Deep-sky Challenge
Explore the Local Group

2016 Spring
Southern Star Party
Bonnievale, South Africa

Hello! And thanks for taking up the challenge at this SSP!

Johan Brink
Peter Harvey
James Smith

The theme for this Challenge is *Galaxies of the Local Group*. I've written up some notes about galaxies & galaxy clusters (pp 3 & 4 of this document).

Late-October is prime time for galaxy viewing, and you'll be exploring the best the sky has to offer. All the objects are visible in binoculars, just make sure you're properly dark adapted to get the best view.

Galaxy viewing starts right after sunset, when the centre of our own Milky Way is visible low in the west. The edge of our spiral disk is draped along the horizon, from Carina in the south to Cygnus in the north. As the night progresses the action turns north- and east-ward as Orion rises, drawing the Milky Way up with it. Before daybreak, the Milky Way spans from Perseus and Auriga in the north to Crux in the South.

Meanwhile, the Large and Small Magellanic Clouds are in pole position for observing. The SMC is perfectly placed at the start of the evening (it culminates at 21:00 on November 30), while the LMC rises throughout the course of the night. Many hundreds of deep-sky objects are on display in the two Clouds, so come prepared! Soon after nightfall, the rich galactic fields of Sculptor and Grus are in view. Gems like Caroline's Galaxy (NGC 253), the Black-Bottomed Galaxy (NGC 247), the Sculptor Pinwheel (NGC 300), and the String of Pearls (NGC 55) are keen to be viewed. Around midnight, the Andromeda Galaxy (NGC 224, M31) and the Triangulum Galaxy (M33) are well placed. Finally, shortly before daybreak, the Hamburger (NGC 5128, Cen A) and the Golden Coin (NGC 4945) swing into view, heralding bed time!

The table on the next page lists the galaxies for this Challenge, while the last pages of this document are all the *ConCards* needed to find these galaxies.

Of course, you don't have to use the *ConCards* - by all means, bring along your favourite star atlas, and if you have a favourite observing form, bring those too. The last page of this document is an example of an observing form for recording your observations. Instead of a pre-printed form, though, consider using a plain notebook to record your notes. As long as you remember to include all the relevant details with each observation (date, time, object name, telescope/binoc details, sky conditions, descriptive narrative and a rough sketch) you're good to go. I find that an A5-sized hard cover book is the most convenient.

The Challenge ends at 03:30 on Sunday morning. At any time before this, please find me so I can take a look at your notes. Until then – happy observing!

Here's another bit of prep you can do if you're using a telescope: compile a handy table of eyepieces (and eyepiece/Barlow combinations) you have, noting the magnification and the angular size of the field of view. The magnification of an eyepiece is easy to determine: simply divide the focal length of your telescope by the focal length of the eyepiece. The size of each field of view is easiest to do using a star chart: find two stars that *just* fit in across your field of view, and then determine the separation between these two stars using software such as Cartes du Ciel, Stellarium, etc. If you need help with this step, I'll give you a hand at the SSP. If you are using binoculars, use the same procedure as for measuring eyepieces: find two stars that snuggly fit in, and determine their separation. The table below summarizes these stats for my telescope.

EXAMPLE: Eyepiece stats for my telescope (Brian, 6-inch refractor, f/6, fl = 900-mm)

Eyepiece/Barlow	magn.	fov	Eyepiece/Barlow	magn.	fov
32mm Erfle (2")	28×	149′	19mm Panoptic+Barlow	118×	33.6′
19mm Panoptic	47×	84′	18mm Ortho+Barlow	125×	20.0′
18mm Ortho	50×	51′	6mm Ortho	150×	17.0′
32mm Plossl+Barlow	70×	44′	11mm Nagler+Barlow	205×	22.8′
11mm Nagler Type6	82×	57′	6mm Ortho+Barlow	375×	7.0′

First half of the session

Object	R.A.	Dec.	Con	Got it?
Andromeda Galaxy (Messier 31, NGC 224)	$00^h\ 42^m\ 44^s$	+41° 16’ 09”	Andromeda	
Triangulum Spiral (Messier 33, NGC 598)	$01^h\ 33^m\ 51^s$	+30° 39’ 37”	Triangulum	

All night

Object	R.A.	Dec.	Con	Got it?
Caroline’s Galaxy, Silver Coin (NGC 253)	$00^h\ 47^m\ 33^s$	–25° 17’ 18”	Sculptor	
Black-Bottomed Galaxy (NGC 247, Bennett 3)	$00^h\ 47^m\ 09^s$	–20° 45’ 38”	Cetus	
Sculptor Pinwheel (NGC 300, Bennett 6)	$00^h\ 54^m\ 54^s$	–37° 40’ 59”	Sculptor	
String of Pearls (NGC 55, Bennett 1)	$00^h\ 14^m\ 54^s$	–39° 11’ 55”	Sculptor	
Small Magellanic Cloud (SMC, NGC 292)	$00^h\ 52^m\ 38^s$	–72° 48’ 01”	Tucana	
Fornax Propeller (NGC 1365, Bennett 16)	$03^h\ 33^m\ 36^s$	–36° 08’ 28”	Fornax	
Large Magellanic Cloud (LMC, ESO 56–115)	$05^h\ 23^m\ 35^s$	–69° 45’ 22”	Doradus	
Milky Way	—	—	—	

Late critical

Object	R.A.	Dec.	Con	Got it?
Golden Coin (NGC 4945, Dunlop 411)	$13^h\ 05^m\ 26^s$	–49° 28’ 15”	Centaurus	
Hamburger Galaxy (NGC 5128, Centaurus A)	$13^h\ 25^m\ 28^s$	–43° 01’ 09”	Centaurus	

Crib notes: Things to keep in mind when writing your description of an object. A more detailed version of this checklist is given in the *ConCards*.

Galaxies

* What are your first impressions?
* How easy is it to see?
* What shape is the galaxy?
* How big is the galaxy?
* How does the brightness change from edge to centre? (brightness profile)
* Is there a nuclear region?
* Are the edges sharp or diffuse?
* Are there darker parts or areas of uneven brightness?
* How well does the galaxy stand out from the background field?
* Are there stars very near, or within, the galaxy?
* How does it relate to the surrounding star field?
* Rate your confidence in this observation.

Rough sketch

* Made a crude drawing if that will help to make your description clearer.
* Remember to include compass directions: stars drift out your field to the **west**.

Galaxies and galaxy clusters

A **galaxy** is a massive collection of stars (between a few million and 10 million million) and interstellar material (gas and dust) held together by gravitation. There are an estimated 200 thousand million galaxies in the Universe.

Galaxies can be classified according to their appearance, using the Hubble classification scheme. Elliptical galaxies are spherical or ellipsoidal in shape and are made up mostly of old red stars with very little interstellar gas. Spiral galaxies consists of a central nucleus of relatively closely packed stars, surrounded by a flattened disk-shaped component of stars, gas, and dust, within which nebulae and the brightest, youngest, stars are gathered into spiral-shaped arms, spreading out from the nuclear region. In barred spirals, the nucleus is elongated and the spiral arms spread from either end of the bar. Irregular galaxies display no obvious structure.

> The first use of the word "galaxy" in its modern context was by the Scottish astronomy popularizer John Pringle Nichol in his 1848 book *The Stellar Universe* who wrote about "galaxies separated from each other by gulfs so awful that they surpass the distances which divide star from star."

The diameters of galaxies range from a few thousand light years to a few hundred thousand light years. The largest galaxies, supergiant ellipticals found in the cores of clusters of galaxies, have diameters of up to five million light years.

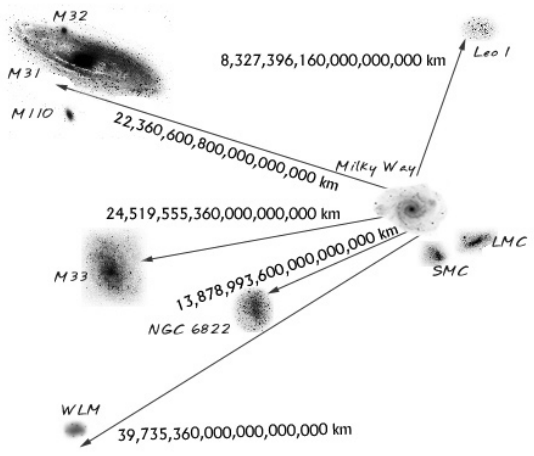
Our Milky Way (also written as our Galaxy) is a barred spiral galaxy with relatively loosely wound arms, spreading out some 110 000 light years in diameter. It appears to have four main spiral arms, named after the constellations in which they are most prominent. These arms are the Perseus, Norma, Scutum-Centaurus, and Carina-Sagittarius Arm. The Orion-Cygnus arm is a minor spiral arm located betwen the Carina-Sagittarius Arm and the Perseus Arm. The Sun lies within the Orion-Cygnus Arm (which is also known as the Local Arm or the Orion Spur) some 26 400 light years from the Galactic centre.

The centre of our Galaxy is seen in the direction of Sagittarius, at RA $17^h 45^m 40^s$, Dec $-29° 00' 28''$. The solar system orbits the Galactic centre in a nearly circular path, taking about 220 million years to complete a single round-trip. It is moving at about 250 km/s towards a point in Cygnus with coordinates RA $21^h 12^m$, Dec $+48° 19'$.

The nucleus of the Milky Way contains a compact source of radio emission called Sagittarius A* which is believed to be black hole with a mass of about two million solar masses.

Galaxies are preferentially found in **galaxy groups**, usually containing up to 50 galaxies in a diameter of five million light years. Our Milky Way is a part of the **Local Group**, which has at least 48 known members spread out over 10 million light years. The Local Group is essentially a binary system of two massive clumps of galaxies centred on our Milky Way and on the Andromeda Galaxy (NGC 224, Messier 31). The best-known "minor" members of the Local Group are the Large and Small Magellanic Clouds, companions of the Milky Way. Two other prominent dwarfs are associated with the Milky Way, too - the Fornax and Sculptor systems.

The nearest neighbour of the Local Group is the small Antlia Group, and the nearest massive neighbour is the Centaurus Group, which contains the Southern Pinwheel (NGC 5236, Messier 83) and the Hamburger (NGC 5128, Centaurus A). In the distant future, the Andromeda Galaxy will merge with the Milky Way, forming a massive elliptical galaxy with a system of about 700 globular clusters.



The Local Volume is a sphere about 65 million light years across centred on the Local Group. It includes at least 550 known galaxies, including those in the Centaurus and M81 Groups, the Sculptor Filament and the CVn I Cloud. Recently,

Russian astronomer Igor Karachentsev and colleagues have demonstrated that the Sculptor Filament contains distinct clumps of galaxies, one centered on NGC 55 and NGC 300, another centered on NGC 253 and NGC 247.

