an undisturbed HI disk and the low surface brightness of the stars at large radii. This dilemma has been resolved by using globular clusters as tracers which are observable over large distances, out to approximately 325 million light years (100 pc). They tend to be billions of years old and are the best example we have of simple stellar populations. In general metal poor blue globular clusters tend to reside in the older galactic halo while the red globulars are associated with the metal rich stellar population of the galaxy. Studying the properties of globular clusters in Lenticular galaxies help us to understand the formation of these objects. If SO galaxies are merely galaxies that have lost their gas then their globular population should have the same properties as in spiral galaxies, and the total number of globulars would be the same in spirals and SOs. In contrast, violent events such as mergers would alter the initial distribution of globulars in galaxies and their numbers. For the spiral gas fading theory, we would expect to find the red globular clusters around the disk area while the blue globulars are likely to belong to the spheroid. This is the pattern the Hubble Space Telescope observed within NGC1023 which lends support to the gas stripping theory. The majority of the red globulars show disk-like movements, while the majority of the blue globulars are consistent with being in the spheroid. This supports the theory that the nuclear disk is the end result of star formation in metal enriched gas which has piled up in the center of the galaxy. The gas can be internal or external in origin. A recent study of the local universe using HI observations of 148 nearby spiral galaxies found that 22% had at least one detected dwarf gas rich satellite companion. If it is assumed that all satellites will merge in the shortest possible time, transferring all of their gas to the main galaxy, this leads to an estimate of the maximum gas accretion rate of 0.8M⊙ per year. This however is about five times lower than the average star formation rate of these galaxies. This results strongly suggests that minor mergers do not play a significant role in the total gas amount found in local galaxies, which favors the spiral gas dissolving theory. Therefore, as so often happens in astronomy, NGC1023 only adds to the confusion as to how it was transformed into an SO galaxy, raising more questions than answers.

"Faint Fuzzies" (FFs) are actually a new class of star cluster which was first found in the nearby SO galaxy NGC1023 using images from the Hubble Space Telescope in 2000. NGC1023 is host to a large population of low surface brightness objects with large sizes from 45 to 130 light years in diameter. 27 Blue and 81 red objects resembling star clusters were found along with two ultracompact dwarf objects with effective diameters of ～65 light years. The red FFs are somewhat larger and more luminous than the typical Milky Way open cluster. The red clusters within NGC1023 are long lived clusters, possibly old remnant open clusters or globular clusters, and in NGC1023 they are of a high metallicity and are associated with the disk of NGC1023. The red FFs lie in a fast rotating ring like structure which suggests they were not formed during a galactic interaction, but rather formed in place and have remained there since formation. Their movements are indistinguishable from the stellar disk population in NGC1023, along with planetary nebulae and neutral Hydrogen. Half of the blue FFs appear to be associated with the satellite galaxy NGC1023A, while the remainder are associated with the densest HI gas that surrounds NGC1023 in the halo regions. The blue FFs have colors consistent with young star clusters of a few 100 million years that were formed during the most recent interaction between NGC1023 and its companion NGC1023A. It is certainly possible that faint fuzzies may also be common in the disks of late-type spirals but are difficult to detect within a complex, dusty disc. The source of the Faint Fuzzies in Lenticular galaxies is unclear.

The NGC1023 galaxy group is comprised of mostly late type (spirals) galaxies, and there is evidence for two dwarf type galaxy populations. One type is in the halo of NGC1023 and is dominated by dwarf elliptical galaxies while the second population is found within the infall region surrounding NGC1023 that contains mainly dwarf irregular type galaxies. Similar distinctive populations are observed elsewhere in the Local Group. In general in dense clusters like the Virgo and Fornax galaxy clusters, dwarf galaxies are many, but dwarf galaxies are rare in diffuse spiral rich environments like the Ursa Major Cluster. This has been called the "missing satellite problem" and efforts are underway to observe down to very faint magnitudes around the nearby NGC1023. This represents a rich group of low density objects which is thought to be representative of the environments in which most galaxies in the universe reside. Within 2.1°, or 1,200 light years (group distance of 10 kpc) of NGC1023 there are 17 dwarf galaxies, while a massive halo of material surrounds NGC1023. NGC1023 is being studied to determine how much galactic infall of dwarf galaxies might lead to the formation of lenticular galaxies, and these studies are ongoing.

