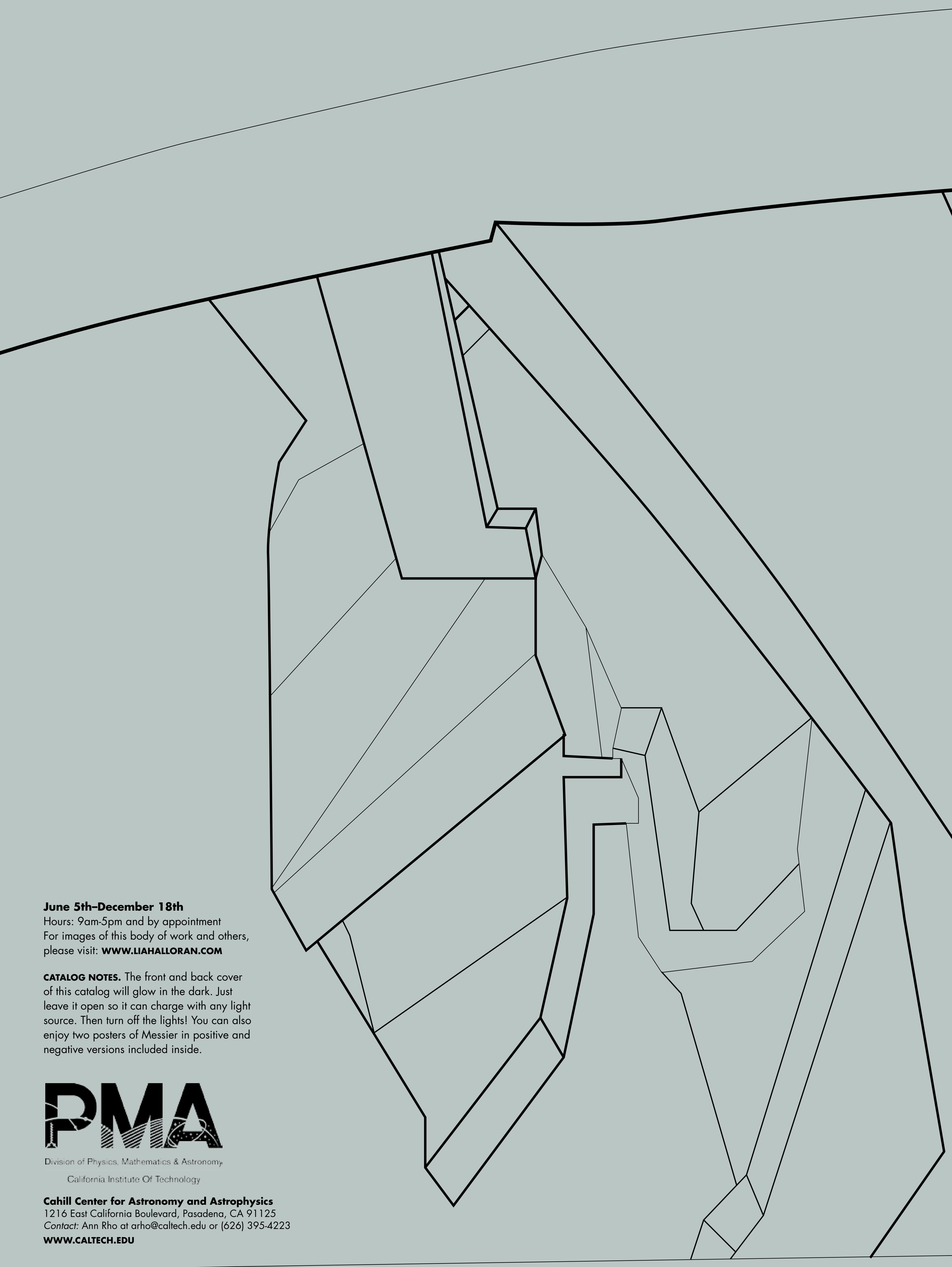


June 5th–December 18th
Hours: 9am-5pm and by appointment
For images of this body of work and others, please visit: **WWW.LIAHALLORAN.COM**

CATALOG NOTES. The front and back cover of this catalog will glow in the dark. Just leave it open so it can charge with any light source. Then turn off the lights! You can also enjoy two posters of Messier in positive and negative versions included inside.

PMA

Division of Physics, Mathematics & Astronomy
California Institute Of Technology

Cahill Center for Astronomy and Astrophysics
1216 East California Boulevard, Pasadena, CA 91125
Contact: Ann Rho at arho@caltech.edu or (626) 395-4223
WWW.CALTECH.EDU

DEEP SKY COMPANION

LIA HALLORAN

DEEP SKY COMPANION

When I first read about French astronomer Charles Messier's initially frustrated attempts at comet hunting, which instead led to a blurry nebulae (M1), I related the account to my own challenging first stabs at observing the night sky. In college, I was given a small Celestron telescope for Christmas and eagerly and faithfully observed planets, Jupiter's moons (wow!) and Saturn's rings (double wow!). When it came to galaxies, I strained and relaxed my eye to activate my peripheral vision and to make out the geometry of the object, or I at least imagined that I did. When unable to find the object of my affection, it was sometimes unclear if I had pointed incorrectly and just how near or far off I was. Yet when the small rudimentary knobs of the telescope did lock onto and successfully track one of these spectacular objects, the excitement and romance of the search eclipsed those previous disappointments. Viewing Saturn from my rooftop was somehow far more impactful on me than the jaw-dropping images from the Cassini satellite because I could *experience* space, and understand that I was in fact a space traveler on a celestial rock, looking out at another rock traveling in space. Observing the Orion Nebula and nearby galaxies seemed to create a fold and overlap in time between myself and Messier. I would imagine his observing sessions and the drawings he made through his telescope to classify the natural world and make sense of the unknown above him. An interest in scientific taxonomy, the narratives that drove the rise of astronomical catalogs and, most importantly, how we have come to know what we know are the origins of the *Deep Sky Companion* series.

When he came across fuzzy objects, or heard about them from others, Messier would take note 'of objects to be avoided while hunting for comets' so he could set them apart from the grand prize: a lonely, wandering comet. Messier was slow in amassing an astronomical catalog filled with galaxies, clusters and nebulae. His catalog of objects numbered 103, posthumously reassessed to 110 based on his journals and drawings. This story is about the experience of discovery and all the things we find when we are not seeking them.

Deep Sky Companion is a series of 110 pairs of paintings and photographs of night sky objects from the Messier Catalog, highlighting Messier's hand in discovery. Each painting was created in ink on semi-transparent paper and was then used as a negative to create the positive photographic equivalent using standard black and white darkroom printing. This process connects to the historical drawings by Messier, here re-drawn and then turned back into positives through a photographic process mimicking early glass plates astro-photography. On view at the Cahill Center for Astronomy and Astrophysics is a site-specific edit of *Deep Sky Companion* comprised of 110 telescopic disks made from the positive prints. Messier's Catalog of original drawings and observations is here reimagined and open for the experience of rediscovery.

