C. Crooks Astrophotographics

July–September Update:

July 31– Messier 17:

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M17 is one of the sky's very brightest and finest HII emission nebulae, and so has earned a rather preposterous number of informal names, including "the Swan", "the Lobster", "the Omega", "the Horseshoe", and "the Checkmark" nebula. As with a number of show-stoppers in the night sky, this one was discovered by Jean-Phillipe Loys de Cheseaux in 1745. In my post on the Eagle Nebula, I talked about his great misfortune in having his fabulous achievements largely ignored before dying at the age of 35... For all that ignominy, however, he received a fortune that no stuffy French academy could ever bestow.

It would have been some time in the Summer, in the village of Cheseaux-sur-Lausanne, Switzerland. The open spaces—meadows on the shores of Lac Leman—would have been especially verdant and picturesque under the horizon of magnificent snowcapped alps. If passersby saw him as the sun went down, it would have been conspicuous to say the least as he prepared his 14-foot refracting telescope and 2-foot Gregorian[1] reflecting telescope in the observatory he had set up on his father's estate. Certainly part of Cheseaux's good fortune was that his father Paul Loys was the village feudal lord or 'Seigneur', and his grandfather Jean-Pierre de Crousaz was an eminent local academic in mathematics and philosophy.

While the institutions around him were rather medieval, the night sky would have been *primeval*: beyond the nearby candlelights and lamps, only the moon would have been able to sketch the shapes of terra firma around him, and on a night like this one, the moon was likely nowhere in evidence. The starscape was a dazzling and untouched bounty on any clear night, like jewels laid out on the blackest velvet display cloth. No planes or satellites or radio towers.

Cheseaux was only 27 at the time—my own age—and in a sense, no less of an amateur. The distinction between a scientist and a scrupulous citizen of the time was often little more than the means to observe novel things and the willingness to do it systematically. As an aristocrat, it was good form to have some heady intellectual pursuits, but it was hardly crucial, and certainly not a job. Telescopes like Cheseaux's weren't cutting edge technology by a good number of decades, but they were rare and very expensive masterworks even so. It was a lucky thing that such instruments were at least bought by a noble with the humility and diligence not to waste them as conversation pieces, playthings, or status symbols.

Still, even among the observatories in academia, these systematic surveys of the sky were hardly done. Why seek more unknowns in the night sky when there was already a surfeit of them? Galileo had long since demonstrated

1. In reference to the Scottish astronomer James Gregory and not any of the Popes Gregory or related monastic orders.

that the moon had craters, that it was a real rocky thing and not a heavenly Platonic sphere. He showed that other planets had moons too, and between Newton and Kepler we'd come to understand that those real, distant places abide by the same physical laws as we do here... Yet we had gotten precious little further than that. What was between those places and us? Fluid? Air? "Luminiferous Aether?" Many had already surmised that the stars were simply distant suns, but what the hell was the sun, anyway? The moon looked like a rock, sure, but what were those other planets and moons; *why does that one have a giant ring around it? WHAT IS A COMET??* Our own solar system was too much of a mystery to preoccupy people looking for fainter things in the darkness.

We knew such things were up there, e.g. the band of the Milky Way's core, the Andromeda galaxy, the Great Orion Nebula. It must have been daunting to consider. Perhaps Cheseaux was brave then, or perhaps he relished the unknown and a good riddle, or perhaps he just wanted to look at stars. Glimpsing it in the eyepiece must have stupefied him, regardless. I imagine he double-checked his eyes and optics for obstructions before realizing that what he saw was moving *along with the stars*. A cloud-like structure hanging impassive and motionless against the stars.

He'd have known at least that it was massive beyond reckoning, and that he was probably the first human to ever lay eyes on it... To see these things firsthand is a humbling and electrifying experience even with the mystery largely stripped away. As Jean-Phillipe beheld this thing, I can only imagine the rapturous sense of wonder: the feeling of the all human vanities effortlessly sublimated before the grand scale of existence and how much he might never know. Chasing that feeling even at its most dilute has been motivation enough to occupy every clear night I can spare for years now, and probably always will. For all that they ignored him, Cheseaux got to slurp right from the cosmic serotonin tap on a few occasions, so maybe we shouldn't write off his tale as wholly tragic.

So, what was that thing up there anyway? One of our galaxies most productive star factories, towards the core about 5-6000 lightyears away in Sagittarius. What you can see is about 800 times the sun's mass of glowing atomic hydrogen, within a dark molecular cloud containing around 30,000 solar masses of gas and dust. The emissive region is heated by a large cluster of giant, young, energetic stars. In charge of the light show are about 35 of the largest O-Type blue supergiants, and over 100 of their slightly smaller B-type siblings. All spectral types accounted for, however: the nebula houses a whopping 800-1,000 stars within a ~40-lightyear diameter, and none of them are older than 1 million years (infants in stellar lifetimes).