Observation: Lauren Herrington, 17 years old, 12 in. telescope

NCG1023A was an averted vision object that popped in and out of view about ten times - Normally 3 "hits" are considered an observation.

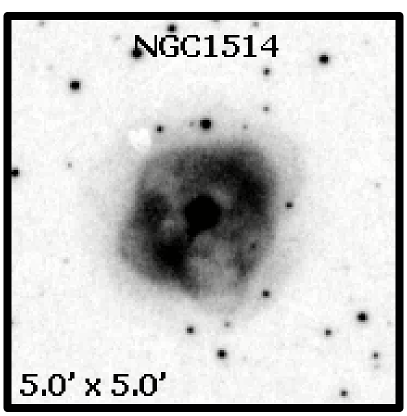


NGC1501, Planetary Nebula

Other: PK 144+6.1, LAN 179, IRAS 04026+6047
J2000: 04 06 59.6 + 60 55 11
Const.: Camelopardalis
Mag. 13.3p
Size: 56.0" x 48.0"
Mag. Central Star: 14.23
Distance: 3,780 – 6,500 light years

NGC1501 is a high excitation densely bound planetary nebula consisting of a mass of irregular condensations and some big holes and bumps over the entire surface, which bears some resemblance to the convolutions of the human brain. The ionized nebular mass is 0.15 ± 0.03 M⊙ and the age of the ionized nebula is only ∼5,000 years. The overall appearance of the nebula is that of a prolate spheroidal (football) shaped object of moderate ellipticity which is deformed by a pair of large lobes along the major and the intermediate axes. It is denser and brighter in the equatorial belt. The single central star is a Wolf Rayet type star (WC4) showing a carbon emission and is another PN with a hydrogen deficient central star. The star is a non-radial g-mode pulsator with periods ranging from 1,154 to 5,200 seconds and pulsation variations of a few percent. The star's temperature has been measured from 80,000K to 135,000K. It is an extremely hot hydrogen deficient O VI type star that has had its hydrogen rich layers ejected in a late thermal pulse, and possibly is a precursor to PG 1159-type stars which are pulsating white hot dwarf stars. The terminal outward wind velocity is 1,800 km per second and the nebula is expanding from 38 to 55 km s^{-1} with the slowest motions occurring in the stellar equatorial densest regions. By combining the Hα and OIII emission lines, an electron temperature of 11,500K and turbulence of 18 km s^{-1} is seen. The peculiar morphology of NGC1501 can be best explained as the results of the fast wind from the WC4 star plowing into the nebular gas and the slow wind of the AGB phase. A small attached halo extends out to 34" from the central star and surrounds the nebula. This halo has a round homogenous appearance suggesting it is photospheric material that was ejected by the star in the late Asymptotic Giant Branch stage (AGB). The halo represents the vestiges of the "superwind" phase which lasted about 5,000 years and generated the nebula. Rather than turning into a bipolar object, it is expected that NGC1501 will keep its ellipsoidal shape and becoming fainter and fainter over time.

Observation – 10" f/5 Telescope: **Bright and easily seen, round in shape. The disk appears evenly lit and is well defined. An occasional glimpse of the central star is seen blinking inside the disk. A UHC filter did not seem to help, only making things darker. NGC1501 is a very nice visual object.**



NGC1514, Planetary Nebula

Other: "Crystal Ball Nebula", PK 165-15.1, VV17, PNG 165.5 5.2, ARO 21
J2000: 04 09 16.9 + 30 46 34
Const.: Taurus
Mag.: 9.48v, 10.0p
Size: 1.9'
Mag. Central Star: 9.4
Radial Velocity: +59.8
Distance: ∼600 light years

In 1790, William Herschel found "a most singular phenomenon, A star of about the 8th magnitude, with a faint luminous atmosphere, of a circular form, and of about 3 arc-minutes in diameter." We now know this object as NGC1514. For Herschel, its central star was inseparable from a "shining Fluid" and this convinced Herschel to reverse himself, as he had previously thought, that all "nebulae" could be resolved into clusters of stars if only he had a large enough telescope to resolve them. He stated we would never know what this 'shining fluid' was made of, and he incorrectly deduced the star was forming out of this 'fluid'. NGC1514 revised many of his previous ideas regarding the structures of the heavens,