—LIA HALLORAN

Lia Halloran's work often uses science as a conceptual bounding point to explore how perception, time and scale inform a constant desire to understand our physical and psychological relationship to the world we inhabit. Solo exhibitions of her work have been held at venues in New York, Miami, Boston, Los Angeles, London, Vienna and Florence. Her work is held in the public collections of the Solomon R. Guggenheim Museum (New York), The Speyer Family Collection (New York), The Progressive Art Collection (Cleveland), and the Art Museum of South Texas. Halloran has been profiled in publications including The New York Times, The New Yorker, The Boston Globe, The Los Angeles Times, ArtNews, *and* New York Magazine. *Halloran was recently awarded an Art Works for Visual Arts Grant from the National Endowment for the Arts for her project, 'Your Body is A Space That Sees', highlighting the historical contribution of women in astronomy. Halloran lives and works in Los Angeles and serves as Assistant Professor of Art and Director of Painting and Drawing at Chapman University where she also teaches courses that look at how creativity and problem solving can be the point of intersection for art and science.*

www.liahalloran.com

The first step to discovery is failing to find the thing you search for. Before there were words to describe the cosmos, human beings struggled to quantify and qualify the things they saw above their heads. No matter what rapid forms of evolution humans may experience in the coming millennia, no matter how many new terminologies the scientific community may conjure to signify all we observe, the only hard and fast law of the universe is that we will never know (and certainly never explain) all it possesses. What we can do, though, is think creatively when we encounter the unknown; to channel our frustration of unknowingness and transmute it into a new gesture. Some would classify this process as art. Los Angeles-based artist Lia Halloran tests the boundaries between seeing, classifying, and reproducing deep-sky objects against those catalogued by French astronomer Charles Messier. Her new site-specific installation, *Deep Sky Companion,* is both an adaptation and variation on the visual data comprising Messier's 110 deep sky objects that he observed in his attempt to chart comets (when, in fact, he had "accidentally" observed whole galaxies and interstellar nebulae).

Without any irony whatsoever, Halloran's exhibition site is architect Thom Mayne's building for the Cahill Center for Astronomy and Astrophysics at the California Institute of Technology. Slanted ceilings, extreme planes, and every possible expression of asymmetry are ideal settings for Halloran's iterations of Messier's amorphous cosmic bodies. The works climb upwards through three stories at varying distances from the viewer; installation directly mimics the inherent difficulty a person would experience in looking at objects in deep space. Halloran collaborated with architect David Ross, of the Fredrick and Fisher Partners Architects and past student of Thom Mayne, on the physical and structural layout of the exhibition.

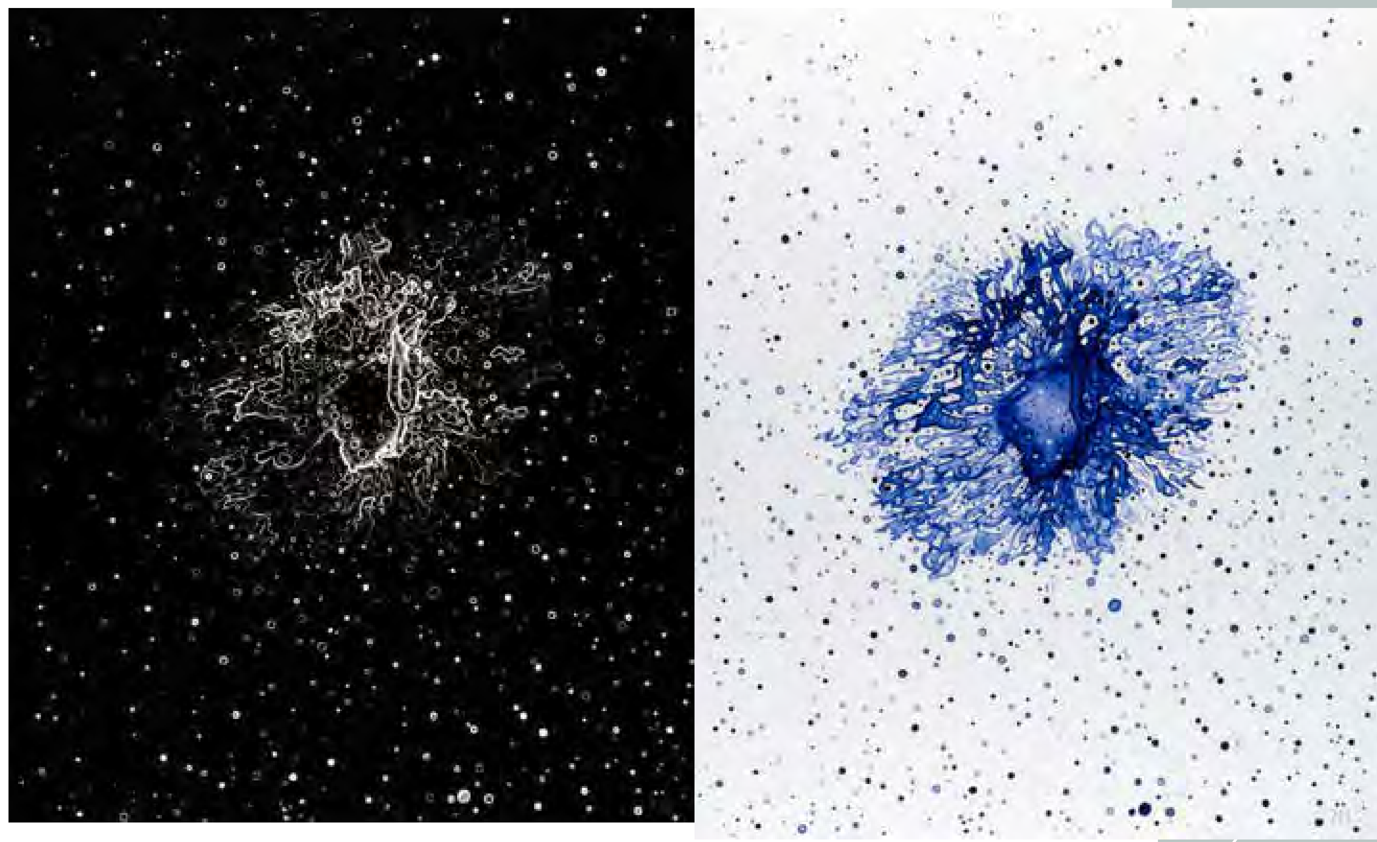
The works themselves are divided into two formats: self-animating blue ink on drafting film (just as light and matter travel gracefully through deep space, so does this deep-blue ink across a print) and camera-less prints on photosensitive paper which appear in a similar way to specks of light appearing against the vacuum of deep space. There are one or more "coincidences" in her process relating to that of Messier's sequential cataloguing of celestial bodies; shapes, densities, shades, and compositions are mostly matters of chance when dealing with her inks and prints, but Halloran's methods are entirely premeditated. She has selected a subject in Messier himself that communicates both his frustration and wonder in equal parts. While he was searching out comets, his actual results proved to be ever greater in scope, far greater than he could see or quantify.