Click the photo to see a .gif overlaying my photo with the imagery from the Chandra X-ray space telescope. You'll note that the positions of the ionizing stars are mostly hidden within the nebula, and the clustering is actually quite pronounced.

I've also prepared here a little visual aid as to where Messier 17 got its many informal names from, especially because some of the ones given by John Herschel (William Herschel's son) are misleading.

JUL 31 / SEP 2 – PLANETARY NEBULAE

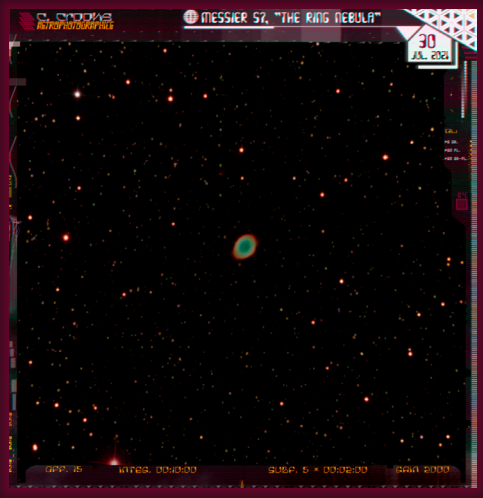
I hope you'll excuse this divergence from a strict chronological organization, as these are both shots I'd like to discuss together. Both are examples of the same kind of target—'planetary nebulae'— but with some salient points of comparison.

To start—I've said as much before but it bears repeating—planetary nebulae have no causal relations to planets of any kind. Astronomers were pretty clueless about any kind of nebulae back in the day, but they noticed that these objects were round, and they figured that planetoids are round, so... *gestures vaguely*.

As much as the confusion is a headache, I actually appreciate the misnomers we keep around. It's the same reason that I devoted much of my last post about M42 to discussing the life and death of "nebulium" theory, or why I like that IC 2574 is often still called "Coddington's Nebula" despite being a dwarf galaxy. The late Dr. Carl Sagan had an excellent bit about those scientists who once proposed that Venus might even have dinosaurs on it. I think it's an important dose of humility, a reminder to be cautious in our assumptions and open to admitting when we (and especially Coddington[1], hahaha) are wrong.

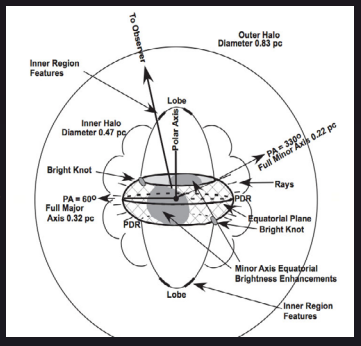
Anyway, planetary nebulae are actually the outer layers of dying, low-intermediate mass stars. Each is a colossal superheated envelope of matter thrown off into space during the last few thousand years of life, due to a final great flourishing(s) of heat and solar wind as the inner layers and the core contract and fuse the last reserves of lighter elements.

M57—"The Ring Nebula"— here is a gorgeous and colorful example, perhaps one of the most famous nebulae of its kind. Planetary nebulae cool rather quickly and so become invisible before they grow nearly as large as many diffuse nebulae lasting only about 20,000 years; as a result they are often quite small to observers. The Ring is no exception, especially at a distance of roughly 2,000-2,300 lightyears and 4,000 years of kinematically estimated age. Despite this, it's a joy to image as it's quite for an astrophotographic target, and displays a tremendously rich color variation due to all of the elements that are expelled at the end of a star's life.



Photographing objects like M57 has both a blessing and a curse: they're bright enough to be seen easily, yet so bright that they are hard to process into HDR composites with both visible dim background objects (e.g. the galaxy IC 1296, visible above M57 here) and well exposed internal details.

The deep blue and green are the result of helium and oxygen respectively, and form a separate structural shell, thought to be football shaped with one end pointing towards us. The other structural element—the outer ring of yellow, orange, and red—is a rather broad 'barrel' shape (think old-school wine-casks) of hydrogen, nitrogen (mainly), and sulfur. So, while many ring like objects observed are roughly spheroid but seen that way due to transpar-



This diagram gives a detailed depiction of the theorized shape as outlined by scientists at the Vanderbuilt university using data from the Hubble Space Telescope. (C. R. O'Dell et al., 2013.)

1 This is totally unfair to Edwin Foster Coddington, who practiced astronomy at a time when all galaxys were called "spiral nebulae" because Hubble had not yet proven what they really were.

ency at various angles, M57 truly does have a complex, dipole shape including a ring, and we have the good fortune of seeing it face-on.