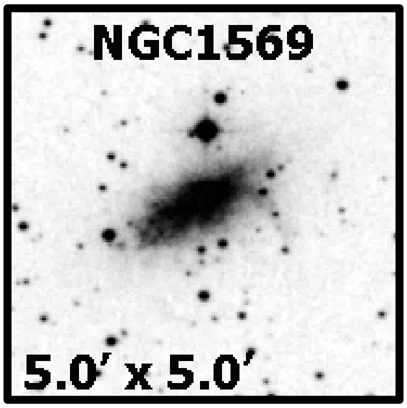
and thus began over 200 years of analyzing this important historical object. Today it is known as a moderately high excitation planetary nebula in Taurus, and is a star near the end of its lifetime. The central star , BD+30-623, appears as a wide binary star with the primary a spectral type A0III star, and is one of the visually brightest central stars in the sky with a Vmag. of 9.5. This however is too late a type star, and therefore not hot enough to produce the observed ionization of the nebula, so the A-type star is now recognized as a post main sequence star with a mass ~3 M⊙ which is currently ascending the red giant branch. The stars temperature is ~9,000K, and this is the star that is seen in telescopes. However, it has an unseen companion which is a sub-luminous dwarf-O star of 60,000K, with a mass of 0.9 ± 0.7 M⊙ and this is the star which produces the observed UV spectrum and illuminates the nebula. The two stars form a true binary system with a 9 year orbital period for the two stars. True binary stars are known to form a significant fraction of approximately 20% of the central stars in planetary nebulae, but there are indications that close binary stars may be found in much higher percentages of planetary nebulae. Bi-polar shaped planetary nebulae are thought to originate from binary systems. It is thought that wide binary stars also affect the shape of the nebulae, but there are so few planetary nebulae with wide binaries that it is difficult to determine their true influence. This makes NGC1514 a valuable laboratory for studying the effects of widely spaced binary stars in shaping their covering nebula.

The nebula has an inner shell or body with a diameter of approximately 136 arc-seconds, and an outer more spherical layer of ~206 arc-seconds. The nebula is highly complex with multiple shells. The outer shell appears elliptical, while the inner region has a more complex structure that has been interpreted as being "composed of numerous small bubbles." The inner shell is a toroid (donut shape) with the axis of symmetry at P.A. of 35 degrees and in 1987 (Chu et al) it was deemed to be a double shelled object with diameters of 132" and 183". In 1997 the inner shell was found to be lumpy and composed of numerous small bubbles. The bubbles at the inner edge of the outer shell are sweeping up the outer shell or halo and providing a pressure confinement situation. In 2003 Muthu & Anandarao found that NGC1514 is an ellipsoidal shaped shell nebula, which is apparent in the infrared, but it also has two bubbles of material emanating from the center. The southeast bubble is blue shifted and the northwest bubble is redshifted, and this defines a polar axis. The peak expansion velocity is 23 km s^{-1} near the center which falls off with radial distance. The inner shell has almost exactly the same appearance in the mid-infrared as in the visible.

The visual extinction has been estimated from 1.5 to 2.5 magnitudes based upon the standard E(B-V) analysis. As with all planetary nebulae the distance to NGC1514 is not well known and estimated distances have ranged from 600 to 4,500 light years. As of 2010, the best distance estimate has fallen in the 650 to 2,000 light year range.

The rings in the nebula can best be described as two parallel unresolved rings with a separation of 40 arc-seconds which equates to 0.16 light year assuming a distance of 250 pc or 800 light years. The southeast ring is 173" in diameter while the northwest ring is 177" in diameter, or roughly .65 light year. The rings are tilted 59° from pole-on and they contribute less than 10% of the integrated emission measurements from the planetary. It appears that the rings do not contain a significant quantity of ionized gas, while the bubbles do, and how the rings formed is uncertain. The rings are part of the dust that is wrapped around the ionized zone. NGC1514 can no longer be considered a simple circular shaped planetary. The morphology is very complex with numerous bubbles found within the inner shell, and rings contained within the outer shell. Therefore NGC1514 joins the large family of hourglass shaped planetary nebulae and is not a simple ring-like structure after all.