Collections of galaxy groups form **galaxy clusters**, containing between 50 and 1 000 galaxies with diameters of up to 32 million light years. Galaxy clusters are the largest known gravitationally bound objects in the universe. The nearest and best-studied rich galaxy cluster is the Virgo Cluster, lying some 55 million light years away. It contains at least 1 300 galaxies in two main concentrations, one around NGC 4486 (M 87) and the other around NGC 4476 (M 49). Other significant nearby clusters include the Coma, Perseus, Hydra I, and Centaurus clusters.

Clusters are organized into larger, non-gravitationally bound collectives called **superclusters**. The Local Group lies in the outer reaches of the Virgo Supercluster. The Shapley Concentration is a collection of 29 clusters of galaxies about 650 million light years away.

The galaxy cluster that isn't

In the 1920s, a cluster of galaxies in Cancer the Crab was identified. Named the "Cancer Cluster" by famous galactic sleuths Edwin Hubble and Milton L. Humason, they described it as "about 150 nebulae distributed over an area of nearly 1 square degree, centered near NGC 2562".

The equally famous Fritz Zwicky studied the cluster in the 1950s and found that it spanned about 6 degrees on the sky and had at least 300 members. By 1983, however, the picture changed when more precise measurements of the movements of individual galaxies became available. A group of astronomer at the Harvard-Smithsonian Centre for Astrophysics (CfA) found that the so-called cluster actually consisted of five groups of galaxies, not gravitationally bound together in a single system. This chance collection of discrete groups are moving away from each other along with the general flow of cosmological expansion.

The brightest "cluster" members are the spiral galaxies NGC 2599 and NGC 2563. They can be seen shortly before sunrise this week-end, located 3° away from the Beehive star cluster (Messier 44). Five bonus points and a chocolate if you locate NGC 2599 on Friday or Saturday!

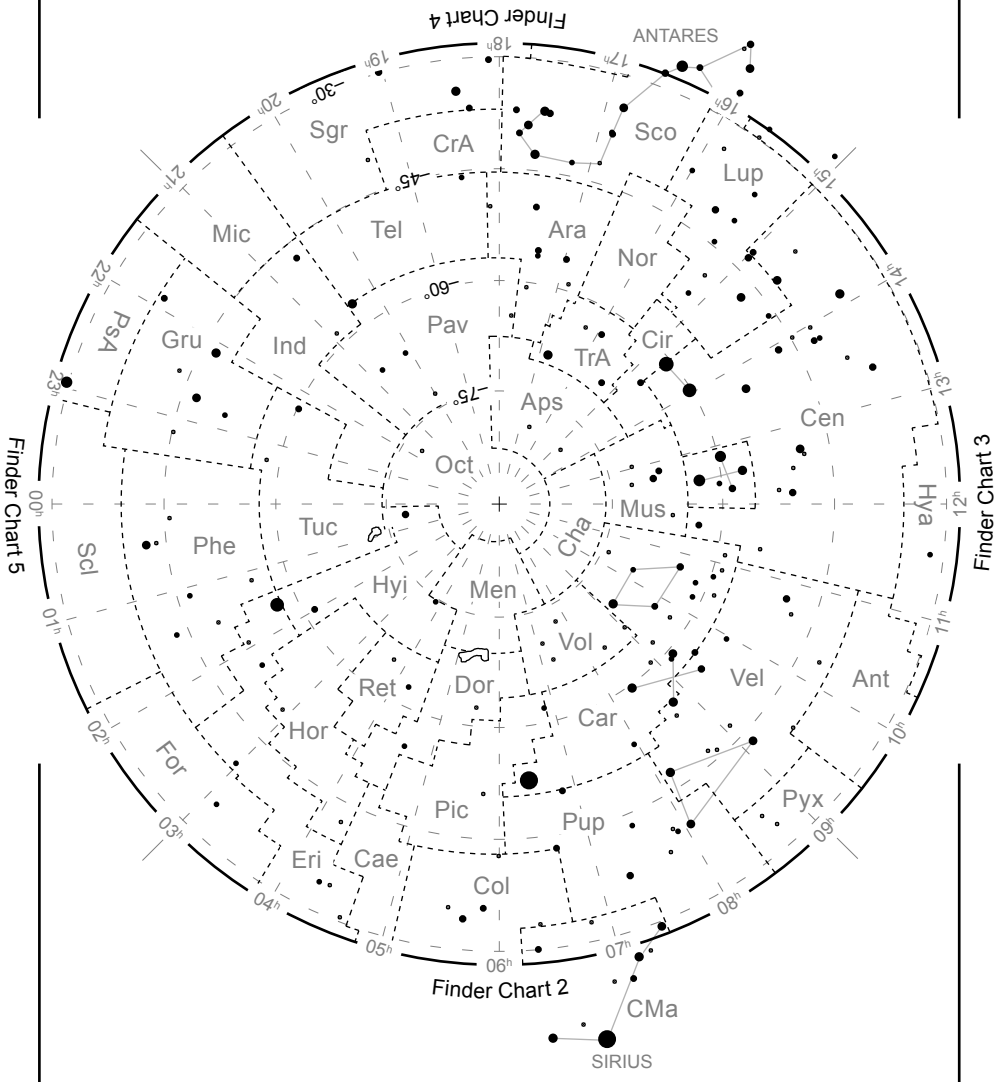
The vast majority (about 90%) of galaxies in the Universe lie outside of rich clusters. They are found in extensive **filaments** and **sheets**, giving the universe an overall bubbly structure. The largest of these sheets of galaxies is the Great Wall, 800 million light years long, 280 million light years "high" but only about 20 million light years "thick". The Coma Cluster forms part of the Great Wall. The dominant large-scale feature of the Universe, however, are **voids**, large regions of very low galaxy density. The Boötes void has a diameter of about 400 million light years within which only a few small galaxies are found. In all, voids occupy about 90% of space in our Universe.

Galaxies in the Local Group

Galaxy	RA (J2000.0) Dec	Galaxy	RA (J2000.0) Dec
WLM, DDO 21	00h 01m 58s −15° 27.7′	Fornax	02h 39m 59s −34° 27.0′
IC 10	00 20 20 +59 18.0	LMC	05 23 34 −69 45.4
Cetus	00 26 11 −11 02.5	Carina	06 41 37 −50 58.0
NGC 147	00 33 12 +48 30.5	Leo A, DDO 69	09 59 26 +30 44.8
And III	00 35 29 +36 30.5	Leo I, Regulus	10 08 27 +12 18.5
NGC 185	00 38 58 +48 20.2	Sextans	10 13 03 −01 36.9
M 110, NGC 205	00 40 22 +41 41.1	Leo II, DDO 93	11 13 29 +22 09.3
M 32, NGC 221	00 42 42 +40 51.9	Ursa Minor	15 09 11 +67 12.9
M 31, Andromeda	00 42 44 +41 16.1	Draco	17 20 12 +57 54.9
And I	00 45 40 +38 02.2	Milky Way	17 45 40 −29 00.5
SMC	00 52 44 −72 49.7	Sagittarius, Sgr I	18 55 03 −30 28.7
Sculptor	01 00 09 −33 42.5	SagDIG	19 29 59 −17 40.7
Pisces, LGS 3	01 03 54 +21 53.0	NGC 6822	19 44 56 −14 48.1
IC 1613	01 04 46 +02 07.1	Aquarius, DDO 210	20 46 52 −12 50.9
And V	01 10 17 +47 37.7	Tucana	22 41 50 −64 25.2
And II	01 16 30 +33 25.2	Cassiopeia, And VII	23 26 31 +50 41.5
M 33, Triangulum	01 33 51 +30 39.6	Pegasus, DDO 216	23 28 35 +14 44.6
Phoenix	01 51 07 −44 26.7	Pegasus II, And VI	23 51 46 +24 35.0

Chart 1: Circumpolar region ($\delta < -30°$)

