In Search of Extragalactic Globulars

What's the farthest star ball you can see with an amateur telescope? Start your hunt outside the Milky Way.

The Milky Way is home to roughly 160 globular clusters, spread around the galactic halo and toward the central bulge. These densely packed stellar spheres formed between 11 and 13 billion years ago and contain tens to hundreds of thousands of gravitationally bound stars. As ancient relics of the Milky Way, they offer important astrophysical clues to stellar evolution and dynamics, as well as to galactic formation and later accretion events. And, of course, they're among the most breathtaking sights in the sky.

The number of globular clusters in a host galaxy correlates strongly with the galaxy's luminosity. The supergiant elliptical M87 boasts an estimated 12,000 clusters while ubiquitous low-luminosity dwarf galaxies contain at most a few. Within the nearly 50 nearby galaxies that comprise our Local Group, M31 commands the largest collection, with more than 500 confirmed globulars. But how many of these can you see with an amateur scope? Let's head outside the Milky Way and explore some of the globulars in our galactic neighbors.

A few words of caution — extragalactic globulars lack the optical impact of familiar ones in the Milky Way so are best appreciated with your mind as well as your eyes. Consider M13, arguably the Northern Hemisphere's finest globular. If it were located at the distance of the Andromeda Galaxy, it would appear as a 16th-magnitude speck! So as you observe, take time to contemplate the astrophysical importance and true grandeur of these globulars — it will make the hunt much more enjoyable.

Our first stop is the well-studied Large Magellanic Cloud (LMC), which lies at a distance of 165,000 light-years. It boasts 16 ancient metal-poor globulars along with 100 "intermediate-age" (1–3 billion years) massive clusters. You'll need to observe these from the Southern Hemisphere, but if you have the opportunity, exploring the cluster and nebula rich fields of the LMC is an unforgettable experience. My observations were made under dark transparent skies in rural Australia.

▲ **SMALL SPARKLER** In amateur scopes, extragalactic globular clusters like NGC 1835 remain unresolved. This Hubble Space Telescope image cluster reveals the 11th-magnitude cluster's core. NGC 1835 is the brightest globular in the Large Magellanic Cloud.

Scottish-born astronomer James Dunlop spied **NGC 1835** in 1826 using his homemade 9-inch speculum metal reflector at Parramatta, near Sydney, Australia. He called it "a small round pretty well-defined nebula, bright at the centre." Dunlop's copper-tin alloy mirror was equivalent in light-gathering to a modern 6.5-inch telescope, but his description applies to most of the LMC globulars — they appear compact and unresolved, with strongly concentrated cores and faint smooth envelopes. NGC 1828 and NGC 1830, both smaller and fainter open clusters, lie in the same field of view, a common occurrence in the LMC.

Eight years later John Herschel began a monumental survey of the southern sky from Cape Town, South Africa and discovered **NGC 1916** along the central bar of the LMC. This compressed globular sports a prominent central hub and a 40″ halo.

Although relatively bright, NGC 1916 is outclassed by **NGC 1903**, a gorgeous open cluster just 8′ to the northwest. NGC 1903 masquerades as a globular but studies yield a relatively youthful age of less than 100 million years. A 24-inch scope revealed a 20″ blazing core encased in a 1′ halo studded with nearly two dozen glittering stars. Northwest of NGC 1903 is NGC 1910, a large star cloud containing **S Doradus**, the prototype of a class of extremely massive, highly evolved stars called Luminous Blue Variables. With a mean magnitude of approximately 9.5, S Doradus is the single brightest star in the LMC.

Argentinean astronomer José Luis Sèrsic discovered the **Reticulum Cluster** in 1973 on plates taken with the 0.7-m Maksutov camera of the Cerro El Roble Observatory in Chile. He described it as a "Dwarf in Reticulum, probably a member of the Local Group." Later photometric investigations demonstrated it was a highly extended, low-luminosity globular. The LMC holds a tenuous grip on the Reticulum Cluster as it lies at the extreme limits of its halo. One day it may be snatched by the Milky Way's gravitational pull.