Observation – 10" f/5 Telescope: **Appears as a bright star surrounded by a faint, wispy halo of material. The nebula is faint but noticeable using a UHC nebula filter. The bright 9th magnitude central star in this object dominates, although this is really not the illuminating object (see above).**



Galaxy: NC1569, Interacting Galaxy

Other: UGC 3056, Arp 210, MCG +11-6-1, 7 ZW 16
J2000: 04 30 49.7 + 64 50 57
Const.: Camelopardalis
Mag. 11.03v, 11.9b
Surface Brightness: 12.0
B-V = +0.83
Size: 3.6′ x 1.7′
Class: IBm
Radial Velocity: -74

NGC1569 is a dwarf irregular dwarf barred galaxy thought to be similar to the Magellanic Clouds in the Southern hemisphere. The disk is inclined 60° to our line of sight. NGC1569 is part of the Local Group of Galaxies, and its distance has been measured from 6.0 to 9.0 million light years. The stellar population of NGC1569 is mostly young and is spread all over the disk with several star clusters found in the central region, two of which are considered super-clusters, with stellar masses of 8.3×10^5 M⊙ and 2.3×10^5 M⊙, and ages around 7 million years. A total of 48 stellar clusters have been noted throughout the galaxy and 54 X-ray point sources have been identified, making NGC1569 an extremely active energetic object.

The central region is dominated by light and the spectrum shows emission lines which indicate very explosive material is being ejected. NGC1569 has recently undergone a spurt of active starburst, which began about 100 million years ago and finished about 10 million years ago. During this phase about 10,000 supernova explosions occurred which in turn triggered the formation of many star clusters. It is thought the full starburst population has produced approximately 30,000 supernovae over the galaxies lifetime. The energy injected into the interstellar medium by these supernovae explosions drives a strong bipolar superwind which extends to each side of the disk, north and south, in Hα light. Some studies have indicated the oldest episode of star formation occurred 1.5 to 13 billion years ago while the most recent started 5 to 10 million years ago. It is thought that an interaction with the dwarf irregular galaxy UCGS 92 is the possible cause of the recent starburst phase. At present the current starburst is still high at $\sim 0.32 M_\odot\ yr^{-1}$ when compared to that normally found in dwarf galaxies. In Hα light the galaxy resembles a lobster because one of its spiral arms resembles an antenna. Hα images of NGC1569 show all of its main features, the antenna-like spiral arm sticking out by itself, 15 internal and external filamentary structures , 12 super-bubbles, 2 super-arcs, 4 super shell like structures and numerous HII regions. In general the galaxy in Hα light looks like the proverbial train-wreck, due to the very active starburst history of the galaxy. The massive supernovae explosions and subsequent star formation has resulted in super-bubbles forming inside the disk of the galaxy with sizes of 30 to 325 light years in diameter. The expansion velocity of these super-bubbles range from 12 km s^{-1} to 48 km s^{-1}, and from these diameters ages of 0.5 to 1.8 million years can be calculated. The ages of the super-bubbles are a factor of 10 shorter than the ages of the super clusters in the interior of the bubbles, which indicates the present star clusters are not the ones that caused the bubble outflows. Super-shells are ring like structures found with sizes as large as 3,260 light years (I kpc). The galactic winds produce the bipolar filamentary structures and provide increased metals abundances into the interstellar medium which are produced by star formation. However it is not known how extreme the super-wind really is as the bubble and shell structures would be hard to explain if the superwind was severe. The expansion velocity of the super-shells is in the range of 57 to 75 km . s^{-1}, while the escape velocity from the galaxy averages 70 km . s^{-1}. A super-shell located on the southeast end of the galaxy has an expansion velocity Vexp > 70 km s^{-1} so the gas accelerated in this area may no longer be bound to the galaxy. It is estimated that hundreds of supernova explosions would be necessary to cause this kind of expansion. A super stellar starburst cluster will generate kinetic energy within the galaxy with two possible outcomes: 1.) If the kinetic energy of the gas is greater than the gravitational attraction of the galaxy the material escapes the galaxy and becomes part of the intergalactic medium. 2.) If the kinetic energy of the gas is less than the galactic gravitational attraction then the gas falls back onto the disk which may be near or far from the position of the starburst. These two parameters will either result in loss of mass of the galaxy or enrichment of the metals content of the galaxy.

