NIGHTFALL

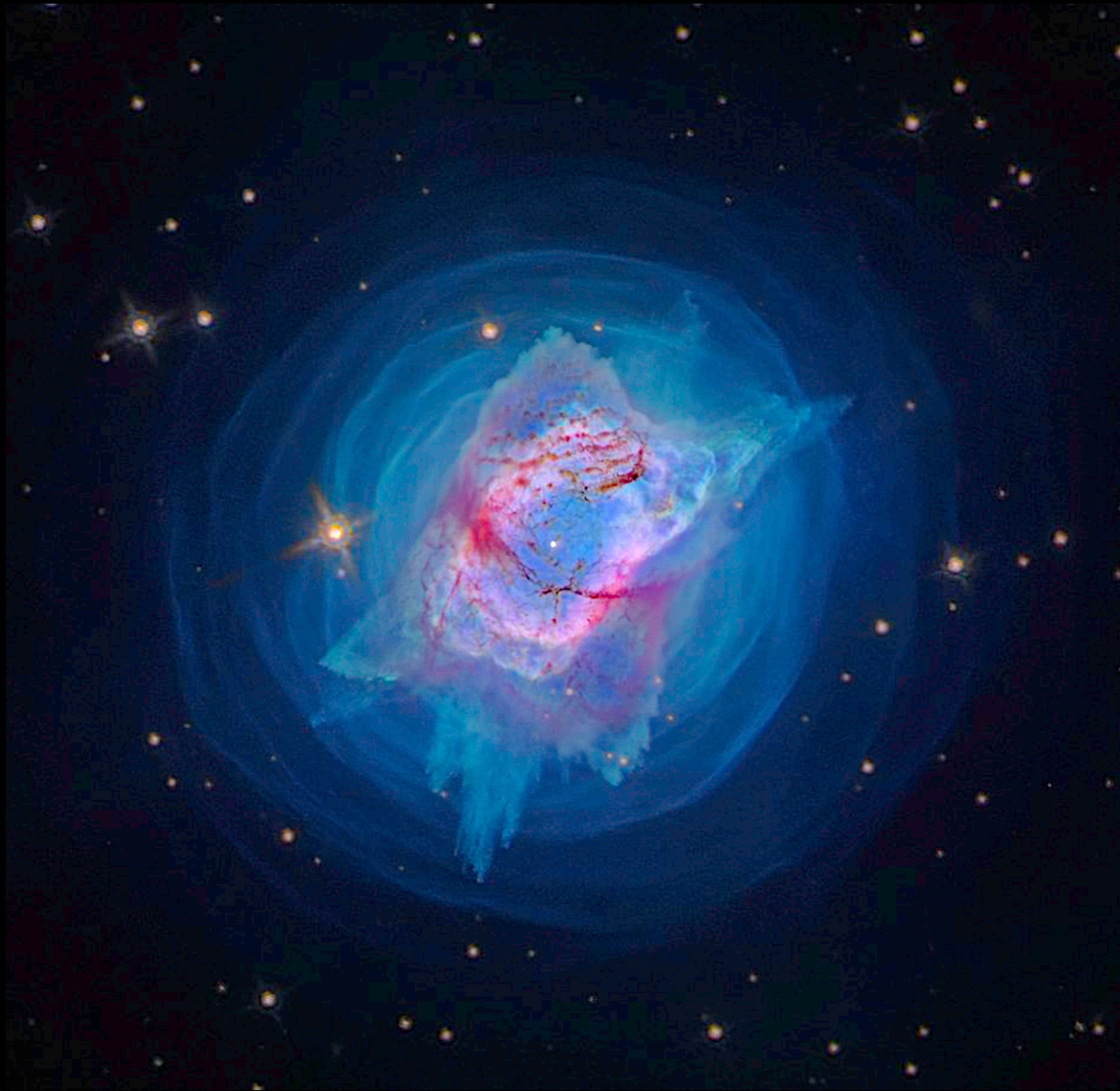
ASTRONOMICAL SOCIETY OF SOUTHERN AFRICA

CAMEOS ON BLACK VELVET

PRECOCIOUS PLANETARIES

Nightfall

Astronomical Society of Southern Africa
Special Report No. 10
January 2021



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Published January 2021
by the Astronomical Society of Southern Africa
Observatory, Cape Town, South Africa
Editorial address: *https://assa.saao.ac.za/*
Website: *http://assa.saao.ac.za/sections/deep-sky/nightfall/*

Produced by Atelier Books LLC
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ISSN 2617-7331

Cameos on Black Velvet

In a letter to Jerome Lalande, William Herschel wrote,

There are celestial bodies of which as yet we have no clear idea and which are perhaps of a type quite different from those that we are familiar with in the heavens. I have already found four that have a visible diameter of between 15 and 30 seconds. These bodies appear to have a disk that is rather like a planet, that is to say, of equal brightness all over, round or somewhat oval, and about as well defined in outline as the disk of the planets, of a light strong enough to be visible with an ordinary telescope of only one foot, yet they have only the appearance of a star of about ninth magnitude.

With image acquisition times in the 50- to 70-hour range, PN imagers typically spend an entire week catching enough photons for a single image.

Endurance marathons on this scale would have been unthinkable just a few brief decades ago when eye-to-eyepiece guiding and the vexations of emulsion film were the norm.

Not so today. This *Nightfall* article draws upon the inspiring methodology of Peter Goodhew, an imager who lives near Heathrow Airport, perhaps the worst place in the world to try one's hand at astro-imaging.

Yet Peter has garnered accolades from around the world for his superb, sometimes unique in the world, planetary nebula images

How does he do it?

Nightfall tags along to learn how Peter Goodhew captures the sky's most precocious planetaries

Source images here and here.

Few planetary nebulae present us with such a comely mystery as Kronberger 63.

Kn 63 was discovered by the indefatigable Matthias Kronberger, who seems to possess an unquenchable thirst for the subtle unseen. Few of his discoveries qualify for that ambition quite like the 63rd catch in his planetary net. At first glance we see a rather thick-shelled canonical sphere with rather messy domestic housekeeping habits.

This 63 hour compilation image by Peter Goodhew is only the second time this frail bit of fluff has been imaged. We see a chubby but not particularly dense outer shell of doubly ionised Oxygen (OIII) expanding into somewhat turbulent local medium. The planetary's progenitor star is the pale blue dot in the centre, slightly beneath one of the curious mottled emission patches whose striated character give this object its mystery. There is a linearity and density distribution to these filaments that defies the usual explanations. It bears the signatures of dense turbulent shock shells, but Kn 63's layered look is contrary to the radiant edge-on views of both expanding shell and internally reflected shock fronts.

A good mystery starts with the absence of information and the presence of disinformation.

The mystery of Kronberger 63 is 'Why does it look like this?'

Dust?

Yes, dust.

When we observe a planetary nebula, we are looking at multiple bodies of dust and gas across which super-hot plasma is being injected via high-velocity gas bubbles. Without dust, we wouldn't see much of it because hot gas emits mainly in ultraviolet bands. Dust absorbs O-III in the UV band and re-emits it at 500.7 µm in the blue-green portion of the visual spectrum. The prettiness of the colour is a lacy veil shading a complex face.

The emission energy of a planetary nebula's central star ionises the various elements that comprise the gas medium of both the nebula itself and the previously undisturbed ambient medium it now passes though. We tend to ignore the pre-existing volume of gas and dust in that location until a super-hot planetary nebula shell arrives. The dust component of the local medium absorbs the energy from the light and converts the diffuse spectral glow into bright features such as shells, filaments, striations, and cometary clumps.

In a quiescent medium ambient dust and gas are coupled. They receive the same energy inputs and covert the photons into other energy forms — fluorescence, astrochemical binding or bond-breaking, atomic and molecular vibrational and rotational transitions, and angular momentum.

In these rather benign conditions astronomers used to conveniently calculate the resulting energy distributions by using simple dust grain models in which the grains were interpreted as spheres whose chemical cross-section was more important than their optical cross section.

Today we know space as too complex for such niceties. For one, gas and dust decouple readily when the local energy equilibrium is upset. That means interpretations must explain the behaviours of two mediums that occupy the same volume. Nebular space is immiscible.

We also know that space dust is complex stuff. Most of it comprises carbon-based molecules organised as hexagonal ring structures called aromatic hydrocarbons. Carbonaceous dust readily attracts water ices and is the primary formation site for molecular hydrogen HII (aka H_2) from which stars are made.

Other dust types include silica and sulphur-based aliphatic or linear structures. These are often bear dipolar electron densities and therefore respond readily to magnetic fields. Silicious dust can exhibit linear features that are magnetically responsive more than temperature responsive. We can expect those lineations to display prominently at low local temperatures but less so at higher temperatures. One way to learn this is comparing O-III spectral energy density with H-alpha. O-III emits a strong band in UV, where H-alpha is in the infrared. Once we know that we can make plausible guesses at the progenitor star's original mass and its present surface temperature and rotation rate. We can also deduce the composition of its gases in the last two stages of a white dwarf's six or seven episodes of gas expulsion, when the last convection layers were hurled into space.