Artists, too, consistently chase objects they cannot define nor accurately replicate; you can see color with your eyes closed, but how do you replicate that once your eyes open again? Halloran builds a sympathetic bridge between the seemingly opposite fields of science and art: science possesses equal expressiveness and passion to a work of art, and art translates formulae, numbers, and theories back into the wondrous forms that the scientist sees in the first place. Where the artist's uncertainty rests in her hand, the astronomer's uncertainty rests in the eye. The collective approach of the scientific community, when applied to objects in deep space, has largely rested on what is seen versus what cannot be seen. Only that which is observable is certain, the light that reaches us has long since gone, and the birth of new stars, new galaxies, and new objects in space may never be comprehensively recorded. By creating her own catalogue in two mediums, ink and photogram (where negative "space" is actually recorded in inverse values to how light is seen by the human eye), Halloran builds a loose visual narrative of Messier's discoveries with no perceivable conclusion.

Mirrors, patterns, and repetition are all underlying principles for the individual images in *Deep Sky Companion*, but like the dynamic universe they are subject to forces and changes beyond our comprehension of three-dimensional space. Halloran unwittingly reveals the frailties of the artist and scientist in a single gesture, while maintaining a small sense of triumph in that we are capable of perceiving these things, at all. Our own observations transform and fluctuate, based on what technology makes available, but both the artist and the astronomer will push further into interpreting what sorts of phenomena our universe holds. Halloran's work echoes Messier's own discoveries as those which are open-ended and unresolvable. In other words, what appears on Halloran's films are progressive, changeable things rather than permanent markers.

Art, essentially, brings deep space back down to earth.

—SHANA BETH MASON



M1

DEGREE OF DIFFICULTY: **3 (OF 5)**
MINIMUM APERTURE: **50MM**
DESIGNATION: **NGC 1952**
TYPE: **GALACTIC NEBULA**
SIZE: **6,200 LY (1999)**
CONSTELLATION: **TAURUS**
MAGNITUDE: **8.4**

I am proud to have played a role in bringing Lia Halloran's Deep Sky Companion exhibit to Caltech. When I first met Lia (ten years ago at a party in Pasadena), I was in the early stages of a collaboration with Steven Spielberg on a movie that would become *Interstellar*. Lia and I talked about how to convey to Spielberg the essence of the "warped side of the universe": objects and phenomena made wholly or partially from warped spacetime—black holes, wormholes, neutron stars, gravitational waves...Lia drew a pencil sketch of a Dr. Seuss-like, ribbon-like universe filled with wormholes linking distant regions and black holes piercing the bulk around the ribbon. I loved it then—and love it now (it hangs framed on the wall of my home office!)—and so I showed it to Spielberg to inspire our discussion; and later, when Christopher Nolan took over as *Interstellar*'s director, I showed it to him as well, as inspiration.

When I came to know Lia and her art more deeply, I embraced them fully, and asked her to collaborate with me on a project (just the two of us) that is becoming a book: her paintings, and my attempts at poetry, conveying the essence of our universe's warped side.

Two years ago, Lia showed me twenty of her Messier-Catalog paintings: a captivating work in progress. We immediately began brainstorming about where—when the paintings were all finished—she might exhibit the entire collection. The entryway of Caltech's Cahill Center for Astrophysics was an immediate, obvious choice; so late in the evening, I went to Cahill with a large tape measure, and reported back to Lia all the relevant dimensions. It looked feasible; our enthusiasm grew; and so I proposed to Tom Soifer, Caltech's Chair of Physics Mathematics and Astronomy (PMA), that Caltech explore with Lia the possibility of introducing her Messier paintings to the world, via an exhibit in Cahill. With Tom's encouragement, others at Caltech—particularly astrophysicist Sterl Phinney and PMA Development officer Ann Rho—took over, and worked with Lia to make it happen. And for that I'm grateful and pleased.

Among the Messier objects, the one closest to my heart is M1: The Crab Nebula. In summer 1961, as a Caltech undergraduate, I worked with astrophysicist Jesse Greenstein on the theory of synchrotron radiation from relativistic electrons spiraling around magnetic field lines. Jesse told me that a beautiful example was M1, and that the polarization M1's light reveals the directions and shapes of its magnetic fields. I spent many hours reading everything I could about M1 and gazing in awe at its photographs. A few years later, astronomers found a pulsar in M1's heart, among the first inhabitants of the warped side of the universe ever discovered by astronomers: it is a neutron star, made in part from warped spacetime, and in part from nuclear matter. A few years after that, I spearheaded the creation of a research effort at Caltech to search for gravitational waves produced by warped-side objects, an effort that helped give birth to LIGO. Among the sources of gravitational waves that we targeted, from the very outset, was the neutron star in M1.

So M1 has been an important part of my life since 1961. To me, personally, Lia's painting of M1 is the centerpiece of her exhibit. I encourage you to gaze on its beauty. **—DR. KIP THORNE**, FEYNMAN PROFESSOR OF THEORETICAL PHYSICS, EMERITUS, CALTECH