Finder charts



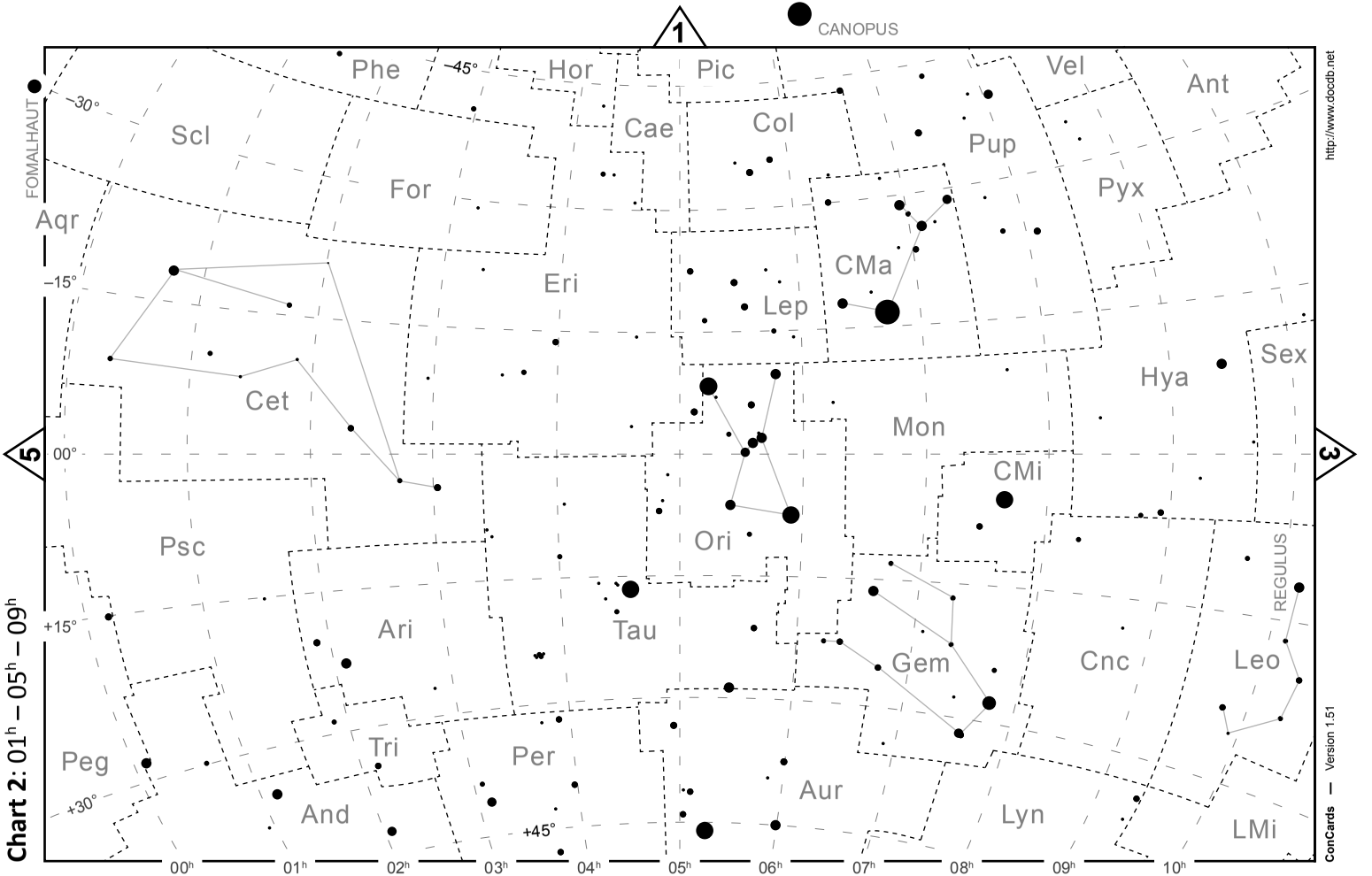


Chart 2: $01^h - 05^h - 09^h$

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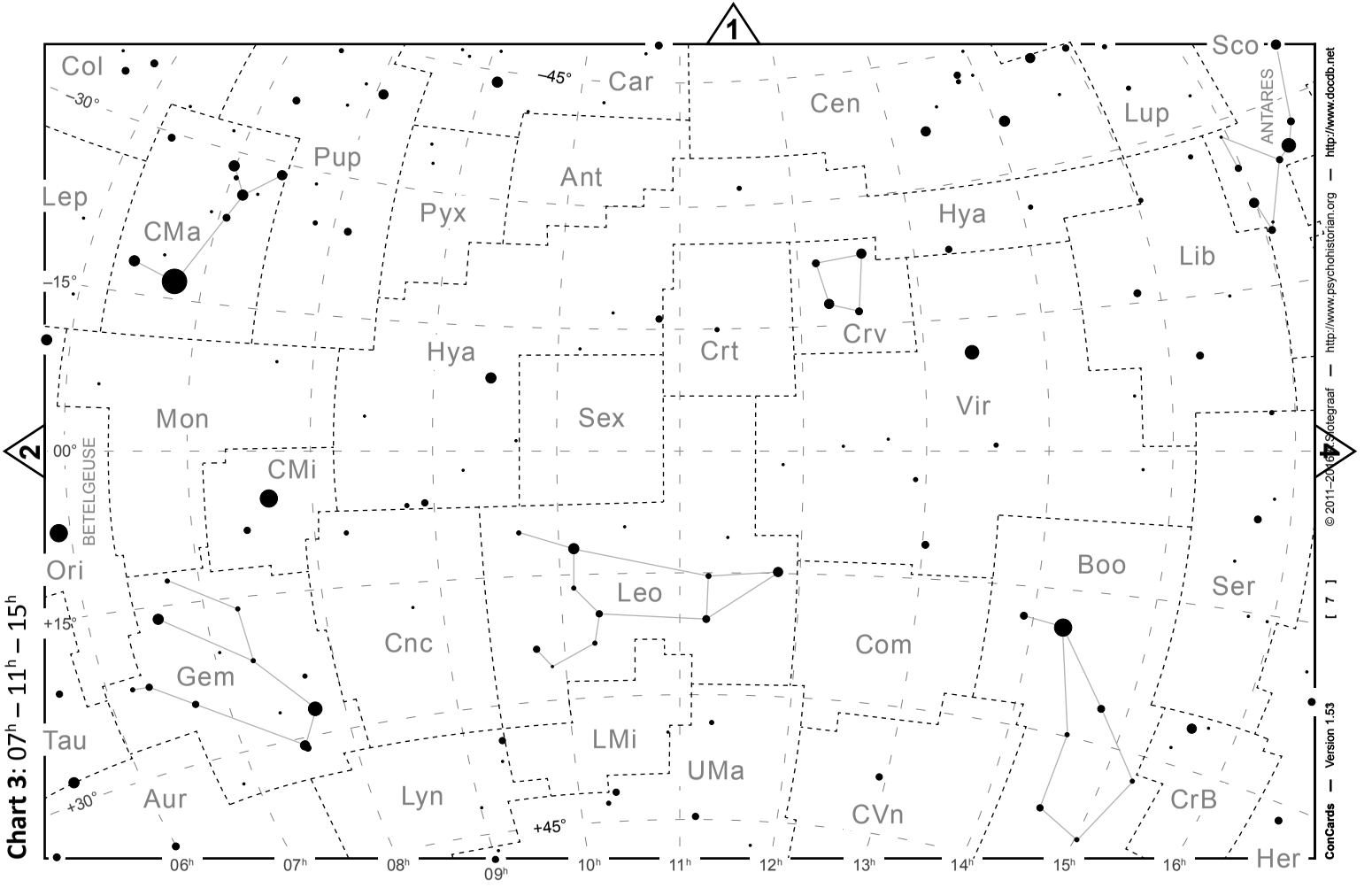
Chart 3: 07h – 11h – 15h
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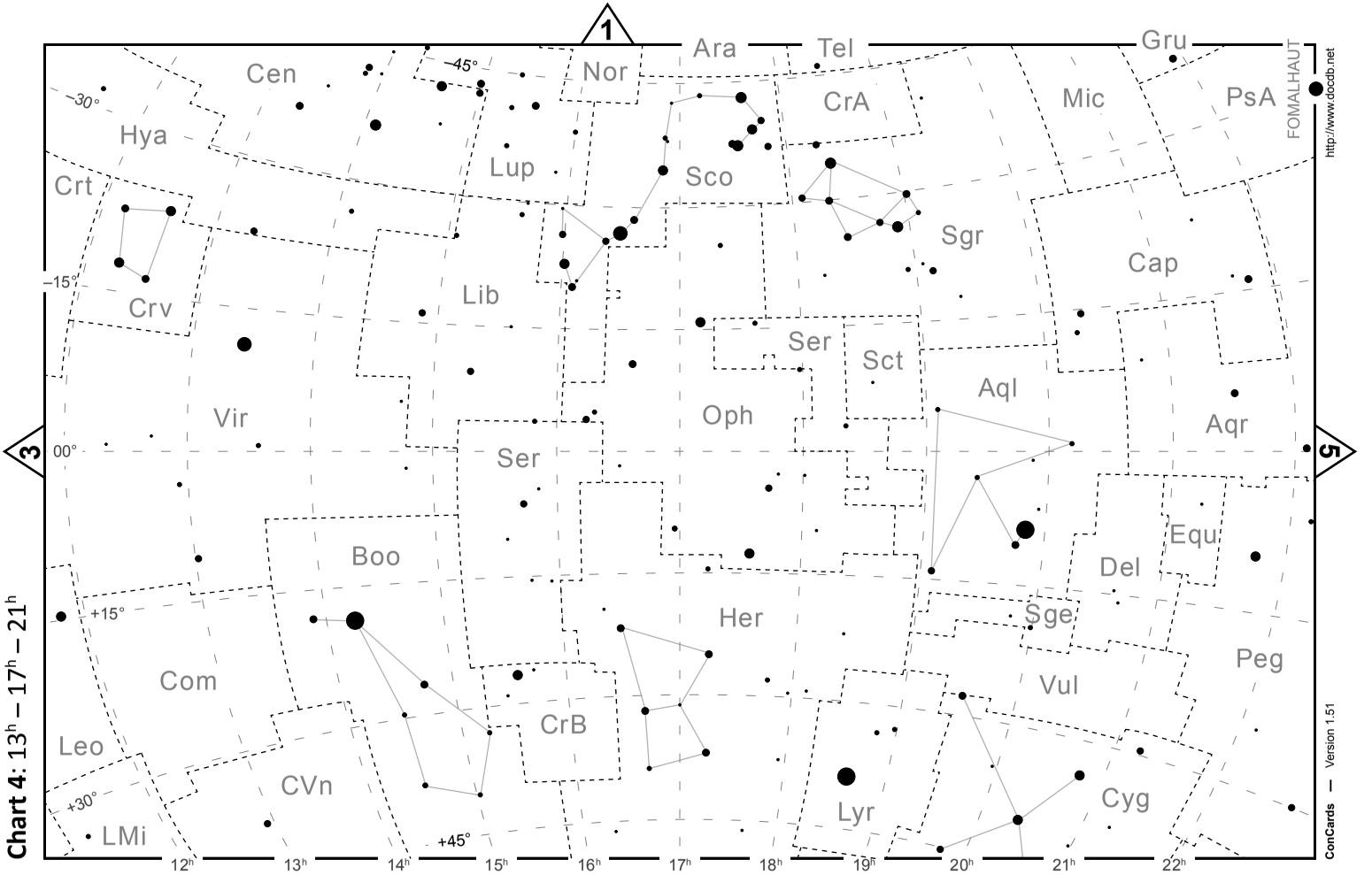
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Chart 4: 13h – 17h – 21h
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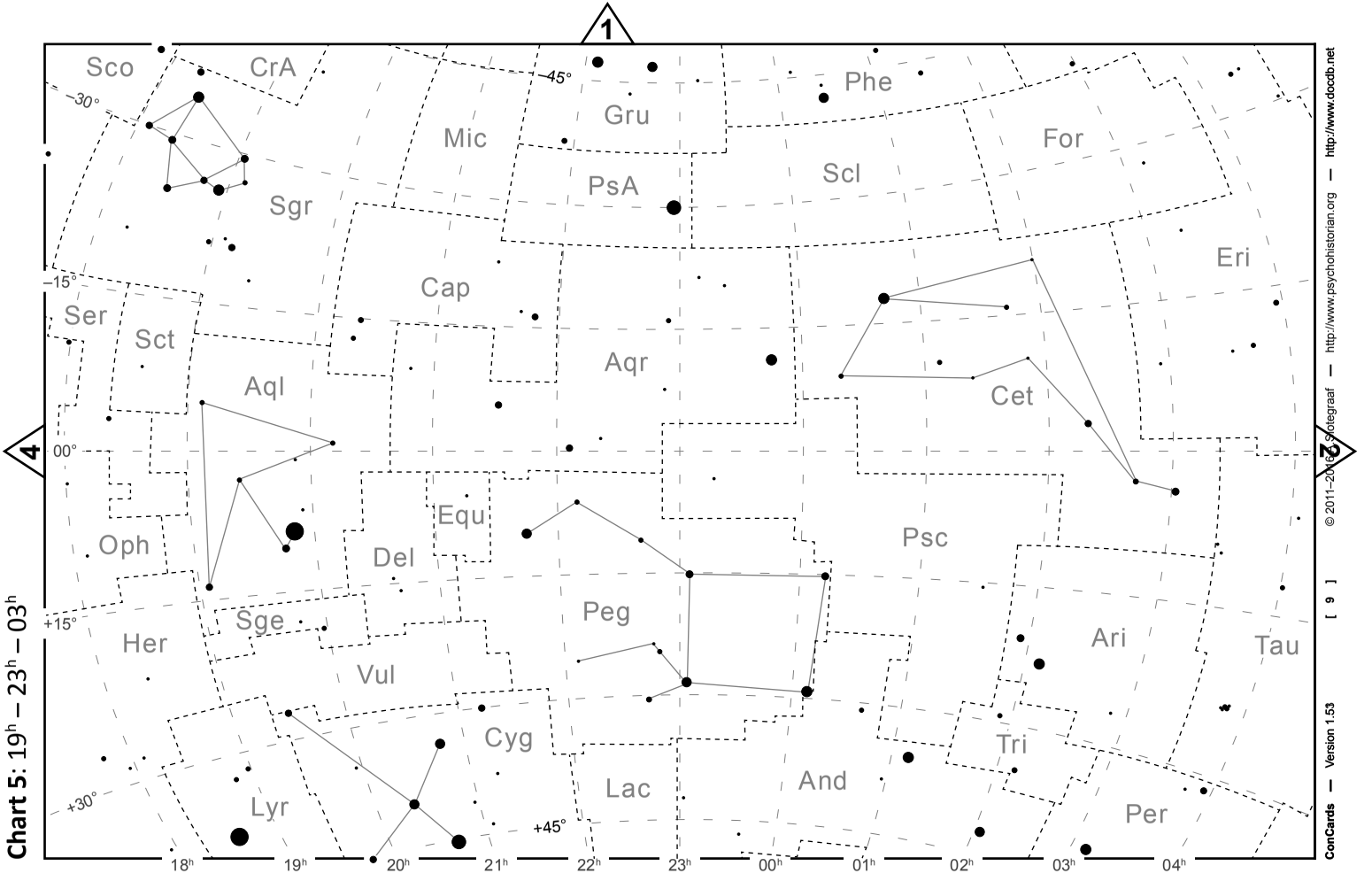