At present those are precisely the facts for which we have little data in the case of Kr 63. What to do?

Today's astronomers model dust grains as energy surfaces whose filling fraction of solid atoms is surrounded by energy fields and empty space. Dust models must also take into account the porosity of dust grains. Porosity is the fraction of the grain volume that is composed of vacuum instead of grain material.

Porous-grain models adopt a fiducial estimate in which grains are 25% vacuum, 50% silicate, and 25% amorphous carbon. Estimates for nonporous grains specify 50% vacuum, 33.5% silicate, and 16.5% amorphous carbon. Both grain models estimate grain sizes lying between 0.0025 to 1.5 µm in a tri-axial cross-section.

Porosity (designated P in the equations) includes terms for composite assemblages that incorporate silicates, graphite, amorphous carbon, and vacuum. The most significant effect of porous grains is that the grain volume per unit mass increases because the overall density of the grain is lowered. Such composites are more efficient radiators of energy, meaning that less total dust mass is required to reproduce an observed IR luminosity.

How does all this apply in the case of Peter Goodhew's image of Kronberger 63?

For grains of the same mass, the grain is heated to a higher temperature if it is solid than if it is porous. The equilibrium temperature is lower for porous grains, hence more kinetic heat is required to fit a porous grain model than a solid grain model. For a fixed plasma temperature, this is achieved by increasing the post-shock density. Increasing the porosity of grains has the dual effect of raising the necessary post-shock density needed to heat grains to an observed temperature while also lowering the total amount of dust required to reproduce an observed luminosity.

When we examine Peter Goodhew's images, we know almost nothing of these niceties. Many of his images are true rarities, They have not enjoyed the multiband attention astronomers need to explain what makes the object look like it does.

Many of Peter's images fall into this informational no-one's land. We are forced to interpret them based on careful examination and previous experience.

This is especially the case with Kr 63. Without a spectral energy distribution (SED) diagram, we cannot pin down the atomic species that populate those vexatious horizontal striations. Nor can we estimate the remnant star's rotation rate or temperature, all of which contribute to the emission luminosity of the primordial dust that existed before the AGB shells arrived some 6,000 years ago. Hence we console ourselves with gazing and guessing.

We first note a faint lobe descending from the shell at a PA of about 185–190° from (N=top, E=left). Other expanding-shell PN, e.g. the Dolphin Nebula, suggest that such lobes are polar jets whose ejecta has a higher energy density than the circumequatorial expansion shell.

It appears that the polar jet passes beneath the image plane at an angle of perhaps –30°. The slight bowed shape of the striations would then be explained as arc segments of turbulence shocks seen nearly face-on as they speed toward us.

For more details on the role of dust in planetary nebulae, see Stasinska 2007 §3.17 ff.

Peter Goodhew's external imaging site is hosted by Entre Encinas y Estrellas (e-EyE located in Extramadura, Spain. See Peter's Astrobin website and take the e-EyE Tour.

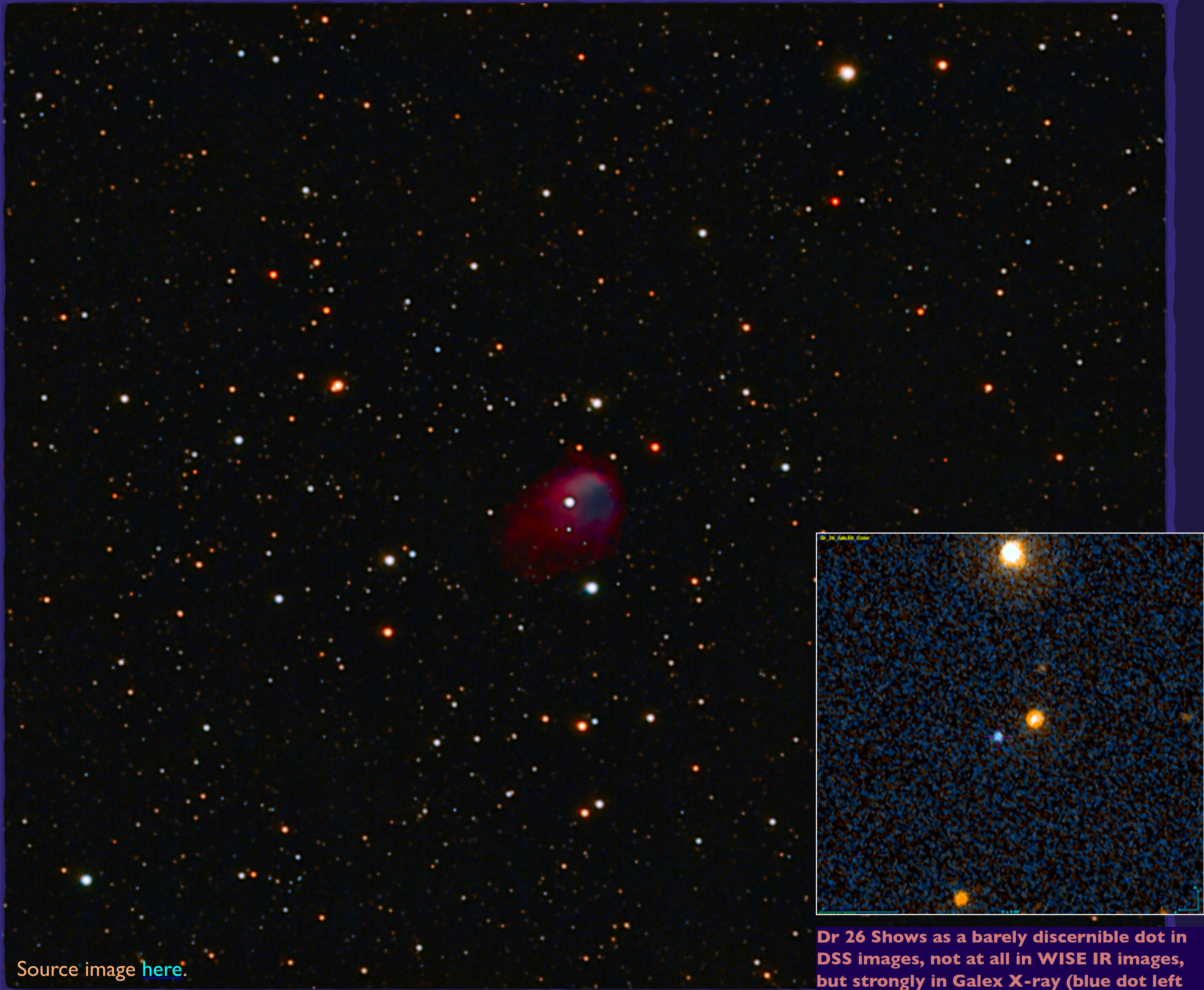
Dreschler Dr 26

Dr 26 is a potential planetary nebula in the constellation Camelopardalis discovered recently by Marcel Drechsler.

Planetary nebulae (PN) mark the end of the line for star of intermediate mass between 1 to 8 solar masses. The Sun, for example, will form a planetary nebula at the end of its life cycle about five billion years from now.

PNs are a relatively brief events in the long lives of most stars. They appear and dissolve within a few ten thousand years. They begin when the voluminous but thin outer envelope of a red giant star's atmosphere is ejected by the central star's energetic ultraviolet radiation. As the envelope hurls outward, the star's core is exposed. It is fearsomely hot—a hundred thousand up to several hundred thousand degrees Kelvin. The searingly energetic ultraviolet light injects photon energy into the shell of nebulous gas, causing it to emit photons as a brightly coloured gas. The colours derive from the chemical elements like sodium, silicon, calcium, sulphur, and so on, that were dredged up from the star and now lie in vast rings and bubbles surrounding the star.

Dr 26 lies at RA 04:06:49 (13.2275) gal l = 145.35212, **Dec** +59:43:46 (56.5776). It its 3 arc min in diameter and a very faint magnitude 18 visually.



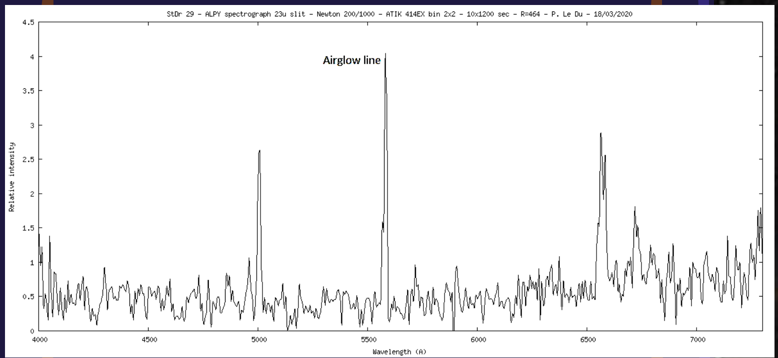
Source image here.