M31

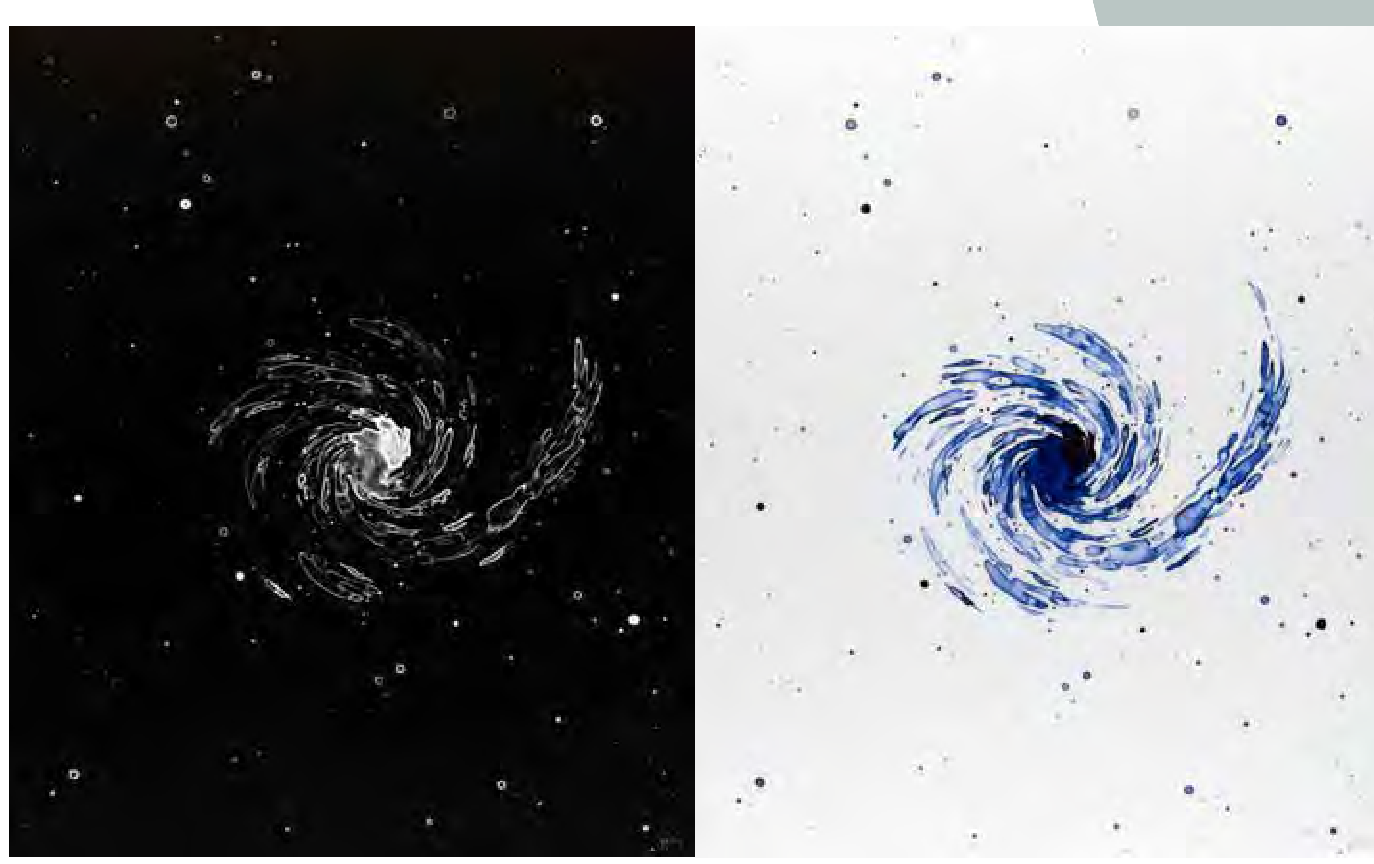
DEGREE OF DIFFICULTY: **1 (OF 5)**
MINIMUM APERTURE: **NAKED EYE**
DESIGNATION: **NGC 224**
TYPE: **GALAXY**
SIZE:**160,000 LY**
CONSTELLATION: **ANDROMEDA**
MAGNITUDE: **3.4**

I got into amateur astronomy when I lived in Montana (we call it "Big Sky Country" for a reason!). Under the dark, Rocky Mountain skies, M31 is a naked eye object, provided you know *where* to look! I was learning constellations and how to use my telescope, and how to see and notice stuff all at the same time. For the life of me, I could NOT recognize Andromeda, nor could I notice M31 with just my eyes. But I could see and recognize Cassiopeia, which I knew was somewhere above M31. The first time I found M31 I spent about 1/2 hour just sweeping my telescope back and forth, methodically across the sky under Cassiopeia, moving it down a little bit with each sweep. Eventually, the milky haze of the galaxy passed into view and it was AWESOME. I barrel-sighted down the side of the telescope and finally was able to recognize the constellation of Andromeda! Recognizing the milky haze in the telescope, and the corresponding faint foggy patch visible to my naked eye in the sky was one of my first lessons in learning how to SEE what is there to be seen in the sky.

My favorite Messier Object (M46): The universal appeal of the Messier Catalogue is that everything can be seen in a small telescope, and there is a wide variety of different kinds of objects—it's kind of like a mini-sampler plate for astronomy! Among my observing buddies, I am well known for the disdain I hold for "open clusters"—loose agglomerations of stars that have formed together and are slowly dispersing back into the galaxy. I just don't like them – they are often just a smattering of stars that are hard to recognize against the background stars. It will come as a surprise to many then that my favorite Messier object is the open cluster M46. The reason I like it is there is a faint planetary nebula—just a small, round bubble of gas that looks like a cotton ball, floating over the cluster. I noticed it quite by accident, and remember being so excited that I had *stumbled* on something I wasn't already looking for! In this case, the planetary nebula is known and plotted on charts if I had noticed; it goes by the name NGC 2438. **—SHANE L. LARSON,** RESEARCH ASSOCIATE PROFESSOR, NORTHWESTERN UNIVERSITY, DEPARTMENT OF ASTRONOMY, ADLER PLANETARIUM