NASA / ESA / HUBBLE LEGACY ARCHIVE

P. HORÁLEK / ESO

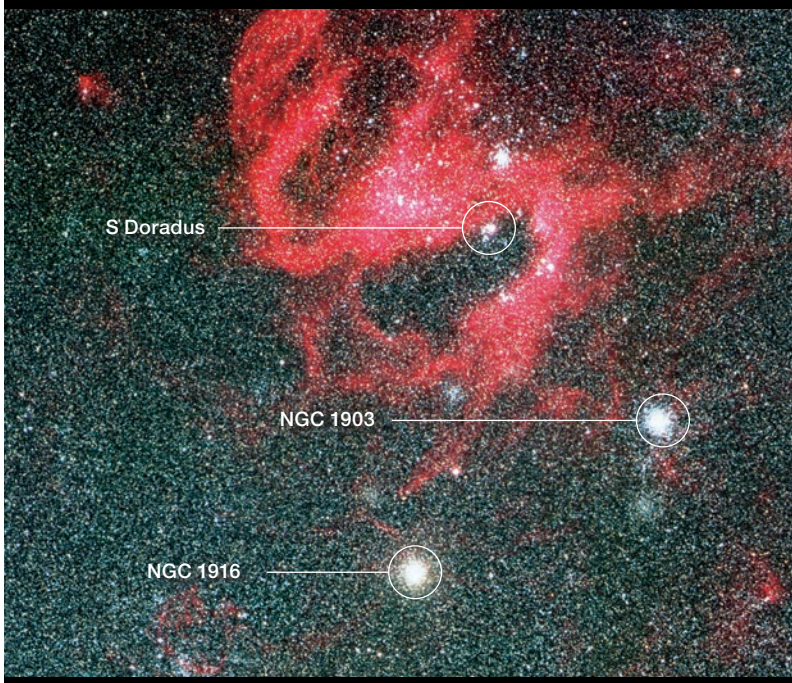
OUTLOOK CLOUDY As this view captured in the Atacama Desert of Chile shows, it's worth a trip to observe in the Southern Hemisphere. The Large and Small Magellanic Clouds are at the right of the frame. The bright star Canopus blazing above them.

Observing with a 14-inch scope, I found a large 3′ glow with a terribly low surface brightness and no noticeable concentration. As a bonus, the cluster is situated 1.3° west-northwest of NGC 1672, a showpiece barred spiral that lies far in the background at 60 million light-years.

