

# NIGHTFALL

NEWSLETTER OF THE ASSA DEEP-SKY SECTION

2015 APRIL (ISSUE #1)



# NIGHTFALL

OFFICIAL NEWSLETTER OF THE  
ASSA DEEP-SKY SECTION

ISSUE #1

2015 APRIL

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On the cover



Wim Filmalter

Official newsletter of the ASSA Deep-Sky Section

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<http://assa.saao.ac.za/sections/deep-sky/>

## 18 E3

*By Douglas Bullis*

*A curious globular cluster in Chamaeleon.*

## 31 BIRTH OF A DEEP-SKY MARATHON

*By Hannes & Pieter Pieterse*

*A report from the 2014 Free State Star Party,  
with guidelines and recommendations for  
conducting a deep-sky observing marathon.*

## 28 HEARTBEAT OF A UNICORN

*By Carol Botha*

*Exploring the fascinating but often  
overlooked constellation of Monoceros.*

## 50 AT MY EYEPiece

*By Magda Streicher*

*Veteran deep-sky observer Magda Streicher  
gives us a look at how she observes.*

## 1 EDITORIAL

## 2 NEWS NOTES

## 8 THREE IN: CARINA

## 56 DEEP-SKY PROJECTS

## 57 PHOTO GALLERY

## 59 ON THE COVER

## APPENDIX

## i BIG 5 OF THE AFRICAN SKY



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Globular cluster NGC 104 (47 Tuc) by Wim Filmalter. Nikon D5100, ISO 6400, single 15-second exposure, 110-mm Jaegers refractor. See page 59 for further details.

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# NEW BEGINNINGS

The ASSA Deepsky Observing Section was established in 1992, and its first newsletter, *Nightfall*, appeared in *MNASSA*, the Society's journal of astronomical record (1993, Vol 52, 5&6, 42–47).

Following the restructuring of the Society c. 2013, the Deep-Sky Section (now with a hyphen) was expanded to include double stars and variable stars, disciplines which formerly enjoyed their own Observing Sections.

Dave Blane, the Section's double star and variable star Specialist, has been leading the way with regular newsletters published since 2013 November.

What you are reading now has been inspired by Dave's initiative. This new *Nightfall* is focussed on the "traditional" deep-sky: star clusters and nebulae.

*Nightfall* will appear at least twice a year, depending on the contributions received from Section members and other interested/interesting folk.

Meanwhile, chunks of thanks to the contributing authors and photographers whose work appears in this edition. Just brilliant, folks!



# NEWS NOTES

THE DEPARTMENT OF ASTRONOMY of the University of Cape Town has produced an attractive handy-sized wall calendar for 2015, featuring deep-sky photographs taken by their research-grade telescope housed in a dome on top of the roof of the RW James building on campus. Charl Cater, a member of the UCT Astronomy Club, explains that future plans for the calendar including having “club members learn how to use the telescope and produce a few images for the calendar, which will be featured along with some research images from actual research in the dept.” For details, write the club at [uctastroclub@gmail.com] or follow them on Twitter [ @UCTspacenastro ].

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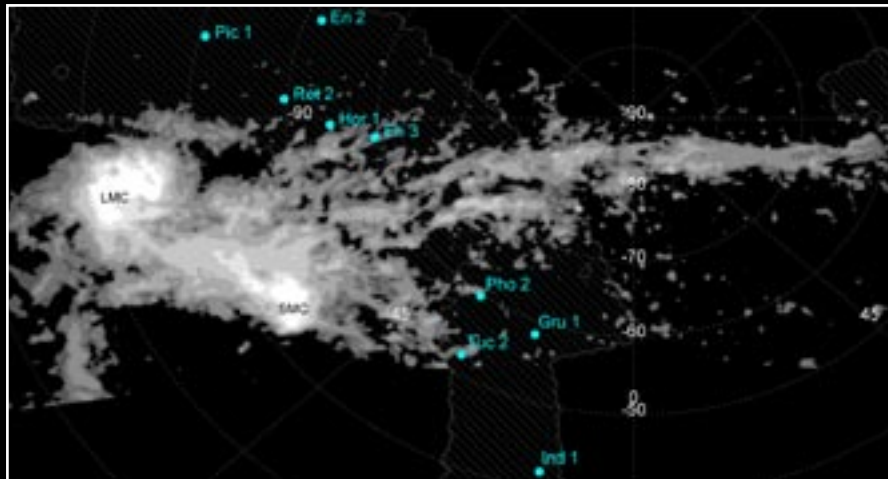
A MINOR UPDATE of the *ConCards* was released in January 2015. The update corrects a few typos, and if you’re using 1.3 or later, there’s no reason to upgrade. For those who don’t know, the *ConCards* – a contraction of ‘Constellation Cards’ – is a set of star maps, one per constellation, aimed at the novice observer. Bright and/or famous deep-sky objects are

plotted, so it’s a good option for binocular observers, too. Complete beginners should pick up their free copy of the *Discover! Naked-eye Constellation Workbook*, the ideal way to learn the constellations. Point your browser to the Section’s website or to [ <http://www.docdb.net/tutorials.php> ]

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SEVERAL NEW SATELLITE GALAXIES OF THE MILKY WAY have been discovered, all in the vicinity of the LMC and SMC, according to a University of Cambridge press release dated 2015 March 10.

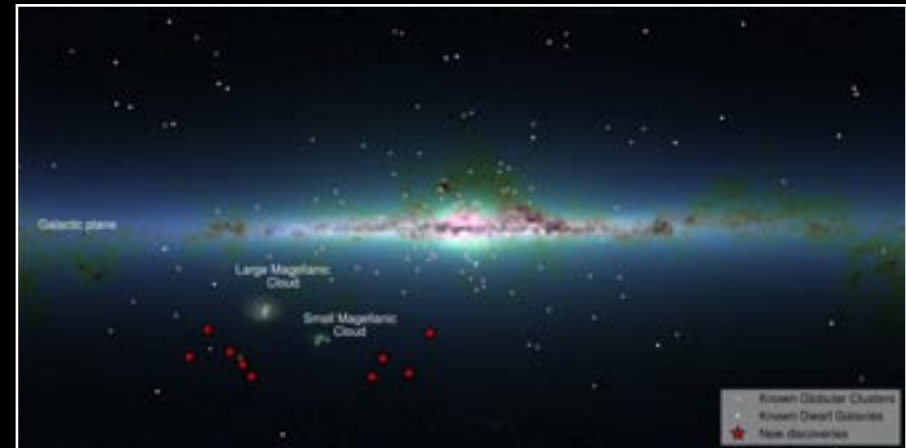
The newly discovered objects are a billion times dimmer than the Milky Way, and a million times less massive. According to the Cambridge team, three of the discovered objects are definite dwarf galaxies, while others could be either dwarf galaxies or globular clusters. “The discovery of so many satellites in such a small area of the sky was completely unexpected,” said Dr. Sergey Koposov of Cambridge’s Institute of Astronomy, the study’s lead author. “I could not believe my eyes.”



**Positions of the satellites with respect to the Magellanic Stream.** The Stream, a vast structure of neutral hydrogen, is shown as filled contours, with lighter shades corresponding to higher densities. The hatched region shows the limit of the area surveyed. Adapted from Figure 22 of [<http://adsabs.harvard.edu/abs/2015arXiv150302079K>].

Dwarf galaxies are the smallest galaxy structures observed, the faintest of which contain just 5,000 stars. Standard cosmological models of the universe predict the existence of hundreds of dwarf galaxies in orbit around the Milky Way, but their dimness and small size makes them incredibly difficult to find, even in our own ‘backyard.’

“Dwarf satellites are the final frontier for testing our theories of dark matter,” said Dr. Vasily Belokurov of the Institute of Astronomy, one of the study’s co-



**All-sky view of the Galactic satellite system.** Distribution of the Galactic satellites on the sky. The underlying background image is the Infrared Map produced by the 2MASS survey. Credit: S. Koposov, V. Belokurov (IoA, Cambridge). Background: 2MASS.

authors. “We need to find them to determine whether our cosmological picture makes sense. Finding such a large group of satellites near the Magellanic Clouds was surprising, though, as earlier surveys of the southern sky found very little, so we were not expecting to stumble on such treasure.”

The closest, Reticulum 2, lies 97 000 light-years away, about halfway to the Magellanic Clouds, and is located in Reticulum. Due to the massive tidal forces of the Milky Way, it is in the process of being torn apart.

The most distant and most luminous of these objects, Eridanus 2, is 1.2 million light-years away in Eridanus.



It is right on the fringes of the Milky Way, and is about to get pulled in. According to the Cambridge team, it looks to have a small globular cluster of stars, which would make it the faintest galaxy to possess one.

“These results are very puzzling,” said co-author Wyn Evans, also of the Institute of Astronomy.

“Perhaps they were once satellites that orbited the Magellanic Clouds and have been thrown out by the interaction of the Small and Large Magellanic Cloud. Perhaps they were once part of a gigantic group of galaxies that – along with the Magellanic Clouds – are falling into our Milky Way galaxy.”

The new results also mark the first discovery of dwarf galaxies in a decade, after dozens were found in 2005 and 2006 in the skies above the northern hemisphere. By detecting slight overdensities in starcounts on the Sloan Digital Sky Survey, over 15 faint satellites of the Milky Way were discovered, including Leo V, Pisces II, Canes Venatici II

Prior to 1990, all dwarf galaxies were discovered by visual inspection of photographic survey images. The first to be found, Sculptor and Fornax, were discovered in 1938 by Harlow Shapley on images taken with the 24-inch telescope at Boyden Observatory. Leo I, Leo II, Ursa Minor and Draco were discovered in the 1950s on 48-inch Schmidt telescope plates taken as

part of the Palomar Observatory Sky Survey. The last Milky Way dwarf to be found by eyeball search was Carina, found in 1977 on photographic plates taken for the ESO/SRC Southern Sky Survey project. The next discovery, Sextans in 1990, was the first to be machine-discovered, during the first large-scale automated search for Milky Way companions.

A preprint of the research paper, “Beasts of the Southern Wild: Discovery of a large number of ultra-faint satellites in the vicinity of the Magellanic Clouds” by Sergey Koposov et al., can be downloaded from [<http://arxiv.org/abs/1503.02079>]. Additional images by the authors are available at [[http://www.ast.cam.ac.uk/~vasily/des\\_pr/](http://www.ast.cam.ac.uk/~vasily/des_pr/)].

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THE HIGH ENERGY STEREO SCOPIC SYSTEM (HESS) telescopes in Namibia have discovered, in the LMC, the most luminous very high-energy gamma-ray sources: three objects of different types, namely the most powerful pulsar wind nebula, the most powerful supernova remnant, and a superbubble: a shell 270 light-years in diameter blown by multiple stars and supernovae. This is the first time that stellar-type gamma-ray sources are detected in an external galaxy at these energies. The superbubble represents a new source class in very high-energy gamma rays.

HESS consists of four 13-m diameter telescopes and has been operational since late 2002. It has recently been complemented with the huge 28-m HESS II telescope and is one of the most sensitive detectors of very high-energy gamma rays. These are absorbed in the atmosphere, where they create a short-lived shower of particles. The HESS telescopes detect the faint, short flashes of bluish light which these particles emit (named Cherenkov light, lasting a few billionths of a second), collecting the light with big mirrors which reflect onto extremely sensitive cameras. Each image gives the position on the sky of a single gamma-ray photon, and the amount of light collected gives the energy of the initial gamma ray. Building up the images photon by photon allows HESS to create maps of astronomical objects as they appear in gamma rays.

Very high-energy gamma rays are the best tracers of cosmic accelerators such as supernova remnants and pulsar wind nebulae, the final stages in the evolution of massive stars. There, charged particles are accelerated to extreme velocities. When these particles encounter light or gas in and around the cosmic accelerators, they emit gamma rays. Very high-energy gamma rays can be measured on Earth by observing the Cherenkov light emitted high up in the atmosphere using large telescopes with fast cameras.

“Both the pulsar wind nebula and the supernova remnant detected in the Large Magellanic Cloud by HESS are more energetic than their most powerful relatives in the Milky Way. Obviously, the high star-formation rate of the LMC causes it to breed very extreme objects,” summarizes Chia Chun Lu, a student who analyzed the LMC data as her thesis project. “Surprisingly, however, the young supernova remnant SN 1987A did not show up, in contrast to theoretical predictions. But we’ll continue the search for it,” adds her advisor Prof Werner Hofmann, HESS spokesperson.

The HESS team consists of scientists from Germany, France, the United Kingdom, Namibia, South Africa, Ireland, Armenia, Poland, Australia, Austria, the Netherlands and Sweden, supported by their respective funding agencies and institutions.

SOURCE: MPI PRESS RELEASE 22 JANUARY 2015

THE BIG 5 OF THE AFRICAN SKY is a new observing project run by the ASSA Deep-Sky Section, designed to encourage novice star gazers to observe the deep-sky. The Observing Handbook is included as an appendix to this issue of Nightfall. The official launch will be in April. Take a look, have a go, and encourage others to observe the best of the African sky!

A CENTURY AGO, THE PLANETARY NEBULAE of our Milky Way galaxy were carefully catalogued during several photographic surveys. In January this year, another thorough catalogue of planetary nebulae was published, listing 1 267 spectroscopically confirmed planetaries, and a further 1 118 candidates requiring follow-up observations to classify correctly. The major difference: the 2015 catalogue lists only planetary nebulae that are located within NGC 5128, the Hamburger Galaxy! Find out more at [ <http://arxiv.org/abs/1501.01853v2> ]

THE PRETORIA CENTRE OF THE SOCIETY is setting a fine example for deep-sky observers nationwide. Under the enthusiastic guidance of Percy Jacobs, 14 observers have taken the challenge of observing the ASSA Top-100 Objects. Four of their number – George Dehlen, Percy, Louis Kloke, and Michael Moller – have observed all 100 objects, and Michael has imaged all of them: see page 128 of the 2015 *Sky Guide*.

The other observers, Michael Poll, Pat Kühn, Craig Kloke, Grant Thompson, Bosman Olivier, Andre de la Ponte, Graham Low, Albie Lombard, and Jacques Mare, are engaged with their own programmes as they work through the Top-100.

Find out more at [ <http://assa.saao.ac.za/sections/deep-sky/nebulae-clusters/assa-top-100/> ].

THE MAGNIFICENT ETA CARINAE NEBULA, located some 7500 light years from the Sun, is one of our Galaxy's most spectacular sights. It is embedded within the much larger Carina complex and is an active star-forming region, home to more than 70 O-type stars. In comparison, the Orion Nebula region has only 10 of these rare, hot luminous blue-white power-houses. Carina is young enough to display much ongoing star formation, and old enough that the most massive, energetic, stars have cleared away enough material to



**eta Carinae Nebula.** Background image by Dale Liebenberg, smaller overlay by Leslie Rose. Prominent parts of the Northern and Southern Pillars are marked. See [ <http://arxiv.org/abs/1502.03798> ] for details.



reveal a spectacular naked-eye HII region with sculpted regions of intricate detail.

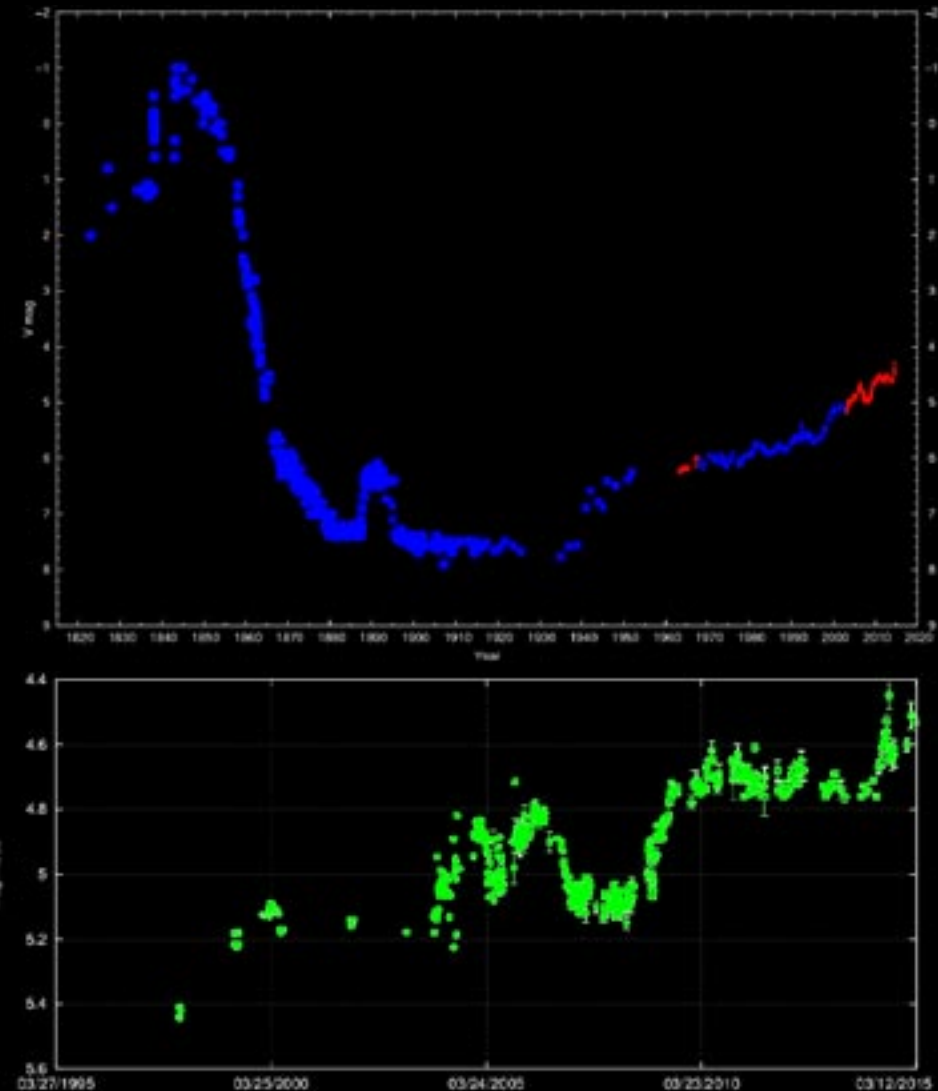
Vast sheets of molecular hydrogen (called “walls”), up to 16 light years across, are blasted by ultraviolet radiation from the O-type stars. On their exposed surfaces, pillars are created. Some of the pillars detach from their parent molecular cloud creating isolated globules, often with a young star located near the apex of the globule.

A new study of the region, *A Survey of Irradiated Pillars, Globules, and Jets in the Carina Nebula* [ <http://arxiv.org/abs/1502.03798> ], was published in February, containing a beautiful gallery of images and a detailed guide to the various components.

The star eta Carinae is itself a splendid object: one of the most massive and brightest stellar systems in the Galaxy and a prime candidate for the next Galactic supernova. Its brightness has undergone spectacular changes, as the adjacent light curves show.

During the exceptional brightening in 1843, the accompanying mass ejection event created a new bipolar nebula surrounding the star. Nick-named the Homunculus (“little man”), this is one of the must-see southern treasures. The Homunculus is bright but small, so even a 6-inch telescope will show it, provided high magnification is used, and the night is steady.