Dr 26 Shows as a barely discernible dot in DSS images, not at all in WISE IR images, but strongly in Galex X-ray (blue dot left of centre). This suggests that Dr 26 is a carbon-oxygen while dwarf . the most common of all white dwarfs.

Strottner Drechsler StDr 29

Discovered by Xavier Strottner and Marcel Drechsler just a few months ago, in 2020.

Almost from the moment it was launched, the Hubble Space Telescope images revealed that many planetary nebulae have extremely complex and varied morphologies. About one-fifth are roughly spherical, but the rest have complex bubbles, cone-like jets from their poles, and dust toruses around the equatorial ring. The mechanisms that produce such a wide variety of shapes and features are not fully understood. Computer simulations and algorithms attribute the features to binary central stars. Stellar winds and magnetic fields play the role of a cosmic sculptors able to mould the most graceful shapes in our galaxy.

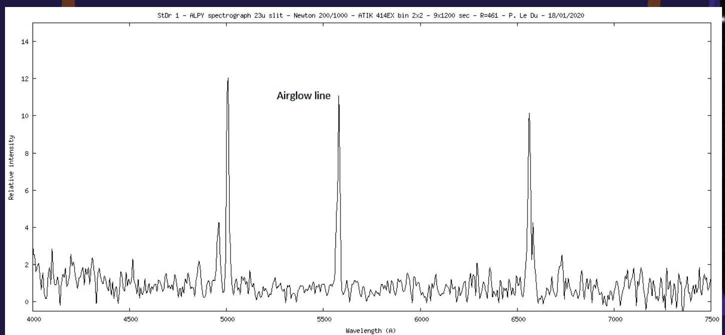


StDr 29's spectrum is typical for radiatively shocked and heated gas dredged up from the lower atmospheres of old evolved stars with complex chemistries. OIII and H-alpha dominate the spectrum. The spike in the middle is caused by radiation from the earth's atmosphere.

Strottner-Drechsler StDr 1

StDr 1is a planetary nebula in the constellation Taurus. Discovered by Xavier Strottner and Marcel Drechsler in November 2019 its status still awaits further imaging and IAU confirmation. It is not visible in WISE IR, DSS, or PanSTARRS images. Peter Goodhew is the first imager to capture this frail, difficult PN in colour. It is extremely faint —1800 second exposures binned 3x3 were necessary.

About 20% of planetary nebulae are spherical or elliptical, inflated by the radiation field of the single star that generated them. But others, like StDr 29 here, have complex, sometimes off-centre shapes. The best explanation for these is the gravitational interaction between two unequal stars in a binary system. In some cases planetary systems around one or both stars may also play a role. Here the soft-edged bilobed asymmetry suggests that magnetic fields, turbulent supersonic shock fronts, Rayleigh-Taylor Instability, and varying dust densities tell a much more intricate tale that is yet to be told in full.



StDr 1 radiates mainly in the OIII and Ha bands. The telluric (Earth's atmosphere) spike in the middle derive from human-made illumination like parking lot lights.

Heckathorn-Fesen-Gull HFG 1

Heckathorn, Fesen, and Gull was discovered in 1982, It is a very old, very large, low-surface-brightness planetary nebula in Cassiopeia. It was produced by a binary star system (V664 Cas) that is moving rapidly through our Galaxy.

HFG 1 progenitor is a white dwarf star and red giant binary—a familiar mix in the realm of planetary nebulae. The two stars are so close to each they rotate around their common centre of gravity every 14 hours. In systems like this, the gases stripped from both stars fill the gravity-hewn Roche lobes that surround them. This condition is called Roche-lobe filling. The lobe surfaces are where inward and outward forces balance. The lobes are filled with luminous gas. They have bipolar shapes when we see them from the sides but M57 ring-like shapes when we look down their polar axes.

The V664 Cas star system is moving at high local velocity towards the lower left of the image. As V664 Cas plows through the thin, cool interstellar gas surrounding it, a bluish bow shock is produced in front of the system while a red trail of gas streams behind in its wake.

Roche-lobe depletion is a one-way street leading to the binary system's eventual demise. Once the stripped-away gases are gone, the nebula will disappear . The old binary pair will waltz around and around into the Galactic sunset.

Learn more about HFG 1 and Roche-lobe binaries in P. Boumis, J. Meaburn, M. Lloyd, S. Akras. *Monthly Notices of the Royal Astronomical Society*, Volume 396, Issue 2, June 2009, Pages 1186–1188,. 10 June 2009.

Yerkes-McDonald YM 16

Discovered by Hugh Johnson at Yerkes and McDonald Observatories in 1955, Yerkes-McDonald 16 is an extremely faint planetary nebula in the constellation of Serpens Cauda.

YM 16 is named after the two observatories that surveyed the sky in 1953/54 in search of faint planetary emissions. The complex intersecting shapes here define surfaces of expanding gas still incandescent from the heat of the central binary system that expelled the nebula. Gas ejected from Roche-lobe binaries seethes like the rising bubbles in a boiling pan. A brighter, sharper example is the surface of Thor's Nebula, NGC 2359 in Canis Major. While Thor's Nebula was made by a different type of star than YM 16, the turbulent surfaces look much the same because they share a common underlying cause: hot gas ejected at high velocity into a cool low-density medium. The red hue of YM 16 here is due to H-alpha emission.

RA 18:54:57 (18.9158) gal l = 38.7105
Dec +06:02:31 (6.0419) gal b = 1.9733
Size: 6 arc min

Source images here and here.

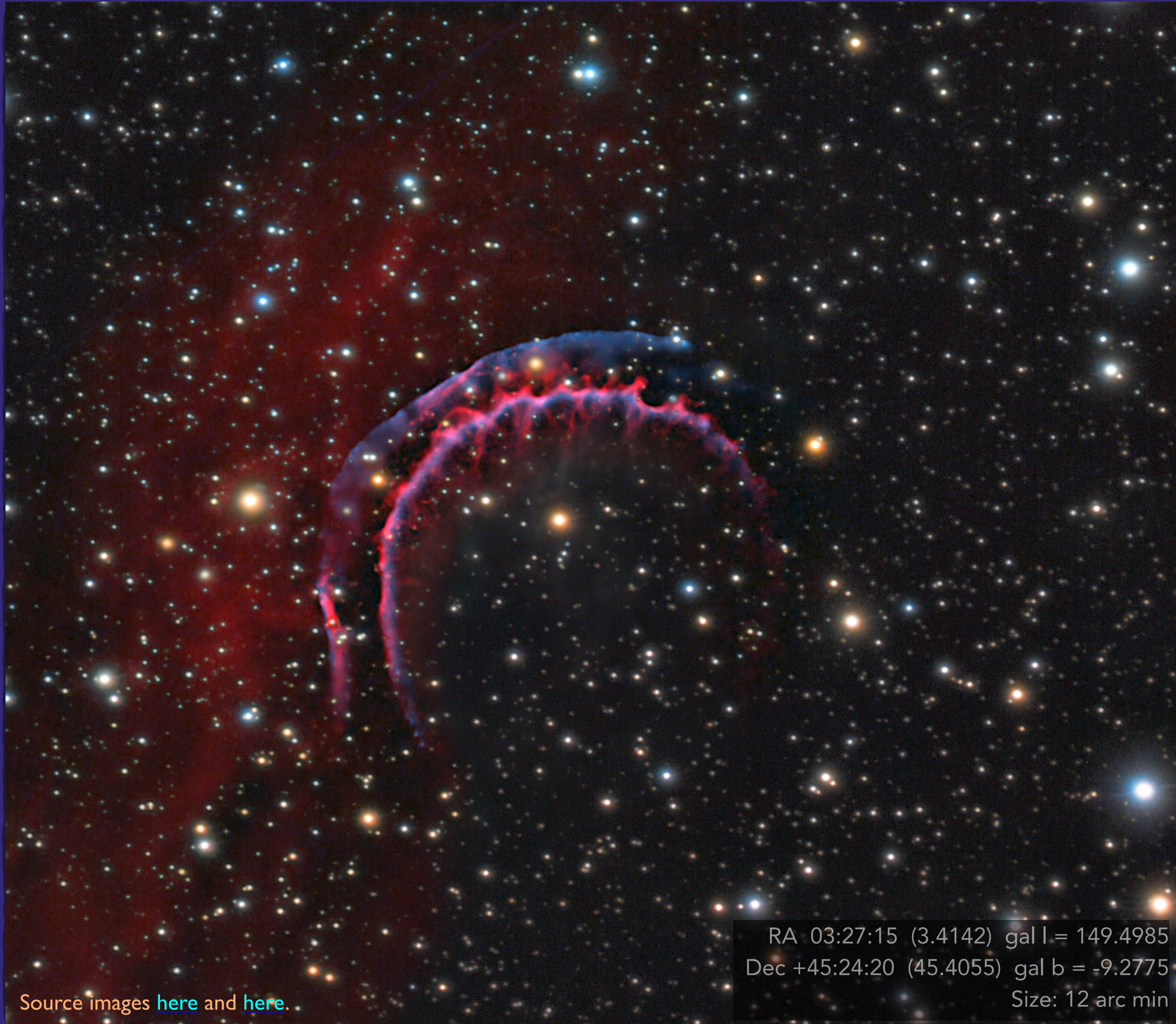
YM 16 in Ha

Hartl-Dengel-Weinberger HDW 3

Discovered by H Hartl, J Dengel, R Weinberger in 1983, HDW 3 is an extremely faint ancient planetary nebula in Perseus. It is very rarely imaged because of its very low surface brightness and the presence of point-source crowding in this rich star field. This is only the 6th time it has been imaged. The exposure required 71 hours combining RGB, O-III, and Ha.