So what gives? Expanding energies in a vacuum are round, unless some bounding force or obstruction channels them otherwise. For a dying star, this can be many things: rotational momentum, magnetic fields, and the influence of nearby objects/matter. Research seems to suggest the primacy that last factor, which encompasses companion stars, giant planets, and the shells thrown off by previous starbursts. M57 seems to have been influenced chiefly by the latter.

Much of the matter expelled in the main ring seems to have been pushed more slowly, soaking up ionization and gaining some speed, but so massive that when the star's intensity dropped again, it was moving along at a leisurely 43,000 miles per hour, and due to any aforementioned factors, had an equatorial bias. The inner 'football' came later; a thinner shell thrown much more forcefully by a more brief and extreme starburst. It came through at the poles where the first shell was thinnest, and now is wearing the first shell as a jaunty belt.

Contrast this curious shape then, with the form of M27, "The Dumbell" or "The Apple Core" nebula:

This too is a planetary nebula, but it's not quite a football-in-a-barrell. Something else must have happened here.

Like M57, we are viewing this nebula from nearly face-on to the equatorial axis of its star. M27 is more than twice the age of M57—about 12,700 years old (O'Dell et al., 2002.)—and a little more than half the distance: ~1,360 lightyears in the constellation Vulpecula. (GAIA Collaboration, Data Release 2, 2018.) As a result, we have an excellent view of it in terms of angular size. M27 falls into the category of planetary nebulae that we refer to as 'prolate spheroid' shaped, which is not only more apt at describing the morphology in 3-dimensions, it's a little more dignified than comparisons invoking weightlifting or dumpsters. What does that mean? Well, as geometry whizzes already know, it means this one is also a football

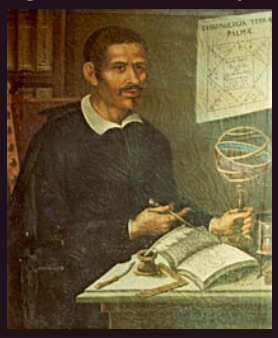
It has no interacting 'barrel', but clearly shows us a variegated and interacting series of shells, including those curious fan-like regions of red emission to either side of the disk, which have been termed "lobes". While no thorough explanation has found a broad consensus for the mechanism at work: it seems that this too was the result of some interaction with the main star's orbital companion, in which its gravity helped to collimate (i.e. focus) the shell of ejected matter preferentially towards two poles.

As it stands, our understanding of the kinematics of planetary nebulae are still only in their infancy, and even their study on the whole is a rather new thing. The two covered here are fully half of all the planetary nebulae in Messier's catalogue, which he only compiled to rule out such objects in his single-minded search for comets. They are small and brief bubbles of brilliance on a cosmic scale, but ones that tell us a great deal about the stars they come from, and 'galactic ecology' on the whole: such nebulae are a major source of the material that will be recycled into new stars with the march of time.

MESSIER 8, "THE LAGOON NEBULA", AUG 5TH:

Sadly it would not have looked nearly this pretty to Messier or Hodierna, but would at least have given a tantalizing glimpse of a larger and more complex structure.

This stunning nebula is bright enough to be seen faintly with the naked eye under truly dark skies, and so was one of the first that Charles Messier added to his catalogue of non-comets. Owing to it's brightness, it was also first discovered much earlier, at some point before 1654 by the Roman Catholic priest and astronomer Giovanni Battista Hodierna, along with at least 19 other verified nebulous objects. Interestingly, his goal was also to rule out objects as being comets, and yet his work seems to have never been read by Messier. He was a man of many interests and also among the first to study insects with optical microscopy.



To be an astronomer in the earliest days required mainly two credentials: do you want to do astronomy? Can you do it?

The object itself is an emission nebula about 5,200 lightyears away in the constellation Sagittarius, spanning an estimated ~110 by ~50 lightyears across. It is truly a behemoth, and due to its size and nearness, was the site in which the first accreting stars were directly observed as "Herbig-Haro" objects. It also contains numerous dark "Bok globules" and overall is a very attractive and dynamic view of a major star-forming region.

ASSORTED OTHER NEBULAE:

Despite about a month of bad weather starting in early August, I've also taken a number of photographs since then, and they generally fall into the category of nebulae that I've already discussed, such as NGC 7635 "The Bubble Nebula", or nebulae that may be discussed in greater detail once better photos have been taken. There is always something worth talking about, such as the Extended Red Emission (ERE) from IC 63, "The Ghost of Cassiopeia", but for as long as this is purely a hobby for me, I will have to find the the time to discuss it all another time. For now, please enjoy the photography.
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