NWASNEWS

Volume25, Issue 7

March 2020

Newsletter for the Wiltshire, Swindon, Beckington Astronomical Societies

Big Explosions in Space and on Launchers

A large news section this month, mainly because the NASA papers are coming in for work to continue on after March and the annual budget pleas for academics.

Venus has been putting on a fine show for us setting in the west and morning views now have Jupiter, Saturn and Mars low to the south east (behind trees from home.

My concern with the skylink 3000+ satellites are making more astronomers scream foul, and Elon Musk has slid over that part of his Space X business into a new business, with means he is feeling pressure. Another 5 nations are looking at getting into the some satellite constellations. Will the lid be shut. Britain's answer to Galileo GPS has been side-lined but this is because of technical and budget issues.

Failures at the launch site pressure tests for SpaceX starlift vehicles are also putting pressure on. It isn't easy. Also a new rocket (Rocket 3) launching from Alaska is meeting postponements through technical issues.

In astronomy the announcement of the biggest explosion ever discovered from Chandra X ray telescopes and analysis from 10 years ago is showing something big happened in a galaxy 6,500 light years away.

NASA has announced a job suitable for Peter Chappell, growing fresh vegetables in a greenhouse on board space orbiter vehicles.

Meanwhile I have been doing more tests with filters on DSLR cameras, and the suitability under different conditions of light pollution and Moonshine across different nebulosity of objects. But the Optilong Lenhancement and LPro sensor cover are producing surprisingly good images.

It is a shame the February window for Messier Marathon challenge come and went with the Friday observing session being a wash out. I have included a viewing list in this newsletter, and an attempt for March could be made at new Moon. A few will be missed due to the position of the Sun, but 90 odd could be possible.

Perhaps our returning speaker Dr Lilian Hobbs could offer us an armchair solution in tonight's talk.

Clear skies   Andy Burns.

Venus setting behind Silbury hill (and rising up through the relfection in the moat.

Startrails and helicopter.

Andy

Wiltshire Society Page

Wiltshire Astronomical Society

Web site: www.wasnet.org.uk

Facebook members page: https://www.facebook.com/groups/wiltshire.astro.society/

Meetings 2018/2019Season.

NEW VENUE the Pavilion, Rusty Lane, Seend

Meet 7.30 for 8.00pm start

Membership Meeting nights £1.00 for members £3 for visitors

Wiltshire AS Contacts

Andy Burns Chair, anglesburns@hotmail.com

Andy Burns Outreach and newsletter editor.

Bob Johnston (Treasurer) Debbie Croker (vice Treasurer)

Philip Proven (Hall coordinator) Dave Buckle (Teas)

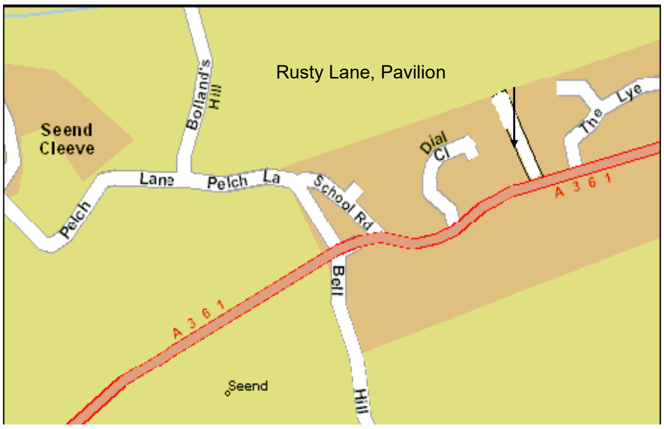
Peter Chappell (Speaker secretary)

Nick Howes (Technical Guru)