M99

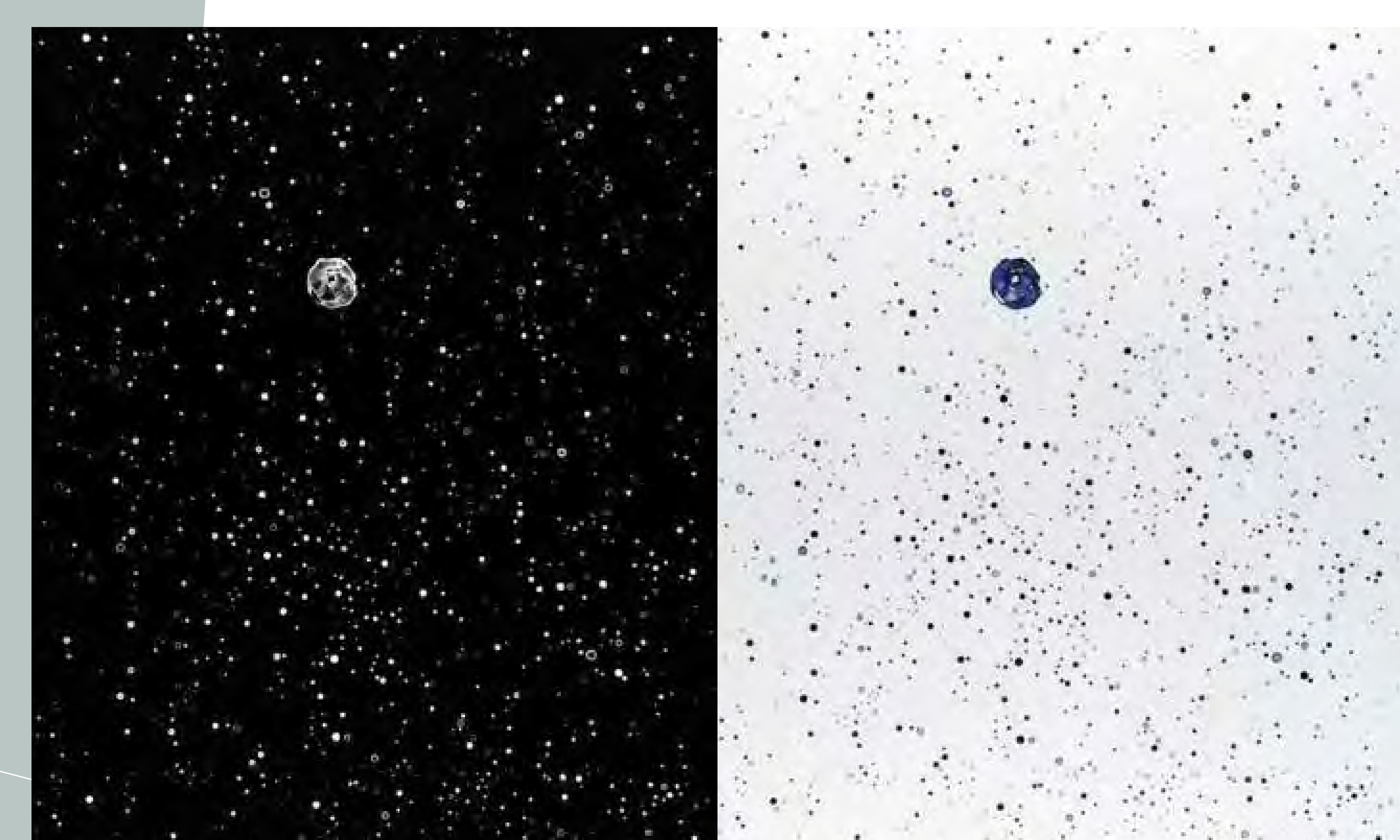
DEGREE OF DIFFICULTY: **5 (OF 5)**
MINIMUM APERTURE: **50MM**
DESIGNATION: **NGC 4254**
TYPE: **GALAXY**
SIZE: **83,000 LY**
CONSTELLATION: **COMA**
MAGNITUDE: **9.9**

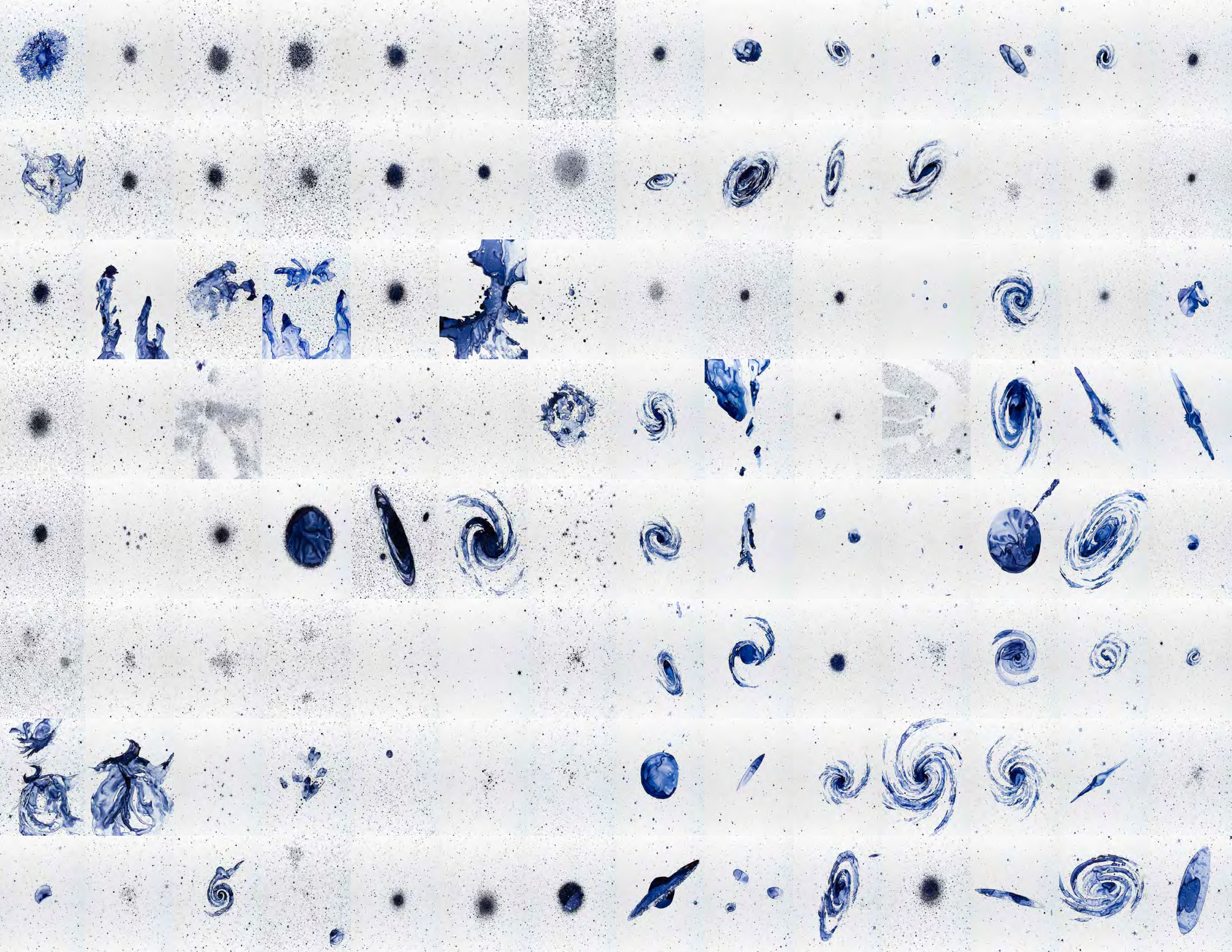


When I was an undergraduate at Cornell University, I did a Messier marathon with an eyepiece on the Fuertes telescope. My most memorable encounters with Messier Objects are when they dramatically change relative to this undergraduate memory. I will give three examples. On 2010 April 17, I was super excited when I discovered a new flash of flight in Messier 99, a rare transient (dubbed PTF10fqs) that lives in the luminosity gap between novae and supernovae. This new picture of Messier 99 became the cover of my PhD thesis. On 2011 August 24, the Palomar Transient Factory (PTF) found a young Type Ia supernova (dubbed PTF11kly) in Messier 101. We celebrated with a star party where a thousand people looked through a telescope on the Cahill rooftop and saw supernova photons fall directly on their eyes. On 2014 April 18, we found an infrared flash of light in the Messier 83 galaxy (dubbed SPIRITS14ajc) which appears to be the birth of a massive star binary. This discovery marked the beginning of my exploration of the dynamic infrared sky. **—MANSI M. KASLIWAL**, ASSISTANT PROFESSOR OF ASTRONOMY, CALTECH