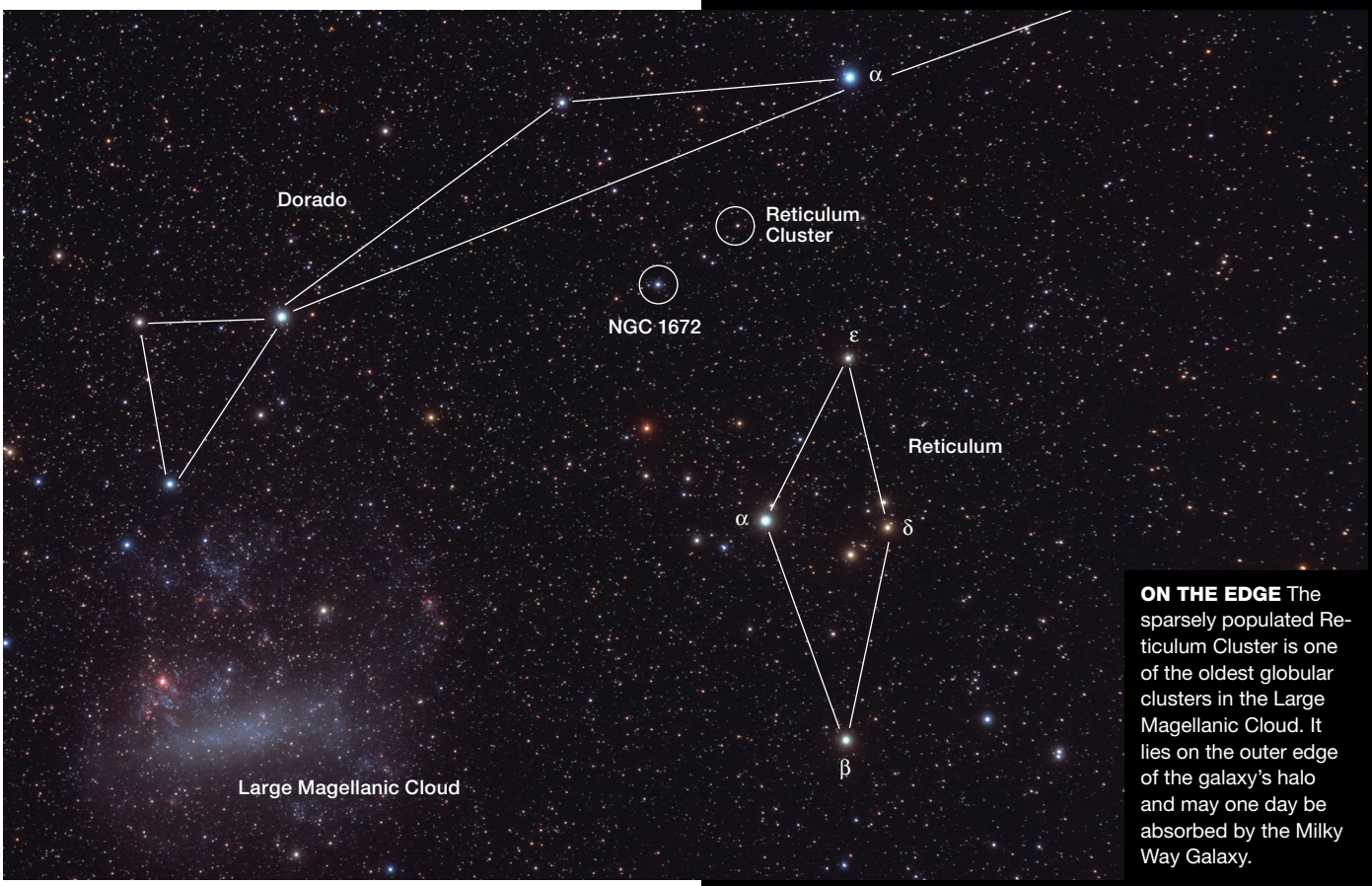
NGC 121 is the only classical globular in the Small Magellanic Cloud, though its age is at least two billion years younger than its counterparts in the Milky Way and LMC. In 1998 it became the first extragalactic globular in which *blue stragglers* were detected by the Hubble Space Telescope (HST). These unusual stars are both bluer (hotter) and brighter than stars at the main-sequence turnoff point and are thought to be the result of a binary merger or mass transfer with a companion.

Shining at a respectable 11th magnitude, NGC 121 stood out well through a 12-inch scope, with a 1′ oval halo that intensified to a conspicuous core. I found it nearly impossible, though, to pry my eyes off the spectacular globular **47 Tucanae** (NGC 104), just ½° south in the same low power field. This duo provides a dramatic depth of field with 47 Tucanae fifteen times closer than NGC 121!

Our next stop is the Fornax Dwarf Spheroidal Galaxy (Fornax dSph), a Milky Way satellite at a distance of 470 thousand light-years. It escaped detection until 1938 when Harlow Shapley noticed it on a 24-inch Bruce astrograph plate taken at Harvard's Boyden Station in South Africa. Although



▲ **SERPENTINE SETTING** N119, a twisted swath of ionized hydrogen associated with the star cloud NGC 1910, contains several luminous stars, including S Doradus, the brightest star in the Large Magellanic Cloud. Globular clusters NGC 1916 and NGC 1903 shimmer nearby.



ON THE EDGE The sparsely populated Reticulum Cluster is one of the oldest globular clusters in the Large Magellanic Cloud. It lies on the outer edge of the galaxy's halo and may one day be absorbed by the Milky Way Galaxy.

N119: ESO; RETICULUM CLUSTER: AKIRA FUJII

the integrated magnitude is an impressive 8.0, don't be misled; the light is spread out over ½° of sky and its anemic surface brightness, along with a low elevation (declination –34.5°) conspire to make the Fornax Dwarf a formidable visual target. My only convincing view was from the Southern Hemisphere with the galaxy high overhead. Even then, I only noticed a subtle brightening confirmed by tracing around the periphery.