NF



**Light curve of eta Carinae. (top)** Change in apparent magnitude from 1822 to the present, compiled by the Observatorio Astronómico de La Plata [ <http://etacar.fcaglp.unlp.edu.ar/> ]. **(bottom)** Sporadic brightening of eta Carinae over the last 20 years, from V-magnitude data gathered by the AAVSO.

# THREE IN CARINA

by Dave Blane & Auke Slotegraaf

photographs by Bob Sim & Auke Slotegraaf

additional images by the Anglo-Australian Observatory Board  
and the ASSA Historical Section

**G**lorious Carina, high in the evening sky, is the creation of 18th century astronomer Nicolas Louis de La Caille during his epic visit to Cape Town (1751–1752).

Located in the southern Milky Way, Carina is rich in both stellar and non-stellar objects. We've chosen three splendid specimens of each type – double star, variable star, and star cluster – to highlight here: the charming upsilon Carinae, the naked-eye Cepheid variable  $\epsilon$  Carinae, and the amazing Galaxy Cluster (NGC 3114).

## UPSILON CARINAE

Double stars are among the most interesting and useful creatures of the starry skies. From them and their interactions we can deduce stellar masses, radii, and all sorts of other properties. At the same time, some pairs can be amazingly frustrating. The bright, third magnitude upsilon Carinae, at the southern edge of the rich southern

Milky Way in Carina about  $10^\circ$  southwest of the eta Carina Nebula, is a case in point.

It was first noticed as being a multiple star by the German astronomer Charles Rumker while working at Thomas Brisbane's observatory in Australia. It was his 11th discovery and so has the discovery code RMK11.

An observer with a small telescope will be well-rewarded

because we have a two-for-one set of double stars in this region of Carina.

Upsilon Carinae is part of the Diamond Cross asterism in southern Carina. Its name is Vathorz Prior, a name of Old Norse-Latin origin meaning "Preceding One of the Waterline". The upsilon Carinae system has a combined apparent magnitude of +2.92 and is approximately 1 600 light years from Earth.



Figure 1. Upsilon Carinae,  $\epsilon$  Carinae and NGC 3114.  $1^\circ \times 1^\circ$  fields from the POSS2 © 1993-5 by the Anglo-Australian Observatory Board.

This superb pair reminds me of Rigel, with a bright magnitude 3.0 primary and a close fainter magnitude 6.0 companion.

In the 150-mm refractor the primary, of spectral type A8, appears pale yellow and the secondary, of spectral type B7, blue-green. This long-period binary has a separation of 5" and



**Figure 2. Upsilon Carinae and HJ 4252.** A 10' field of view (north up, east left) showing the pair of pairs, courtesy *Cartes du Ciel*.

has shown little change since the first reliable measure made in 1836 by Rumker.

But clearly the star, one of the brightest in the sky with so little known about it, is ripe for study. That the two stars are truly connected is unquestioned as they have been tracking each other at their current separation for nearly 200 years. They must be at least 1 900 astronomical units apart, and given that they are each around nine solar masses the orbital period must be at least 20 000 years.

But there is more! Located just 5' south-east is the fainter, wider, more-equal pair HJ 4252, which shares the field with upsilon in a 150-mm f/8 refractor at 136x. This second set consists of 8.7 and 9.1 magnitude stars separated by 12.2". Both doubles provide an interesting study in contrasts: faint and wide versus bright and close.

## ℓ CARINAE

Located between the Diamond and False Crosses, this amazing variable star requires no optical aid to follow throughout its light cycle. Even under average urban sky conditions, without the need for a telescope or even binoculars, it can be seen to vary between magnitudes 3.4 and 4.1 over a period of 35.5 days. The light curve in Figure 3 was produced by Rod Stubbings (Victoria, Australia) using his naked eye observations over six cycles.

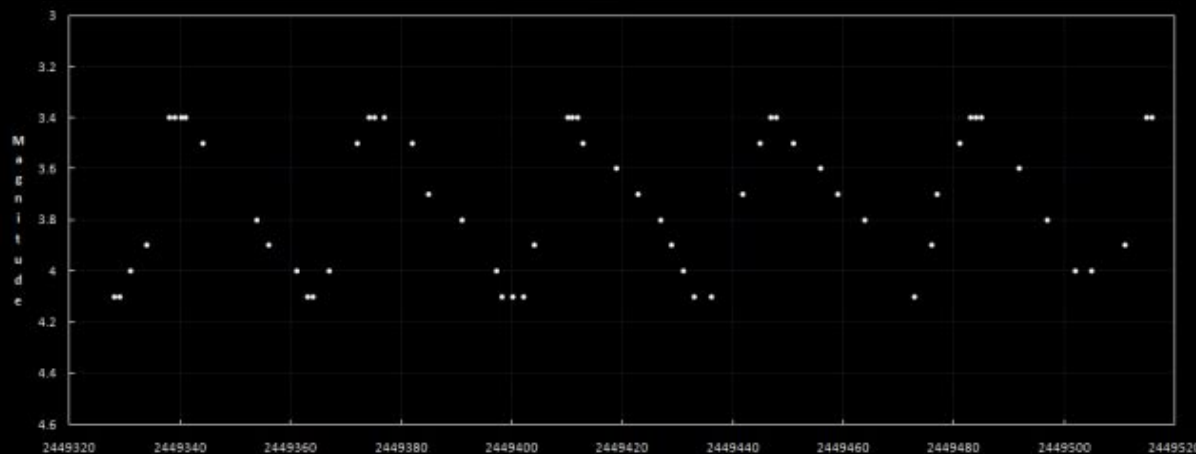
The curious designation, ℓ Car, (lower-case L) comes to us from Lacaille. When he ran out of letters in the Greek alphabet to apply to naked-eye stars within a constellation, he used lower-case, then upper-case, Roman letters. More recent designations include SAO 250683 and HD 84810.

ℓ Car is a classical Cepheid, or delta Cep-type variable. They are comparatively young objects that have left the main sequence and evolved into the instability strip of the Hertzsprung-Russell diagram. These stars are pulsating, and their size changes correlated with brightness, being largest near maximum light. ℓ Car varies between an impressive 160 and 194 times the Sun's diameter: it is 90% the size of the Earth's orbit at greatest diameter!

This direct relationship between a Cepheid variable's luminosity and pulsation period makes them very important distance indicators for establishing the galactic, and thus extragalactic, distance scales. The longer a Cepheid's pulsation period, the more intrinsically luminous the star is (Fig 4). Since measuring a Cepheid's period is easy, the period-luminosity relation allows us to determine the Cepheid's intrinsic brightness and hence its distance from

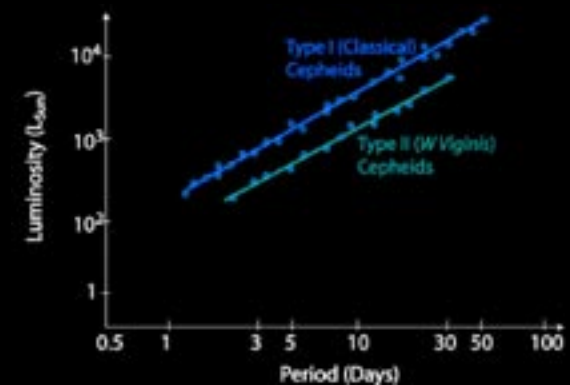
$m - M = 5 \log(d/10)$   
where  $m$  is the apparent magnitude,  $M$  is the absolute magnitude, and  $d$  is the distance in parsecs.

So, by just using the naked eye and noting the period as the star brightens and fades one can work out that the distance to this star is 1850 light years – quite remarkable!



**Figure 3. Naked-eye light curve of I Car compiled by Rod Stubbings.**

Source: <https://rodstubbingsobservatory.wordpress.com/lightcurves/classical-cepheid/i-car/>



**Figure 4. Cepheid period-luminosity relationship.** Source: CSIRO Australia Telescope National Facility. (<http://www.atnf.csiro.au/outreach/>)



## NGC 3114

I don't doubt that Nicolas-Louis de La Caille (1713-1762) during his Cape visit must have seen NGC 3114. His tiny (13.5-mm aperture) telescope had an almost 3° field of view and magnified 8x, so he certainly had the optical punch to see it. Nevertheless he didn't record it officially.

That honour went to James Dunlop (1793-1848), the 19th century Scottish astronomer who was the first observer to undertake



Figure 5. James Dunlop (Cozens 2008:28)

a systematic search for southern-hemisphere nebulae, producing a catalogue of these objects in 1826.

Although Dunlop's published work contained many errors, and was quickly eclipsed by the larger, more complete, catalogue compiled by John Herschel, it remains an important milestone in observational astronomy.

Astronomy historian Glen Cozens summarizes Dunlop's situation as follows: "Major problems for him included a lack of financial and personnel support, a homemade telescope with poor resolving power and a lack of accurate equipment. He was an inexperienced observer who did not have the educational or financial advantages of John Herschel." (Cozens 2008:85).

In the face of these challenges, Dunlop's contribution is even more remarkable: there are numerous objects which were first

seen by him, and his "descriptions are also important because they were the first made of many bright far southern objects, including genuine objects that John Herschel failed to see" (ibid.).

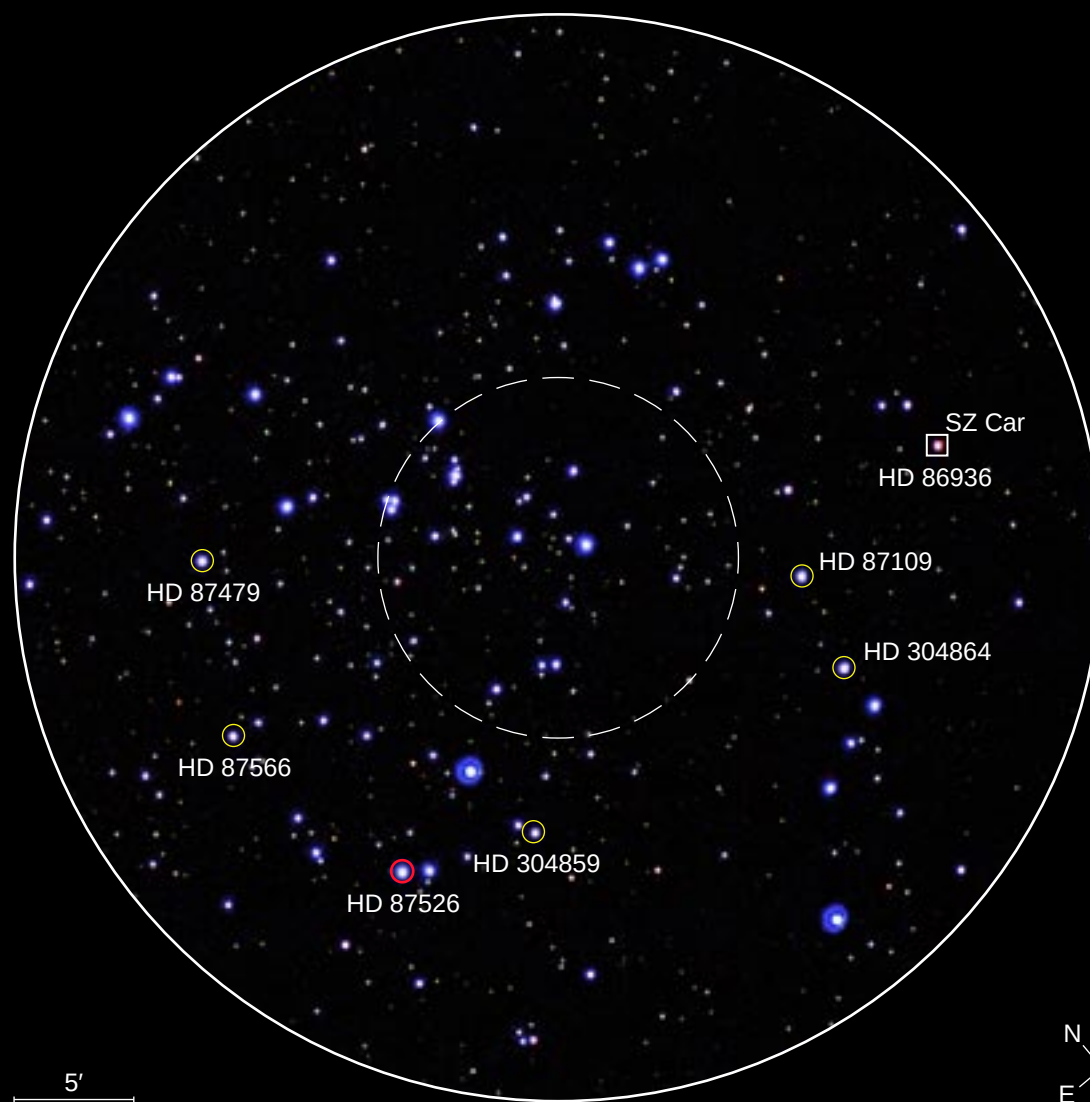
Dunlop observed from the backyard of the house he was renting in Parramatta, Australia, with a 9-inch f/12 reflector that he designed and built himself. His telescope was the equivalent of a modern 6.5-inch Newtonian, and his limiting magnitude was 13.1. Probably because of the poor-quality eyepieces he used, however, the telescope's resolution was only about 4 arcseconds (Cozens 2008:175).

He completed his survey of southern nebulae in just seven months, observing from April 27 to November 30 of 1826, logging 77 nights of observing and 1059 individual observations. (Cozens 2008:133)

On the evening of 1826 May 08, he swept up NGC 3114 (he would catalogue it as No. 297). The low-power eyepiece he used gave him a field of view of about 45' diameter, which is a bit larger than the cluster (Figure 6). Dunlop described it as “a beautiful cluster of stars, arranged in curvilinear lines intersecting each other, about 40' diameter, extended S.p. [south-west], and N.f. [north-east]”, nicely capturing its most striking feature: those curves of stars.

Less than a decade later, John Herschel (1792-1871) was in Cape Town and observed the cluster, cataloguing it as h 3224. Herschel used a much larger instrument, an 18.25-inch f/13 reflector with a 39-mm eyepiece delivering 157x magnification and a 15' field of view. He logged it on three occasions as follows:

“The chief star 9th mag of a very large, loose, brilliant cluster, which fills many fields” (1834 Mar 14), “The chief star 8th mag of a very large, loose cluster of stars, 9...13 mag, which fills many fields” (1834 Apr 01), and “An



**Figure 6. NGC 3114.** This 45' field matches the view through James Dunlop's telescope. The dashed circle shows the extent of John Herschel's 15' field. Stars circled in yellow are giant members of the cluster. HD 87526 is a field star.

enormous congeries or clustering region of stars 2 or 3 fields in diameter, constituting a decided cluster. Stars 9...14 mag, the larger magnitudes predominating. There must be many hundreds. The place taken in the centre of a bright equilateral triangle" (1835 Feb 04).

His telescope's much narrower field of view (see Fig 6 for a comparison with Dunlop's field of view) didn't allow him to appreciate the cluster to its fullest, although I suspect he viewed it with his refractor, too (used for double star measurements); I certainly can't imagine him resisting the temptation.

Herschel's survey was the first – and last – major visual survey undertaken of the whole sky, truly the end of an era.

Soon after the adoption of a new technique for use by astronomers (astrophotography,

discovered by another Scott visiting the south, i.e. David Gill in Cape Town), NGC 3114 turns up in the record books of these pioneering surveyors, essentially the Next Generation Herschels.

Solon Bailey's 1908 "A catalogue of bright stars and nebulae" records it as a 50' irregular cluster, fairly condensed, lying in a rich region of the Milky Way. Philibert Melotte's 1915 work "A catalogue of star clusters shown on Franklin-Adams chart plates" reports a 30' cluster, classified as one of the "loose clusters having a regular, well-defined outline" and described specifically as a "well-defined, loose cluster in a rich region". In the 1920s Raab (at Lund Observatory) and Trumpler (at Lick Observatory) referenced it too, but the first detailed study of NGC 3114 would have to wait for the 1960s.

In 1958, Swedish astronomer Gösta Lyngå (also of Lund) travelled to Bloemfontein to use the 60-inch (1.5-m) f/5.3 Rockefeller reflector and the 35.5-inch f/3.4 ADH Baker-Schmidt telescope at Boyden Observatory to carry out the first in-depth study of NGC 3114. The photographic plates he took, between January and May 1958, went home with him to Lund Observatory for analysis, and he published the results in



**Figure 7. Boyden Observatory, 1952.** The 60-inch Rockefeller at bottom-left, and the ADH telescope at far right. Source: ASSA Historical Section archives.

1960 and 1962. In his discussion Lyngå notes a feature that all later researchers would repeat: “Although the cluster is rich, it is difficult to handle because of the bad separation from the surroundings.” In other words, it is particularly tricky to know which stars belong to the cluster, and which are just field stars (in the background or foreground).

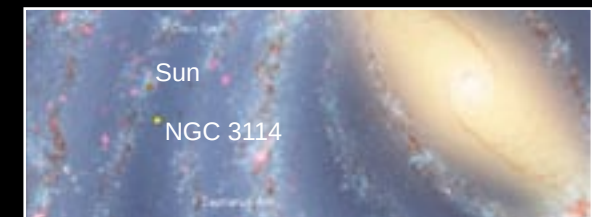
Meanwhile in Cape Town, N E Jankowitz and C J McCosh observed NGC 3114 with the 24-inch Victoria refractor at the Royal Observatory. They took images of the cluster during several sessions, between February and July 1962, with exposure times ranging from 1 minute up to an hour. Their analysis revealed that the cluster lies about 2 960 light years away, locating it between our Local Arm and the Sagittarius Arm of our Galaxy. Based on star counts

on one of the photographs they found its angular diameter to be 32'. They wrote: “NGC 3114 appears to be a normal cluster with a number of red giants and its brightest main sequence stars of HD spectral type B9. The three bright red stars, Nos 150 [HD 87479], 170 [HD 87526] and 181 [HD 87566] occur near the centre of the cluster and are almost certainly members.”

The writers were wise to be cautious in their certainty about the membership of these stars. A high-resolution spectroscopic study of the cluster in 2013, using the 2.2-m ESO telescope at La Silla (Chile), revealed that HD 87526 is not a member of NGC 3114: it belongs to the thick disk/Galactic halo because its metallicity and chemical abundances are very different from the other giants within the cluster.

From the dozen or so studies carried out on this cluster, the following picture emerges: NGC 3114 is a young (160 million year old), sparse star cluster, 3 000 light years from the Sun. That it lies 5° on the sky from NGC 3372 (the glorious eta Carinae Nebula) is no coincidence: both are members of the Carina complex.

This complex, dominated by the giant H II region NGC 3372, is one of the youngest structures known in our Galaxy. It exhibits an age gradient: in the inner region it is populated by very young clusters (e.g. Cr 228, NGC 3324, Bo 11) and by young and intermediate objects (VDBH 99, Loden 165) in the outskirts – which is where NGC 3114 lives.







**Figure 8. Carina Milky Way.** NGC 3114 is an obvious feature at top-centre in this wide-field image captured by Bob Sim. Details: Canon 70D, Tamron SP17-50mm at 48-mm f/2.8, ISO 1000, 20-sec exposure. 2014 March 21. © Bob Sim.

