A backyard imager ADVANCES SCIENCE

An unexpected email opened the door for this astroimager to contribute to our understanding of the universe.

text and images by R. Jay GaBany

I was born too soon. Unlike the generations that will follow, I will never experience the wonder of traveling beyond Earth's atmosphere, walking on the Moon, venturing to another planet, or visiting the remote places that fill my imagery. Astrophotography is my only method of personally exploring the universe, and such an interest has allowed me to discover previously unsuspected talents and forge long-lasting relationships.

In and out of imaging

My interest in astronomy began at age 5 when my father held me on his shoulders and pointed to Sputnik moving through the night sky shortly after it launched. Like many others, I grew up during the Space Age, and the race to the Moon propelled my enthusiasm for the hobby.

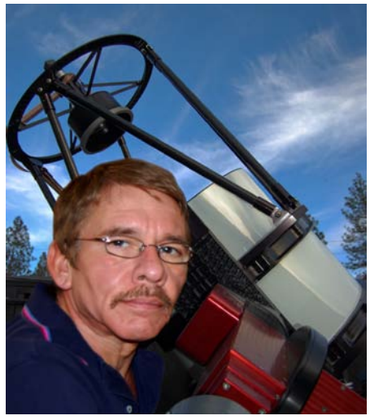
This image of the Diamond Ring Galaxy (NGC 4013) in Ursa Major first revealed an enormous river of old stars cast off during the ancient merger of a dwarf satellite galaxy with this edge-on spiral located about 55 million light-years distant. The author used his 20-inch RC Optical Systems Ritchey-Chrétien telescope, an SBIG STL-11000 CCD camera, and LRGB exposures of 630, 90, 54, and 108 minutes, respectively, for this image.

I dabbled in astrophotography early, starting with a high school science fair project in 1970. For it, I took an image of Comet Bennett along with an 8mm motion picture of the Mercury transit May 9 through my 2.5-inch department store refractor. To my surprise, the exhibit ultimately received a state championship award the following year.

I returned to imaging for the 1986 apparition of Halley's Comet. For the event, I learned the tedious art of long-exposure photography with a single lens reflex film camera attached to a 16-inch reflector on a wobbly equatorial mount. To get the pictures, I chased a guide star through a crosshair eyepiece with a joy-stick control. But after Halley, frustrations with manual guiding, career objectives, and family obligations combined to distract my interest until I discovered the capabilities of digital cameras around 2004.

Away from the light

While I am fortunate to live in an area in Northern California with seemingly endless clear nights from May to October, I also have to contend with intense light pollution. So I began following the paths first trod by professionals. For more than a century, astronomers have evaded the blinding effects of light pollution by locating their instruments on high mountaintops, far from civilization.



The author images through a 20-inch RC Optical Systems Ritchey-Chrétien telescope located high in the California Sierra Nevada between Yosemite and Kings Canyon national parks.

Likewise, after many months of imaging from my somewhat light-polluted backyard with modest success, I began exposing pictures using remote-controlled instruments located under dark skies in New Mexico and near Melbourne, Australia. My target list favored many of the most popular deep-sky objects because they are inherently evocative to me. However, I preferred very long exposures because they could reveal previously unseen or unsuspected structures.

Today, my Blackbird II Observatory, which includes a 20-inch RC Optical Systems Ritchey-Chrétien telescope and an Apogee Alta U16M-HC 16-megapixel CCD camera, lies in the Sierra Nevada between Yosemite and Kings Canyon national parks. I continue to use the Internet to operate everything remotely.

Unfortunately, many professional astronomers five to 10 years ago couldn't do the same. They had to journey to distant observatories when gathering observations. And some of these sessions were mundane, accompanied by tedious hours monitoring the progress of a pre-established observing plan. So, how did professional astronomers avoid the tedium of an uneventful observing run? It turns out that some surfed the Internet and reviewed amateur astrophotography galleries, searching for possible hints of new discoveries unsuspected by the imagers.

The author's image of spiral galaxy M94 inspired his collaboration with astronomer David Martinez-Delgado. The photo revealed a pattern of spiral arms later confirmed in infrared and ultraviolet images provided by the Spitzer and Galaxy Evolution Explorer space telescopes. To capture such detail, the author used his 20-inch RC Optical Systems Ritchey-Chrétien telescope, an Apogee Alta U16M CCD camera, and LRGB exposures of 550, 90, 54, and 108 minutes, respectively.