The galaxy itself may be barely detectable but four of its five globulars can be seen through a 10-inch scope (my comments are based on the view through a 13-inch). John Herschel found **NGC 1049** (Fornax 3), the brightest and most massive cluster, 103 years prior to Shapley's discovery. He reported seeing an object "pretty bright; small; round; like a star 12th magnitude a very little rubbed at the edges, a curious little object and easily mistaken for a star, which, however, it certainly is not." That reads pretty close to my own notes at 166×: "moderately bright, small (about 30″ diameter), very small bright core with a faint halo." Look for this 12.6-magnitude globular 15′ north of 8th-magnitude HD 16690.

While examining additional plates taken from Boyden Station, Shapley also discovered the globular clusters **Fornax 2** (visual magnitude 14.1) and **Fornax 4** (13.6). Fornax 2 is an easy 25′ star hop to the southeast of 5.8-magnitude Lambda^2 (λ^2) Fornacis, but it only appeared as a gauzy 20″ spot of uniform low surface brightness. Fornax 4 is a strange beast. Although ancient stars dominate the other clusters, Fornax 4 is younger by 2 to 3 billion years. Furthermore, its central position suggests Fornax 4 may be the actual core of the Fornax Dwarf, but its radial velocity and population indicate it's a legitimate globular coincidentally in our line of sight to the center. I noted a hazy 20″ patch rising suddenly to a small, brighter core.

In the late 1950s Paul Hodge (University of Washington) added the outer halo globulars **Fornax 1** and **Fornax 5** using plates taken in South Africa with the Armagh-Dunsink-Harvard (ADH) Baker-Schmidt telescope. Fornax 5 resembles Fornax 4, with a tight luminous core and a thin fainter halo. Look for it 13′ west of 7.3-magnitude HD 17060 and 10′ northeast of a string of four stars that point the way to the globular. With a visual magnitude of 15.6, Fornax 1 is easily the most challenging of the five globulars. Good luck!