Observation: Lauren Herrington, 17 years old, 12 in. telescope

Nice detail within the body of the galaxy. Could not see the separate spiral arm.

Definitions:

Blue Stragglers: Massive stars found in clusters that are located above the turn-off point on the main sequence and theoretically should not be there. They are not fully understood, but the prevailing theory is they are the product of a binary system that has merged into one star, or obtained material from its companion, giving the false impression they are young objects.

Color Magnitude Diagram (CMD): A two dimensional graph that shows the relationship between spectral type or temperature and the luminosity of star clusters...Independently discovered by E. Hertsprung (1911) and HN Russel (1913).

Main Sequence: Based upon its mass, the location on the CMD where a stellar system spends about 90% of its lifetime, fusing hydrogen into helium either by the P-P chain or the CNO cycle depending upon its mass. These stars are in hydrostatic equilibrium. The more massive the star is the less time it spends on the main sequence. The earliest spectral type of star found within a cluster therefore gives a good idea as to the age of that cluster.

Red Giant Branch (RGB): Where the internal hydrostatic equilibrium is thrown off and the stellar interiors outward pressure overcomes the tendency to gravitationally collapse. The core no longer fuses hydrogen and consists of inert helium. The stars diameter expands from 10 to several 1,000 times greater than the sun, and stars at the foot of the RGB all have similar temperatures of around 5,000K.

Horizontal Branch (HB): A stellar evolution stage which follows the RGB phase. Stars massive enough to reach this stage experience the "Helium Flash" and are fusing helium in their cores. These stars have similar core masses and luminosities. Stars of lower metallicity are typically found on the blue end of the HB while higher metal abundance stars are located toward the red end. For reasons not fully understood this is not always found within stellar clusters and is called the "Second Parameter, Effect."

Kelvin: Absolute zero (0 K) = -273.15°C = -459.67°F. Convert from Kelvin, K: °C = [K] – 273.15 / °F = [K] x 9/5 – 459.67

Metallicity [Fe/H]: The Big Bang event created Hydrogen (H_1) and Helium (H_2), but all heavier elements were created in the cores of stars or in stellar explosions known as supernova. In astronomy these heavier elements are referred to as metals and usually is expressed relative to solar metallicity [He/H] = +0.012 and typically is expressed as the ratio of iron to hydrogen. Metals took time to originate, so the metal abundance is used to age stars and star clusters, with stars of lower abundances being more ancient.

Parsec (pc): 3.26 light years

Kiloparsec (Kpc): 1,000 parsecs or 3,260 light years

Radial Velocity: Line of sight velocity, based upon the Doppler shift, where objects approaching have blue shifted spectral lines which are narrowed, while receding objects are redshifted with elongated spectral lines. Used to determine distances.

Wolf Rayet Star (W): Very luminous massive stars that are near the end of their lifetimes and shedding material in very strong stellar winds. They are among the hottest known with temperatures from 30,000K to 200,000K, making them highly luminous. These are massive objects ranging from 10 MΘ to nearly 200 MΘ. WR stars are identified by their broad emission lines of ionized nitrogen (WN), carbon (WC) or sometimes oxygen (WO), and the surrounding nebula has often led to mislabeling with planetary nebula.

Interstellar reddening, E(B-V): Reddening occurs due to the light scattering off dust and other matter in the interstellar medium. The extinction of blue light is greater than that of red light rendering objects redder in appearance than they really are. The reddening is expressed in terms of a color excess, E = (B-V) – (B-V)0, where (B-V) is the measured extinction while (B-V)0 is the normal calculated color index of the object. Normally this is expressed as E(B-V). Reddening can cause objects to appear up to 30 magnitudes fainter that they should be, rendering false distance estimates.

Each and Every Object in the Universe is Unique.

A little Knowledge turns a Faint Object Barely Visible

Into a Fascinating Incredible Experience Enabling the Mind to Soar

"sudum ad astra"

Clear Skies – To the Stars

Larry Mitchell - Eileen Myers

Stellafane Observing Olympics – August 2018