With all this as background, let's wrap up with an actual look at the cluster.

Based on its catalogued magnitude of  $V=4.2$ , one would expect NGC 3114 to be an easy naked-eye object from a dark-sky site. For comparison, omega Centauri has  $V = 3.9$ . However, unlike the noble globular cluster, NGC 3114 lies within the stream of the Milky Way, as Figure 8 shows, and this bright background presents a challenge. But if you dark adapt, and the sky is reasonably dark, you will see it as a luminous patch within the Milky Way. Use a star map to confirm you've got it.

With the slightest optical aid, NGC 3114 becomes a jaw-dropping spectacle. Veteran observer Phil Harrington calls it an “absolutely ravishing open cluster”, noting that “three 6th mag beacons rule over another 100 or so citizens in this brilliant stellar blaze ... the best view will be through your lowest-power eyepiece or binoculars. I could only stare in silent awe when I saw NGC 3114 through my 11x80 glasses at last year's Winter Star Party [Miami, Florida]. I also heard other binocularists nearby whimper their sadness that this cluster is not visible from back home.”

In his inspiring *Touring the Universe Through Binoculars* (Wiley, 1990), Harrington says: “One view of NGC 3114 and you will surely add it to your ‘favorite clusters’ list, as I have.”



Of all the clusters in all the galaxies, NGC 3114 is my favourite. It was one of the first deep-sky objects I ever saw. I began my exploration of the southern sky in 1979 with a pair of 8x40 binoculars, and I still frequently re-visit NGC 3114 to experience some of that initial thrill.

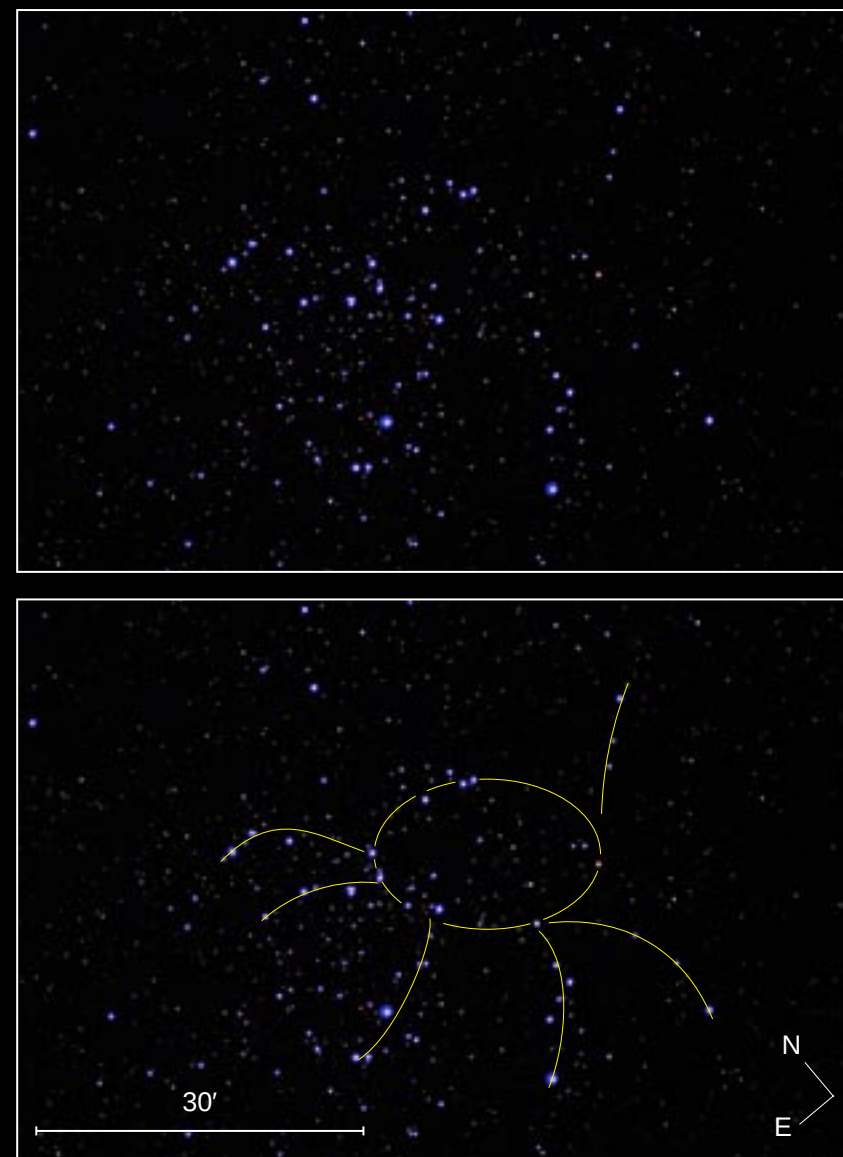
To my eye, the interplay of stars and dark patches is magnificent. The central area of the cluster has an oval vacuity elongated northeast to southwest (see Figure 9). Six 'arms' meander out from the central region, two of which have bright stars in or near their tips.

When I first saw these 'arms' it reminded me of a stylized, multi-armed spiral galaxy. Other comparisons have been made to a snail (by Glen Cozens), a spider, an octopus, a butterfly (Magda Streicher) and a flying bug (Carol Botha). On a lovely summer's evening in 2008, Dieter Willasch tried to convince me that it should be called the "Hand Cluster", and I have to agree: the curves of stars do indeed look like an X-ray of a human hand. Whatever else you do, take a long look at this cluster for yourself, see what you see, and make it your own.


NF

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**Figure 9. Star chains in NGC 3114.** EOS 60D, 4.7-inch f/8.3 refractor, ISO 1600, 5-sec. Enhanced to emphasise the stars.



**Globular cluster E3** (below centre) and the galaxy NGC 2915 (top-left). The brightest stars in the image have  $V=7.8$ . POSS2/UKSTU Blue image © 1993-5 by the Anglo-Australian Observatory Board.

# E 3

*A curious globular cluster in Chamaeleon*

*by Douglas Bullis*

*douglasbullis@gmail.com*

**T**he Milky Way's halo globulars clusters are probes of the star formation and chemical enrichment history of the Galactic halo and thick disk. The globular E 3, formally ESO 37-01, is a seldom observed or studied globular in Chamaeleon. It is visible in telescopes as modest as 150-mm under dark sky conditions. E 3 is a halo globular in a state of tidal disruption. It was last studied extensively using the HST ACS in 2005. Its colour-magnitude diagram exhibits an unusual population of equal-mass binary main sequence stars brighter by 0.75 mag., which led to the term 'yellow straggler' in 1985. E 3 also exhibits very little evidence of a horizontal branch, which makes its actual age uncertain. Hence E 3's metallicity and Galactocentric distance are yet to fully established.

## OBSERVATIONS

I observe E 3 often at my dark site 15 km west of Nieu Bethesda, 1450-m altitude, 8 to 10 transparency, 6 to 9 seeing, and zero light pollution. E 3 is one of a dozen seasonal test objects I use to assess seeing quality. E 3 appears as a faint patch in a 180-mm Santel Mak at 90x and 164x. The patch quavers in and out of view at first but settles down to a steady but dim 1.5' diameter glow in averted vision with no apparent core brightening; it fades into sky background at higher power.

E 3 lies 43' south of the 12.6-mag. dwarf galaxy NGC 2915 [see previous page], which is a worthy linger in its own right because it's been classified as a blue compact dwarf and possible quasar suspect.

The Harris catalog (Harris 1996, 2010 edition) lists E 3's integrated visual magnitude as 11.35 and surface brightness as 14.8 mag/arcmin<sup>2</sup>. The difference implies that E 3 is either very sparse or reddened. Visually, the Small Magellanic Cloud's lone globular NGC 121 is more easily spotted than E 3, despite being nine times further away. NED lists the Galactic extinction in this part of the Milky Way at 0.54 mag., hence that does not explain E 3's wan visual presentation. Nor is E 3 notably remote. At 8.1 kpc (26 410 ly) from the Sun, E 3 is closer to us than the frequently observed



[<http://www.skythisweek.info/GC/E3.jpg>]

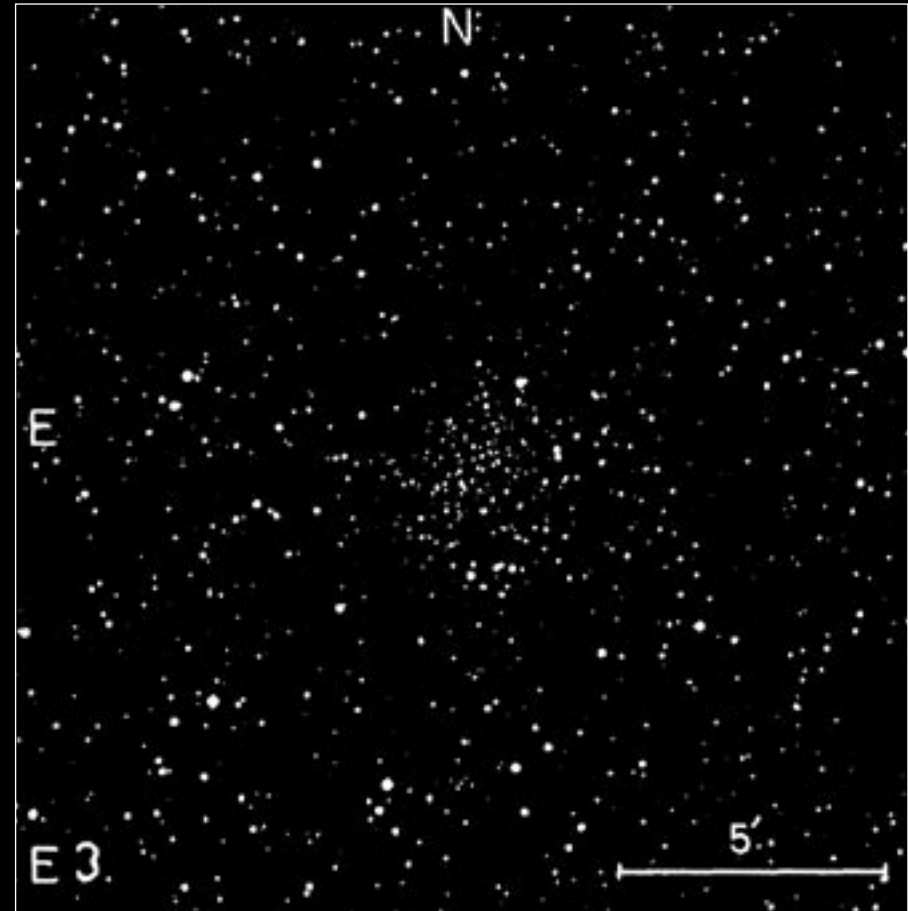
globulars NGC 288 in Sculptor (8.9 kpc) and NGC 362 adjacent to the Small Magellanic Cloud (8.6 kpc). E 3 lies at Galactic coordinates  $R_{\odot} = 8.1$  kpc,  $\omega = 9.1$  kpc from the centre of the Galaxy, and  $Z = -2.6$  kpc below

the Galactic plane. This location is typical of a Galactic halo globular >12 billion years old.

E 3's listed surface brightness of  $23.10 \text{ mag/arcsec}^2$  accords with my visual impression. The surface brightness limit for the eye is considered to be  $\approx 25 \text{ mag/arcsec}^2$ . At E 3's distance, its column density (the number of atoms) between your eye and E 3 at  $1.77 \times 10^{-21} / \text{cm}^2$ . By comparison, Earth's sea-level atmospheric density is  $2.7 \times 10^{19}$  molecules per  $\text{cm}^3$ .<sup>[1]</sup> E 3 should appear brighter; why doesn't it?

## BACKGROUND

E 3 was discovered in 1976 on an ESO survey plate (see Figure 1). It is one of the faintest intrinsic globulars at  $M_V = -4.2$ . Visually E 3 resembles a Class X to XII cluster with a flat luminosity profile and no halo. If E 3 is a curiosity to us, it's all the more so to professional astronomers. E 3's colour-magnitude diagram (CMD; Figure 2) differs from most globular clusters. It is notably sparse in horizontal branch (HB) and asymptotic giant branch (AGB) stars. There is also a decline in stellar density toward the lower Main Sequence (MS), which is the opposite of typical globulars. This suggests significant mass segregation in the core with similarly significant mass loss in the halo.



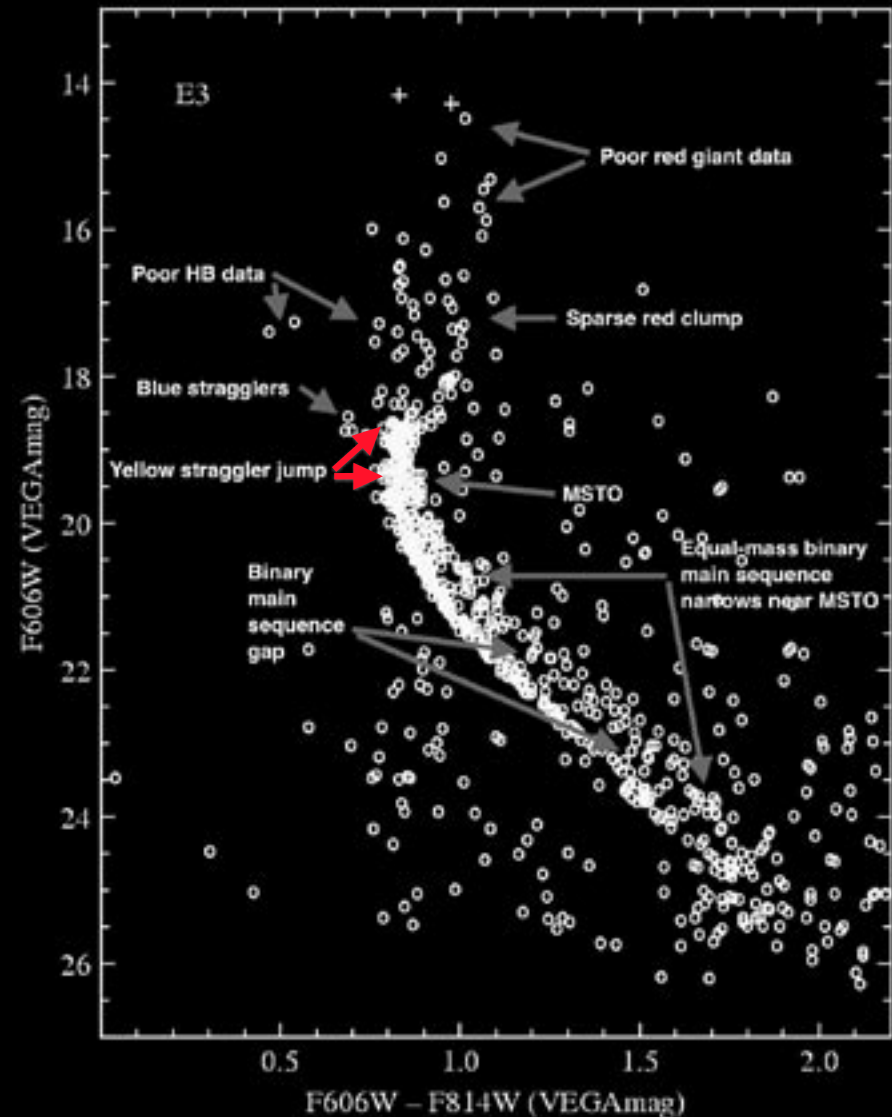
**Figure 1. Discovery image of E3.** Andris Lauberts (Uppsala Observatory, Sweden) discovered three new faint southern star clusters on photographic plates taken with the then-recently completed ESO 1-metre Schmidt telescope at La Silla, Chile. The image above shows the appearance of E 3 on the ESO plates and is taken from Lauberts, A. (1976) Three Distant Stellar Clusters Found on ESO Blue Survey Plates. *Astronomy & Astrophysics*, 52, 309 [1976A&A....52..309L]. The cluster E 1 lies in Horologium while E 2 lies in Dorado.



Many of E3's old, evolved stars seem to have gone missing. But where? And how?

The CMD in Figure 2 was extracted in 2005 from one orbit each for the two Hubble Space Telescope filters used in Sarajedini *et al.* (2007). The HST F606W filter corresponds roughly to the Johnson-Cousins (J-C) green V filter at 554 nm, and the F814W lies near the J-C near-infrared 806 nm I band. This CMD includes only stars which registered in both filters with no brighter stars within 3 pixels. The clump of stars at the MSTO samples 852 photometric points.

The annotated arrows in Figure 2 highlight several important E3 properties. There is little evidence of a red giant (RG), red clump (RC), or horizontal branch (HB) in this CMD – standard staples when calculating the stellar distributions, distance, and age-metallicity relationship (AMR) of globulars via their CMDs. The absence of a HB imposes strong constraints because the standard formula to relate a star's metals content  $[Fe/H]$  to the visual magnitude of the horizontal branch  $M_{HB} = 0.15 [Fe/H] + 0.80$ . HB stars are one of the defining properties of an old globular; they tend to inhabit a cluster's outer core while more massive red giants and main-sequence binaries mass-segregate to the inner core. Moreover, E3's missing red clump stars – which at an absolute magnitude of  $-1.52$  are



**Figure 2. CMD of E3** from Sarajedini, A. et al. (2006) The ACS Survey of Galactic Globular Clusters. I. Overview and Clusters Without Previous HST Photometry. [2006arXiv0612..598S]



the same intrinsic brightness in any cluster – place restrictions on distancing the cluster. Red clump and HB stars are  $0.52 - 1.51 M_{\odot}$  stars with helium-burning cores of  $0.46 M_{\odot}$ . In E 3 we know quite a bit about these stars, except where they are.

E 3's elongated and skinny blue main sequence (bMS) features a second fainter red main sequence (rMS) 0.3 mag. to the right. There is a hint of a 0.1 mag. gap between the two sequences, especially visible between mag. 21.5 and 24. The abnormally slender bMS is partly an optical effect from the narrow colour distribution of the two filters used, but mostly because the stars that make such a feature aren't observed. Earlier CMDs from van den Bergh *et al.* (1980) and McClure *et al.* (1985) exhibited the plump, pear-shaped lower main sequence that typifies most lower MS populations in globular clusters. The difference between the 1980s-era CMDs and the 2005 Hubble ACS CMD is the living history of one of the significant advances in the history of image interpretation: signal processing algorithms.

The E 3 main sequence also exhibits an unusual vertical leap upward of 0.8 mag. from mag. 19.5 to 18.7 before turning abruptly rightward toward the subgiant branch. This is quite unlike a canonical MSTO which veers sharply right into a downslope of both

luminosity and surface temperature. The extraordinary number of stars between the red arrows in the 'yellow straggler jump' make E 3 unique in the Milky Way's population of 158 known globulars.