M46

DEGREE OF DIFFICULTY: **3 (OF 5)**
MINIMUM APERTURE: **NAKED EYE**
DESIGNATION: **NGC 2437**
TYPE: **OPEN CLUSTER**
SIZE: **26 LY**
CONSTELLATION: **PUPPIS**
MAGNITUDE: **6.1**





M42

DEGREE OF DIFFICULTY: **1 (OF 5)**
MINIMUM APERTURE: **NAKED EYE**
DESIGNATION: **NGC 1976**
TYPE: **GALACTIC NEBULA**
SIZE: **35 LY**
CONSTELLATION: **ORION**
MAGNITUDE: **3.7**

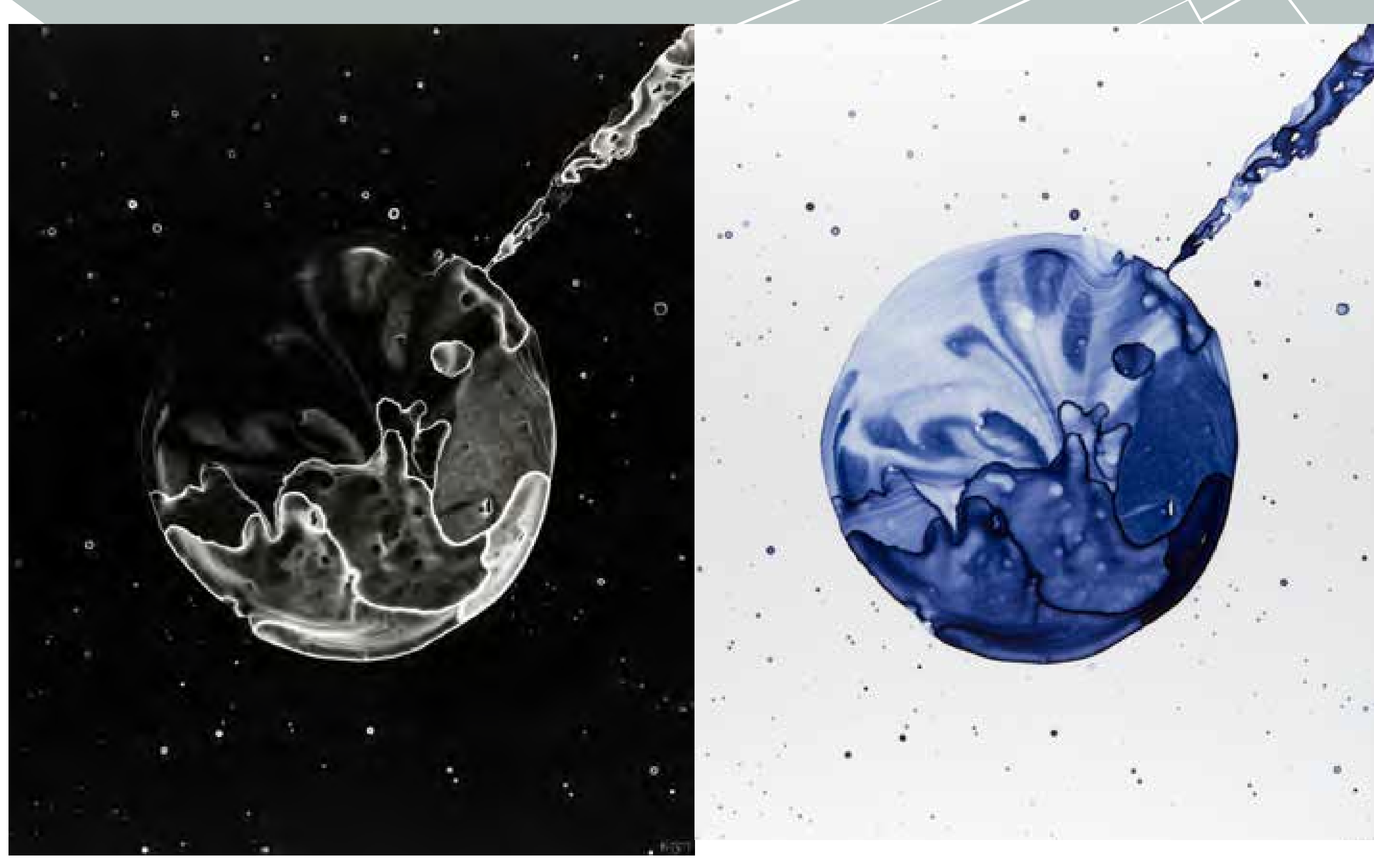
The famous M42 and associated M43 are part of a large, contiguous region of star formation in the constellation of Orion, called the Sword. The extended fuzzy area can be seen with the naked eye. My first encounter with these Messier objects was actually in research. As a young graduate student, I was asked to find photometry and other information in the research literature for a set of stars in the M42/M43 vicinity, and to identify those with "ultraviolet excess"so that they could be followed up with spectroscopy at a telescope on Kitt Peak. I took my literature search very seriously and dug up all the classic, many decades old work, much of it by giants in the field of astronomy, and began to understand the role of M42 in telescope and detector history, and indeed, in establishing the field of star formation. I simply could not *believe* that there was actual science to be done on something as famous as Orion. But the more I learned about it, the more I appreciated how little we actually knew regarding what was happening there. I went on to work on the additional Messier objects M8, M16, and M17 before defining my Ph.D. thesis project. And then as a senior graduate student I came back to M42, hoping to establish some ground truth there for interpreting my thesis results on other moreminor regions of star formation. M42 continues to be one of the first objects observed with any new astronomical technology or telescope. **—LYNNE HILLENBRAND**, PROFESSOR OF ASTRONOMY, CALTECH

M45

DEGREE OF DIFFICULTY: **1 (OF 5)**
MINIMUM APERTURE: **NAKED EYE**
DESIGNATION: **—**
TYPE: **OPEN CLUSTER**
SIZE: **15 LY**
CONSTELLATION: **TAURUS**
MAGNITUDE: **1.5**

The stars in M45 (the Pleiades cluster) gave me a lot of trouble during one of my first research projects. They were younger and denser than the other stars we were investigating, and we had to bend over backwards to get their data to behave properly. Now, when I see M45 in the night sky, I feel a bit of intimacy. I can say, "I have your fingerprints on my computer!" and, with satisfaction, "Despite all the trouble you gave me, I can use those fingerprints to figure out how old you are and what you're made of." **—ANNA HO,** GRADUATE STUDENT IN ASTRONOMY, CALTECH