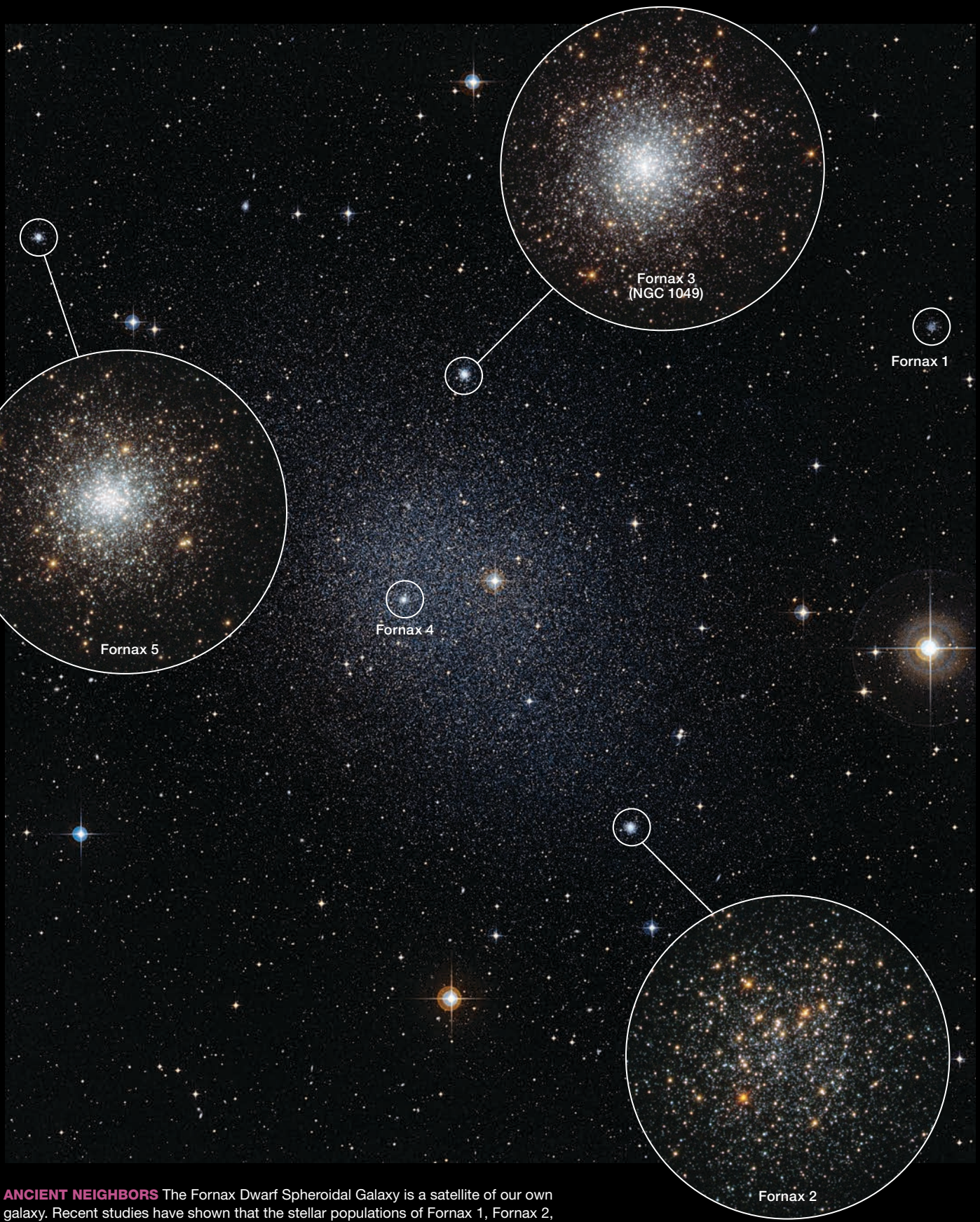
Legendary observer E. E. Barnard swept up **NGC 6822** (Barnard's Galaxy) in 1884 using his 5-inch Byrne refractor. The galaxy gained fame in 1925 when Edwin Hubble discovered 15 variable stars in it including 11 Cepheids. Using Henrietta Leavitt's relationship between the period and luminosity of Cepheids, Hubble announced NGC 6822 as "the first object definitely assigned to a region outside the galactic system." Extragalactic astronomy was now firmly established. Modern studies place the distance at 1.6 million light-years, making it an isolated member of the Local Group.

While examining NGC 6822 Hubble also found 10 nebulous objects (five giant emission nebulae and five compact objects) that he labeled with Roman numerals I through X. He doubted any of these were globulars, but later studies proved **Hubble VII**, buried near the center, was a bona fide 16th-magnitude globular with an age of 10 to 11 billion years.

It took a painstaking search in 2010 using my 18-inch reflector in superb conditions just to glimpse Hubble VII as

NGC 121: NASA / ESA / HST / STEFANO CAMPANI; 47 TUCANAE: ESO / M.-R. CIONI / VISTA MAGELLANIC CLOUD SURVEY / CAMBRIDGE ASTRONOMICAL SURVEY UNIT

▲ *Left:* **LONE WOLF** The only classical globular cluster in the Small Magellanic Cloud, NGC 121 glitters with an abundance of hot, blue stars. NGC 121 lies about 200,000 light-years from Earth in the direction of the constellation Tucana. *Right:* **BLAZE OF GLORY** Visually, the globular cluster 47 Tucanae appears to be a close neighbor to NGC 121; only ½° separates the pair in the sky from our point of view. In fact, with a distance of about 13,500 light-years, 47 Tucanae is some 15 times closer to us than NGC 121.



ANCIENT NEIGHBORS The Fornax Dwarf Spheroidal Galaxy is a satellite of our own galaxy. Recent studies have shown that the stellar populations of Fornax 1, Fornax 2, Fornax 3, and Fornax 5 are dominated by metal-poor stars more than 10 billion years old, while Fornax 4 is formed of younger, metal-rich stars.