## STRAGGLER STARS AND THE ANALYSIS OF PAIRED MAIN SEQUENCES

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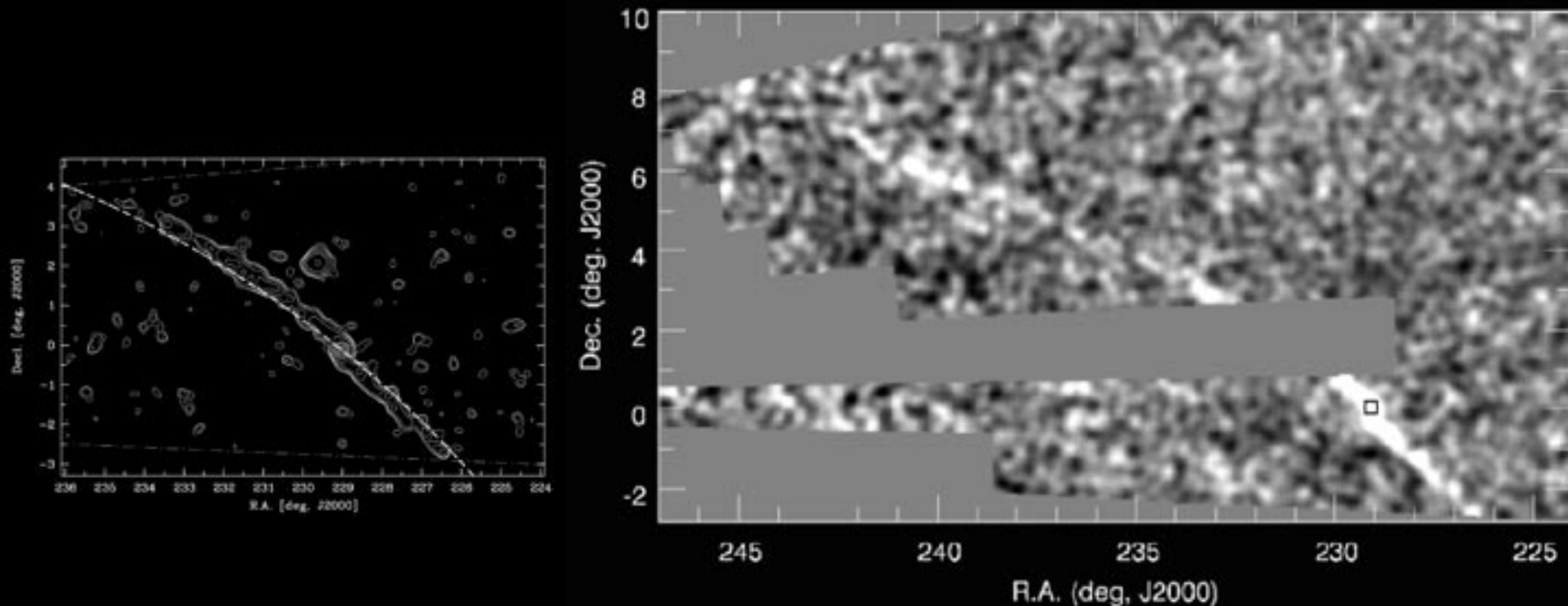
The fact of binary main sequences in globular clusters is not new; the evidence became firm with the Hubble observations of globular clusters (Bedin *et al.* 2004). However, the discovery that binary main sequences can have wholly different origins is quite new.

The van den Bergh *et al.* (1980) and McClure *et al.* (1985) CMD data is a baseline from which the 2005 data can be compared. Is the seeming merger of the redMS and blueMS at the MSTO suggested by the Hubble CMD real? How does one interpret this?

Presently E 3's core radius  $r_c$  is 4.4 pc, but the cluster has an unusually large tidal radius  $r_t$  of 26.4 pc – six times the  $r_c$ . Core concentration is important to an old, low-mass globular like E 3. E 3's large ratio points to tidal stripping of low-mass stars into the Galaxy. Mass loss from a globular cluster's tidal interaction with the Milky Way serves to compact the cluster's core inexorably over time while loosening the cluster's grip

on its halo stars. The net gain is to the Galaxy halo, which is enriched by higher-metallicity gas and stars. The cluster, alas, does not fare so well – see Figure 3 for an example of the tidally disrupted globular cluster Palomar 5 in Serpens.

In large globulars over  $\approx 60\,000\,M_{\odot}$ , a double main sequence is evidence for two primordial star-formation episodes roughly 250 million years apart. In these globulars, the first star formation epoch left



**Figure 3. Cluster's Last Stand: the tidal tail of Pal 5.** The left-hand panel is from Odenkirchen, M. et al. (2003) Palomar 5 and its Tidal Tails: New Observational Results. *New Horizons in Globular Cluster Astronomy*, ASPCS, 296, 501. The contours plot stellar surface density gleaned from the first data release of the Sloan Digital Sky Survey (SDSS). The cluster located at (RA 229°, declination  $-0.1^{\circ}$ ) and a stream of debris spanning an arc of  $10^{\circ}$  on the sky can be made out. The right-hand panel is from Grillmair, C. J. (2006) A  $22^{\circ}$  Tidal Tail for Palomar 5, *Astrophysical Journal*, 641, L37. This diagram was constructed from Data Release 4 of the SDSS, and now the tail can be seen to span about  $22^{\circ}$  on the sky.

enough residual unused gas to combine with the AGB ejecta of the first generation, from which a higher-metallicity second generation formed. After that there was insufficient gas for a third star-form epoch. (NGC 2808 with a triple main sequence is the sole exception.) Although multiple MSs were definitely shown only in 2004, they are now known to be so common that only one definitively single-generation globular is known, Ruprecht 106 in Centaurus.

A very different type of double main-sequence evolved from low-mass globulars whose initial mass function (IMF) was  $\approx 60\,000\,M_{\odot}$ .<sup>[2]</sup> E 3 is “Exhibit A” of this cluster type. E 3 was noted very early on for its high proportion of binaries. The 2005 Hubble CMD in Sarajedini *et al.* was the first to firmly establish E 3 population counts extending to seven magnitudes below the MSTO. Colour excess on the leftward bMS indicates that the right-side rMS population is made of binaries  $\sim 0.3$  mag. warmer than the stars in the bMS. In low-mass globulars, a double main sequence identifies binary populations, not successive early star formation episodes as in high-mass globulars. (A further study of the differences in paired main sequences in bulge, bar, disc, and halo globulars is in preparation.)

Elevated levels of binarism occur in low-mass globulars because of severe tidal disruption from

encounters with our Galaxy’s disc, a process called tidal truncation. When the globular undergoes a disc crossing, its leading stars are compressed toward the cluster core, while the trailing stars are lost as higher evaporation rates into the Galactic medium. (Spiral galaxies know how to subtract, not how to add.) The compression-rarefaction effect of a Galactic disc crossing induces core contraction in the cluster, in turn enabling its halo stars to ease outward to the cluster’s tidal radius. This explains E 3’s 6:1 core radius to tidal radius ratio – and also the very wan, thin look in my eyepiece.

## WHAT STRAGGLES?

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While we often hear of ‘blue stragglers’, it’s not always clear what the word ‘straggler’ means. Stragglers are members of the stellar exotica club, along with neutron stars and black holes. They are what happens when two stars in a globular cluster actually merge. Stragglers are the progeny of cluster core collapse. The stars in an old globular cluster core are rather alike in mass, luminosity, composition, and age – between about  $0.2$  to  $2.1\,M_{\odot}$ . Normally, simple Keplerian dynamics keeps them from hitting each other, but in the dense conditions of a core-collapsed cluster like E 3,  $1\,000\,M_{\odot}/\text{pc}^3$  is not unusual. In this traffic, fender-benders

happen. What we see in our telescopes is not the crumple but the broken glass on the street.

Most become blue stragglers. These involve mergers of unequal binaries when one star is several times the mass of the other. The large star reaches the MS turn-off point before the small star. As it expands into the red giant stage, its gravitational surface area – its capture cross-section – expands, too. Eventually the red giant absorbs the smaller star. The slow pace and one-sided exchange of atmospheric gas – Roche-lobe overflow – is a sublimely beautiful death spiral of gas into the medium as the two stars clench ever tighter.

Roche-lobe filling in merging stars redistributes 10% to 20% of a binary's mass as a stripped gas which is eventually lost to the cluster medium. That gas will later be removed by tidal interaction with the Galactic disc, which will in turn compact the cluster's core concentration and loosen its halo distribution. This can take many millions of years. Unhappily for we backyard stargazers with our modest optics, the birth of a straggler is not the big fissile blast in the sky we all dream about.

In the blue case, the combined mass enables the star to remain on the main sequence longer – trending blueward and warmward in other words. Blue stragglers show up on a CMD as a sprinkle of stars

on the main sequence which continue past the normal right-turn MSTO point into a region inhabited by more massive MS stars. Eventually a blue straggler will reach a point where its core can no longer supply enough energy to thermalize the envelope; it will then contract rightward toward the red giant branch like other stars of its mass. Blue stragglers are so common in cluster studies that they have their own acronym, BS. We see the name all the time in the astro magazines and on *Astronomy Picture of the Day*.

So what are yellow stragglers? The YS star classification doesn't come up very often in cluster studies – indeed, the McClure *et al.* 1985 study of E 3 coined the term. What happens when a pair of equal-mass stars merge? Already they are 'hard' binaries – so close they can be broken up only by a more massive binary. They show up on a CMD as a second main sequence redward of the single-star MS of the same magnitude and colour. They ascend the main sequence together, but we see the combined light of two stars of the same mass and composition. Spectroscopists call these suspected couples 'blends' and apply algorithms to distinguish real from spurious line-of-sight pseudo-pairs from real binaries. Only when they turn off the main sequence together can we identify them as binaries. 'Yellow' binaries merge when their collective

envelopes expand beyond their gravitational capture radius. Roche lobe gas mass is lost to space just as with dissimilar-mass binaries. Interactive gas turbulence slows down their orbital speeds; their former orbital velocity becomes their new rotational velocity.

## CONCLUSION

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By now astronomers have a good understanding of E 3's historical contribution to the Galaxy. What about the future? Will this curious merged star class ever make a difference on the grand scheme of things? Globular seeding of stellar by-products into the Galactic halo is a low-budget affair compared with dwarf galaxy accretion and massive galaxy interaction.

The Universe's galaxies sum to a history of mass-density to energy-density transfer over a Hubble time – the reciprocal of the Big Bang's energy-to-mass transfer in a yoctosecond. Galactic halos preserve historical records better than discs. In our small Local Group halfway into the next Hubble time, the residual halo metallicity stripped from clusters like E 3 today will inform future astronomers what life was like back in our day. Let's hope astronomers are still around to check it out.

## DESIDERATA

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The HST's two orbits devoted to E 3 in 2005 is likely the cluster's last deep look for a while. Except for E 3's higher-than-normal smattering of YSs, it's simply not a very important cluster. There is nothing peculiar about yellow stragglers; they are simply a type of binary produced in the environment of a compact-core globular with a history of tidal compression episodes. E 3 is in fact more notable for its poverty of HB, RG, and AGB stars than for its abundance of yellow stragglers. What could be on the shopping list for a James Webb look?

- Does E 3 have an RR Lyrae population? If not, why not?
- Is there chemical evidence of planetary nebulae seeding (e.g., elevated barium and Ne/O levels) and therefore an unobserved AGB population?
- White dwarfs can represent up to half the stellar mass in a cluster population. We need to know E 3's white dwarf mass before making a firm calculation about its mass density and therefore its orbital dynamics.



- It would be helpful to quantify the point spread function between the red MS and blue MS following the examples of Piotto *et al.* (2007; Fig 3 centre & right panels) with a Gaussian fit for both MSs down to a 25% detection limit.
- Na/O anticorrelation and [a/Fe] ratios for E 3 need quantification. A globular seeded with only primordial gas would have an [O/Fe] (called a Y ratio) of 0.28; a second generation seeded from the first would have an He/H of  $0.27 < Y < 0.35$ . What is E 3's actual helium ratio today?
- Does E 3 exhibit a spread between [CNO/Na] and He abundance that would trace the effect a large yellow straggler population has on E 3's core-halo mass ratio?

Farewell, lovely little, lissome E 3. It's been fun.

NF

#### Endnotes:

[1] As a matter of curious coincidence, the baryon (atomic particle) density of the Universe at the time the 2.7K cosmic microwave background emission was nearly the same as the Earth's atmospheric pressure at sea level today, assuming the WMAP  $10^9$  photon-per-baryon density.

[2] The  $60\,000\ M_{\odot}$  figure is a fiducial of convenience for this discussion; the actual small-vs-massive demarcation depends on unique secular conditions, e.g., IMF, core/halo densities, and tidal interactions.

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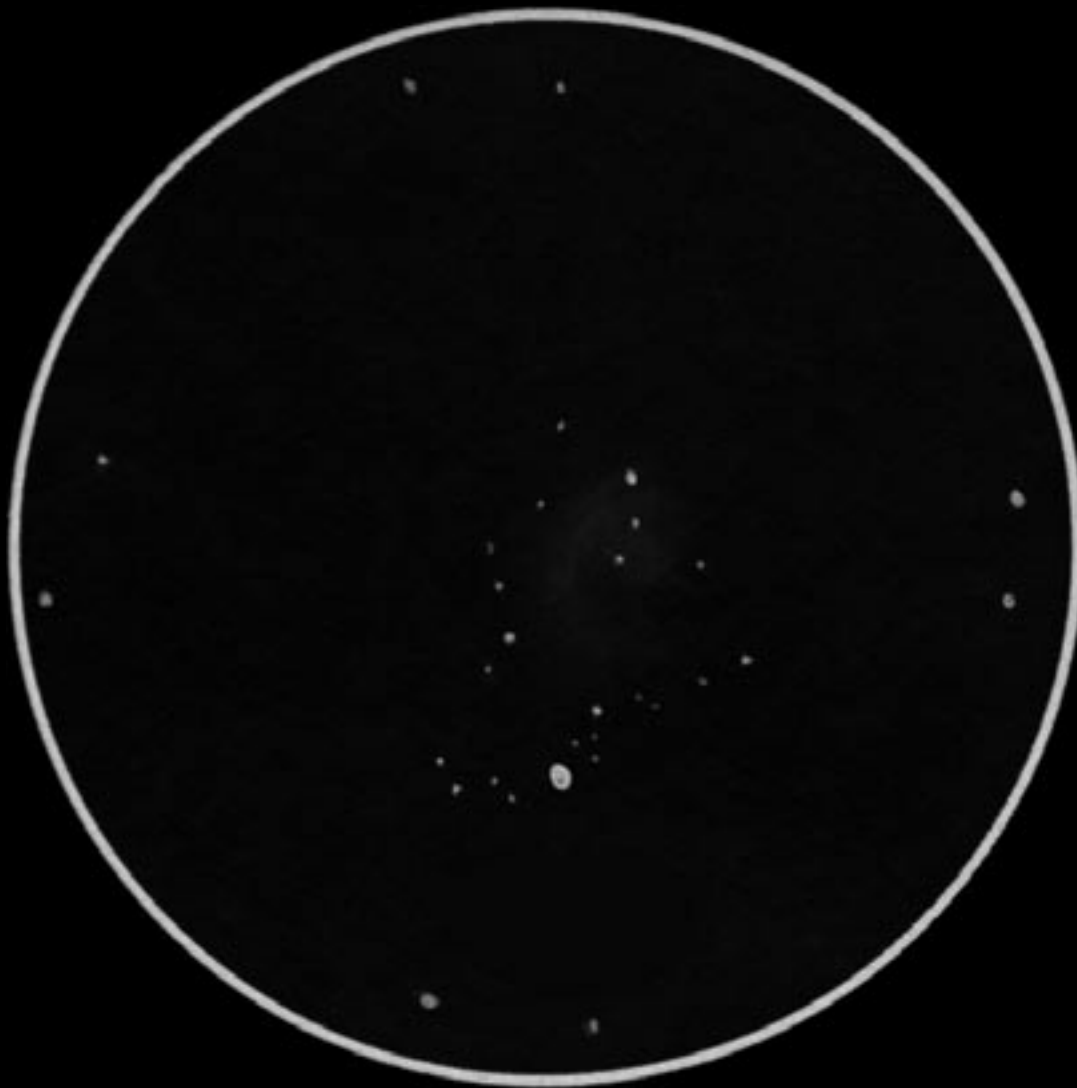
A page of clickable links to these references, and other supporting material mentioned in the article, is available on the *Nightfall* homepage on the ASSA website: <http://assa.sao.ac.za/sections/deep-sky/nebulae-clusters/nightfall/links-in-nightfall-issue-1-2015-april/>

Doug Bullis built his first telescope, the classic 6-inch F/8 Newt, in the same year Sputnik went up. Sputnik dropped out, Doug kept going. By day he keeps up with the professional literature. By night he observes from a remote farm in the Karoo. Until he retired to devote more time to astronomy, he wrote books for publishers around the world; 23 are still listed on Amazon.

# HEARTBEAT OF A UNICORN

*Exploring the fascinating but often overlooked constellation of Monoceros.*

*by Carol Botha*



**Messier 50** sketched by **Carol Botha**. Betty's Bay, 2015 January 21 22:00 SAST.  
12-inch Dobsonian, 25-mm eyepiece, 60X magnification, 50' field of view.

I was browsing *Stellarium*'s constellation art while preparing for an outreach event. "One hunter, one bull, and two dogs" would be a perfect theme. Out of the (*Stellarium*) blue, another creature joined this all too familiar scene. Goodness me! Would you believe there is a whole horse tucked away in the dark patch of sky between the two dogs? If I

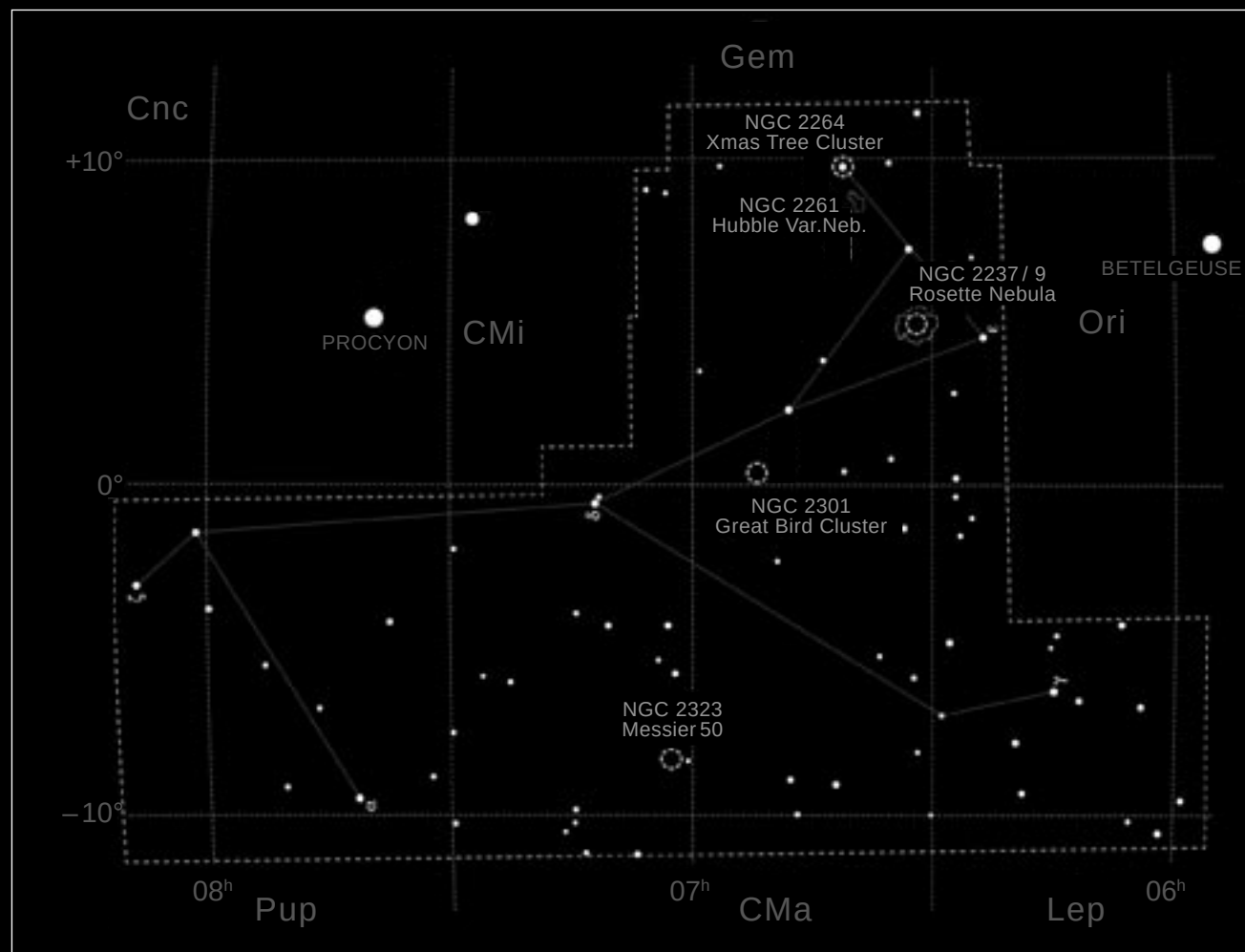
were mystical Monoceros, I would also rather remain out of sight out of mind in such close proximity to the boastful Orion.