A lucky happenchance

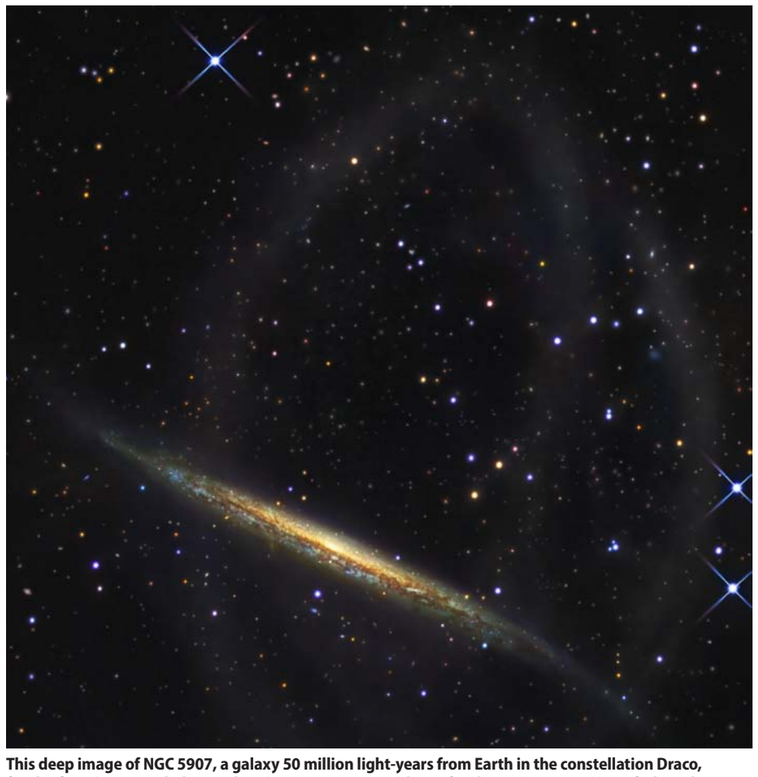
Such was the circumstance when I received an email message from David Martínez-Delgado of the Max Planck Institute for Astronomy in Germany, after he serendipitously chanced upon my website, www.cosmotography.com, more than seven years ago. Martinez-Delgado leads an international team of professional astronomers searching for evidence of ancient stellar remnants around spiral galaxies in the local universe to support the cold dark matter (CDM) theory of galactic evolution. According to CDM theory, dwarf galaxies were the first star systems to form after the birth of the universe. Then, over time, they merged to build larger island universes like the Milky Way.

The aptly named Umbrella Galaxy (NGC 4651) lies about 35 million light-years away in the constellation Coma Berenices. The faint fan-shaped and narrow structures extending about 50,000 light-years beyond the galactic disk represent the remnants of a dwarf galaxy that the spiral ripped apart and consumed. This image combines RGB data collected by the author with luminance data from the 8.2-meter Subaru Telescope.

Martínez-Delgado's message indicated that my image of spiral galaxy M94 in Canes Venatici had caught his attention. It turns out that my more than 13-hour total exposure had revealed a ringlike structure, reminiscent of a stellar stream, extending from the galaxy's bright central region where previous photographs only had displayed an amorphous band of encircling

R. Jay GaBany *is a amateur astrophotographer in San Jose, California. During the fall of 2012, the editors of* Time *magazine included him in "The 25 Most Influential People in Space."*

NGC 3521 is also known as the Bubble Galaxy because it lies within debris shells that have persisted after the assimilation of one or more dwarf satellite galaxies in the distant past. The author used his 20-inch RC Optical Systems Ritchey-Chrétien telescope, an Apogee Alta U16M CCD camera, and LRGB exposures of 570, 240, 240, and 240 minutes, respectively.



This deep image of NGC 5907, a galaxy 50 million light-years from Earth in the constellation Draco, for the first time revealed a vast looping structure as evidence for the ancient accretion of a long-lost satellite galaxy. The author used his 20-inch RC Optical Systems Ritchey-Chrétien telescope, an SBIG STL-11000 CCD camera, and LRGB exposures of 465, 120, 72, and 144 minutes, respectively, for this image.

stars. He asked if I would like to join his team of astronomers in a quest for galactic stellar fossils. I eagerly agreed.

Pro-am collaboration

As the first project, Martínez-Delgado asked me to process infrared and ultraviolet images of M94 produced through NASA's Spitzer and Galaxy Evolution Explorer space telescopes. These pictures confirmed that an extended set of faint spiral arms surrounds M94, as first indicated by my digital photograph. Ultimately, the team's research paper proposed that these dim structures were not caused by the gravitational disruption of a dwarf galaxy but instead an oval distortion propagating outward from M94's core.