FORNAX GALAXY: ESO / DSS2; NGC 1049, FORNAX 2 AND FORNAX 5: NASA / ESA / S. LARSEN (RADBOUD UNIVERSITY)

a dim smudge. I thought Hubble VII would be my last globular sighting in the galaxy. But in 2011 a wide-field imaging survey with the Canada-France-Hawaii Telescope (CFHT) uncovered four new halo globulars in NGC 6822 designated SC1–SC4. Two years later, three more globulars (SC5–SC8) were identified using archival CFHT/MegaCam data. New globulars and a new challenge!

SC7 (not to be confused with Hubble VII) lies outside the visual boundary of NGC 6822, 22′ northeast of center, making a positive identification much easier. At 375× in my 24-inch, I immediately noticed a swollen 15th-magnitude "star" about 6″ to 8″ in diameter. The globular could be held steadily and seemed to have a brighter stellar nucleus.

SC6 is over a half-magnitude fainter than SC7 and a much tougher catch due to a brighter 14th-magnitude star at its north edge. I needed 500×, good seeing, and a healthy dose of patience to tease out an occasional nonstellar sparkle.

Hunting globular clusters in M31 is a popular project for seasoned deep-sky observers. I've tallied 45 (mostly with an 18-inch) along with 10 open clusters. Three of the brightest, G76, G78, and G280, are close to 14.3-magnitude and readily accessible in a 10-inch under dark skies. Contributing Editor Alan Whitman covered these and many more in his article on M31 (*S&T:* Nov. 2013, p. 58).

In 1932 Hubble charted 140 nebulous objects in M31 found on 100-inch Hooker telescope plates and tentatively identified these as globulars based on "their forms, structure, colors, luminosities, and dimensions." Hubble missed **G1** (also called Mayall II), the most luminous globular in the Local Group, as it resides in M31's halo, 2.5° southwest of center at a projected separation of 130,000 light-years. A kinematic study of G1's nucleus in 2002 using the HST's Imaging Spectrograph provided strong evidence it houses a 20,000 solar mass black hole.

But is G1 a true globular cluster? With over twice the mass of Omega Centauri (Milky Way's heftiest globular), G1 may be the remnant core of a stripped dwarf galaxy that was digested by M31 earlier in its history.

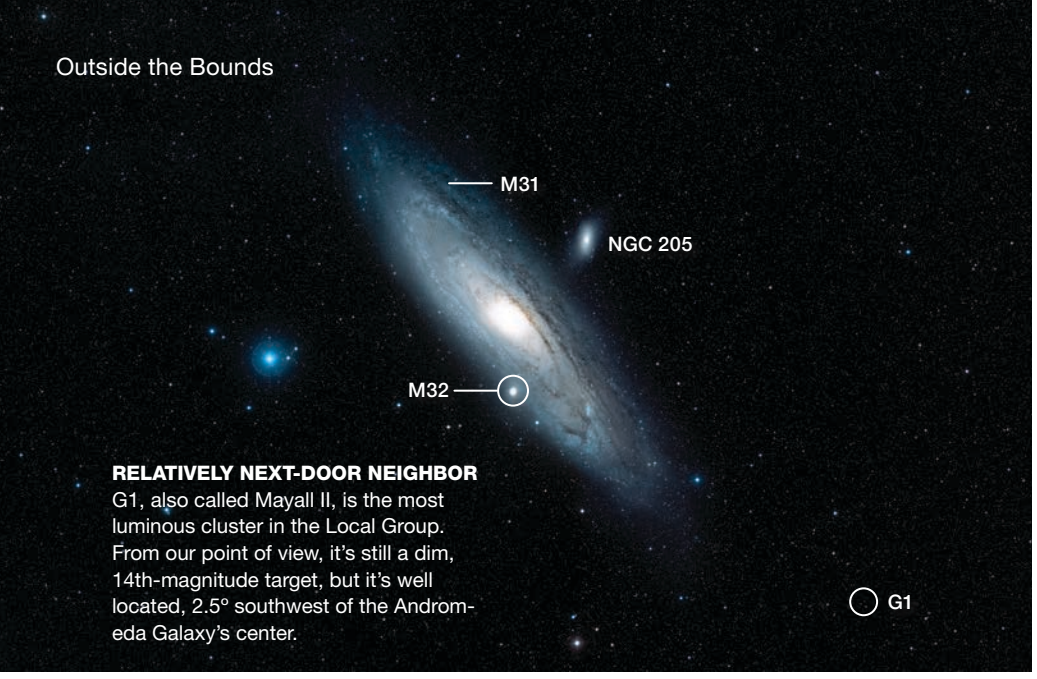
I've seen 13.8-magnitude G1 with only an 8-inch scope, though two 14–15th-magnitude stars on the west edge confuse the view at low power. Using 323× in my 18-inch, G1 was easily visible as a 10″ puffball punctuated by a star-like nucleus and the two nearby foreground stars form a cute pair of "Mickey Mouse" ears.