If only kids could see “my” Little Pony but Monoceros is such a faint constellation in the shadow of mighty Orion that it has received no attention at our outreach events. To set the record straight I took the first opportunity to explore the constellation. My heartbeat increased when I saw hundreds of stars and very obvious deep sky objects in this, once quite unfamiliar patch of sky. So this is where that famous Rosetta nebula resides!

You need dark skies to appreciate what Monoceros has to offer. From Betty’s Bay I could find the deep sky objects fairly easily but observing all the faint nebulae was quite tricky. Names like the Xmas Tree (NGC 2264), the Great Bird (NGC 2301) and the Heart Cluster (M50) captured my attention.

Anything with an M designation deserves to be first in line. You just

know you’ll be hitting on something Magnificent. There is a saying: my heart is pumping custard. Well this was the feeling I got when I observed M50. I could definitely see the brightest part of the nebula centred in the heart shaped open cluster.



Rosetta was my next target. Oh gosh, a whole lot of NGC numbers are assigned to this nebula but lucky for me the two parallel lines of stars (NGC 2244) associated with the Rosetta nebula were easy to locate. At first I could see no nebulosity, switching between binoculars and telescope, trying a filter as well as averted vision. In the end binoculars proved the best as the nebula is really large. To me it looked more like a girl with a cheeky ponytail than a rosette.

En route to the next target I stumbled on an asterism of 6 bright stars. After a few tots of whiskey, this could maybe be a xmas tree? I felt quite cheated. I would have at least added a bit of romance and decided to name this wanna-be xmas tree the Eiffel tower. I read later that Phil Harrington christened this asterism the Unicorn's Horn.

I was about to pack up but decided to go searching for a real tree (like the one with the 1000 multi-coloured lights on the slope of Mt Ingino near the medieval town of Gubbio in Umbria, central Italy) that Pope Francis lit up with a tap on his tablet last December.

The real Xmas Tree cluster and Cone nebula (NGC 2264) go hand-in-hand but by the time I started sketching this one my eyes were really scratchy. The Xmas tree's lights were pretty and bright, the cone elusive but back home I was able to observe it in more comfortable conditions in Dieter Willasch's superb APOD winning photograph in *Pearls of the Southern Skies*.

Monoceros will get all the attention it deserves from me. It is one of the most fascinating constellations to explore.

NF



Carol Botha observes the deep-sky with her 12-inch Dobsonian from her back yard in suburban Cape Town, the dark skies of Betty's Bay, and various other exotic locations, when she isn't busy with outreach and other OOG (Orion Observasie Groep) activities. Her husband's name, in English, means "ant".

Auke's  
ASSA 100  
Deepsky Marathon

# BIRTH OF A DEEP-SKY MARATHON

*A report from the 2014 Free State Star Party, with guidelines and recommendations for conducting a deep-sky observing marathon.*

*by Hannes & Pieter Pieterse*

*photographs by the author*

Compiled by Hannes Pieterse  
ASSA Bloemfontein  
June 2014

**T**his whole write-up began as a feedback report but ended up as a practical guide for future deep-sky marathons. I hope others find this compilation useful – it can perhaps be used as a reference for an ASSA Deep-Sky Section marathon activity. Neither of us (Hannes & Pieter) are astronomy gurus but we do enjoy this eye-to-eyepiece hobby.

## FIRST THOUGHTS

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One of the controversial topics surrounding a marathon is the issue of GoTo vs. star hopping. At the outset it was my intention to use the 'honourable' star hopping method and to this end I generated some star charts. Due to limited preparation time, however, I had to give up on this approach.

We ended up using a combination of methods, star hopping to the well-known objects and “pushing to” others with our Orion SkyQuest XT10i IntelliScope.

With the marathon now completed, it is interesting to recall the reaction of others upon hearing about it: mostly surprise with a dash of disbelief. “Did you really look at all 100 in one night?”, with the usual follow-up question being “What proof do you have that you looked at them all?”

The idea was not to set a new record. Nor to publish in *Nature*. Does one need three referees on hand to ensure we’re not cheating?

This was purely an exercise I just had to do, for my own pleasure. Furthermore it was a wonderful experience to be able to share it with my son, Pieter. Together we have attended three Karoo Star Parties (in Britstown)

and as a father-and-son team observed many night sky treasures: priceless!

The guidelines given by the Saguaro Astronomy Club (SAC) in their *2015 All Arizona Messier Marathon* set my mind at ease after our marathon attempt by confirming that our method wasn’t flawed. Their guidelines will also be useful should a marathon activity be established by the Deep-Sky Section.

In the northern hemisphere, many Messier Marathons are conducted each year. Here in the south, Messier’s list is somewhat gap-toothed, with some objects never rising, and some very poorly placed for observing. (During the 2014 Free State Star Party some 20 Messier objects were only briefly visible while 10 objects never rose at all). Fortunately the ASSA Deep-Sky Section has a *Top-100 Deep-Sky Objects* observing

list and we could use it for our marathon effort.

## PLANNING A MARATHON

A deep-sky marathon is a group activity that could be undertaken by members of an ASSA Centre. Someone with the necessary computer skills and astronomy background can take the lead and do the basic planning. (This volunteer will also find that they will gain the most out of the project since they will have the deepest understanding of how it unfolds.)

It is perhaps a good idea to do the basic planning only up to (but before) the point where the sequence of viewing the objects is determined and the star charts are prepared. If each participant does this, then things should go smoothly for all. The last part of the planning (scheduling when



the objects should be viewed, and preparing a star chart to show the progress of the marathon) could also be done as a group activity. As an aside, this planning phase will also identify those who are sincerely interested in taking part!

The planning for a marathon takes longer than actually performing it! Once the marathon begins, you're actively engaged and on the ball and then some 11 hours later, you're done. The better your planning is, the easier the marathon will go.

Ultimately this is a social event, but each observer is on their own (or with a single team mate). My son and I did our first marathon together, but the experience wasn't entirely novel as we have worked together often (e.g. at star parties and at Boyden Observatory).

### IN THE BEGINNING

The deep-sky marathon at the 1st Free State Star Party (FSSP) has a long history. Some two weeks before the gathering at Gansvlei farm I lay in bed thinking about

the two cold nights under the Free State night sky ahead of us. My thoughts then drifted to the three Karoo Star Parties (KSPs) we had attended. Two of these went well, and during the third we could at least use the first night before rain spoiled the event. Fortunately there was good company, a big braai, home made bread, beer and red wine – thank you ASSA Pretoria, Johan Smit & Co.

At one of the KSPs (2010 August) Auke Slotegraaf of the Cape contingent gave a talk on how to see faint fuzzies and what to pay attention to. The longer you spend at the eyepiece, the easier things become. It is slowly (!) becoming easier for me.

At the first KSP, Pieter and I looked at the usual popular objects – omega Centauri, Tarantula & eta Carinae nebulae, and a few others – these being the beautiful, bright objects we customarily look at,

## DATES TO DIARIZE: 2015

The **Free State Star Party** will be held from 12-16 June on the guest farm Gansvlei, near Brandfort, about 50km from Bloemfontein. There is accommodation for 40 people (mostly sharing) and there are numerous guest houses in the vicinity.

Contact: [ [assabfn@gmail.com](mailto:assabfn@gmail.com) ] or visit [ [www.assabfn.co.za](http://www.assabfn.co.za) ] for further details.

The **National Karoo Star Party** (first held in 2009) is organized by ASSA Pretoria Centre members Johan Smit and Danie Barnardo, and is held on the Kambro guest farm, 20 km north of Britstown. The 2015 Karoo Star Party will be held from 12–16 June. Booking is essential. Contact: [ <http://www.pretoria-astronomy.co.za> ]

and show to visitors, at Boyden Observatory. The exceptionally dark skies ensure that we revisit these old favourites year after year. Then we began with Auke's *Top-100* list, ticking off those we found, noting the time, and making a few occasional notes. We did this again at the second KSP, while at the third star party we added a few objects before the rain shut us down. So we spent the nights observing, taking photos with a hand-driven barn door mount, strolling around chatting, drinking coffee or getting fed up and heading off to bed.

What I remember from the 2012 KSP was Percy Jacobs with his *Cambridge Atlas* (Double Stars?) and Wayne Mitchell's *Star Gazer's Deep Space Atlas*. Bosman Olivier, too, had a pile of books and star atlases. Johan Moolman, as per usual, had his list on display in the form of a large poster stuck to the

side of his small tent, and he would mark off his progress during the course of the night. Focussed and with an action plan they forged ahead, while the Pieterse duo worked on the ASSA 100. Using *Skytools 3* we could tick off the objects we'd seen and with the new list could skip over those we'd done. We were still without a thorough plan, but each time we progressed.

Another incident that floated about in my consciousness was a visit in December 2007 by family from America. Robert Wade has

been an amateur astronomer for over 40 years, and he regularly attends large star parties in the USA with his 20-inch Obsession and TeleVue 'hand grenades'. And obsession is an apt word. Here in South Africa he had to be content with our 10-inch Orion Dobsonian and 1.25-inch eyepieces. At the time, Robert was busy with the *Herschel 400* list and it was a bonus to be able to see many of the southern objects.

Earlier one evening, while the Moon was still a hassle, 47 Tuc was in the eyepiece. 'A kid with

## ASSA Top-100 Deep-Sky Observing List



<http://assa.saao.ac.za/sections/deep-sky/assa-top-100/>

a new toy' would be a fitting description. Around 03:30 in the morning, with the Moon gone, Robert peered through the light polluted skies of Bloemfontein to get his first view of omega Centauri, low on the horizon.

The southern gems, which we take for granted, kept him at the eyepiece until dawn. This I only heard the next day, as I'd already gone home. None of the objects he observed was on the Herschel list – he simply *had* to look at them, despite the poor conditions.

Robert also showed me how easy it was to use *Skytools*, and I started saving right away.

Then it came to pass that the ASSA Bloemfontein Centre, under the leadership of Thinus van der Merwe, decided that June would be star party month. Perhaps our nagging about the KSP was the spark. Unfortunately this year both star parties will happen

## BORN VIA E-MAIL

I went through the e-mails in my Sent folder and found this email that Auke Slotegraaf sent (just three weeks before the first FSSP). And it is here that the marathon was born, shortly after midnight:

On 2014-06-07 00:09, Hannes Pieterse wrote:

- > Hallo daar in die geboorteplek van koue en reën!
- > Jammer dat jy nie by ons 'n draai kan kom maak met die VS
- > Sterpartytjie nie. Hoor so tussen die lyne dat jy nie meer
- > kom nie. (Ons kon towerrekkies uitgeruil het.)
- > Het iemand al probeer om al 100 "Top-100 Deepsky Objects" in
- > een nag te kyk. Of doen niemand die Messier Marathon-ding nie?
- > Ek merk dat al 100 met ons sterpartytjie sigbaar gaan wees.
- > Al is sommiges laag op die horison. Dit kan dalk lekker pret wees.

Auke's reply:

Sent: Sat 2014-06-07 10:30 AM

To: Hannes Pieterse

Top-100 Marathon -- briljant. Nee, sover ek weet, nog niemand nie. Ekself het dit nog nie amptelik gedoen nie, het net kloppe in 'n aand gedoen om als te check

I'd be keen to hear if anyone in South Africa has attempted such a marathon. Perhaps this was the first one, here in the heart of the cold Free State. Please get in touch!

on the same weekend. ASSA Bloemfontein intends to hold future Free State Star Parties over a suitable weekend in June, so in 2016 there shouldn't be a conflict of dates. Hopefully there will be a suitable weekend in June each year – sometimes a long week-end and other times just two evenings – one doesn't want to over-do it, either.

With all these thoughts and recollections mulling around in my head I began to wonder what to do during the 1st FSSP. Possibly continue with the ASSA *Top-100* (I still needed a few) or maybe something else? June is the best time for observing in the Free State, free of mosquitoes, free of light pollution – free in the Freestate! And cloud-free, too. The cold creates good stable conditions and the nights are long and dark: almost 11 hours of deep time if the weather co-operates and body & soul don't give in. And it almost

never rains. (Never say never, though: the second night of the 1st FSSP an intrusive bank of clouds caused poor seeing for a while.)

On previous occasions I had considered a marathon but had always shelved the idea, mainly because the Messier option would not work this far south. Meanwhile I realized that the ASSA *Top 100 Deep-Sky Objects* list would make good marathon material as *Skytools 3* showed that all the objects would be visible in June. The list includes naked eye, binocular and telescopic targets:

the easy and the challenging were all present.

## HOMEWORK

OK, so we have the idea, but what now? I started by searching the Internet, and repeatedly found one piece of advice: “do your homework”. As with any observing project, planning is important.

I also found two books very helpful: *The Observing Guide to the Messier Marathon* by Don Macholz, and *The Year-Round Messier Marathon Field Guide* by Harvard Pennington.



Using *Skytools 3* I could construct a basic time line. To establish the final time line I had to use the star charts generated by *TheSky6* to determine where and when the objects would be visible.

### CHOOSE A DATE

Choosing a date to do the marathon is tricky. Which was first, the chicken or the egg? Dates around New Moon falling on a long week end are usually the first choice for a star party. The Bloemfontein Centre had already decided that June would be star party month: long nights, best weather, a holiday possibly falling near a week end.

So consult a calendar and keep in mind the New Moon, expected weather conditions, holidays and availability of the venue.

### CHOOSE A VENUE

When considering a possible venue, make sure you visit

it beforehand, preferably at night. People who kindly make their property available don't necessarily know the requirements of amateur astronomers, and don't always understand the "no lights" concept the same way we do.

Check that the eastern and western horizons are visible. This is mainly so that you get to tick off those objects that only rise before dawn, or set in the evening twilight.

With the co-ordinates of the venue in hand, use *DOCdb's* PLAN function or *Skytools 3's* observing list to determine if all the objects will be visible.

### CHOOSE THE CATALOGUE

This stage of the planning can be done early on, perhaps even first, as you need to figure out if the objects in the list will be visible.

Messier's catalogue kicked off the marathon craze, and if you

page back through the history books you read that several folk were doing the Messier marathon without being aware of each other. This, of course, led to some confusion about who should properly be called the "Father of the Marathon", but let's not throw the astronomy out with the bath water! Anyway, the Messier list is only suitable for the Northern hemisphere, so we have to find other sources. Some possibilities, in addition to Bennett's, Dunlop's and Lacaille's lists include:

*ASSA Top-100 Deep Sky Objects*. This list was compiled for the Southern hemisphere by Auke Slotegraaf, director of the ASSA Deep-Sky Section. It was possibly not designed with a marathon in mind since (with one exception: 2014 June 27/28) I could not find a date when all 100 objects will be visible during a single night. (The first and last object always elude

us, and even if one stretches the time limits slightly, they are low on the horizon in a too-bright sky.)

The *Southern Messier Catalogue* is a South American concoction in which objects that are either very low or do not rise are omitted and replaced arbitrarily by other southern objects. As such it is a bit of a non-official exercise.

You could always make your own list to marathon, of course. *Skytools 3*, for example, can generate a list of best objects for a given night, which could be used for a marathon. Another possibility is to select all deep-sky objects

brighter than a certain limiting magnitude. This is relatively easy to do with software such as *Stellarium*, *TheSky*, or *Cartes du Ciel*, and then working from west to east to select objects for your marathon.

### WHAT RESOURCES WERE PREPARED?

In this section I discuss the software I used during preparation: *Skytools 3* and *TheSky6*. Free software, such as *Stellarium* and *Cartes du Ciel* can also be used for the initial planning and generation of the star charts.

### OBJECT VISIBILITY USING DOCDB AND/OR SKYTOOLS 3

You can use *DOCdb*'s MARATHON function to see if all the objects on your list will be visible. If the search results shows that one or more objects are not visible, don't give up right away. Below the list of dates is a "Find marathon dates" section, which includes the option to ignore the strict limitation of objects being visible only between astronomical twilight. This gives an extra 18 minutes leeway and may just do the trick.

## USING DOCDB TO SEARCH FOR A MARATHON OR PLAN YOUR SESSION

1. Go to <http://www.docdb.net> and REGISTER and/or LOGIN.
2. Click on EDIT SESSION to set your location and date & time. Save your changes.
3. Under *List Options*, click on LOAD, then tick the "ASSA Top-100" option and click the load button.
4. Under *List Options*, click on PLAN, to get a suggested observing schedule for the date set in step #2.
5. Under *List Options*, click on MARATHON, to get a day-by-day summary of results for the list chosen in step #3.





An alternative is to use *Skytools* 3. I'm mentioning it last because not all readers may have it. I suspect there are other software packages, free or commercial, that can also be used. When using *Skytools* 3, keep in mind that an observing list such as the ASSA *Top-100* will not be included in the program's database, although

it does have the well-known lists such as Messier's and Herschel's, etc. All the deep-sky objects in the *Top-100* are in the database, but you will have to create your own list by adding them one by one. (Lists created in this way can be exported to *Sky Safari*.)

*Skytools* 3 is a good way to start your planning by generating an

observing list arranged according to "Optimum time to view". The software also indicates times of "Complete Darkness". The list includes information such as object type, constellation, magnitude, angular size, and star atlas page numbers (see Figure 1).

Good, so all 100 objects are visible – what now?