HDW 3's progenitor star is the small blue star at the 5 o-clock position just below the large yellow star in HDW 3. The progenitor is not in the centre of the nebula because it is moving rapidly in a north-westerly direction through a dense interstellar medium (ISM). The ISM slows down the glowing nebula gases but not the star itself. The outer smooth blue arc is a compression shock ahead of the onrushing ball of nebular gases. The braided appearance of the nebula is shaped by Rayleigh-Taylor instabilities, an instability in the interface between two fluids of different densities. This R–T instability occurred because hot low-density gas has pushed into the cooler, denser interstellar gas. The rising, roiling cloud of an atomic 'mushroom' cloud is also an example of R–T instability.

See also Rayleigh-Taylor Instability Example 1, High-Resolution Example 2, Smoothed-particle Hydrodynamic example 3.

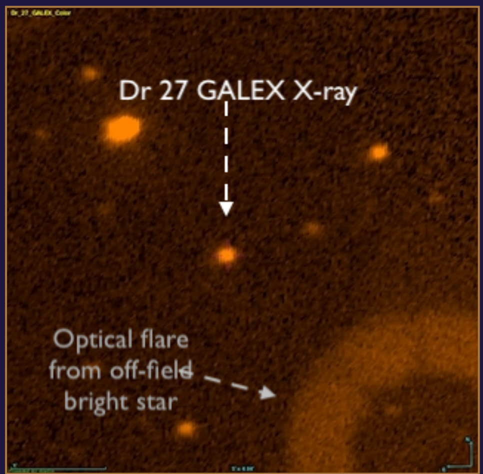


Source images here and here.

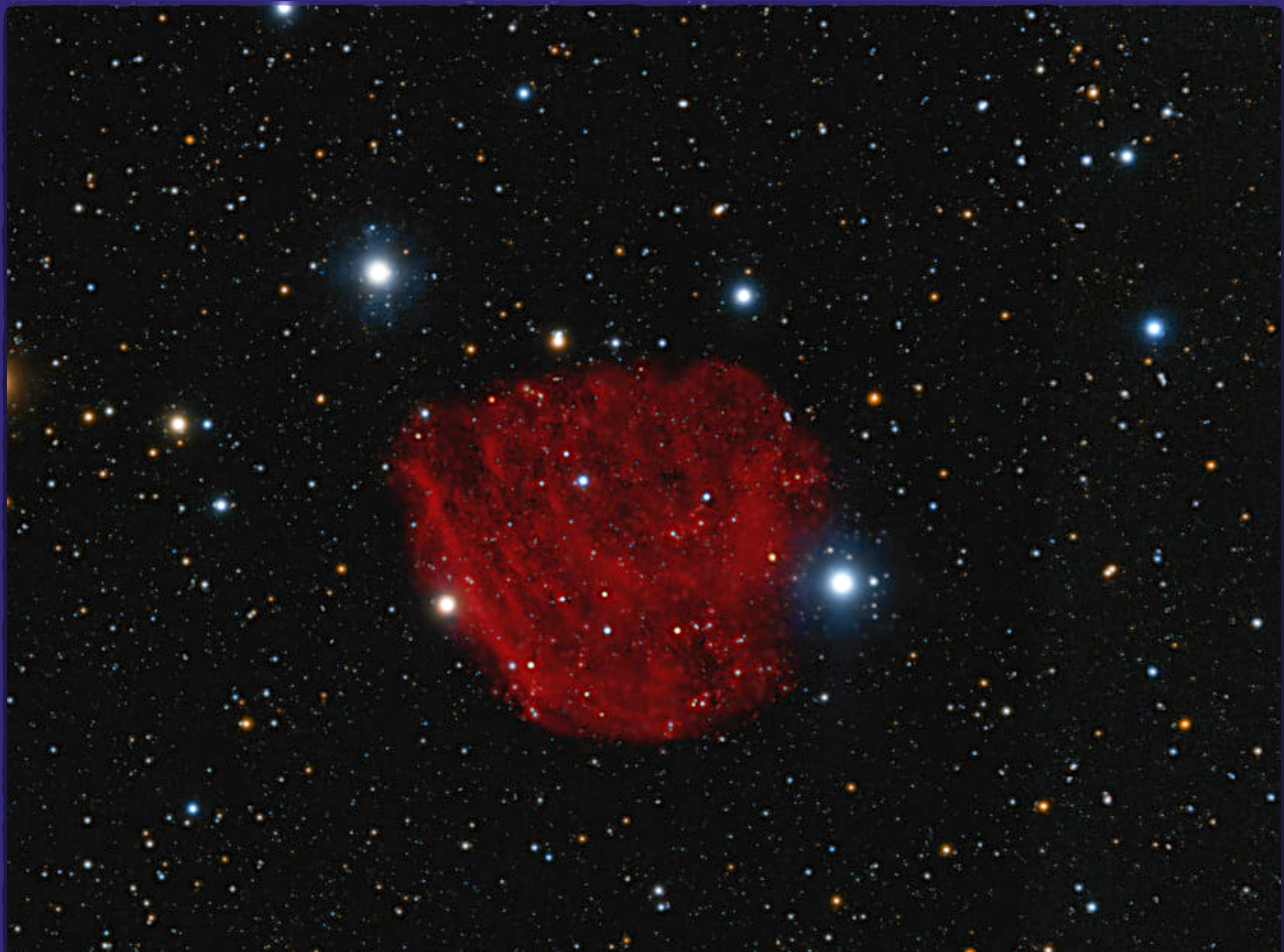
Drechsler Dr 27

Discovered by Marcel Drechsler in May 2019, Dr 27 is an exceptionally faint planetary nebula in Cassiopeia.

Dr 27's irregular outer shape and seemingly concentric filament-like striations defy the usual explanations for planetary shell morphology. The central star has not yet been positively identified, but in any event is very faint indeed. Also puzzling is the seeming absence of an OIII signal. It is positively identified as a planetary nebula due to the strong GALEX X-ray signature (below). It is barely discernible in DSS and PanSTARRs images, but practically shouts in X-ray. These suggest a binary ejector, but the dearth of OIII throws a big question mark over any traditional interpretation.



No central star stands out in Peter Goodhew's image of Dr 27, but a star is slightly visible in DSS images. The nebulosity is bright in this GALEX image).



Source image here.

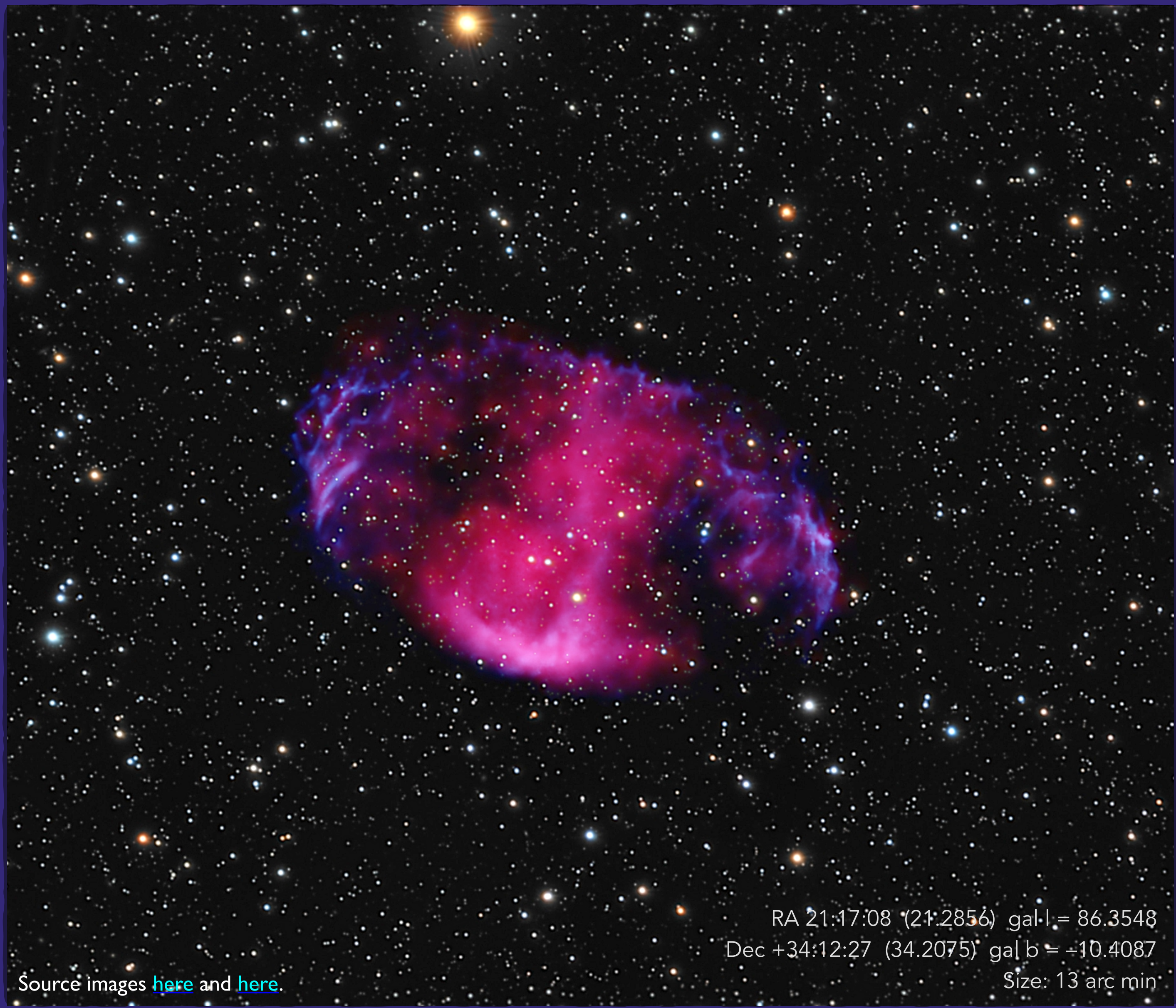
RA 00:11:03 (0.1842) gal l = 117.4577
Dec +57:10:36 (57.1767) gal b = –5.2650
Size: 9 arc min