Recently, astronomers have found a cache of new globulars in the extreme outer halo of M31. **Martin-GC1** (MGC1) was discovered in 2006 during a CHFT/MegaCam survey, a whopping 8.6° south of M31 in the constellation Pisces! A 2009

Extragalactic Globulars & Friends

Galaxy	Galaxy Type	# of GCs	GC	Mag(v)	RA	Dec.	Notes
LMC	Irr	16	NGC 1835	10.2	$05^h\ 05.1^m$	–69° 24′	Milky Way satellite
			NGC 1916	10.4	$05^h\ 18.6^m$	–69° 24′	
			NGC 1903	11.9	$05^h\ 17.4^m$	–69° 20′	Open cluster
			S Doradus	8.6–11.5	$05^h\ 18.3^m$	–69° 15′	Variable star
			Reticulum Cluster	14.7	$04^h\ 36.2^m$	–58° 52′	
SMC	dIrr	1	NGC 121	11.2	$00^h\ 26.8^m$	–71° 32′	Milky Way satellite
Milky Way	SBbc	160	47 Tucanae	4.1	$00^h\ 24.1^m$	–72° 05′	
Fornax Dwarf	dSph	5	NGC 1049	12.6	$02^h\ 39.8^m$	–34° 15′	Milky Way satellite
			Fornax 2	14.1	$02^h\ 38.7^m$	–34° 49′	
			Fornax 4	13.6	$02^h\ 40.1^m$	–34° 32′	
			Fornax 5	13.6	$02^h\ 42.4^m$	–34° 06′	
NGC 6822	dIrr	8	SC 7	14.8	$19^h\ 46.0^m$	–14° 33′	Local Group Member
			Hubble VII	16.3	$19^h\ 44.9^m$	–14° 49′	
			SC 6	15.3	$19^h\ 45.6^m$	–14° 41′	
M31	Sb	> 500	G1	13.8	$00^h\ 32.8^m$	+39° 35′	
			Martin-GC1	15.5	$00^h\ 50.7^m$	+32° 55′	
			PAndAS-53/54	15.5	$01^h\ 18.0^m$	+39° 15′	
WLM	dIrr	1	WLM-1	16.1	$00^h\ 01.9^m$	–15° 28′	Local Group Member
Sgr Dwarf	dSph	4	M54	7.7	$18^h\ 55.1^m$	–30° 29′	Milky Way satellite

Angular sizes and separations are from recent catalogs. Visually, an object's size is often smaller than the cataloged value and varies according to the aperture and magnification of the viewing instrument. Right ascension and declination are for equinox 2000.0.



RELATIVELY NEXT-DOOR NEIGHBOR G1, also called Mayall II, is the most luminous cluster in the Local Group. From our point of view, it's still a dim, 14th-magnitude target, but it's well located, 2.5° southwest of the Andromeda Galaxy's center.

▲ **CRYPTIC CLUSTER** G1 is the brightest globular cluster in the Local Group. It consists of more than 300,000 stars. Current research suggests that G1 could be a remnant galactic core and may have an intermediate-mass black hole at its center.

study using the Gemini Multi-Object Spectrograph found MGC1 was the most isolated globular in the Local Group at a galactocentric distance from M31 of 650,000 light years.