Although this initial project failed to uncover evidence for galactic merger activity, it did provide other conclusions. Our pro-am collaboration supported Martínez-Delgado's suspicion that such a partnership could equal or outperform results obtained from professional instruments in the detection of faint, diffuse wide-field features. His belief arose from recent CCD advances both in larger affordable chips and sensitivity combined with the virtually limitless observation time available to privately owned observatories.

Next, Martínez-Delgado asked me to obtain deep images of NGC 4013, an edge-on spiral located about 55 million light-years from Earth toward the constellation Ursa Major. Also known as the Diamond Ring Galaxy because of its coincidental alignment behind a bright Milky Way star, this stellar system had always been regarded as a galaxy in isolation. Based on hints seen in images collected with the Kitt Peak National Observatory 0.9-meter and the Isaac Newton 100-inch telescopes, however, the team suspected it might be surrounded by a river of stars — the relics of a satellite galaxy absorbed by its larger host spiral. The results of my nearly 15-hour exposure revealed, for the first time, a giant looping structure that matched predictions for an edge-on, projected view of a stellar tidal stream from a dwarf satellite moving in a close, nearly circular orbit.

Continued success

Although I had anticipated each project with Martínez-Delgado would be my last, the relationship has continued. Next up was the Splinter Galaxy (NGC 5907) in Draco, long considered a prototypical example of a warped spiral in relative isolation. My more than 13-hour exposure revealed, however, that spectacular looping stellar contrails surround the galaxy. These structures represent the final orbits of a small satellite galaxy that was subsequently disrupted and absorbed by its larger companion long ago.

For a survey of stellar tidal streams in nearby spiral galaxies, we studied the Umbrella Galaxy (NGC 4651) in Coma Berenices, one of the most remarkable and brightest examples of galactic accretion we've so far detected. The galaxy exhibits a jetlike spear that's strikingly coherent and narrow. Although astronomers previously reported this structure in 1959, no scientist ever interpreted it as a stellar tidal stream. However, my 13-hour image also revealed a spectacular crescent-shaped shell surrounding the east side of the star system that resembles an umbrella and corresponds to the epicenter of the former dwarf galaxy.

We also studied the Bubble Galaxy (NGC 3521) in Leo, which scientists have classically categorized as a flocculent galaxy due to the enormous amount of material partially obscuring its spiral structure. However, my 21-hour image revealed evidence of one or more previous mergers with dwarf galaxies that left discernible substructures, such as an almost spherical cloud of debris visible on its eastern side and a large, elongated cloud to the west. Both represent debris shells belonging to an umbrella-like structure similar to that seen in my image of NGC 4651. But their looser appearance suggests they were accreted much further in the past. Moreover, the galaxy is enveloped in a bubble of multiple debris shells that may represent additional evidence of ancient mergers.

Moving forward

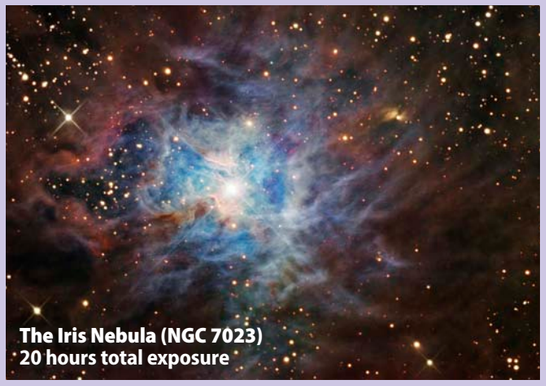
Today, I'm a co-author on 10 peer-reviewed scientific papers, and several others are in various stages of completion. Martínez-Delgado and I also intend to publish a book summarizing the results of our research sometime in the near future. Because of this continued relationship, my imaging target list now includes seldom-pictured galaxies that greatly interest Martínez-Delgado and his team. Who knew one email encounter could open the exciting potential for an amateur astroimager to make contributions to our understanding of the universe.

LONG EXPOSURES

The author often captures long-exposure photographs of well-known targets beyond the galaxies he currently images for his research. He used a 20-inch RC Optical Systems Ritchey-Chrétien telescope and an SBIG STL-11000 CCD camera for each of these LRGB photos.

The Omega Nebula (M17)
18.7 hours total exposure

The Crab Nebula (M1)
24.2 hours total exposure



The Iris Nebula (NGC 7023)
20 hours total exposure

The Christmas Tree Cluster (NGC 2264)
74.75 hours total exposure

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