Observing Sessions coordinators: Chris Brooks, Jon Gale,

Web coordinator: Sam Franklin

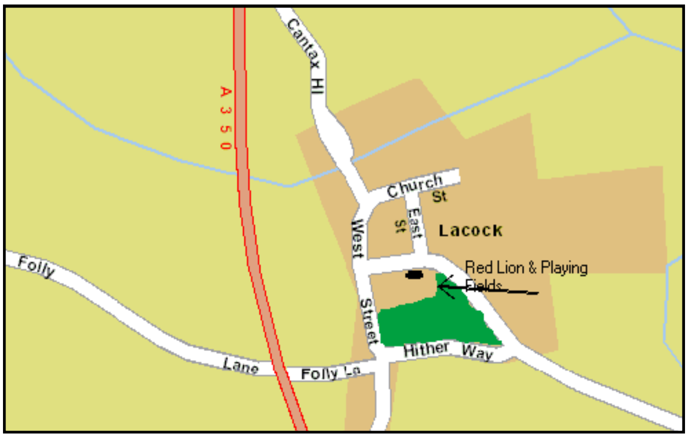
Contact via the web site details.



NEW SEASON 2019/2020
2020

3rd Mar Dr Lilian Hobbs 'Armchair Messier Marathon'.
7th Apr Pete Williamson 'The Moon and Moons of the Solar System'.
5th May Martin Griffiths 'The Habitable Zone – What is it and How is it determined'.
2nd Jun Paul Money 'Triumphs of Voyager (part 2) – Where no probe has gone before'.

Observing Sessions see back page



Dr Lilian Hobbs

I have been interested in Astronomy for many years. My first telescope, a small refractor, was purchased from Dixons and served me very well. I still have a paperweight containing my first astro photograph, the moon. Since then I have purchased several telescopes and I currently like Meade, Celestron , Takahashi & TMB Telescopes.

The Meade ETX/EC-90 or the 125 , is ideal for travelling and I have taken my 90 on several business trips which enabled me to see the transit of Mercury. Under clear skies, the views in the ETX are great and I highly recommend it.

My other telescopes include a TMB 7" and an Astro-Physics 4.75" refractor on a Paramount ME mount which is housed in a dome and is being used to observe deep-sky objects. There is another dome with houses a Celestron 11" on an NEQ6 which is used for planetary imaging. For wide-field imaging I use a Takahashi FS60. I also have a Coronado Nearstar and a Solarmax 90 filter to observe solar prominences.

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Swindon's own astronomy group

March meeting

Our meeting on the 20 March will be our AGM and this will be followed by a talk called 'The Red Planet' by Dr Bob Gatton who has been an active member of the club since 2013.

Ad-hoc viewing sessions

Regular stargazing evenings are being organised near Swindon. To join these events please visit our website for further information.

Lately we have been stargazing at Blakehill Farm Nature Reserve near Cricklade, a very good spot with no distractions from car headlights.

We often meet regularly at a lay-by just outside the village of Uffcott, near Wroughton. Directions are also shown on the website link below.

Information about our evenings and viewing spots can be found here:

http://www.swindonstargazers.com/noticeboard/noticeboard06.htm

For insurance reasons you need to be a club member to take part.

If you think you might be interested email the organiser Robin Wilkey (see below). With this you will then be emailed regarding the event, whether it is going ahead or whether it will be cancelled because of cloud etc.

We are a small keen group and I would ask you to note that you DO NOT have to own a telescope to take part, just turn up and have a great evening looking through other people's scopes. We are out there to share an interest and the hobby. There's nothing better than practical astronomy in the great cold British winter! And hot drinks are often available, you can also bring your own.

Enjoy astronomy at it's best!