In 7th grade, I got a department store 2-inch (5cm) refractor telescope. By 8th grade, I'd figured out that to find anything in the sky with it, I needed lower power, wider field eyepieces than the impressive-sounding but useless 150x eyepiece that came with the telescope. I later got a set of 110 index cards ("Astro Cards" by George R. Kepple).These cards, one for each Messier object, have marvellous naked-eye and telescopic-view finding charts, with helpful instructions and descriptions. I spent many, many memorable nights out in our sheep pasture with the 2-inch telescope, working my way through the cards and seasons while being screamed at by mating racoons, eaten by mosquitoes, and frozen in the snow. Alt-az mount, no setting circles and no computer-controlled motors in those days: I found the Messier objects by carefully hopping from star to star to the field on the cards' finding charts. I still have the cards, and the checkmarks and notes pencilled on them indicate that I eventually found 99 of the 110 (I got bored with faint galaxies in the Virgo cluster, it seems). I remember being most excited by M1, knowing that it was the remains of an exploded star, by M27, M76 and M97, knowing that they were the shells of old stars whose cores were now white dwarfs, and by the beauty of the Pleiades (M45) and the star cluster M11. My little telescope could not resolve globular clusters into individual stars, but during a band visit to a nearby college with a 24-inch telescope, I still remember my heart pounding at the sight of thousands of stars in the globular cluster M3. All those glorious nights alone in the pasture with the Messier objects cemented my love of astronomy. The cold and mosquitoes may have contributed to my decision to become a theorist. **—STERL PHINNEY**, PROFESSOR OF THEORETICAL ASTROPHYSICS, AND EXECUTIVE OFFICER FOR ASTRONOMY, CALTECH



M87

DEGREE OF DIFFICULTY: **4 (OF 5)**
MINIMUM APERTURE: **50MM**
DESIGNATION: **NGC 4486**
TYPE: **GALAXY**
SIZE: **132,000 LY**
CONSTELLATION: **VIRGO**
MAGNITUDE: **8.6**

I think the first time I had heard of Messier objects was through the band M83. On discovering them and their history I quickly figured out they were named after a celestial object, and in fact Messier object. I had run across Messier objects in the past without knowing it, but wasn't aware of their history, and I read the Wikipedia article on them at that time. Now I've published several papers on M87, which is my favorite Messier object. I've even recorded space electronica music (including an M83 cover) under the pseudonym Charles Messier as a homage to my interest in space and music (https://soundcloud.com/messier-etoiles/sets/featured-space-electronica). So Messier objects are a part of my life. **—DR. CHRISTINE CORBETT MORAN,** SOUTH POLE TELESCOPE WINTEROVER SCIENTIST

I've certainly seen M31 once with the naked eye, and that's a thrill. You're seeing another galaxy! I've observed M31 to search for pulsars, in a couple of different approaches. I think that one of my impressions from a science perspective is that, even though M31 is the closest galaxy, it is also *far away*. Actually, one of my searches has been with the Green Bank Telescope, looking for single pulses. (Unfortunately, the data are only partially reduced.) I remember sitting at the telescope late at night, somewhat sleep deprived, having that thrill of commanding one of the world's largest telescopes to look for that blip that might hint at the first pulsar beyond the Milky Way's satellite galaxies. **—JOE LAZIO,** CHIEF SCIENTIST, INTERPLANETARY NETWORK DIRECTORATE, JPL

M104

DEGREE OF DIFFICULTY: **3 (OF 5)**
MINIMUM APERTURE: **50MM**
DESIGNATION: **NGC 4594**
TYPE: **GALAXY**
SIZE: **105,000 LY**
CONSTELLATION: **VIRGO**
MAGNITUDE: **8.0**

The Sombrero Galaxy, M104, was one of the first Hubble images I ever saw, back in early days of the internet (and when I was still in High School). I liked its clean lines, simplicity and stunningly bright core. I remember marveling at how scientists had managed to take a picture of an object which is 28 million light-years away, with a telescope in outer space!

My mother loves the Orion Constellation, and often pointed it out to me when I was child. If you could stand the sub-zero temperatures of a Canadian winter, it was especially stunning to observe on clear nights. Bundled up, I used to walk a few minutes to a large open field, where I was rewarded with a sky so bright and full of stars, that it was easy to get lost in its vastness and brilliance. I wondered what the blob (M42) under Orion's belt was, and my father told me that it was a huge collection of gas called a "nebula". I often imagined aliens living there, looking back at me, who in turn wondering what it was like to live on Earth. **—CHIARA M. F. MINGARELLI,** MARIE CURIE POSTDOCTORAL SCHOLAR, CALTECH

CALTECH'S HISTORIC CONNECTION

M1: At the center of the Crab nebula, the first entry in Messier's catalog, is a pulsar, a neutron star spinning an incredible 30 times per second. This was created in 1054CE by the explosion of a star, recorded by 11th century Chinese astronomers. That stars could explode, that the explosions would appear as bright transient events, and that the explosions could leave a remnant neutron star, was predicted in 1934 in a pair of remarkable papers by Fritz Zwicky and Walter Baade, both of Caltech.