Motch-Werner-Pakull MWP 1 ('Methuselah')

Discovered in 2009 by C Motch, K Werner, M Pakull, MWP 1 is a seldom-imaged faint bi-polar planetary nebula in Cygnus, some 1380 pc (4500 light years) from Earth. It is known as The Methuselah Nebula because it is one of the oldest known PN, some 150,000 years old.

In its youth, the Methuselah was a ripple-muscled Adonis, probably resembling the young bilobed planetary Mayall-Cannon 18 (described in detail below). The reddish diffuse central gas here was once an opaque, bright potato-shaped feature with a hot red rim. The ragged bluish lobes seen here would have once been bright cone-like jets spreading away from the central ring like a garden watering nozzle set on fine-spray.

The reason the Methuselah has aged so gracefully is the low, uniform density of the volume of our Galaxy that the young planetary expanded into. Gas densities of between 100 and 1000 atoms / cc are typical for such regions.We see here the signs of quiescent dissipation in which once-hot gas cooled and spread ever more thinly. For its age, Methuselah is remarkably intact. Closer to home, our Sun lies within a similar low-turbulence volume called the Local Bubble. Lucky for us, too. We might not be here if space was hotter out there.



Source images here and here.

Further reading: Stasinska 2007.

Hartl-Dengel-Weinberger HDW 2

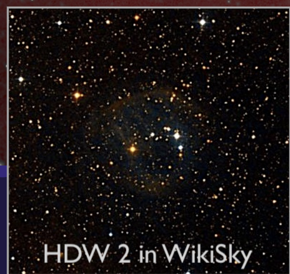
At first glance HDW2 and our initial mystery object Kn 63 appear to be fraternal twins. But does the similarity in the shape and linearity of the striations in both objects point to common causes?

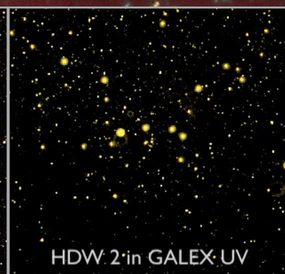
We begin with the ambient dust/gas mix that occupied the volume before HDW 2's progenitor star commenced ejecting ints atmosphere. There exist many mid- and far- IR spectral observations of PNe that show a strong continuous emission at 100 - 200 K. This is typical of dust grains heated by ionising stars. But is that dust the expanding gas shell's dust, or was it there beforehand?

Wikisky shows only spare hints at the complex surface nebulosity seen in Peter's image. The Aladin composite image library show few signs of it—notably, the Galex X-ray images shows nothing in the coordinates of the PN central star, and no hints of nebulosity. Age-cooling is showing its traces here.

The most revealing marker is the striated appearance of the nebula's surface. It is not intervening dust because of its absence outside the PN. Galactic cirrus would leave shadows, not luminosity. The shape and slight protrusions of the shell rim suggest that the PN's polar axis is approx. 45°–235°. Hence we may be looking at PN ejecta dust aligned along toroidal magnetic field lines. The next step would be a check for Faraday rotation of the field lines, but this nebula might be too faint to detect it.

Source images here and here.





Making sense out of the messiness

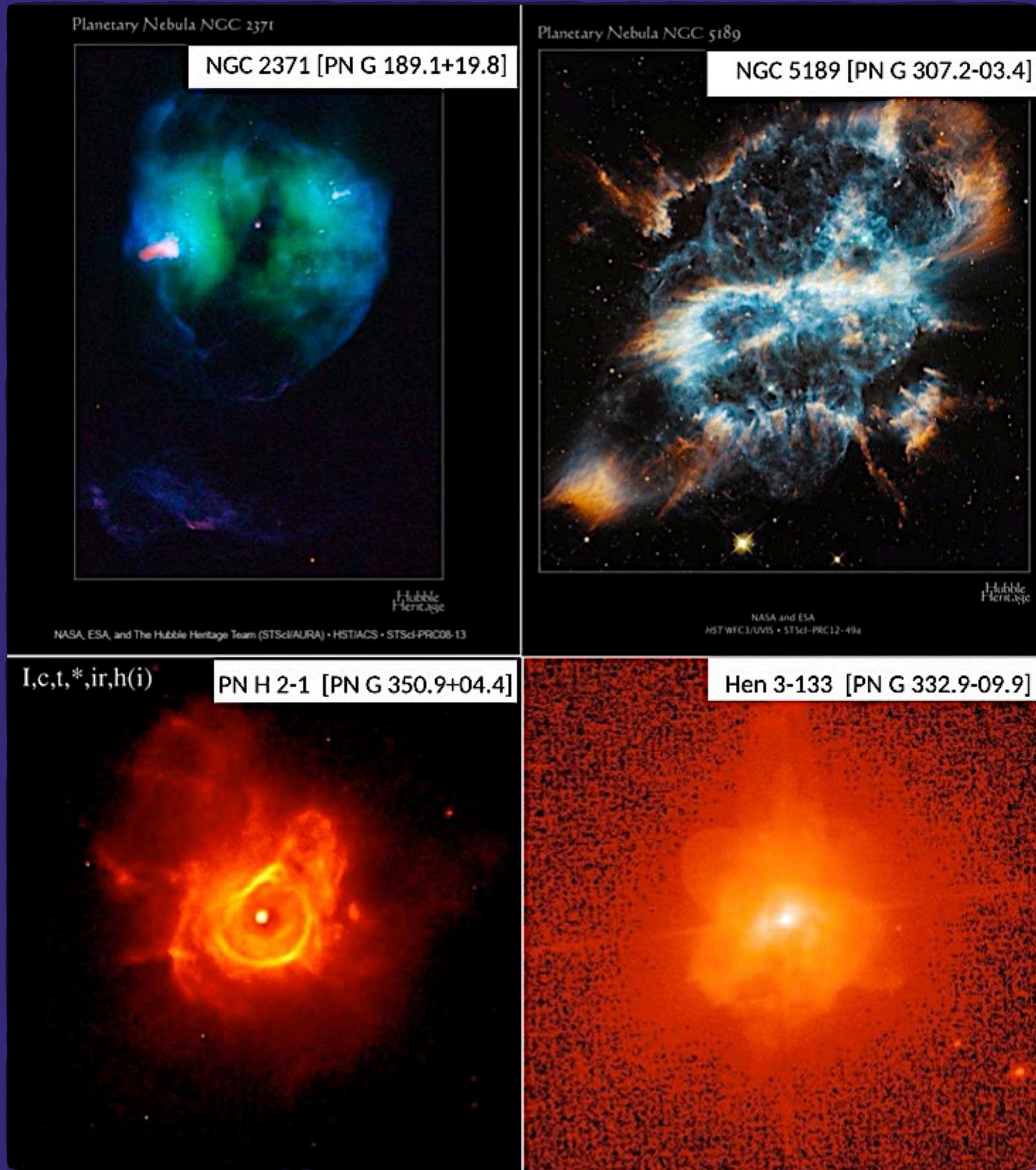
How does one explain the rich diversity on planetary nebulae shapes, colours, and sizes? Approximately 20% look like the smooth transparent sphere we see in iconic images like the NGC 7635 Bubble Nebula in Cassiopeia or SNR B0509-67.5 in the Large Magellanic Cloud.