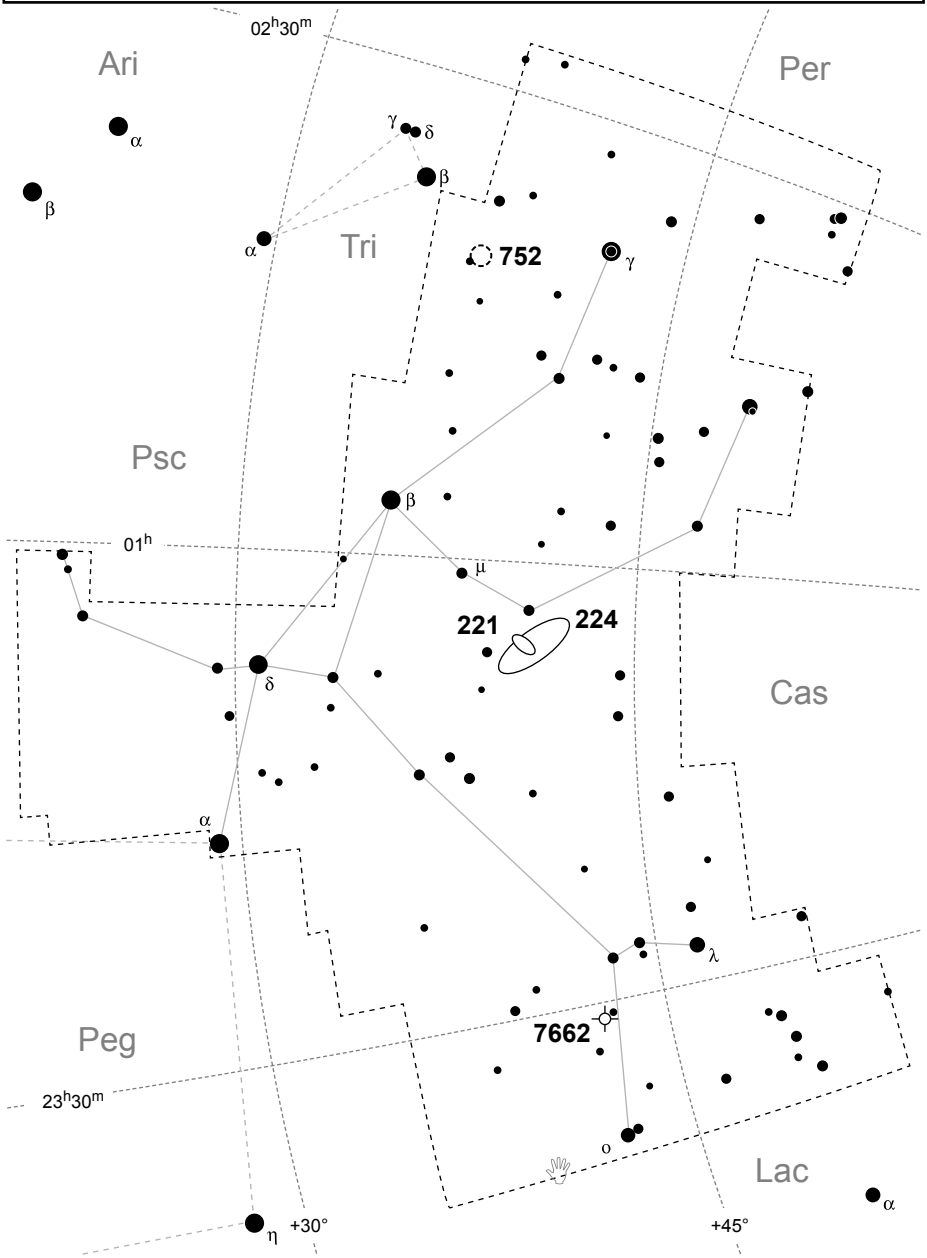
Chart 5: $19^h - 23^h - 03^h$

Andromeda

The Chained Maiden

And, Andromedae
00h40m,+39°

Visibility: July to early January
Culmination: Nov 27 (21:00), Oct 13 (00:00), Aug 28 (03:00)
N★ 152
Origin: Ancient Greek (Ptolemy)



NGC 7662, C22	23h25m54s +42°32′06″	NGC 221, M32	00h42m42s +40°51′57″
NGC 224, M31	00h42m44s +41°16′09″	NGC 752, C28	01h57m35s +37°50′

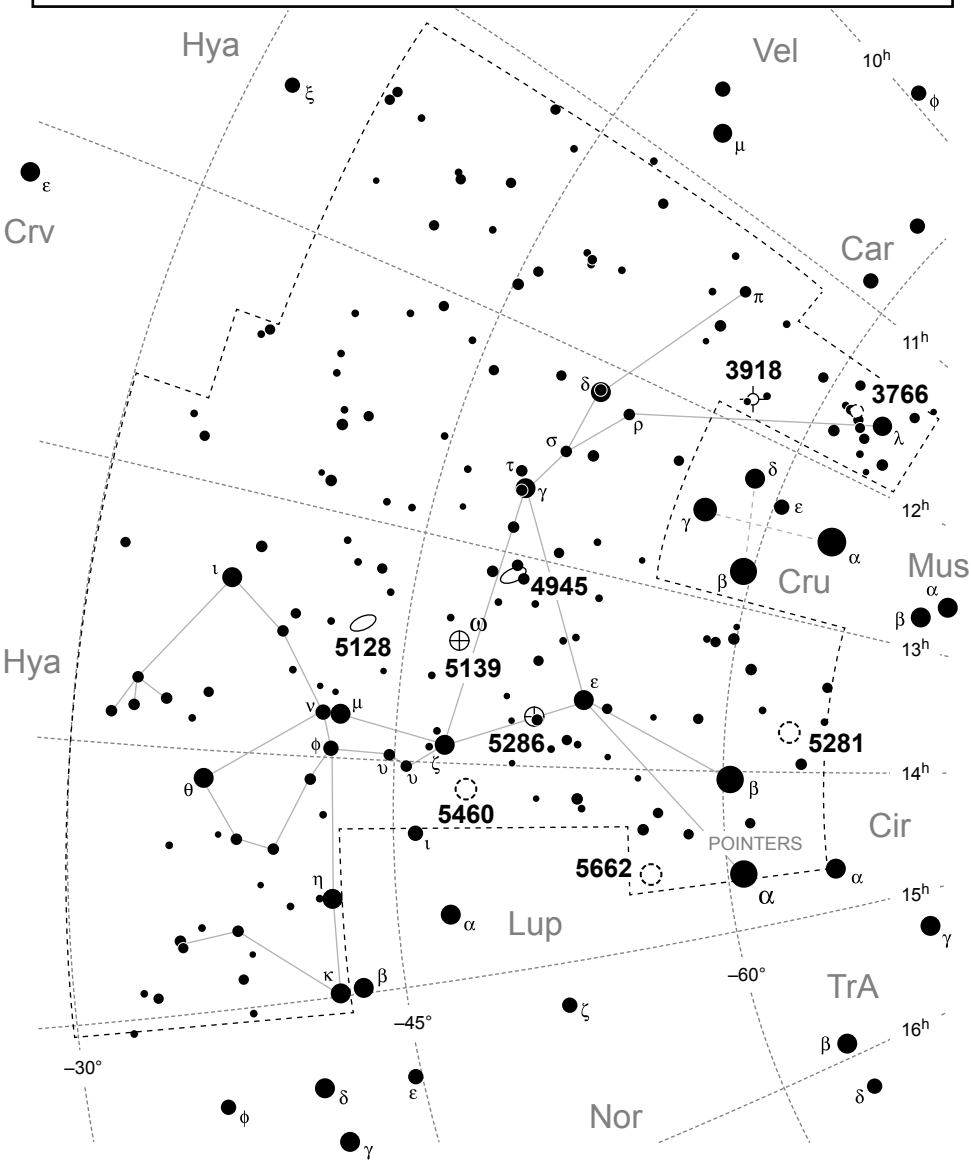
Centaurus

The Centaur

Cen, Centauri
13h00m, –44°

★★★★★

Visibility: Year-round; best early February to mid-July
Culmination: Jun 01 (21:00), Apr 17 (00:00), Mar 03 (03:00)
N★ 281
Origin: Ancient Greek (Ptolemy)