Last year I tracked down this 15.5-magnitude globular using my 24-inch reflector at 260×. Upping the magnification to 500× I held it continuously as a fuzzy 8″ glow. It was barely smaller than G1 and had a slightly bright pip at the center.

In 2014 the Pan-Andromeda Archaeological Survey (PAndAS) announced the discovery of 59 new outer halo denizens of M31, primarily by visual inspection of CHFT/MegaCam images. **PAndAS-53** and **PAndAS-54** form an exceptionally close 2′ pair, uncovered 7° east of M31. Both are quite dim at 15.5- and 16.0-magnitude and barely nonstellar in my 24-inch. These twin globulars either formed together at the fringes of M31 or more likely were captured from an accreted dwarf galaxy.

Our most remote target is in the Wolf-Lundmark-Melotte galaxy (WLM), discovered by German astronomer Max Wolf on a plate taken in 1909 at the Heidelberg-Königstuhl State Observatory. Philibert Jacques Melotte and Knut Lundmark independently found this dwarf galaxy 17 years later on Franklin-Adams plates and described it as "strikingly similar" to Barnard's Galaxy. WLM is located in western Cetus at the outskirts of the Local Group, 3.1 million light-years away. As a result of its isolation, the stellar population is probably in a pristine state, uncontaminated by galactic mergers and interactions.

In an early campaign to determine the Hubble constant, Milton Humason, Mount Wilson Observatory's mule-driver-turned-astronomer, measured the radial velocity of WLM as well as a nearby cluster with a similar velocity, **WLM-1**. In 1999 Paul Hodge obtained a color-magnitude diagram for WLM-1 using the HST and established it as a massive globular over 13 billion years old. WLM-1 surprisingly formed despite the dwarf's very small intrinsic mass and low luminosity.

Visually, WLM is a challenging low-contrast galaxy. Sweeping 1° northeast of 6.3-magnitude 1 Ceti with my 18-inch, it appeared as a large, very diffuse oval, extending 10′ × 5′ north to south. At high power a 15.5-magnitude Milky Way star was superimposed at the center, and just northwest a tiny H II region was glimpsed. The globular WLM-1 is situated just off the west edge of the galaxy and 40″ south of a 14.6-magnitude field star. At 16th magnitude, I found it a difficult quarry even through a 20-inch scope, though in rock-steady seeing it seemed slightly soft, a few arcseconds in diameter.

If observing such faint extragalactic globulars seems daunting, then consider instead **M54**, which is visible even in 50-mm binoculars. M54 is embedded at the center of our closest neighbor, the Sagittarius Dwarf Spheroidal Galaxy (Sgr dSph), which was discovered serendipitously in 1994 during a spectroscopic study of the Milky Way's bulge. The Sagittarius Dwarf lies at a distance of 80,000 light-years on the far side of the galactic center, covers a vast area of sky, and is in the process of being shredded under the tidal strain of the Milky Way Galaxy.

Three dim globulars, Arp 2, Terzan 7, and Terzan 8 are members of the Sagittarius Dwarf, while NGC 5634, Palomar 12, and Whiting 1 are associated with two tidal streams of stars encircling the Milky Way that were ripped from the dwarf. M54 has been proposed as the actual nucleus of the galaxy, but a 2008 investigation using velocity and metallicity data concluded M54 formed independently and plunged to its current location at 87,000 light-years distant due to dynamical friction. The Sagittarius Dwarf galaxy is much too large and dispersed to see visually but M54 gains new luster once you know of its extragalactic origin.

■ Contributing Editor **STEVE GOTTLIEB** is willing to explore well beyond our galaxy's limits to bag the best star clusters.

FURTHER READING: For a complete list of globular clusters in the Local Group, as well as links to recent research on the topic, see **https://is.gd/extraglobs**.

G1: NASA / ESA / DSS2 / DAVID DE MARTIN; G1 CLOSE-UP: MICHAEL RICH / KENNETH MIGHELL / JAMES D. NEILL (COLUMBIA UNIVERSITY) / WENDY FREEMAN (CARNEGIE OBSERVATORIES) / NASA / ESA