Others, such as Mayall-Cannon 18 in Musca (discussed below) show obvious polar jets and an equatorial gas ejection ring. Many, but not all, can be attributed to a progenitor binary star system—readily seen in MyCn 18 by the off-centre central star. These PNs exhibit strong H-alpha signal from the hydrogen envelope gas stripped from the white dwarf's companion, often a red giant with a relatively tenuous atmosphere and low surface gravity.

Even so, the average binary fraction of field stars in the MW is only about 50%, that still leaves us with 30% of the planetaries whose shapes have to be explained some other way. The examples to the right are detailed in Stasinska 2007.

The shapes of PNe are also affected by irregularities in internal or external gas pressure, internal and external dust, turbulent shocks from star formation dynamics, and magnetic fields. We saw the effect of magnetic fields in HDW 2 on the previous page (and which may also explain the mysterious Kronberger 63 that launched this article). Magnetic fields are responsible for rapid outflow streaming events such as we see in Mz 3 / ESO 229-5 The Ant Nebula in Norma.

PNe are distinguished from stellar mass outflows or fluorescing protostellar cloud cores by emission spectra containing OIII, H-alpha, and H-beta lines.



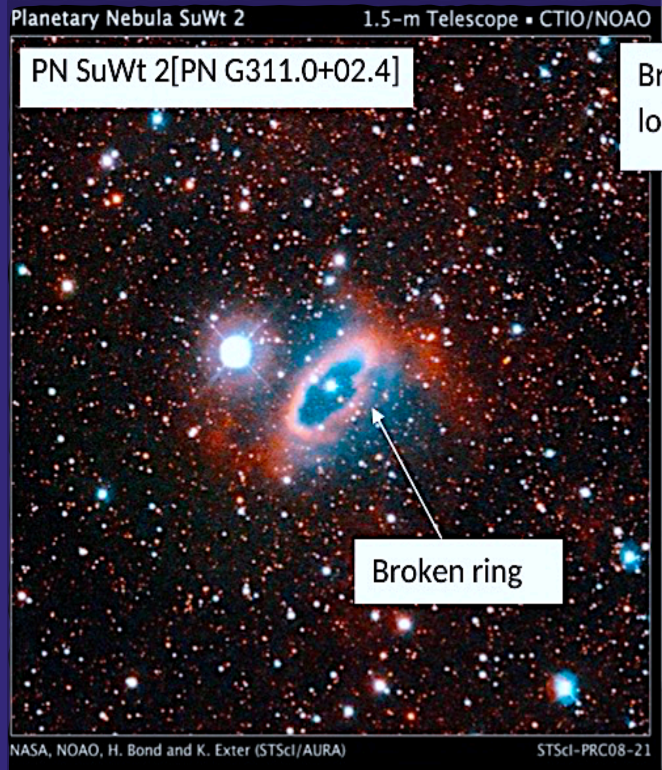
Compressed or broken-lobe instabilities

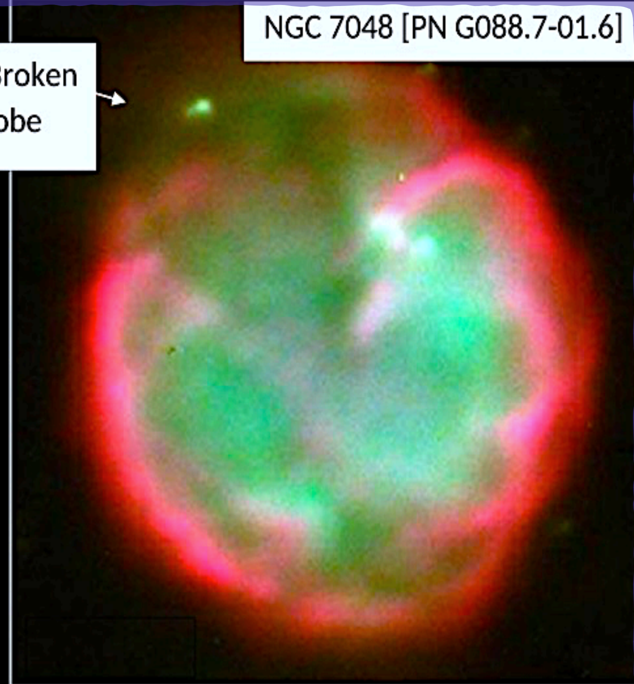
After a star passes through the asymptotic giant branch (AGB) phase, the brief planetary nebula phase of stellar evolution begins as gases blow away from the central star at speeds of a few tens of kilometres per second. The central star is the remnant of its AGB progenitor, an electron-degenerate carbon-oxygen core that has lost most of its hydrogen envelope due to mass loss on the AGB.

As the ejected envelope gases expand, the central star undergoes a two-stage evolution, first glowing hotter as it continues to contract. Hydrogen fusion begins in a shell around the core. When the hydrogen shell is exhausted through fusion and mass loss, it radiates away its energy and fusion reactions cease. The central star is not massive enough to generate the core temperatures and density required for carbon-oxygen fusion (about 600 million K and 3 billion kg per cubic metre). Carbon burning in stars is where the Earth gets its neon, sodium, and magnesium.

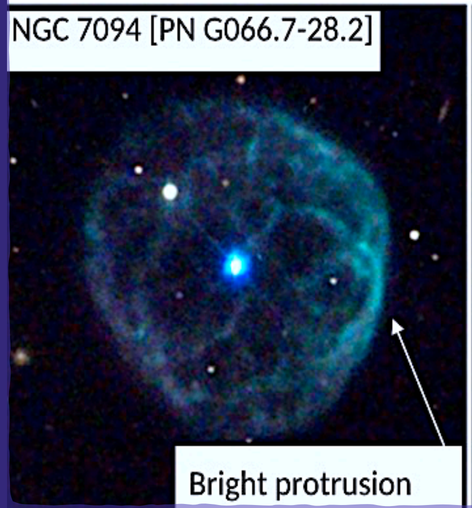
For a typical planetary nebula, about 10,000 years passes between its formation and recombination of the resulting plasma. In the examples to the right, the broken ring in SuWt 2 upper left could be the result of the onset of a CEE, the unequal lobes of NGC 7048 and NGC 2818 would result from instabilities during the phase of launching the jets, and the bright patch in NGC 7094 lower left shows where the uniformly expanding gas impacts a pocket of local higher density gas.

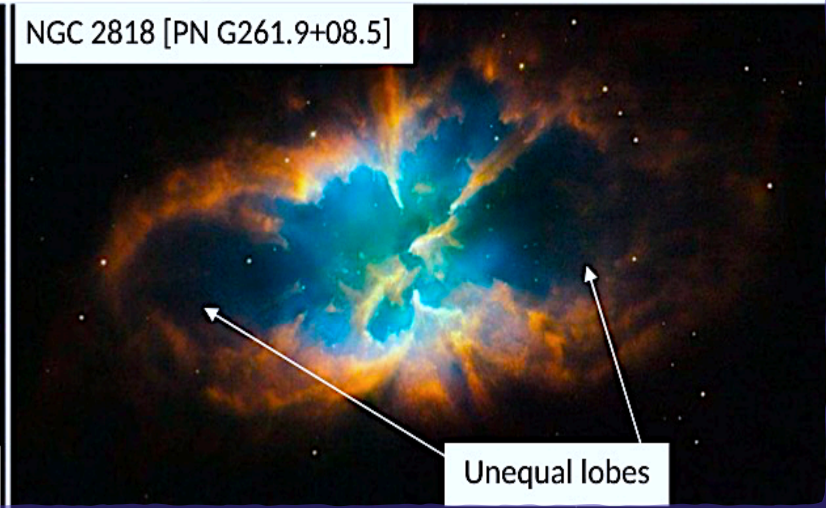
Deducing the exact causes of any particular planetary's gas structure involves theoretical models, computer number-crunching, algorithms modified for the specifics of local conditions, and detailed examination of spectra. It is not a job for the equationally challenged.





NGC 7048 G088.7-01.6 21 14 15.22 +46 17 17.5
R = log[NII], G = log[OIII], B = ??
Balick 1987 AJ 94, 671





Signatures of multiple-star progenitor systems

All four of these PNe were shaped by a binary or triple star system. They exhibit large deviations from an underlying symmetrical structure. They have neither a symmetry plane, nor a symmetry axis, nor a point-symmetric morphology.