### ASSA Deepsky 100 Observing List Evening of 2014 Jun 27 at VS Star Party - Gansvlei

Sunset 17:33, Twilight ends 18:51, Twilight begins 05:43, Sunrise 07:01, Moon rise 07:32, Moon set 17:55  
Completely dark from 18:51 to 05:43. New Moon. All times local (GMT+2).

Listing All Deep Sky Objects visible above the perfect horizon and in complete darkness after 18:51 and before 05:43.

Cls	Primary ID	Alternate ID	Con	Mag	Size	RA 2000	Dec 2000	Distance	Begin	Optimum	End	S.A.	Ur. 2	PSA	Difficulty
Open	NGC 2287	M 41	CMa	5.0	39.0'	06h46m01.0s	-20°45'24"	2300 ly	18:34	18:42	18:53	19	154	27	detectable
Open	NGC 2362	Collinder 136	CMa	3.8	5.0'	07h18m41.0s	-24°57'18"	4500 ly	18:24	18:48	19:34	19	154	27	obvious
Open	NGC 2437	M 46	Pup	6.6	20.0'	07h41m46.0s	-14°48'36"	4500 ly	18:37	18:49	19:10	12	135	26	detectable
Open	NGC 2422	M 47	Pup	4.3	25.0'	07h36m35.0s	-14°29'00"	1600 ly	18:33	18:49	19:16	12	135	26	easy
Open	NGC 2447	M 93	Pup	6.5	10.0'	07h44m30.0s	-23°51'24"	3400 ly	18:34	18:50	19:32	19	153	26	easy
Open	NGC 2548	M 48	Hya	5.5	30.0'	08h13m43.0s	-05°45'00"	2500 ly	18:37	18:51	19:19	12	134	26	detectable
Open	NGC 2477	Collinder 165	Pup	5.7	15.0'	07h52m10.0s	-38°31'48"	4000 ly	18:33	18:52	20:01	19	171	28	easy

Figure 1. Sample output from *SkyTools* 3, showing the Top-100 list sorted according to 'Optimum time to view' for the specified date.



## FINDER CHARTS (TheSky6)

On the Internet I found a graphic of the night sky showing the Messier objects as they can be seen from evening to morning. This gives an overview of how a marathon could be executed. Initially I thought I could use this chart as the basis for my own marathon scheduling but soon realized it was drawn for the Northern hemisphere and wouldn't be of use. When I couldn't find a useable template chart, I set this idea aside.

Fortunately using *Skytools 3* I could determine the initial timeline. I noticed that certain objects were listed earlier and others later. Looking at a star chart I noticed that these objects lay far apart, in larger constellations. So it isn't truly feasible to group objects primarily by their home constellations. Objects in smaller constellations adjacent to larger

ones prevent the sequence being determined by constellation alone. If one had enough time, one could observe by constellation but that would entail jumping around the night sky, which is a recipe for missing an object and realizing this too late.

Eventually I printed 21 star charts with *TheSky6* showing all 100 objects, with an additional chart for NGC 1976 & 1977.

I edited the PDFs by enlarging the observing sequence numbers which made them more legible (see Figure 2).



Figure 2. Sample finder chart generated with *TheSky6*.



## TIME TABLE

With the finder charts in hand, the time table began to take shape. It turned out that five time slots would fit the bill. Objects in a given constellation were, where possible, assigned to the same time slot. A few objects in the larger constellations had to be included in a later time slot. Such sub-division is something which each observer has to make the call on themselves.

The time table was drawn up based on the finder charts; see Figure 3. Items marked in red were moved and were observed earlier or later. Several iterations of the time table were performed as objects were moved to different time slots. Even during the marathon we ended up moving some objects around.

My initial scheduling was done bearing in mind that, this being our first marathon, we would probably

struggle to get started. At the same time, one has to keep in mind those objects that start the evening in the west and set soonest.

The 21 finder charts and the schedule became the primary tools

for our marathon effort. I don't think that one can use only the *Skytools 3* list – you need to also work out a sequence by examining star charts.

18:30 – 20:00 26	20:00 – 21:30 17	22:00 – 23:30 17
<b>Map 1</b> 1   ASSA 21   NGC 2287   CMa 2   ASSA 22   NGC 2362   CMa 3   ASSA 23   NGC 2422   Pup 4   ASSA 24   NGC 2437   Pup 5   ASSA 26   NGC 2447   Pup 6   ASSA 25   NGC 2451   Pup 7   ASSA 27   NGC 2477   Pup  <b>Map 2</b> 8   ASSA 33   NGC 2818   Bcy	<b>Map 7</b> 27   ASSA 48   NGC 4361   Crv 28   ASSA 50   NGC 4594   Vir  <b>Map 8</b> 29   ASSA 47   NGC 3918   Cen 30   ASSA 46   NGC 3766   Cen 31   ASSA 49   Dark Doodad   Mus 32   ASSA 53   NGC 4833   Mus 33   ASSA 57   NGC 5189   Mus 34   ASSA 51   Coalbrook   Cru	<b>Map 9</b> 44   ASSA 73   NGC 6254   Oph 45   ASSA 71   NGC 6218   Oph 46   ASSA 80   NGC 6475   Sco 47   ASSA 78   NGC 6405   Sco 48   ASSA 77   B 59-78   Oph 49   ASSA 75   NGC 6273   Oph 50   ASSA 74   NGC 6266   Oph 51   ASSA 68   NGC 6121   Sco 52   ASSA 76   NGC 6281   Sco 53   ASSA 72   NGC 6231   Sco
00:00 – 02:00 20	03:00 – 06:00 20	
<b>Map 11</b> 61   ASSA 85   NGC 6541   CrA 62   ASSA 93   Bernes 157   CrA 63   ASSA 92   NGC 6723   Sgr 64   ASSA 96   NGC 6809   Sgr 65   ASSA 90   NGC 6656   Sgr 66   ASSA 83   NGC 6523   Sgr 67   ASSA 82   NGC 6514   Sgr 68   ASSA 84   NGC 6531   Sgr 69   ASSA 89   M 25   Sgr 70   ASSA 88   NGC 6603   Sgr 71   ASSA 87   NGC 6618   Sgr 72   ASSA 81   NGC 6494   Sgr 73   ASSA 91   NGC 6705   Sct	<b>Map 14</b> 81   ASSA 4   NGC 246   Cet 82   ASSA 3   NGC 247   Cet 83   ASSA 5   NGC 253   Scl 84   ASSA 6   NGC 288   Scl 85   ASSA 1   NGC 55   Scl  <b>Map 15</b> 86   ASSA 9   NGC 1068   Cet  <b>Map 16</b> 87   ASSA 14   NGC 1535   Eri  <b>Map 17</b> 88   ASSA 13   NGC 1365   For 89   ASSA 12   NGC 1316   For	

Figure 3. Extract from the time table, showing the observing sequence by map number.



## DEVELOPING A REPORT FORM IN SYNC WITH THE SCHEDULE

The report form (Figure 4) was ordered so that the sequence of items corresponded to that on the finder charts and schedule.

In the first column, I numbered the items, 1 to 100, according to their appearance on the charts and schedule. It takes a bit of effort to synchronise the charts, schedule and report form, but once done, you're ready for the long night

ahead. Column 2 shows the ASSA numbering scheme. There are also columns for recording the time of observation, temperature and relative humidity (as measured with a Celestron 47003 Compact Barometric Weather Station).

## STAR CHARTS & INFORMATION SHEETS FROM *SKYTOOLS 3*

A more comprehensive document was compiled as an additional aid. Information and charts for

each object resulted in a 300-page document. Talk about over-kill!

*Skytools* provides a great deal of additional information from various sources, which are collected in the “Notes” section. Valuable information was also gleaned from Michael E. Bakich's *1,001 Celestial Wonders to See Before You Die – The Best Sky Objects for Star Gazers*.

Three charts for each object, generated by *Skytools 3*, were

VS Star Party Report Form – 27/28 June 2014												
Auke's ASSA Deepsky 100 Observing List, evening of 2014 Jun 27 at VS Star Party – Gansvlei. Sunset 17:33, Twilight ends 18:51, Twilight begins 05:43, Sunrise 07:01, Moon rise 07:32, Moon set 17:55. Completely dark from 18:51 to 05:43. New Moon. All times local (GMT+2).												
No	ASSA	Primary ID	Alternate ID	Type	Con	Mag	Size	Time	Temp	Humid	Notes	Obs
1	21	NGC 2287	M 41	Open	CMa	5.0	39.0'					
2	22	NGC 2362	Collinder 136	Open	CMa	3.8	5.0'					
3	24	NGC 2437	M 46	Open	Pup	6.6	20.0'					

Figure 4. Report form for recording observations.



printed on a single page, showing the naked eye view, finder scope view, and simulated eyepiece view. An example is shown in Figure 5.

## A WEEK BEFORE THE MARATHON

More time was spent on chart work, generating observing lists, and consulting the Internet and books, than was spent on doing the marathon. But that's how it goes with any observing evening. Good preparation makes things go smoother.

## COLLIMATE YOUR TELESCOPE

Make sure you do this beforehand, and transport your telescope gently to the venue. If the drive was a bit bumpy, re-check the collimation.

## WHAT TO BRING ALONG

I retrieved my packing list for the previous KSPs and adapted it for conditions at the FSSP. (One of the big changes was Karoo lamb ribs

which we could buy at the Kambro farm stall.) Anyway, I always pack too much, because what if...

My packing list (stored on my computer and in my diary) includes: telescope & accessories, observing spot accessories, observing aids, computer equipment, camera equipment, books & star charts, battery & electrical equipment, clothes &

warm clothes, toiletries & pills, food & drink for meals and snacks, things to do before the time, things to not forget, tools for the car, and other. At the end of the day, however, it is you looking through one eyepiece on one telescope.

## WEATHER

Start keeping an eye on the weather. Not that it will be of

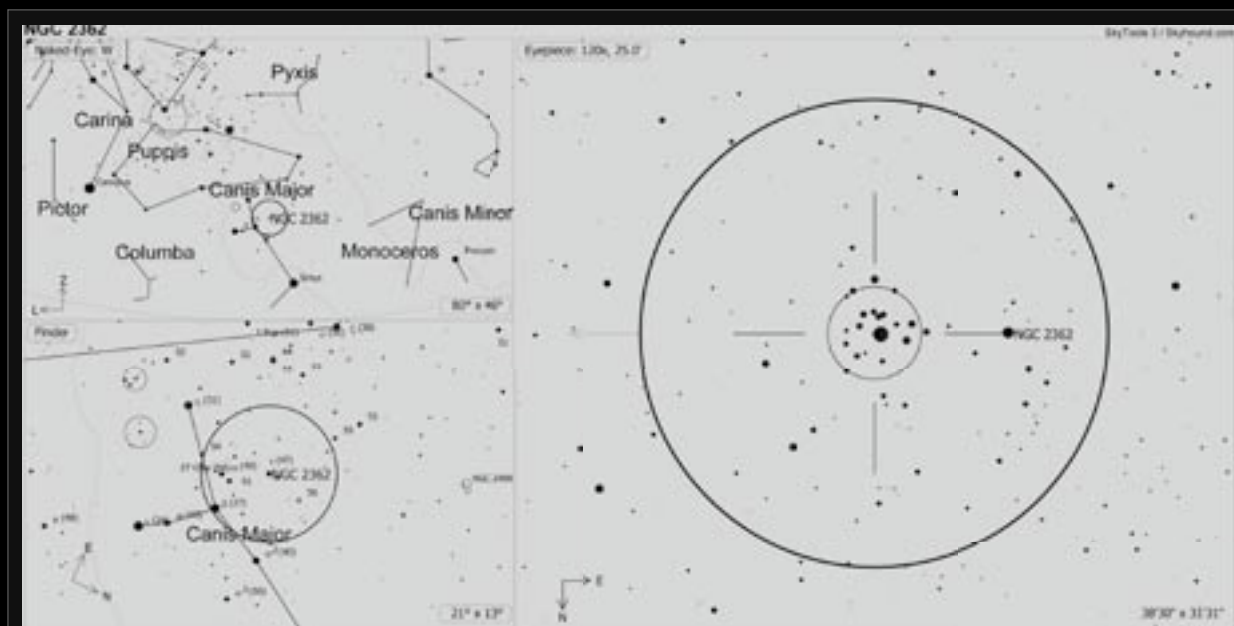


Figure 5. Finder charts output by SkyTools 3.

much help, because bookings and travel plans have already been made, and it will be a matter of see what transpires, adapt, and enjoy it. Yet it is nice to know what lies ahead; you may be able to line up an alternative date for your marathon if the weather turns nasty.

### JET STREAMS

Something which few amateurs consider are the fast, high-altitude winds known as jet streams.

Figure 6 shows the predicted jet streams for 2014 June 27 at 20:00. Bloemfontein lies more or less at the tip of the red arrow. You'll notice that there are no fast winds that would hamper conditions. And this was also what we experienced that evening - we probably had the most ideal conditions.

Keep in mind that if you're going to try to account for all possible influences on your

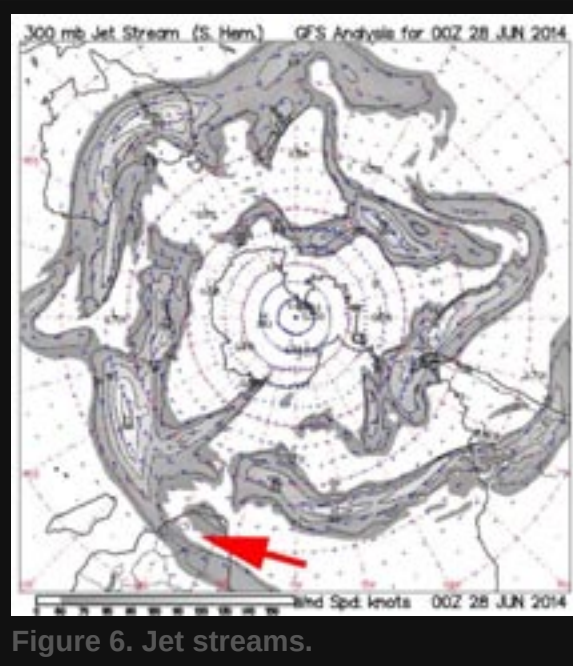


Figure 6. Jet streams.

planned observing evening, you're never going to get to the eyepiece. Just be aware of potential influences and adapt to the conditions.

### TEMPERATURE AND RELATIVE HUMIDITY

In Dries van Zyl's book *Suid-Afrikaanse Weer en Atmosferiese Verskynsels* he gives the following

definition of humidity: "Absolute humidity is the amount of moisture in a given volume of air at its present temperature. Relative humidity is the ratio of the moisture in a given volume of air and the maximum it can hold, at the current temperature."

In other words, saturated air has a 100% relative humidity.

We recorded approximately hourly values of temperature and relative humidity as measured by a Celestron 47003 Compact Barometric Weather Station.

### LEARN THE CONSTELLATIONS

Familiarize yourself with the constellations that you will be marathoning in, and get an idea of where in the night sky they will be during your observing session. While compiling the finder charts you will have noticed less familiar constellations amongst those that you know already.



Particularly when the stars of the less familiar constellation are quite faint, knowing their relation to the better-known constellations helps you locate them. It often happens that an object lies in a certain constellation but that it is easier to locate using the brighter stars of a different constellation.

## THE MARATHON

### OUR WAY OF DOING IT

I did the paper work and sometimes operated the green laser, in addition to keeping track of the temperature and relative humidity. I also used a digital voice recorder to record the entire marathon. The cold became an issue for the sound recorder from time to time and I tucked it into my sleeve periodically (unfortunately leading to a very faint recording).

Pieter operated the telescope since he knows his 10-inch Orion

Intelliscope well. At times he took over with the star charts and it was my turn at the eyepiece, so this was truly a team effort.

Once an object was located, we took turns looking at it, discussing it, and then looking again. We compared how it appeared to us, and made a few notes. Incidentally, in the cold clammy air, a pencil works very well!

At the previous star parties, Pieter and I alternated between

objects. I'd begin with the chart work and he would hunt the object. Once he'd taken a look and given his impression, we would note it down, and then it was my turn to look and record. Pieter would then take over with the paper work and I would search for the next object. In this way, we both get to do everything, a methodology that we found works quite well.

Once we'd completed the marathon, it was interesting to look

## NGC 6920 AND COLLINDER 411

Observing the less-familiar objects on the Top-100 led to some interesting experiences. While searching for the star cluster Collinder 411 (Mel 227) in Octans we used the galaxy NGC 6920 as one step of the star hop. Fortunately the seeing was good and we could see the galaxy and then move on to the star cluster. To check that we did indeed see this faint cluster we star hopped to it later, during an off-time. We used star charts and Skytools 3 on the computer just to check we didn't make a mistake. The next evening the seeing was worse and we couldn't see NGC 6920 at all, but we could confirm our sighting of the star cluster.

at our time graph, which showed how long we spent on each object. On some objects we only spent two minutes: these were typically the well-known subjects. On less familiar objects, such as Collinder 411, we spent quite a bit more! (See the box on the previous page.)

From time to time there was a lull in our observing schedule, and we wandered over to the other observers for a quick visit. And of course, we simply had to look through Brett du Preez's monster binoculars!

#### PROBLEMS ENCOUNTERED DURING THE MARATHON

People who arrived late at the observing site interrupted our viewing, costing us 30 minutes of observing time. This despite our numerous pleas beforehand that late-comers should park elsewhere and rather carry their telescopes to the observing area. It's almost

as if we're living in a new world where it's everyone for themselves without a care for other's discomfort.

The low temperatures (reaching  $-7^{\circ}\text{C}$ ) caused batteries to function intermittently. For our next outing I'm definitely going to make

### GREEN LASERS AND COLD NIGHTS

It would appear – if one can believe all the information published on Internet forums – it is the diodes and how the green light is generated, and to a lesser extent the chemical properties of the batteries, that causes the brightness of a green laser to vary with temperature. As of this writing (2015 January) the following remedies can be tried:

- (a) Keep the laser in your pocket. Your body heat will keep the laser warm.
- (b) Place a short section of plastic piping over the front of the laser. It should act as a wind shield, delaying the inevitable cooling effect.
- (c) Make a heater for the front (where the diode and other electronics are) and back (where the batteries are). I'm experimenting with nichrome wire from an old electrical blanket, slipped into a thin silicon tube. The tube can apparently handle the heat well and will also transmit it well. These tubes are available from model aeroplane shops, where they are sold for use as fuel lines.
- (d) You can make a conventional dew heater, i.e. a string of ordinary resistors wired together. There are many plans for this available on the Internet.
- (e) Energizer Ultimate Lithium batteries can also help alleviate the problem. They are rated to work to  $-40^{\circ}\text{C}$ . Four batteries cost between R83 and R130, depending on where you buy them – **takealot.com** seems to be the cheapest.

warmers for torches, lasers and the voice recorder. Or dream up other solutions: perhaps a flat bed heater on which the battery-operated peripherals can lie, or a Velcro-attached heater bag. Prof. Google and I are working on it.

It's important that you're familiar with how your equipment works. During our first marathon I thought the temperature was around 3°C for a while, and that it was warming up to 6°C. Then Pieter pointed out the negative sign, displayed off to the side of Celestron device. It was actually getting colder, and eventually reached -7°C. Fortunately we were well prepared clothes-wise: two pairs of socks, two pairs of thermal underwear, two t-shirts, a thick long-sleeved shirt, a cold-weather jacket, a balaclava with ear muffs, and gloves with cut-off fingertips.