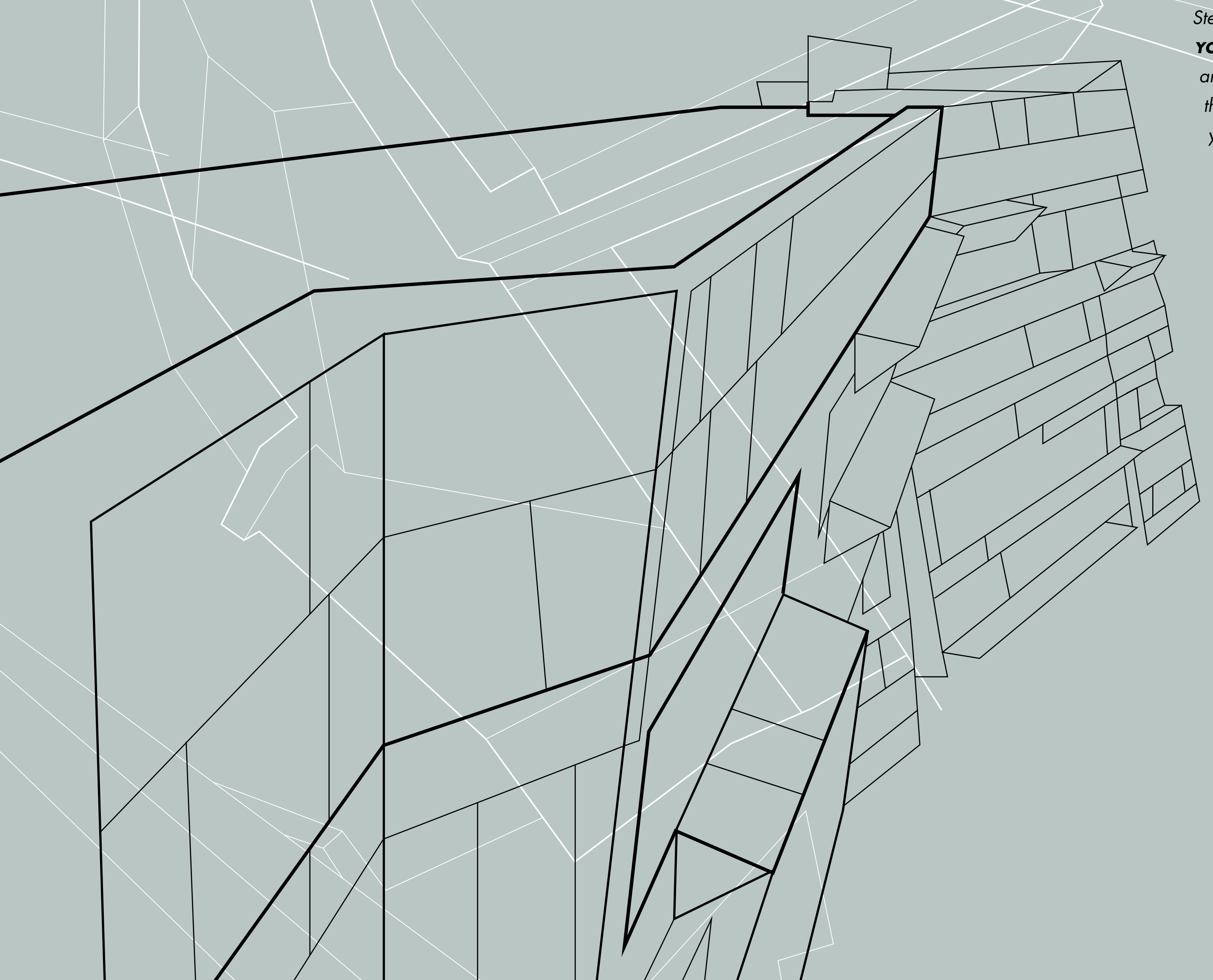
The second paper contains the famous lines "With all reserve we advance the view that a super-nova represents the transition of an ordinary star into a neutron star, consisting mainly of neutrons. Such a star may possess a very small radius and an extremely high density." Remarkably, the neutron had only been discovered two years before! That radius is now known to be about 10km, and the central density about 10^{15} (a million billion) times the density of water!

In 1968, the year the pulsar was discovered, Caltech graduate student Virginia Trimble used photographic plates taken between 1939 and 1966 with the telescopes at Mt. Wilson and Palomar, to measure the expansion of the filaments in Messier 1. She discovered that they not just been coasting since 1054, but instead have been accelerating. It is now understood that the acceleration has been powered by a powerful wind of ultra-relativistic particles created and accelerated by the pulsar, that taps its enormous rotational energy. The blue glow between the filaments is due to highly polarized synchrotron radiation from these particles. This polarized light was first mapped in detail with the Palomar 200-inch telescope in 1955 but not understood until much later, after the discovery of the pulsar. Prof. Gregg Hallinan's CHIMERA camera on the Palomar 200 inch telescope can now take images so fast that it can detect the optical pulsations of the pulsar while simultaneously imaging the whole nebula.

FUN FACT: VIRGINIA TRIMBLE LATER MARRIED JOSEPH WEBER (U. MARYLAND). LIGO WAS INSPIRED BY HIS PIONEERING WORK, IN THE 1950S AND 1960S, ON METHODS TO DETECT GRAVITATIONAL WAVES.

M15, M31, M42: To the eye, the Orion nebula, M42 looks green through a telescope. Putting the light through a spectrograph reveals that the green light has a wavelength of 500.7 nanometers. When discovered in the 1860's, no known element emitted light at this wavelength, and a new element "nebulium" was invented to explain it. In 1927, Caltech's Ira Sprague Bowen proved by calculation that the emission was in fact from oxygen atoms from which two electrons had been removed, at densities much lower than could be produced in terrestrial laboratories, but very common in interstellar space. Bowen's so-called "forbidden" transitions are powerful coolants of cosmic gas, and following pioneering work by Donald Osterbrock at Caltech in the 1950's have become valuable tools with which astronomers measure the density and 2 temperature of ionized gas throughout the universe. Osterbrock wrote the textbook from which generations of students worldwide have since learned these methods. One of those former Caltech students, Prof. Charles Steidel, and his own Caltech students have recently used this technique, and the new infrared MOSFIRE spectrograph on the Keck telescope, to reveal the unusual properties of stars forming in high-redshift galaxies. Bowen later became the first director of Palomar Observatory, serving from 1948 to 1964. NASA's Spitzer Space Telescope, headquartered at Caltech, took an infrared (heat) image of M42, which penetrates the dust and reveals all the rapidly spinning and variable young stars newly formed out of the molecular gas (visible as dark clouds covering the nebular emission).

M51: One of the first simulations of near-collisions between galaxies, published by Alar and Juri Toomre in 1972, convincingly showed that M51's strong spiral arms and long tails had been created by the close passage of the smaller galaxy NGC 5195 now cradled in its arms. **—STERL PHINNEY**, PROFESSOR OF THEORETICAL ASTROPHYSICS, AND EXECUTIVE OFFICER FOR ASTRONOMY, CALTECH



CREDITS

DEBTS OF GRATITUDE *are owed to all involved in the substantial undertaking of this project, three years in the making. First, to my dear friend and collaborator, Dr. Kip Thorne for bringing this work to the community at the California Institute of Technology and for his endless passion for communicating the bizarre and strange aspects of the universe to the rest of use here on earth.* ***MY APPRECIATION*** *to the Caltech community and contributors to this catalog, particularly Sterl Phinney, for the enthusiasm and input.* ***THANK YOU TO:*** *David Ross for the wonderful conversations on architecture, art and exhibition design which all led to the realization of this installation; Dennis Christie for your sharp curatorial eye, endless mentoring, dedication and engagement with this project; my fantastic studio assistants Adam Ottke, Garret Hill and especially Jennifer Seo who has worked on this project from its origins and has painted more stars than any one person should have to; Claudine Jaenchien for her talent in designing our exhibition catalog. And finally* ***A UNIVERSE SIZED THANKS*** *to Dr. and Mrs. David Groce, and Ann Rho who made this project a reality with continual excitement and support. This installation would never have come to fruition without you and for that, I am forever grateful.*