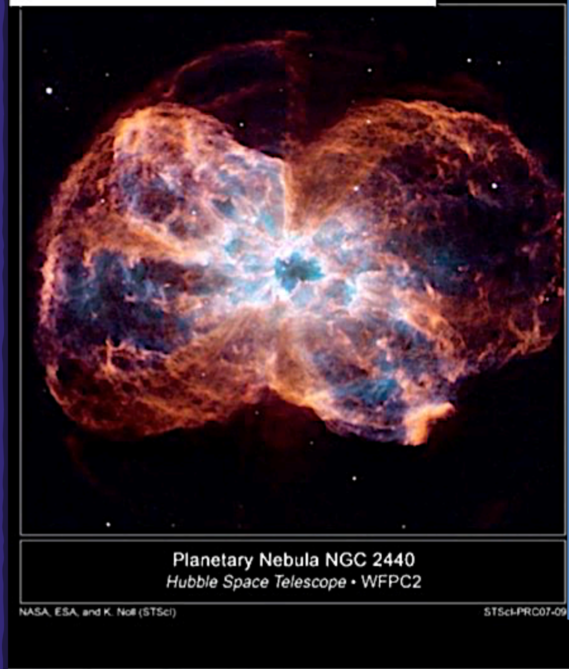
NGC 7027 (upper r.) is a very young 600 year old PN whose tortured interior reveals several different types of PN-shaping forces. The placid outer shells were made by a long history of slow bubble-like ejections from the pre-planetary central star. The stair-step rings reflect a cycle of helium flashes in the star's core—thermonuclear detonations whose energy was totally absorbed by the star's massive envelope. Each detonation hurled off envelope gas, slowly depleting the envelope to bare the hot, bright central dwarf.

The eccentric dark striations are layers of dust that respond to the interior energy outflow differently from the gas. Dust particles are massive by comparison and thus resist photon pressure.

The multiple shell patterns in NGC 7027 suggest that the central binary is a red giant star that has swallowed its smaller stellar companion. The companion is so dense it lives its own hot-headed life inside the red giant, fiercely asserting its presence via virulent ejection episodes.

The other three PN on this page share many of NGC 7027's features, pointing to similar conditions during formation.

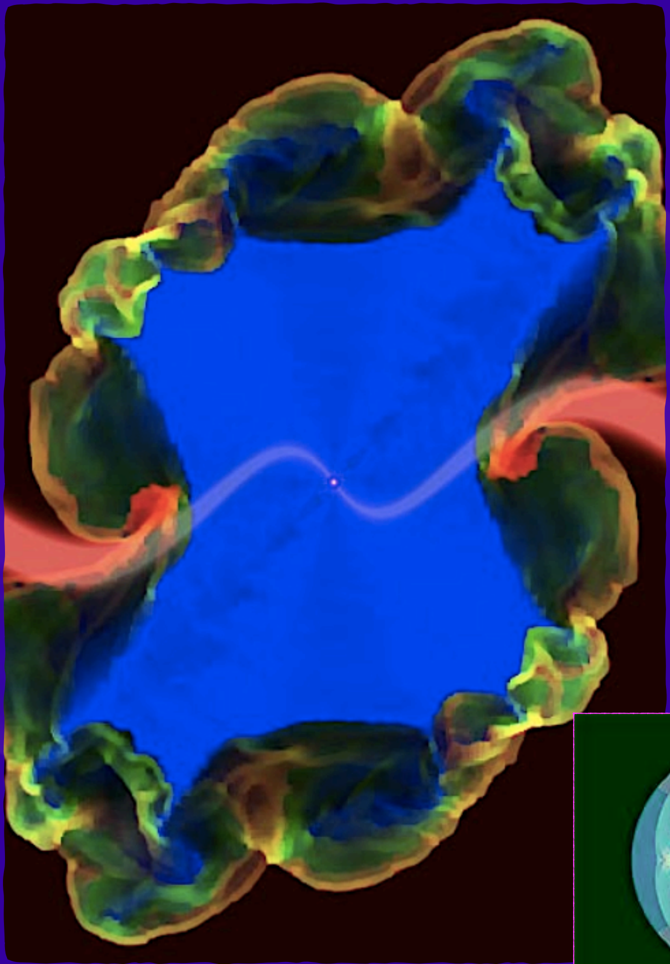
NGC 2440 [PN G234.8+02.4]



NGC 2899 [PN G277.1-03.8]

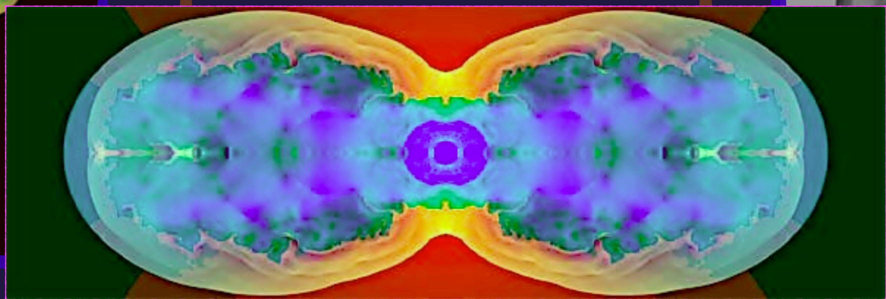
PN Hf 38 [PN G288.4+00.3]

When spectacular physics comes in small packages

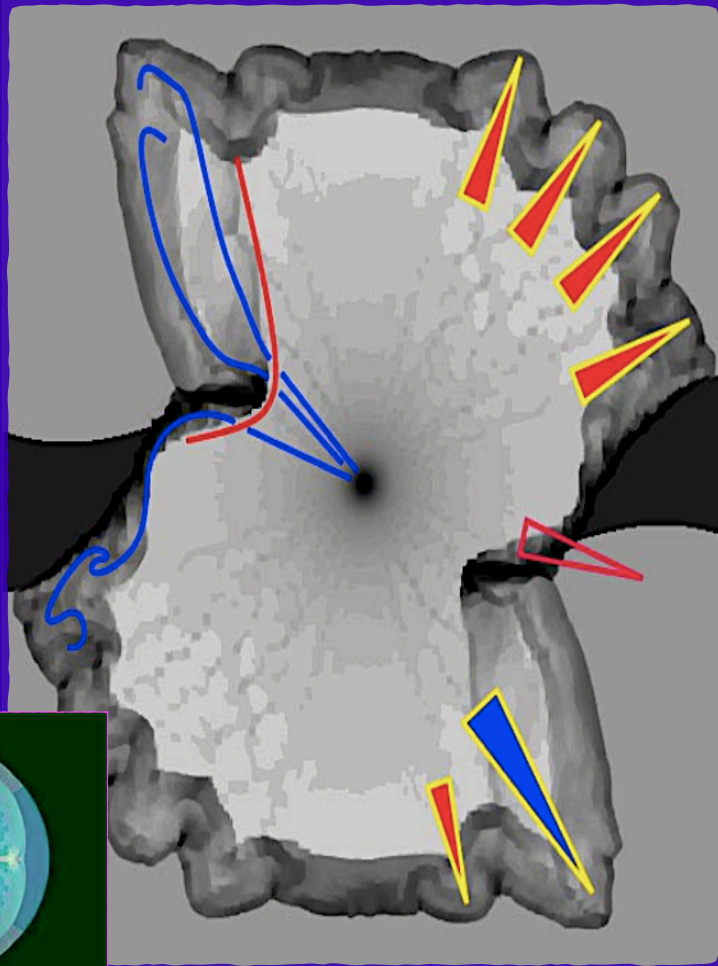


Notice how the supersonic wind from the central star curves around the inward-pointing edges of the disk, forming a bow shock. One branch of this shock flies off into space, forming a finger-like protrusion. The other branch slams into the concave side of the disk, creating all sorts of complicated shapes. Ultimately, if the disk is not too dense, this shock will break through the disk, producing another finger-like extension. Source: Prof. Vincent Icke, Univ. Leiden..

Watch this video of how the polar jets from a pair of stars produce the complex shapes of bipolar planetary nebulae.



Cross-section of a gas thermal-density diagram showing the temperature distribution of 'hourglass' lobes. Source: Prof. Vincent Icke, Univ. Leiden.



Mechanism responsible for the main episode of point-symmetric nebula formation. The background shows a greyscale map of the logarithm of the gas density with a 25° wedge angle. The blue wedge shows the main protrusion; red wedges show the secondary unstable lobes. The open wedge shows the place where the disk will be breached by the wind. The red curve indicates the bow shock surrounding the remains of the inner rim, while the blue curves sketch the gas flow. Source: Icke, A&A, 2003, Fig. 5.

Agent Provocateur: MyCn 18

The Engraved Hourglass Nebula MyCn18 is a young planetary nebula in Musca . Its descriptive name was devised to distinguish it from another Hourglass Nebula, a gas vortex feature associated with H36, a bright O supergiant just now forming a star cluster in the middle of the M8 Lagoon Nebula.