Some of the objects we had never seen before (or only on a

star chart or photograph). When viewing an object through the eyepiece, it is sometimes difficult to know if you're looking at the right one!

For those observers not familiar with using star charts it can be frustrating to know their proper orientation. When you make the finder charts you can print them out so that they show the correct orientation at the time of viewing.

How much detail should you record on your observing report form? One could ask, what is the purpose of a marathon? It is to see all the objects, or to record a thorough description of each? The SAC's marathon guide lines say one should find the object in the eyepiece, tick it off, and move on.

You have the option of using a computer during your observing session to show the appearance of the night sky from moment to moment. I'm not in favour of this

## END OF OUR MARATHON

I became quite concerned about the final object on our observing list because we did not know how dark it would be early morning. We had to wait for this running man, who eventually didn't appear at a trot but rather at a crawl. Rigel was the first indication that Orion was on his way. Eventually the running man crept out behind a distant tree. Meanwhile, the clock was ticking and the Sun was on its way. In the end we did manage to catch the Running Man – maybe not like on APOD but as it appeared at the eyepiece of our 10-inch Dobsonian.

approach, as it impairs my night vision too much. I have to admit, though, that I did once or twice use my computer to check up on things.

Using a variety of eyepieces and filters will lead to better observations, but this takes more time. This can be stressful if you don't know if you're going to finish in time. During our marathon we only changed eyepieces infrequently, particularly when we looked at small planetary nebulae and large open clusters.

## RETROSPECT

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### WHAT NEXT?

As I discussed earlier, it appears as if dates on which the *ASSA Top-100* list can be marathoned are few and far between: the 2014 June 27 date seems to be one of these rare opportunities.

This raises another question: do we stick to just the one marathon (*ASSA Top-100*, with usually less than the 100 objects visible) or do we use more than one observing list to marathon? Reading the

northern hemisphere books reveals that different marathons are conducted – so I guess I've answered my own question: make several marathons available and choose from amongst them.

At the moment I'm considering the Bennett Catalogue for the 2015 FSSP, although James Dunlop's list is also a possibility.

### TO GOTO OR NOT

Another issue that comes up from time to time is if it is OK to use a GoTo telescope. Who cares? We used both methods for our marathon attempt, and I didn't hide this fact. As I've mentioned, I didn't hope to win a prize or publish in *Nature*. Observing through the night with my son, and seeing all 100 objects, was priceless. Have you seen all 100 in a single night? So the debate will go on, and I don't think there are guidelines in South Africa about

how it should be done.

The guidelines published on the 2015 *All Arizona Messier Marathon* web page (see box) could serve as a model for ASSA's marathon programme.

One could thus do different types of marathons: one for

## 2015 ALL ARIZONA MESSIER MARATHON

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Extracted from:

<http://www.saguaroastro.org/content/messier2015.htm>.

“Locating Objects: Participants may use a variety of means to locate objects. This includes memorizing positions; using binoculars, books or star charts for star hopping. The use of setting circles, either analog or digital is also permissible. GoTo telescopes can also be used.”

star-hopping, one for GoTo telescopes, and one for a two-person team. One could also add more permutations. But for me the most important thing about such an exercise is that one should enjoy doing it.

### FINAL THOUGHTS

On which evening do you do the marathon once you've arrived at the venue? This is likely to depend on the individual's inclinations. Pieter was cool, calm and collected (he was a student at the time). On the other hand, I just wanted to get it over and done with. We only had two evenings so I wanted to get it done on the first night. That was fortunate as viewing conditions on the second night were poor, with cloud cover eventually putting a damper on things.

The all-nighter did, however, drain our batteries, so to speak, and the brief sleep that morning wasn't

enough after the adrenaline-filled night. We just couldn't seem to get started the next evening and were quite relieved when the clouds moved in.

Things may be different during the 2015 FSSP, which spans four nights. The Moon will be somewhat troublesome on the first and second mornings, so perhaps the marathon should be done on the second or third nights.

And finally, no doubt there will be other amateur astronomers with different and better ideas about planning a marathon; all comments are welcome and we look forward to hearing from you.

And we look forward to seeing you at the 2015 Free State Star Party!

**NF**

*Hannes Pieterse observes the deep-sky from his back yard in Bloemfontein. He is an avid satellite hunter and wannabe DSLR astrophotographer. When not at the eyepiece he builds innovative astronomy gadgets, reads widely, listens to classical music and opera, fiddles with a variety of astro software, all while enjoying a good cuppa coffee.*





# AT MY EYEPiece

*Veteran deep-sky observer Magda Streicher gives us a look at how she prepares for a night's observing.*

*by Magda Streicher*  
*photographs by the author*

**M**agda was gearing up for a night's observing in January this year, so I asked her to share with us her process.

“Vela was my aim for what looked like a clear night,” she said and decided to concentrate on a few star clusters in this rich part of the southern sky.



Her first step, as always, was to do preparatory map work. In the same way that a star chart is a guide to the night sky, the stars are guide posts which help set up boundaries within which to explore. “I find it best and essential to start off by identifying an area of around  $10^\circ$  of sky,” Magda says, so she selected three bright stars to define her search area: delta Velorum, kappa Velorum and gamma Velorum.

“A print-out of the working area from a planetarium program is easy to work with,” she says, “it usually shows the numbers of the brightest catalogued clusters (usually the NGC and IC catalogues) and can be enlarged to make checking on it with a red light at night even easier.”

Once she has the basic printed star chart in hand, Magda hits the books. “My next step is to consult Brent Archinal and Steven Hynes’ book *Star Clusters*. This is such a useful volume, and my favourite! It not only includes data on well-known star clusters but also includes lots of information on obscure, unknown objects and the history behind them. I work through the book from the RA and Declination limits set by my area of interest, and add to my list other catalogue objects situated in this particular area. Pismis, Alessi, vdB-Ha, Ruprecht and plenty more add flavour to what will be an interesting observing session.”



Magda keeps several books by her side at the telescope, preferring to use them instead of a computer, since she wants to preserve her sensitive night vision.

“I make use of *The Night Sky Observer’s Guide* (Kepple, Cooper & Kay: 1998) which gives descriptions of the objects one can refer to during an observation. Also with me at the telescope are both volumes of *Uranometria 2000.0* in case I want to dig deeper into the deep-sky objects.” Looking at the charts

for this region from the *Uranometria*, she notices other interesting objects: planetary nebulae, dark nebulae, variable stars and even a pulsar.

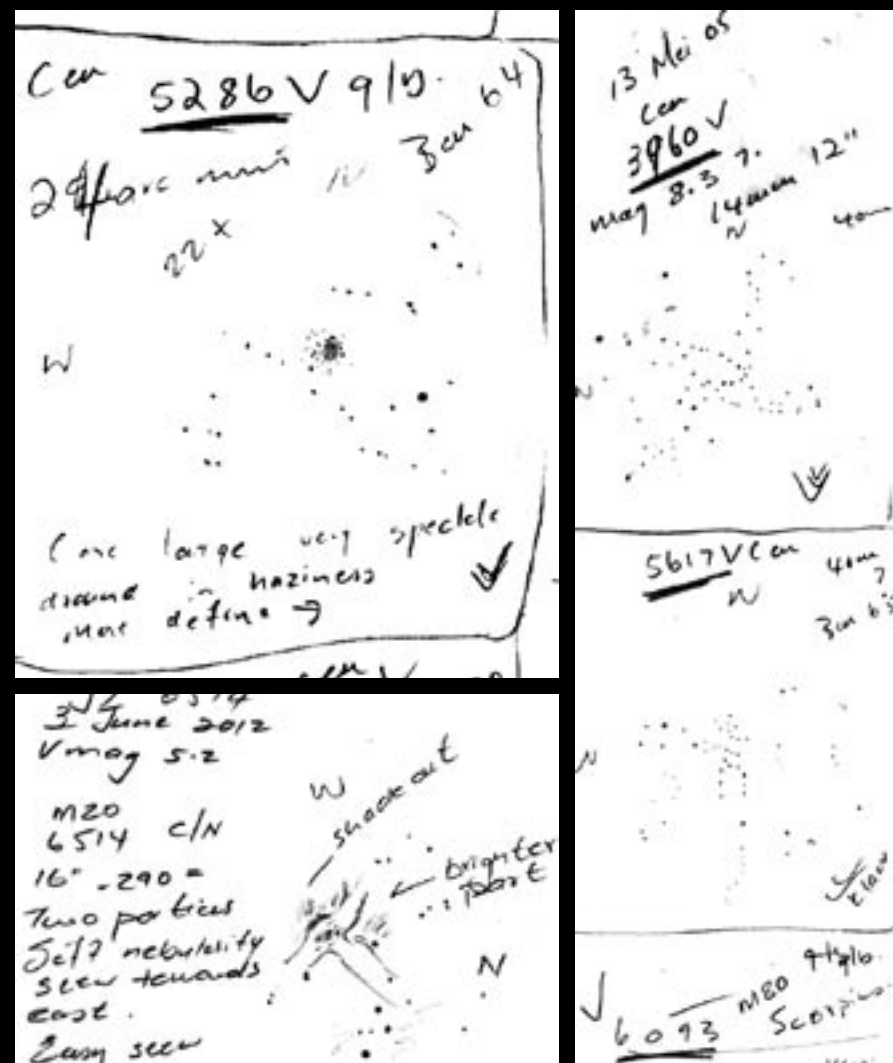
“When I’m at the telescope, time stops, for a change,” Magda says. “There’s this peaceful, pleasant, mood. I listen to Dean Martin, eat chocolate, talk to myself, and relish at the wonderful objects that, one after the other, appear in my eyepiece.”

“I’ve learnt that it’s important to spend some time looking at an object. Not only do I remember it more clearly and can conjure up a mental image of the object the next day, but it helps me make a better sketch.

“I try to describe each object to the best of my ability, and making a sketch helps. And on a very practical level, faint red torchlight to work by is best!”

“Another thing I learnt to do was to look at the region around the object, and not only the object itself. The star field around a deep-sky objects helps me to build up a more complete picture. This also makes it easier to determine direction, by the way.

“I really enjoy sketching, filling in stars and scribbling a question mark to remind me to follow something up. I just let the pencil do its own thing, find its own way. Amazingly, things are sometimes recorded in this way that at the time I didn’t think would be important.



“Looking back at my earliest observations is a bit embarrassing! Sometimes I’d forget to note some feature, like a star, or some nebulosity, and then the next day, when writing up my final notes, I’d be cross with myself for not taking better notes! But it was necessary to go through this stage, to learn.”

“When I’m sketching nebulae at the telescope, I use a magnifying glass and a soft pencil. And also a red light, which I hang around my neck from a string. The next day, usually, I then put on a special pair of glasses I had made, and re-work the image, giving me the

opportunity to more precisely place down faint stars and soft hazy nebulousity. For the final sketch I also use a soft tissue, rolled around a pencil, to help emphasise the fading-out of the nebula.

“Recently I’ve been using a dictaphone and then I simply talk, saying everything I see, even if it comes out a bit haphazard and clumsy! But I can make sense out of it once the whole thought has been laid down. So nothing gets lost. As soon as possible after the evening’s observing, preferably the very next day, I type out my observations on my computer, working systematically through my notes. This is rather important, I think. I have the sketch next to me when I’m listening to my voice recording and making the final notes, which helps in creating a fuller picture. And when I view an object at a later stage, I make additional notes to add to those I have, thus getting a more complete description.”

After just a few observing sessions, one’s collection of observations begins to grow, and some sort of archiving system

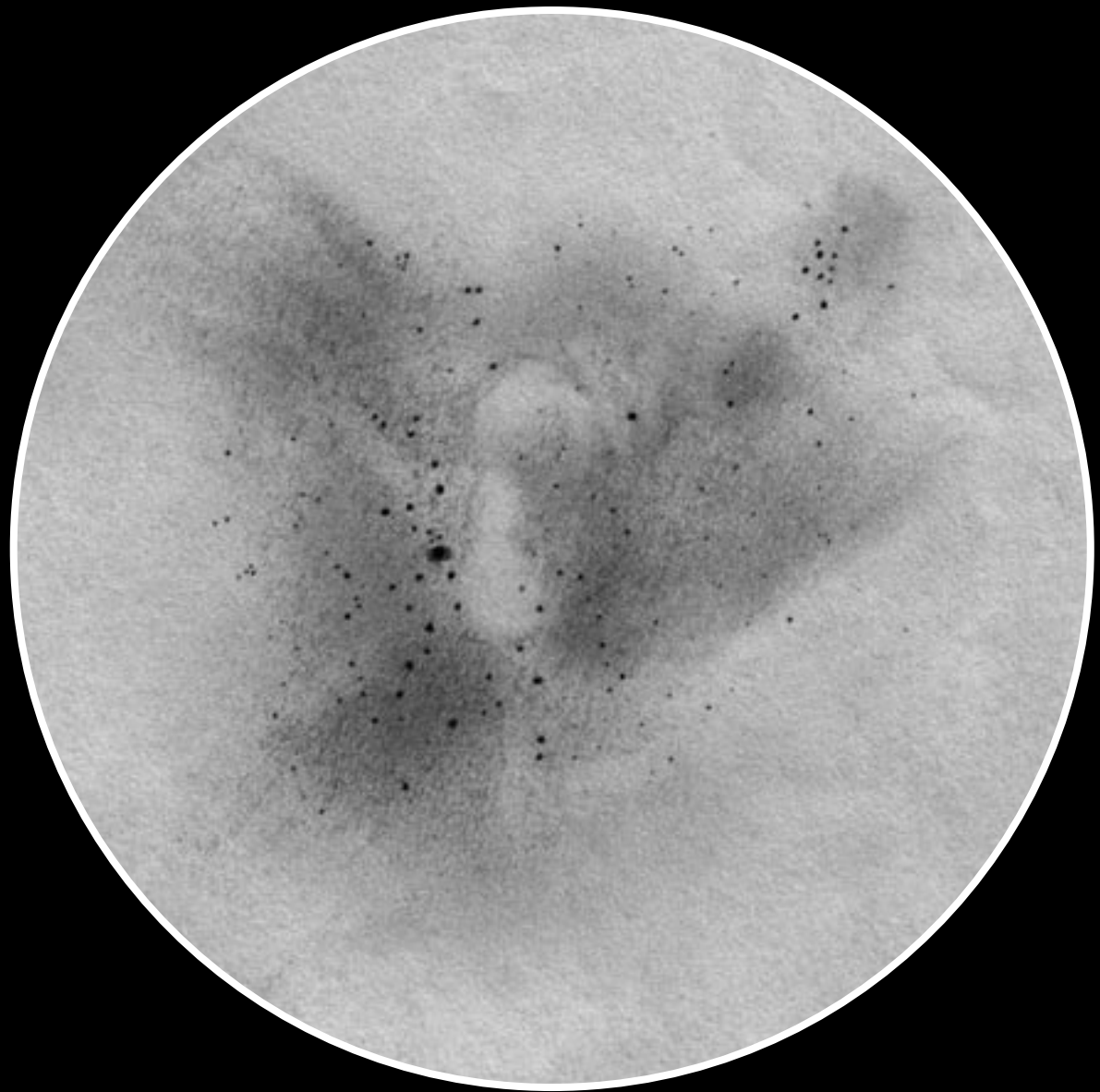


**Magda’s observing table.** “I have a clip board with a red light mounted on it. In the table there are holes in which I place the eyepieces I’m using; after the session they go back into their protective cases. At the side of the table, at a slant, is a space where I can put a book or two. I always make sure that everything is laid out before the Sun goes down so that I don’t have to fumble about in the dark too much.”

and record keeping strategy becomes necessary. Magda organizes her materials primarily by constellation, and maintains a separate inventory (as an Excel spread sheet) to keep track of what is stored where.

“My typed-out observations I keep on my computer, sorted by constellation. After the observing session, after I’ve typed up my notes, I use the *Deep Sky Field Guide* to flesh out any details that are interesting.”

Magda stresses the importance of keeping all the original material generated at the eyepiece. “I keep all my original observing notes, including the dictated recordings, in a box file, labelled with the year. Even if I think it was really just a terrible crude scribble, I don’t throw away any of my rough observations. I remember there was a double star I was observing and by going back through my old rough notes we could determine that the one component had indeed grown dimmer over the past 10 years, a cause for a little celebration!”



10'

Central part of the eta Carinae Nebula



Magda uses large black box files, suitably labelled by constellation, for archiving. “I know this may sound cumbersome, but it works for me! In this way, I’m assured that my data is safe. And when I have write an article, it is easy to find the data I need.”

Her sketches are stored in these box files, too: “I place each of my final sketches in a plastic filing sleeve, and file these together by constellation. I also keep a backup of these sketches on CDs.”

In addition to clusters and nebulae, Magda is also a double star observer: “A list of double stars in the working area will also be accompany me to my observatory. I use *Sky Catalogue 2000.0* to check the data of the stars, and I also prepare enlarged prints of some of the double stars since I need to star-hop to find the fainter double stars.”



Her final thoughts: “Prepare well, take it easy, stay calm, take your time, and you can be assured of a sense of pleasure and satisfaction after a successful night’s observation!”



Magda Streicher joined the ASSA Deep-Sky Section in 1995 and is a Specialist of the Section. She has written numerous articles, manuscripts and books about the deep-sky and lives in Polokwane, Limpopo Province.





# DEEP-SKY PROJECTS

Since it's establishment in 1992, members of the ASSA Deep-Sky Section have undertaken various projects and observing programmes. The following is a summary list of **currently on-going projects**:

- An Observer's Atlas of the Large and Small Magellanic Clouds <sup>O, P</sup>
- An Observer's Atlas of Southern Dark Nebulae <sup>O, P</sup>
- Big 5 of the African Sky / Groot 5 van die Afrika Nag <sup>O</sup>
- Biographical Notes: Who's Who of the Deep-Sky <sup>R</sup>
- Deep-sky marathons <sup>O</sup>
- Deep-sky Nick-names <sup>R</sup>
- Digital Archive of Historical Deep-Sky Texts <sup>R</sup>
- Documentary Film: *Into the Deep*
- Historical Archive of the Visual Deep-Sky <sup>R</sup>
- *Nightfall* newsletter <sup>R</sup>
- Photo-to-visual conversion <sup>P, R</sup>
- Telescopes in Movies: The good and the bad <sup>R</sup>

Subscript letters help characterize the projects, as O = observing project, P = with a significant practical and/or theoretical astrophotography component, and R = lots of reading/research/desk work involved.

ASSA members – and any other interested parties – are warmly invited to take part in the Section's projects, and/or suggest new avenues of exploration.



SCENES FROM THE 1<sup>ST</sup> FREE STATE STAR PARTY





(top-left) Paul Kruger. (top-right) Jaco Brink.  
(bottom-left) Andre Potgieter. (bottom-right) Allen Versfeld.