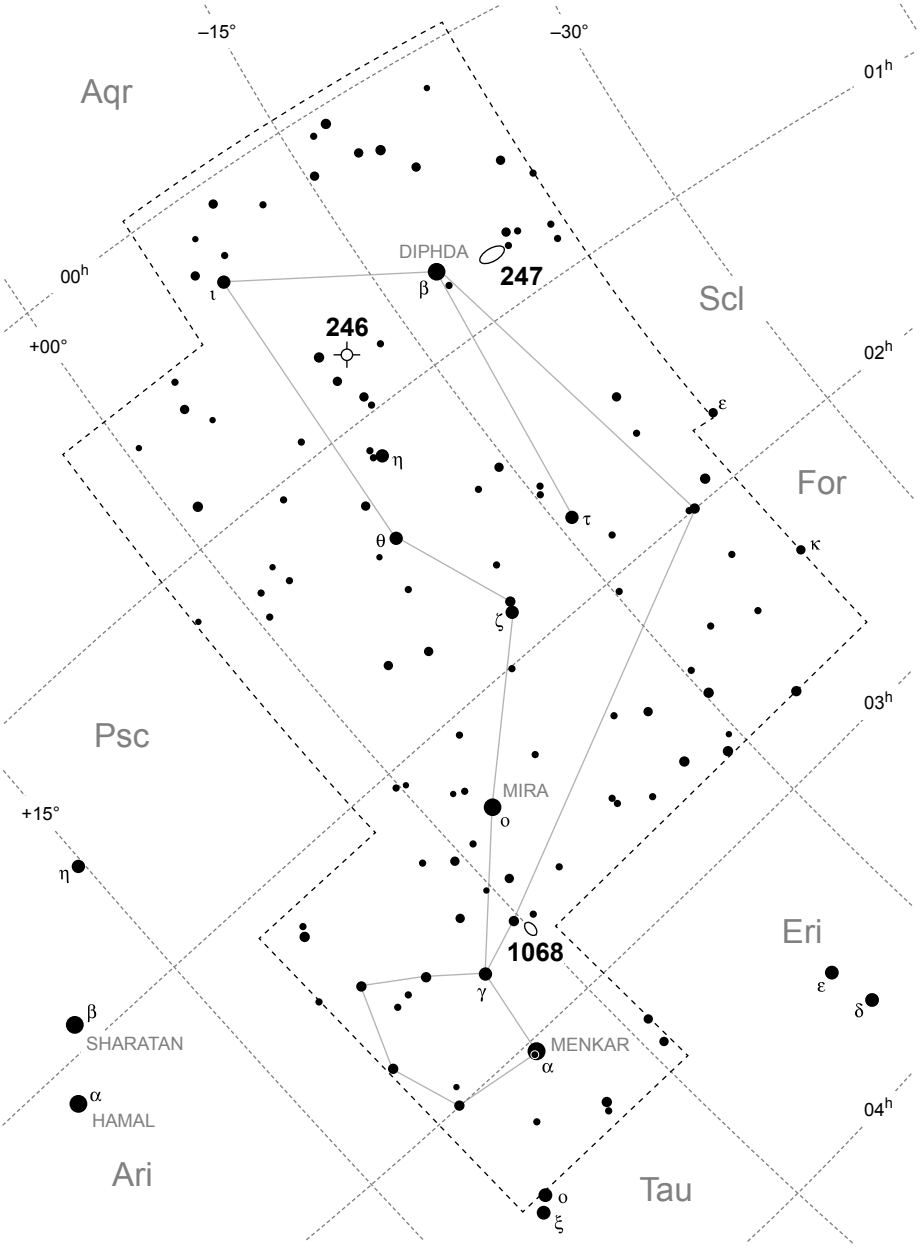
NGC 3766, C 97, A 46	11h36m13s –61°36′55″	NGC 5286, B 64, C 84	13h46m27s –51°22′25″
NGC 3918, A 47	11h50m18s –57°10′57″	NGC 5281, A 59	13h46m30s –62°54′54″
NGC 4945, B 57, C 83, A 54	13h05m26s –49°28′15″	NGC 5460, A 60	14h07m24s –48°20′
NGC 5128, B 60, C 77, A 55	13h25m28s –43°01′09″	alpha & Proxima Centauri	
NGC 5139, omega Cen	13h26m46s –47°28′37″	NGC 5662, A 61	14h35m36s –56°37′

Cetus

The Sea Monster

Cet, Ceti
01h45m, –07°

Visibility: Late May to Feb (best: early Aug to late Dec)
Culmination: Dec 12 (21:00), Oct 29 (00:00), Sep 13 (03:00)
N★ 189
Origin: Ancient Greek (Ptolemy)



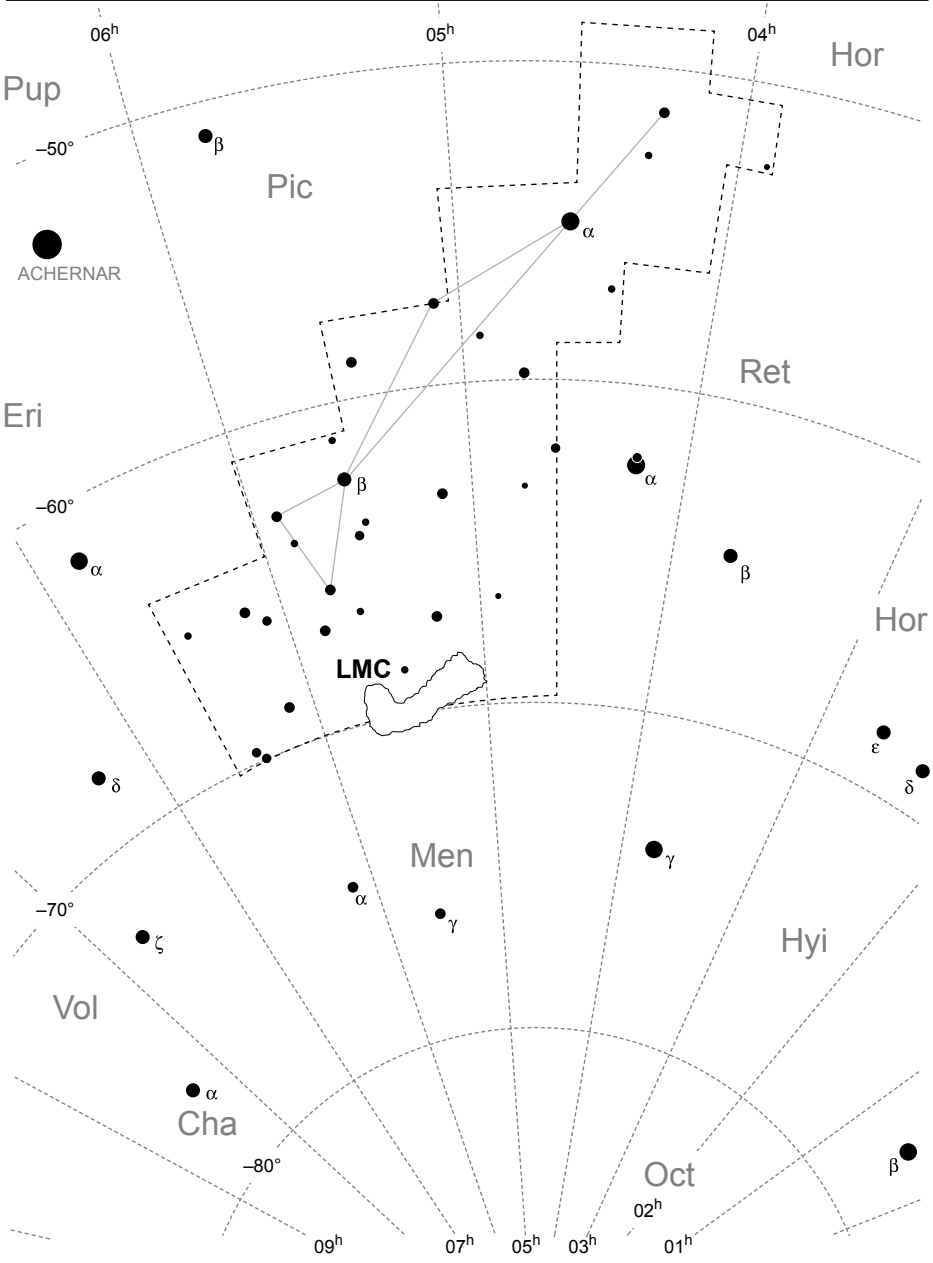
NGC 246, C 56, A 4	00h47m03s –11°52′19″	NGC 1068, M 77, B 9, A 9	02h42m41s –00°00′48″
NGC 247, B 3, C 62, A 3	00h47m09s –20°45′38″		

Dorado

The Swordfish

Dor, Doradus
05h10m, –61°

Visibility: Year-round; best late Oct through Feb
Culmination: Feb 03 (21:00), Dec 20 (00:00), Nov 04 (03:00)
N★ 29
Origin: Keyser & de Houtman (1597)