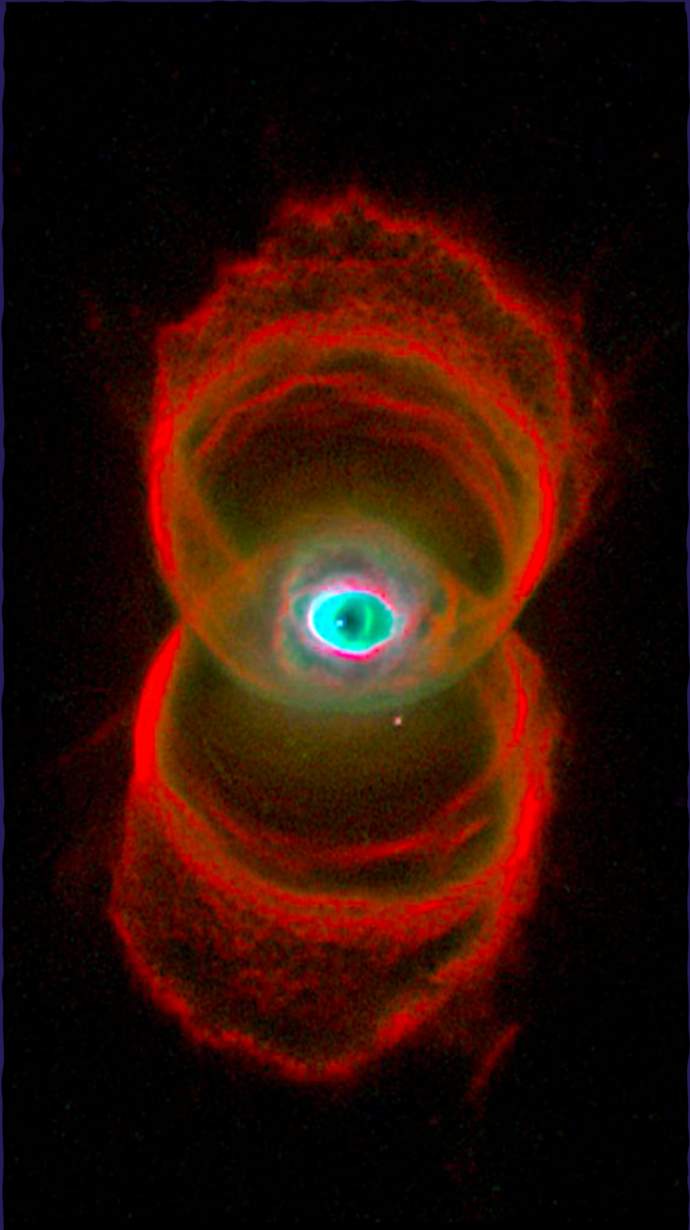
MyCn 18's hourglass shape was produced by the expansion of a fast stellar wind within a slowly expanding cloud denser near its equator than its poles. The vivid colours are products of different shells of elements being expelled from the dying star, in this case helium, carbon, oxygen and nitrogen. These three elements were dredged up from the star's helium-ash core via enormous convection currents induced between the helium-burning and outer hydrogen-burning shells.

By analysing the Hourglass's shapes, chemistry, and densities, astronomers can trace the history of nuclear and chemical changes that occur deep down inside the star's seething furnace.

The upper cone of MyCn 18 tilts toward Earth. The hourglass shape results from the expansion of a fast stellar wind within the nebula's central cloud—the pale blue potato-like feature around the tiny somewhat offset progenitor star.

The off-centre location is caused by an unseen binary companion to the white dwarf. Hydrogen-alpha spectra reveal the presence of a massive, but dim, companion which is being stripped of its outer layers by the gravity of the white dwarf. Strong Ha emission is typical in binary-star PNe.

Watch it all happen here.



MyCn stands for Margaret Walton Mayall (My) and Annie Jump Cannon (Cn), their 39-object catalogue was published in 1940

The mass loss rate of late-stage AGB stars can last hundreds to thousands of years. The early PN forming terminal stage takes place within months to tens of years, 0.03 – 30 yr. This brief era defines the shape the rest of the PN's career will expand till it diffuses into the host galaxy's ultra-thin gas disc only about 100 pc thick.

The greenish-tinged central 'potato' was formed when the white dwarf central star orbited so close to its red giant companion that gas from the companion's surface filled the red giant's Roche lobe. Early in the PN's life the gas is expelled equatorially. As the nebula gains gas volume, much of the gas is forced into relatively slow-moving polar jets by the star's magnetic field and the binary's rotational speed.

At first glance, the bright elliptical ring in the centre of the Hourglass Nebula appears as a dense disc here, but in reality is a potato-shaped structure with a different symmetry axis from that of the larger cone-shaped nebulae. When we see nebulae like thispole-on, we see only ring structures, e.g., M57 in Lyra and the Helix Nebula in Aquarius. Long-exposure M57 images reveal these delicate rings extending much further outward. In 3D views like MyCn 18 here, we see that M57 traceries are in fact hourglass cones.

The hourglass nebula will slowly fade and disperse into space over the next tens of thousands of years. The central ring will cool as it expands over a much longer interval—30,000 to over a million years. The central star remains a cooling white dwarf that survives practically forever. The red giant will evolve into a white dwarf, too, but in most cases decouples from the first start some point due to Galactic tidal stresses.

Peter Goodhew – in his own write

As a child I would look up at the night sky in awe of what I could see - wondering what might he going on up there in this unexplored universe. I recall as a schoolboy going to the public library with my younger brother and borrowing every book that they had on astronomy. My interest developed further in my teenage years, encouraged by watching Patrick Moore's monthly television program, The Sky At Night, on the BBC.

Around five years ago a friend had bought his first telescope and started showing me some of the images that he had taken. I was in awe at what he showed me - even though they were done with just a small refractor and a DSLR. Inevitably I had to get a telescope and camera of my own, with his advice and guidance. My first telescope was a 4 1/2" refractor, on an AZ/EQ6 Mount and tripod - with a Canon DSLR. Naively I thought I could just stick it in the garden, point it at the sky, and start taking photographs

The learning curve was steep - and painful - with things such as polar alignment, guiding, image calibration, stacking and processing being far more complicated than I had ever imagined. This, coupled with the rarity of clear skies with the British weather, meant that the first year was intensely frustrating. On more than one occasion I was very close to selling up everything and abandoning astrophotography as a hobby. However seeing for the first time in my life the

craters on the moon, the rings of Saturn, and the moons of Jupiter helped me persevere.

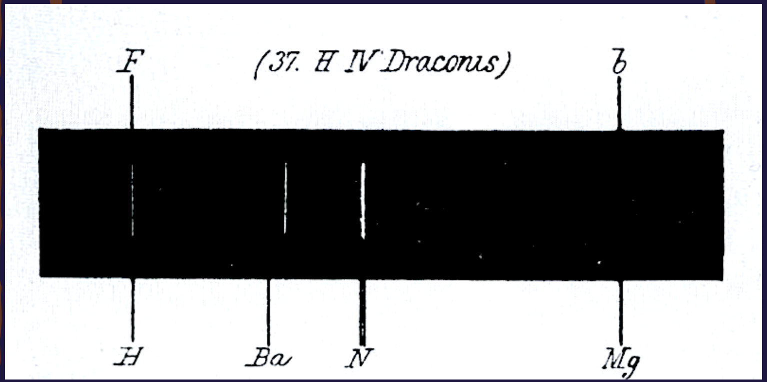
I started digging into my wallet and had a roll-off roof observatory installed in my garden. This meant I didn't have the hassle of setting up and breaking down the rig every time the clouds cleared. Being more productive I then took the leap into CCD cameras and filter wheels with a QSI683wsg8 camera.

The more that I progressed the more I got frustrated with the limitations of imaging from London. After visiting an astronomy holiday location in southern France it became obvious that I needed to establish a robotic remote observatory at dark site somewhere in Europe.

I ended up choosing southern Spain where there are around 270 clear nights a year (in contrast to more than 270 cloudy nights in London!). I used a hosting site and acquired even better equipment: An APM 6" refractor with Russian-made LZOS glass, a 10 Micron GM2000 HPS Mount, a QSI 6120ws8 CCD camera and a set of Astrodon filters. This totally transformed my astrophotographic capabilities.

I have my own robotic observatory with a roll-off roof and everything is fully automated and robotic, based on Sequence Generator Pro. Images are sent to my PC at home throughout the night and are ready for me to process when I wake up in the morning.

It gets better with coffee!



NGC 6543 the famed Cat's Eye Nebula was the first planetary nebula whose spectrum was investigated by the pioneering amateur astronomer William Huggins in 1864.

Astronomical Society of Southern Africa

NIGHTFALL

DEEP-SKY JOURNAL OF THE ASTRONOMICAL SOCIETY OF SOUTHERN AFRICA

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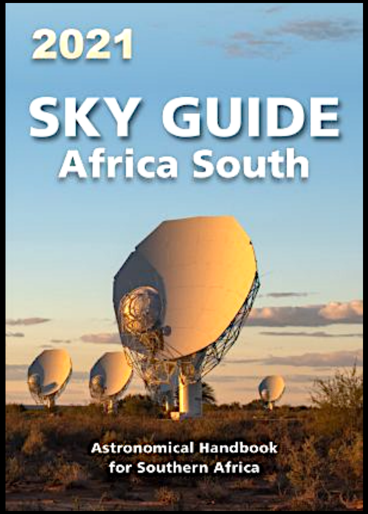

ASSA 2021 SKY GUIDE

MONTHLY NOTES OF THE ASTRONOMICAL SOCIETY OF SOUTHERN AFRICA

ISSN 2617-7331