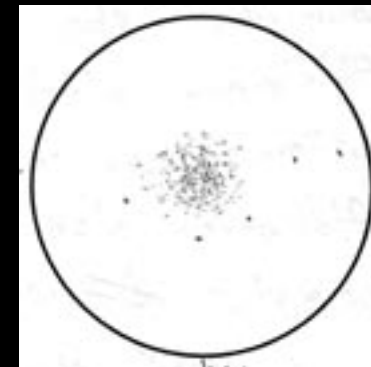
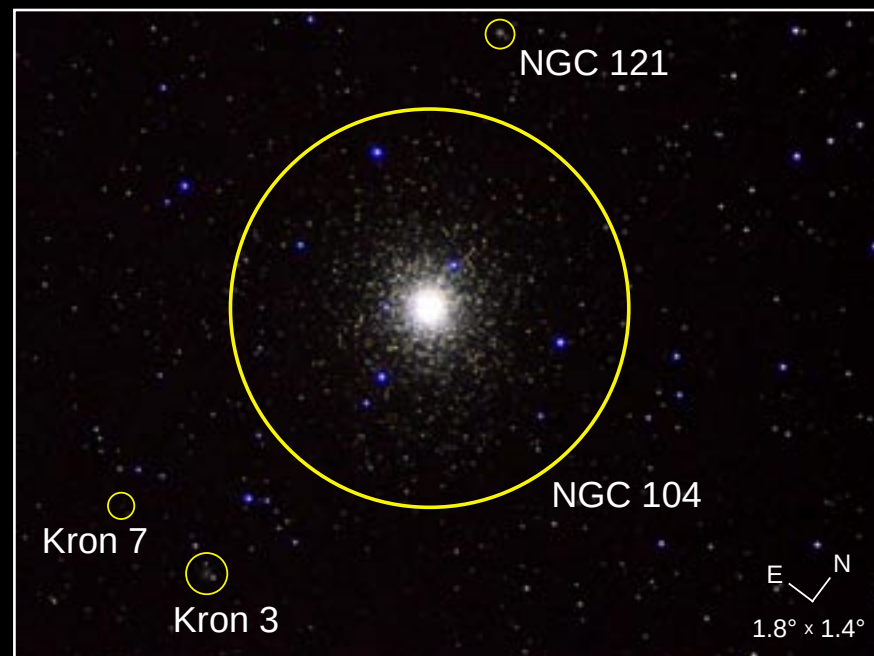
## ON THE COVER

Iconic southern globular cluster 47 Tucanae (NGC 104 or 47 Tuc to friends) graces the cover of this edition. This glorious naked-eye cluster near the Small Magellanic Cloud was imaged by Wim Filmatter during the 2014 Spring Southern Star Party. Wim built a refractor based around a Jaegers 110-mm cemented doublet (F=495-mm, f/4.5) objective, shown in the photograph below. He attached a Nikon D5100 (set to ISO 6400) and took a single 15-second exposure, with the camera and telescope placed on his self-designed multi-purpose tracking platform.

Besides the splendid NGC 104, his image also captures NGC 121 (discovered by John Herschel on 1835 August 20) and two more recently-found clusters, Kron 3 and Kron 7. These latter faint clusters were first seen in the 1920s by Harvard astronomers studying photographs taken at Boyden Observatory.

The image on the far right shows Wim's observing sketch of 47 Tuc made during the 2011 Spring Southern Star Party. Using an 8-inch Dobsonian, he noted the dense central area of the cluster where the stars are seen "interconnected forming criss-cross lines" as well as a "few darker areas between the stars towards the south."

NF



*Wim is a keen telescope maker who hails from Warden in the Free State and has settled in Riversdal. When not creating innovative astronomical kit he hosts astronomy outreach events and travels the bundu on his Yamaha TT 600.*



# BIG 5 OF THE AFRICAN SKY

## Observing Handbook

Powered by the Deep-Sky Section of the  
Astronomical Society of Southern Africa





# Getting started

Frequently asked questions about the Big 5 of the African Sky.

## What are the Big 5?

The Big 5 of the African Sky are five celestial objects that represent the best specimens of each type of deep-sky class: the Southern Pleiades (an open star cluster), omega Centauri (a globular cluster), the eta Carinae Nebula (a bright nebula), the Coal Sack (a dark nebula), and the Milky Way (a galaxy).

## Where can I see the Big 5?

The Big 5 are visible anywhere from within the southern hemisphere. Two of the Big 5 lie in Carina, one lies in Centaurus, and one in Crux. The fifth – the Milky Way – lies in a narrow band dividing the sky in half. The brightest parts of the Milky Way are in Sagittarius, Scutum, Norma and Carina.

The accompanying table gives their celestial coordinates and basic data. Two star maps illustrate their general location, with one map devoted specifically to the Milky Way.

### BASIC STATS

Names & designation	Type	RA & Dec	Constellation
Southern Pleiades, IC 2602	open cluster	10 <sup>h</sup> 43.2 <sup>m</sup> – 64° 24.0'	Carina
omega Centauri, NGC 5139	globular cluster	13 <sup>h</sup> 26.8 <sup>m</sup> – 47° 28.6'	Centaurus
eta Carinae Nebula, NGC 3372	bright nebula	10 <sup>h</sup> 44.3 <sup>m</sup> – 59° 53.4'	Carina
Coal Sack Nebula	dark nebula	12 <sup>h</sup> 31.3 <sup>m</sup> – 63° 44.6'	Crux
Milky Way, the Galaxy †	galaxy	10 <sup>h</sup> 45 <sup>m</sup> – 60°	Carina
"	"	16 <sup>h</sup> 18 <sup>m</sup> – 53°	Norma
"	"	18 <sup>h</sup> 00 <sup>m</sup> – 29°	Sagittarius
"	"	18 <sup>h</sup> 45 <sup>m</sup> – 07°	Scutum
"	"	19 <sup>h</sup> 30 <sup>m</sup> + 30°	Cygnus

† The Milky Way circles the entire sky so a single position cannot represent it. The last five rows of the table lists the positions of the five brightest portions. The Galactic centre is in Sagittarius.



## When can I see the Big 5?

All five objects will not be visible at the same time. This is mainly because the Milky Way is a large object and it will take more than one session to see it at its full extent. There are a number of tools you can use to find out when a particular region of sky is visible. You could, for example, use the *Southern Star Wheel* planisphere, a free DIY download. Your favourite planetarium program (e.g. “Stellarium”) or app (e.g. “Google Sky Map”, “Sky Safari”) are also great options. The following table gives a general indication of when the Big-5 can be seen.

### VISIBILITY PERIODS

Names	Evening visibility	Midnight visibility	Morning visibility
Southern Pleiades	January to late-August	Mid-November to early July	Mid-September to early May
eta Carinae Nebula	Early January to mid-August	Late November to early July	Late September to early May
Coal Sack Nebula	February to late-September	Mid-December to early August	Mid-October to early June
omega Centauri	March to mid-September	Mid-January to early August	Mid-November to early June
Milky Way (Car)	Early January to mid-August	Late November to early July	Late September to early May
Milky Way (Nor)	Early April to end-October	Late February to mid-September	Late December to mid-July
Milky Way (Sgr)	Late May to early November	Mid-April to late September	Mid-February to late July
Milky Way (Sct)	Late June to early November	Early May to late September	March to late July
Milky Way (Cyg)	Early August - mid-October	Late June to late August	Late April to early July

## How do I see the Big 5?

Once you know where the Big 5 are and when they are visible, decide on what equipment you would like to use. The Big 5 can be seen with the naked eye alone if you observe from a dark-sky site. Under these conditions the Milky Way in particular is a spectacular sight. If you will be observing under suburban skies you will need to use at least a pair of binoculars. A telescope will, of course, show the objects more easily, but the large size of the Milky Way means that most telescopes are too “powerful” – use binoculars instead.



## How do I record the Big 5?

For each object, write a clear description of what you see. Imagine explaining the view to a blind friend who knows nothing about astronomy. Sometimes making a rough sketch, too, is a good idea. Also write up a few lines (like a diary entry or a blog post) telling about your observing experience. This journal is a great way to capture your thoughts and feelings of the moment: you'll enjoy reading it a few years down the line!

## How do I report my observations?

Collect your observations of each object, add your observing journal entries (and sketches if you made them) and submit them to the ASSA Deep-Sky Section. The easiest way is to send an e-mail to [Auke Slotegraaf, [auke@psychohistorian.org](mailto:auke@psychohistorian.org)].

A great idea is to share your observations with other observers: you can post your notes on the Big 5 Facebook Group and on the ASSA Deep-Sky Section YahooGroup mailing list.

## What happens after I submit my observations?

All reports will receive feedback from the ASSA Deep-Sky Section. If you've successfully observed the Big 5, your name will be listed on the ASSA website *Big 5 Honour Roll*. You will also be issued with a virtual sticker – a graphic that is created uniquely for you, officially hosted on the ASSA website, that you can link to and embed in online media. In addition, your descriptions and journal will be published on the ASSA Deep-Sky Section webpages for other observers to read and enjoy.

## What about the Big 5 Bling I've heard about?

Once you've successfully observed the Big 5, you are eligible to buy a beautiful *Big 5 of the African Sky T-shirt*, and a must-have car license disk sticker. Use this bling to proudly show off what you've achieved! While you are still hunting the Big 5, you can pick up a very attractive coffee mug to keep you going at night.

## Keep in touch

ASSA Deep-Sky Section: [ [auke@psychohistorian.org](mailto:auke@psychohistorian.org) ] [ 14 Mount Grace, Somerset Ridge, Somerset West, 7130 ]

Whatsapp chat group: [ 074 100 7237 ]

Official Big 5 of the African Sky web page: [ <http://assa.sao.ac.za/sections/deep-sky/big5/> ]

Official Big 5 Facebook group: [ <https://www.facebook.com/groups/big5africansky/> ]

ASSA Deep-Sky Section mailing list: [ <https://groups.yahoo.com/neo/groups/assa-deep-sky/info> ]

## Resources

*Southern Star Wheel* planisphere: [ <http://assa.sao.ac.za/how-to-observe/getting-started/planisphere/> ]

*Discover!* and *ConCards* star charts: [ <http://assa.sao.ac.za/how-to-observe/getting-started/star-charts/> ]

*Andrew Johnson's Mag 7 Star Atlas Project*: [ [http://www.cloudynights.com/item.php?item\\_id=1052](http://www.cloudynights.com/item.php?item_id=1052) ]

“Deep-sky Observer’s Companion” database: [ [http://www.docdb.net/object\\_index.php](http://www.docdb.net/object_index.php) ]

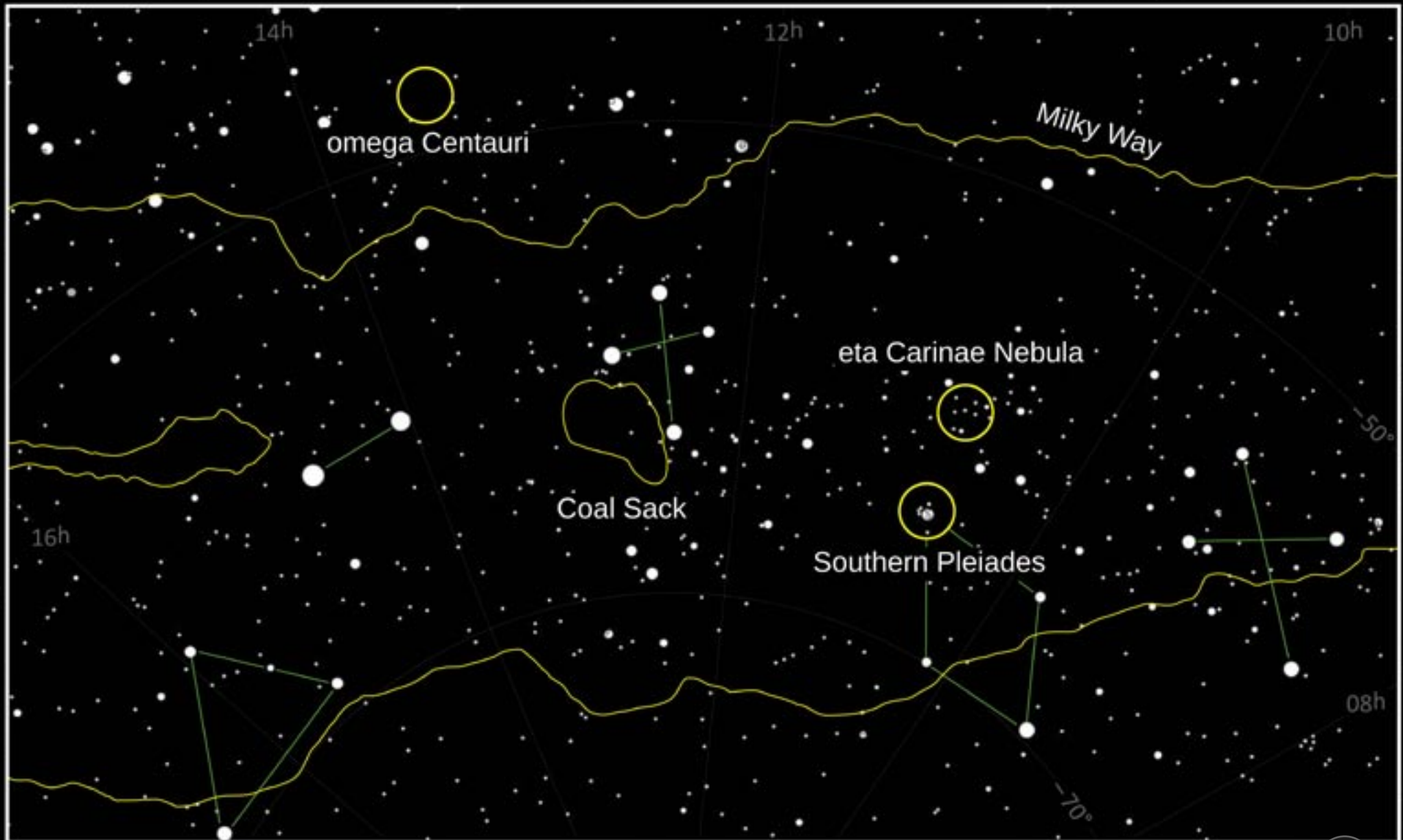
“Cartes du Ciel” planetarium software: [ <http://www.ap-i.net/skychart/en/start> ]

“Stellarium” planetarium software: [ <http://www.stellarium.org/> ]

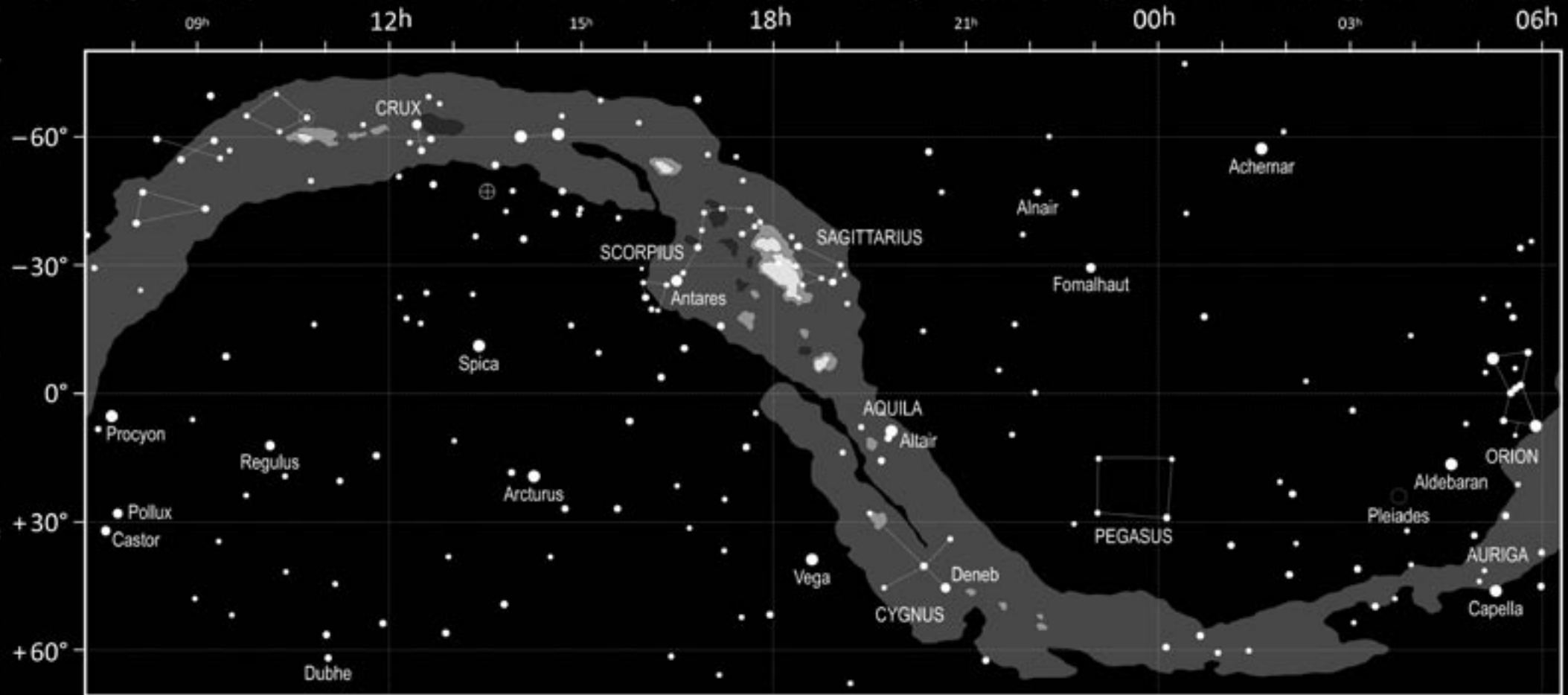
“Google Sky Map” app: [ <http://www.google.com/mobile/skymap/> ]



# Star map



# The Milky Way



The outline of the Milky Way is shown at three brightness contours. The faintest (outer) contour shows the extent of the Milky Way as it may appear at a true-dark site to a perfectly dark-adapted observer. The innermost contour shows the brightest portions of the Milky Way. These are the Great Sagittarius Star Cloud [ $18^{\text{h}}, -30^{\circ}$ ], the Scutum Star Cloud [ $18^{\text{h}}45^{\text{m}}, -07^{\circ}$ ], the Norma Star Cloud [ $16^{\text{h}}15^{\text{m}}, -54^{\circ}$ ], and the region around eta Carinae [ $10^{\text{h}}45^{\text{m}}, -60^{\circ}$ ]. An intermediate contour level shows the next-brightest regions, mostly surrounding the star clouds just mentioned, with noticeable zones in Cygnus, Aquila, Ophiuchus and Centaurus. The most indistinct portion of the Milky Way is around the Anti-centre,  $180^{\circ}$  away from Sagittarius, along the Taurus-Auriga border. Noticeable dark patches include the Coal Sack near Crux and the Pipe Nebula in Ophiuchus [ $17^{\text{h}}30^{\text{m}}, -26^{\circ}$ ]. Extensive dark regions include the Dark Emu or Great Llama (from epsilon Scorpii towards the Coal Sack, with alpha and beta Centauri seen as the Eyes of the Llama) and the Great Rift (stretching from Sagittarius past Altair towards De

Deep-sky photographs © Dieter Willasch & Brett du Preez

Earth globe generated using Google Earth



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