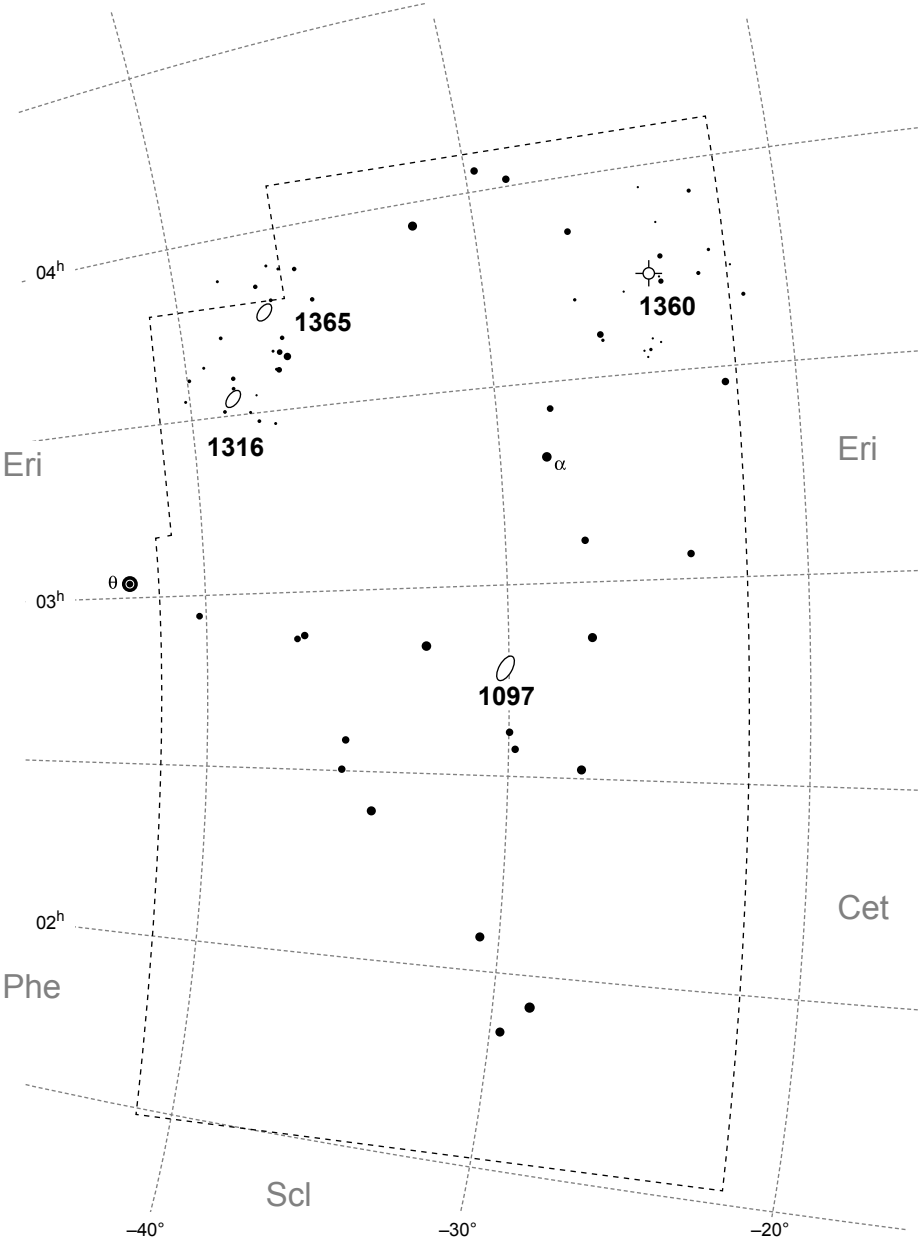
LMC, A 16	05h24m	–69°45′

Fornax

The Chemical Furnace

For, Fornacis
02h45m, –32°

Visibility: Mid-June to April (early Sep to Jan)
Culmination: Dec 28 (21:00), Nov 13 (00:00), Sep 29 (03:00)
N★ 59
Origin: La Caille (1752)



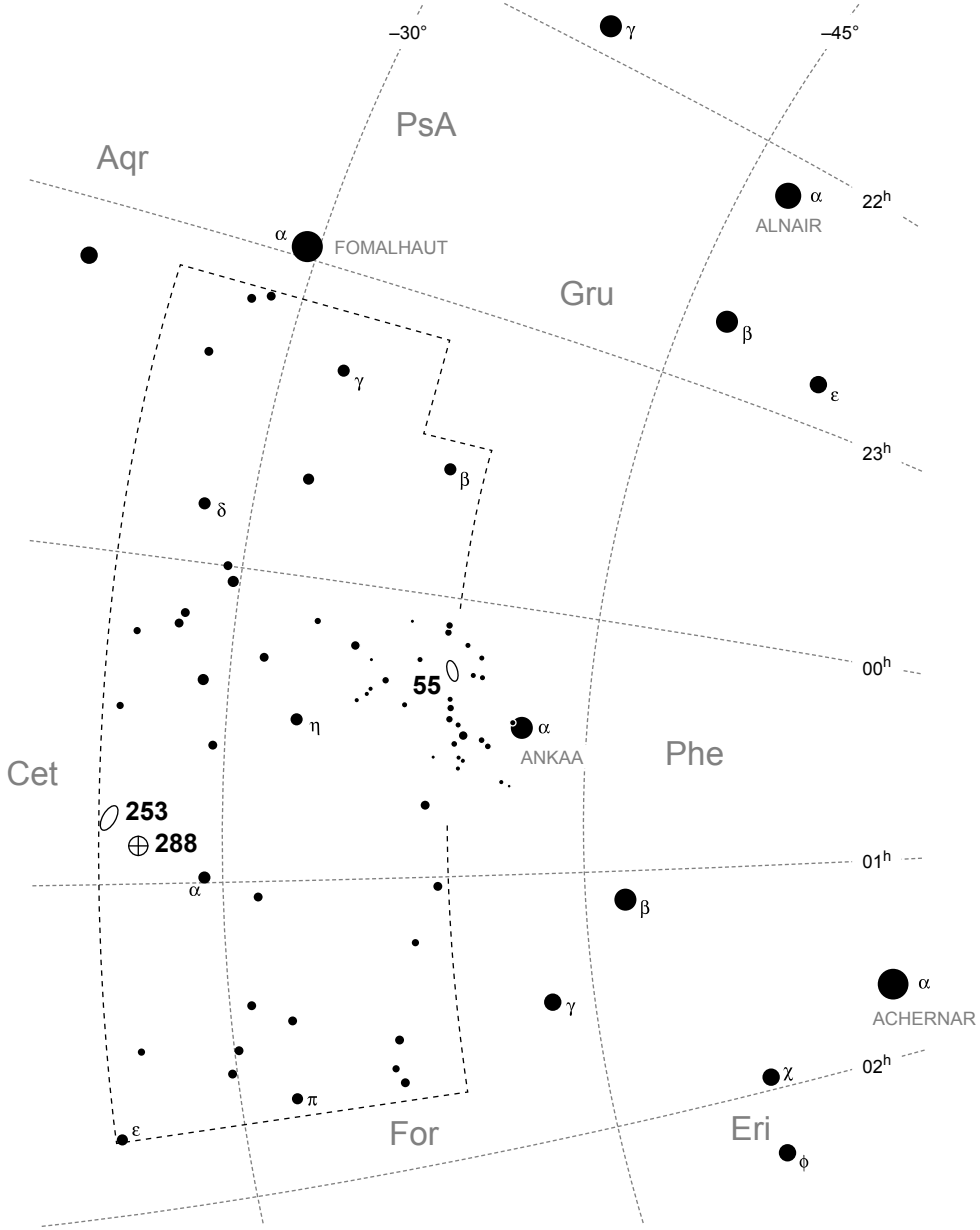
NGC 1097, B 10, C 67	02h46m19s –30°16′29″	NGC 1360, B 15	03h33m15s –25°52′18″
NGC 1316, B 14, A 12	03h22m42s –37°12′34″	NGC 1365, B 16, A 13	03h33m36s –36°08′28″

Sculptor

The Sculptor's Workshop

Scl, Sculptoris
00^h20^m, –32°

Visibility: May to late February (late Jul to late Nov)
Culmination: Nov 21 (21:00), Oct 07 (00:00), Aug 22 (03:00)
N★ 52
Origin: La Caille (1752)



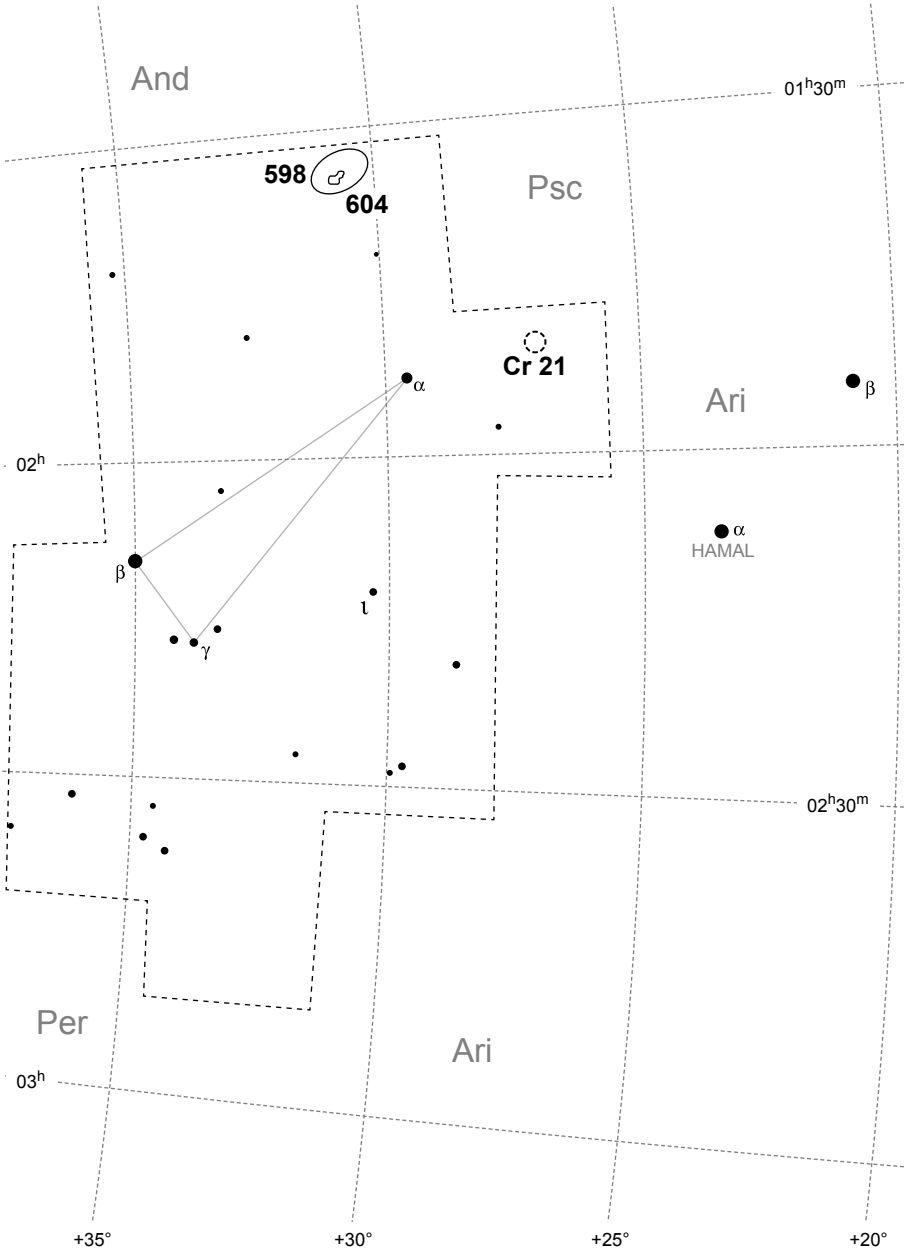
NGC 55, B 1, C 72, A 1	$00^h14^m54^s$ –39°11′55″	NGC 288, B 5, A 6	$00^h52^m45^s$ –26°34′51″
NGC 253, C 65, A 5	$00^h47^m33^s$ –25°17′18″		

Triangulum

The Triangle

Tri, Trianguli
02h05m, +32°

Visibility: August through early February
Culmination: Dec 18 (21:00), Nov 03 (00:00), Sep 18 (03:00)
N★ 25
Origin: Ancient Greek (Ptolemy)



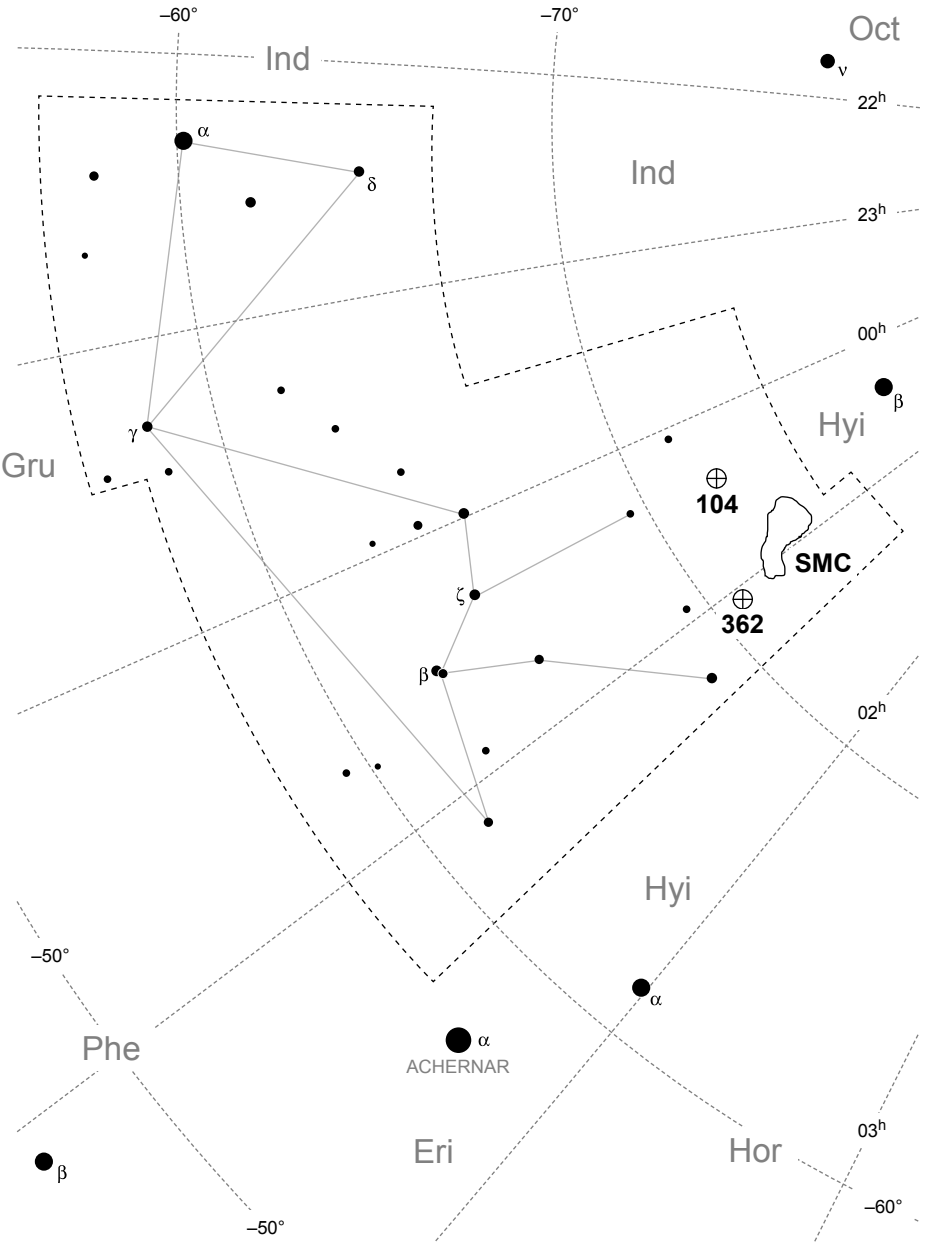
NGC 598, M 33	01h33m51s +30°39′37″	Collinder 21	01h50m12s +27°04′48″
NGC 604	01h34m33s +30°47′06″	iota Tri, HD 13480	02h12m22s +30°18′11″

Tucana

The Toucan

Tuc, Tucanae
23^h50^m, –64°

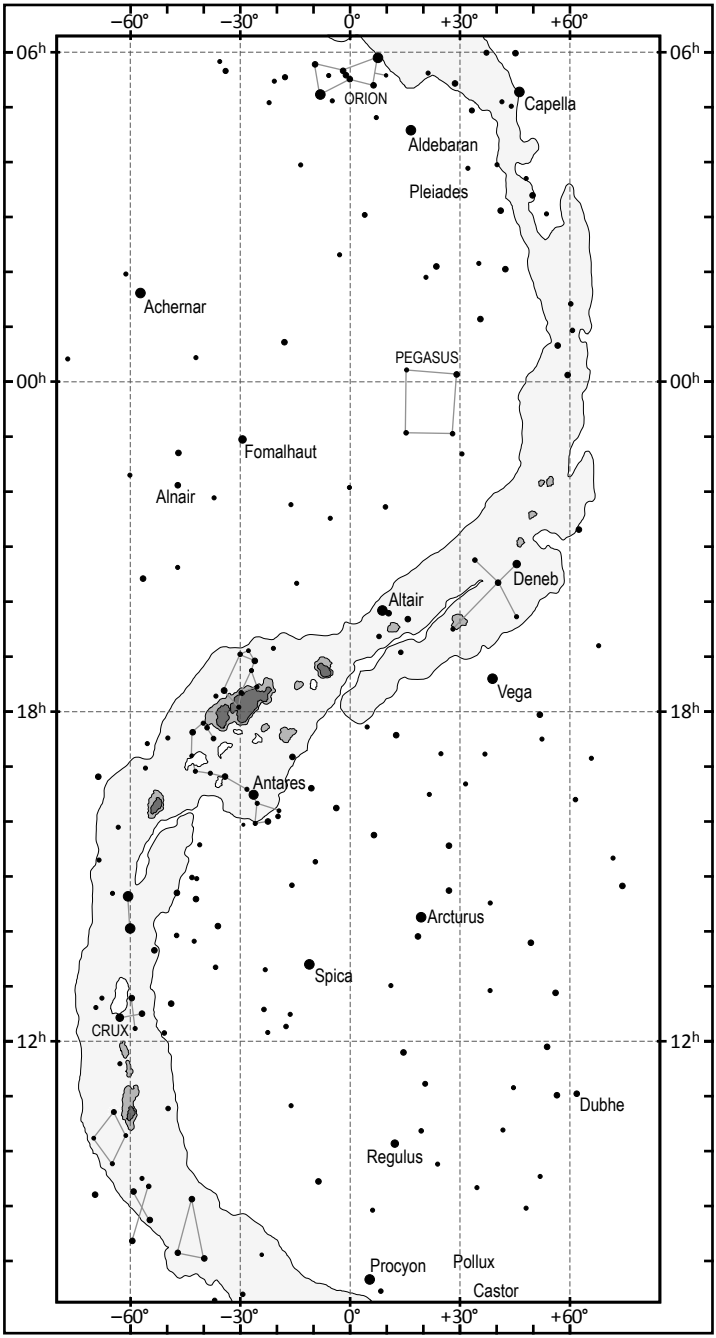
Visibility: Year-round; best July through November
Culmination: Nov 14 (21:00), Sep 30 (00:00), Aug 15 (03:00)
N★ 45
Origin: Keyser & de Houtman (1597)



⊕ NGC 104, 47 Tuc, C 106, A 2	$00^h24^m06^s$ –72°04′53″	⊕ NGC 362, B 7, C 104, A 8	$01^h03^m14^s$ –70°50′54″
SMC, A 7, (NGC 292)	$00^h52^m38^s$ –72°48′01″		

The Milky Way

Galactic centre: RA 17h 46m, Dec −29° 00′
Galactic anticentre: RA 05h 46m, Dec +29° 00′



The outline of the Milky Way is shown in the accompanying diagram, at three brightness contours. The faintest (outer) contour shows 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 [18h, −30°], the Scutum Star Cloud [18h45m, −07°], the Norma Star Cloud [16h15m, −54°], and the region around eta Carinae [10h45m, −60°].

An intermediate contour level shows the next-brightest regions, mostly surrounding the star clouds just mentioned, with noticeable zones in Cygnus, Aquila, Ophiuchuis and Centaurus.

The most indistinct portion of the Milky Way is around the Anti-centre, 180° away from Sagittarius, along the Taurus-Auriga border.

Noticeable dark patches include the Coal Sack near Crux and the Pipe Nebula in Ophiuchus [17h30m, −26°].

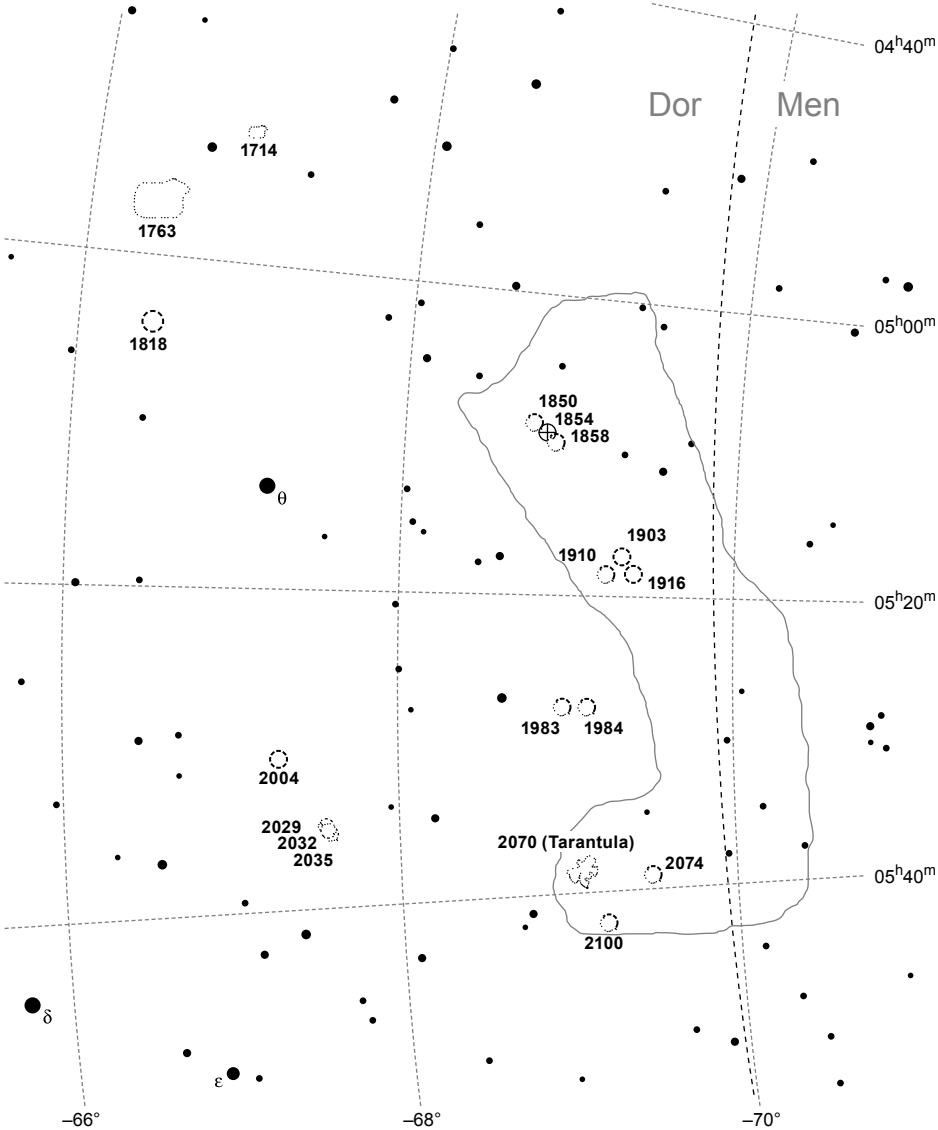
Extensive dark regions include the Great Rift (stretching from Sagittarius past Altair towards Deneb) and the Great Llama (from epsilon Scorpii towards the Coal Sack, with alpha and beta Centauri seen as the Eyes of the Llama). The Great Llama is known as the Dark Emu to certain Aboriginal peoples.

Large Magellanic Cloud

LMC 05h25m, –70°

Visibility: Year-round; best early October to mid-March
Culmination: Feb 06 (21:00), Dec 23 (00:00), Nov 08 (03:00)

★★★★★



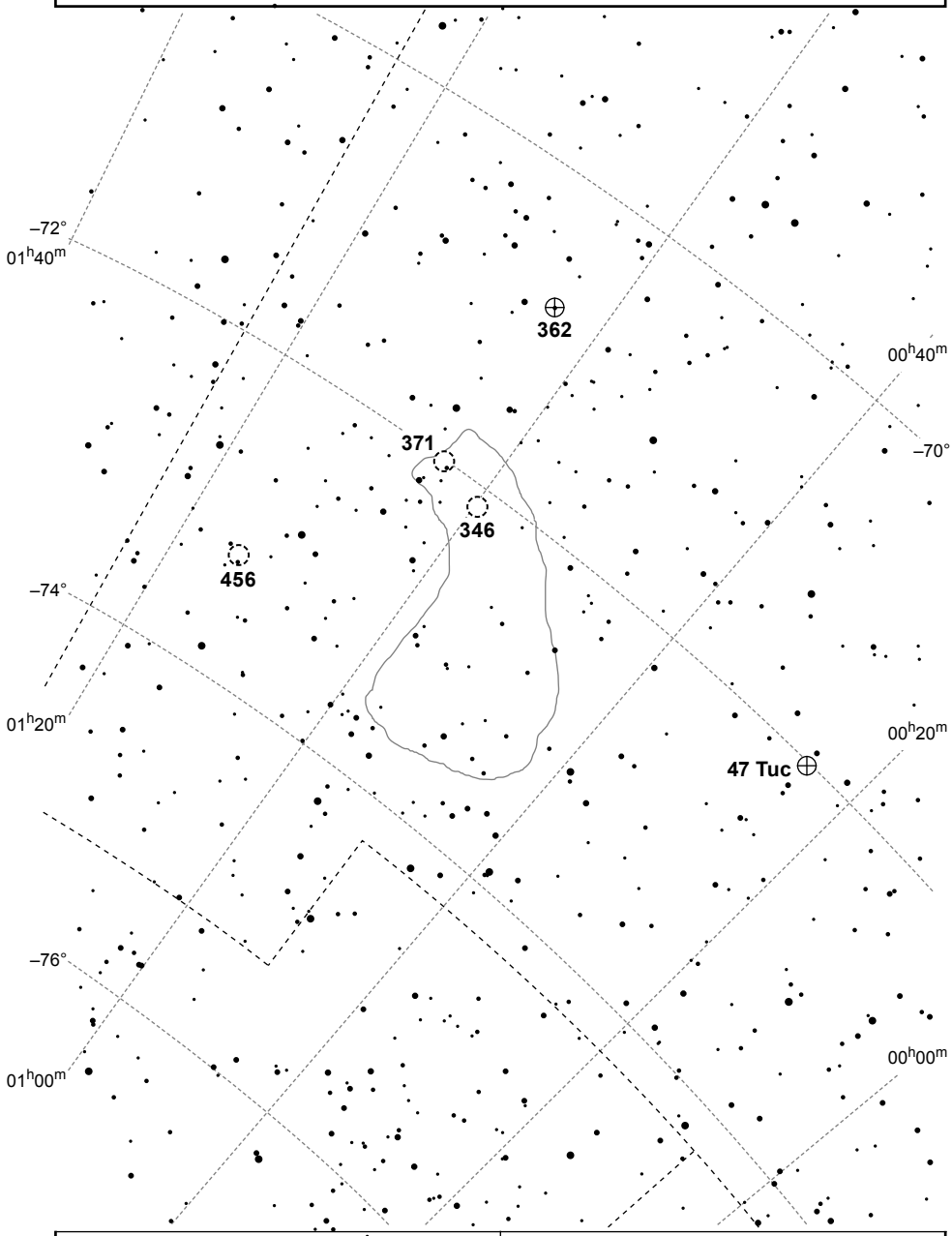
NGC 1714 04h52m08s –66°55′23″	NGC 1903 05h17m22s –69°20′16″	NGC 2032 05h35m24s –67°35′01″
NGC 1763 04h56m52s –66°24′25″	NGC 1916 05h18m38s –69°24′23″	NGC 2029 05h35m29s –67°34′06″
NGC 1818 05h04m14s –66°26′02″	NGC 1910 05h18m43s –69°14′12″	NGC 2035 05h35m32s –67°35′06″
NGC 1850 05h08m46s –68°45′39″	NGC 1984 05h27m41s –69°08′05″	NGC 2070 05h38m42s –69°06′00″
NGC 1854 05h09m20s –68°50′53″	NGC 1983 05h27m48s –68°59′12″	NGC 2074 05h39m03s –69°29′54″
NGC 1858 05h09m56s –68°54′06″	NGC 2004 05h30m40s –67°17′14″	NGC 2100 05h42m09s –69°12′44″

Small Magellanic Cloud

SMC 00h55m, –73°

Visibility: Year-round; best mid-July to mid-January
Culmination: Nov 30 (21:00), Oct 16 (00:00), Aug 31 (03:00)

★★★★☆



NGC 346	00h59m04s –72°10′42″	NGC 456	01h13m42s –73°17′30″
NGC 371	01h03m30s –72°03′18″		

A checklist for composing descriptions of deep-sky objects

These guidelines will help you to get the most out of your observing sessions by providing a checklist of things to look out for when you examine a deep-sky object. The checklist is not meant as a rigid thought-constraining framework, but rather as a tool to make sure you don't forget to note a particular aspect.

Nebulae

* What are your first impressions?
* How easy is it to see? (visibility; brightness; magnitude)
* What shape is the nebula?
* How big is the nebula?
* How does the brightness change from edge to centre? (brightness profile)
* Is there a nuclear region?
* Are the edges sharp or diffuse?
* Are there darker parts or areas of uneven brightness?
* How well does the nebula stand out from the background field?
* What colour is the nebula?
* Are there stars very near, or within, the nebula?
* How does it relate to the surrounding star field?
* Rate your confidence in this observation.

Star clusters

* What are your first impressions?
* How easy is it to see? (visibility; brightness; magnitude)
* What shape is the cluster?
* How big is the cluster?
* Are individual stars seen? (unresolved ... granular ... partially resolved ... well resolved, etc.)
* Are the stars concentrated towards the centre? (not at all ... slightly ... strongly, etc.)
* How does the brightness change from edge to centre? (brightness profile)
* How many stars can you see? (make an estimate; count the number within a specified diameter)
* What is the range of their brightness? (nearly the same ... mixed; estimate magnitudes)
* Is there an obvious central or other prominent star?
* Do any of the stars have a particular colour?
* Are any of the stars double?
* Are there chains, rows, or clumps of stars?
* Are there prominent empty spaces or starless patches?
* Is there a background glow (unresolved stars/nebulosity)?
* How does the cluster relate to the surrounding star field?
* Rate your confidence in this observation.

Acknowledgements

A long list of folk responded with insights and helpful suggestions to an earlier version of the list that I circulated. Thanks for sharing your expertise. In order of the number of characters in their name, they are: Steve Coe, David Levy, Dave Kratz, Lew Gramer, Dennis Webb, Bert Dekker, Brian Skiff, Tom Polakis, Doug Snyder, Marilyn Head, Tom Lorenzin, Owen Brazell, Alan McRobert, Murray Cragin, John Callender, Steve Gottlieb, Brent Archinal, Darren Bushnall, Phil Harrington, and Malcolm Thomson.

Object ..... Instrument .....

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Sky conditions ..... Date & time .....

Observation quality ..... Location .....

Description .....

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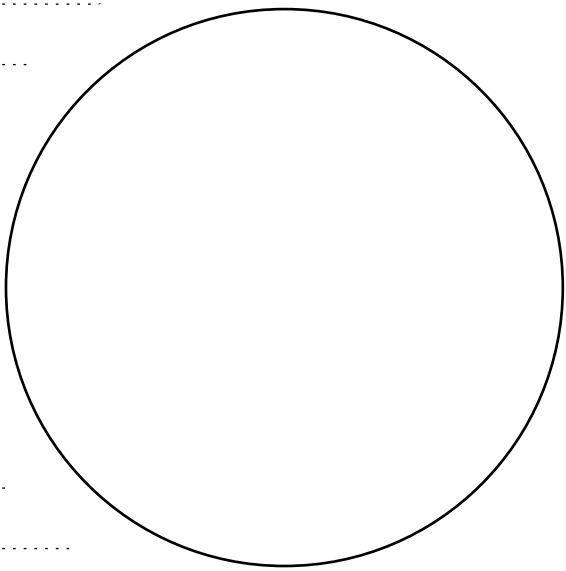

blue	blue white	white	yellow white	light yellow	deep yellow	light orange	deep orange	orange red	red