Meetings at Liddington Village Hall, Church Road, Liddington, SN4 0HB – 7.30pm onwards

The hall has easy access from Junction 15 of the M4, a map and directions can be found on our website at:

http://www.swindonstargazers.com/clubdiary/directions01.htm

Meeting Dates for 2020

Friday 20 March
Programme: AGM / Bob Gatton: The Red Planet

Friday 17 April
Programme: Gary Poyner - Variable Stars around the Perseus Double Cluster

Friday 15 May
Programme: Mike Foulkes: Herschel's Planet

Friday 19 June
Programme: Graham Bryant - Pluto from Myth to Discovery

-------Summer Break------

Friday 18 September

Programme: Ian Smith - Narrowband Imaging

Friday 16 October

Programme: Dr James Fradgley MSc, FRAS: The Universe - 'A brief overview of what we know, or think we know'

Friday 20 November

Programme: Dave Eagle FRAS PGCE BSc (Hons): 'Comets, Enigmatic and Beautiful Visitors'

Website:

http://www.swindonstargazers.com

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dark sky wales
dywyllwch awyr cymru

The Night Sky in March 2020

Martin Griffiths

The bright winter constellations are fading and the spring groups begin to dominate with the promise of lots of galaxies. Planets dominate the morning sky in March whilst Venus still rides high in the west after sunset.

Moon in March
New: 24th March
First quarter: 2ndMarch
Full: 9th March
Last Quarter: 16thMarch

Planets in March

Mercury: is at greatest western elongation on the 24th of the month where it will shine as a bright star-like object on the eastern horizon before sunrise.

Venus: moves into Aries toward the month's end and is getting brighter at magnitude -4 and is still unmistakable as a bright white star-like object in the west. It is at greatest eastern elongation on the 24th and is a slim crescent through the telescope.

Mars: is an early morning object in the constellation of Sagittarius, rising at 02:00 by mid month and shining feebly at magnitude 0.9.

Jupiter: Is still in Sagittarius rising about the same time as Mars and although shining at magnitude -1.9 it is not at its best until later in the year

Saturn: Is in Capricorn and rises with Mars and Jupiter but is a dim object shining at magnitude 0.7 though its rings can still be seen well.

Uranus: is in the constellation of Aries shining at magnitude 5.9 and setting by 20:00.. It can be seen as a small disk in a moderate telescope.

Neptune: can be found in Aquarius but it is in conjunction with the sun on the 8th March so not well placed this month.

Meteor showers in March

There are no major showers this month

Interesting Events in March

Mars is within half a degree of the moon on the 18th March and two days later on the 20th, Jupiter is also very close to the crescent moon. All three make a good photo opportunity at this conjunction.

The vernal equinox, marking the passing of the Sun through the Equator occurs on the 20thMarch.at 04:00.

The minor body Interamnia is at opposition on the 21st March. Finder charts can be found online.

Comets in March

There are no bright comets reported for observation this month though Comet 2017 T2 PanSTARRS remains a target for northern observers though it is beginning to fade. It continues into Cassiopeia and finder charts can be obtained online.

Constellation of the Month: Hydra

Hydra is the longest and most sinuous constellation in the whole sky. In fact so long is it that its head is visible in winter, and its tail disappears mid-way through summer! Despite its length, Hydra is a constellation of faint stars, none of which rise to more than second magnitude. However, the head of Hydra is very distinctive, and once found, becomes the gateway to tracing out the rest of the constellation. Hydra lies under the constellations of Leo, Corvus, Crater and Virgo, but despite its association with such rich constellations, it does not have many deep sky objects of interest to the casual observer. In mythology, the Hydra is a snake associated in Babylonian records with waters and fountains and is the sign of the goddess Tiamat. In Greek mythology, Hercules killed this legendary monster as one of his 12 labours.

One of the finest deep sky wonders in Hydra is the star cluster M 48 which is a large irregular cluster of 50 or so stars in a fairly rich field close to the Milky Way, and lies adjacent to the constellation's border with Monoceros. M 48 shines at magnitude 5.5; its stars are mostly A type giants which have a visual magnitude of 9th to 13th mag. The cluster lies 1500 light years away, and is famous in the Messier catalogue for its spurious position. The cluster in fact lies over 5 degrees away from the position Messier indicated. A beautiful sight in a small telescope or binoculars, and may even be visible to the naked eye on a night of exceptional "seeing".

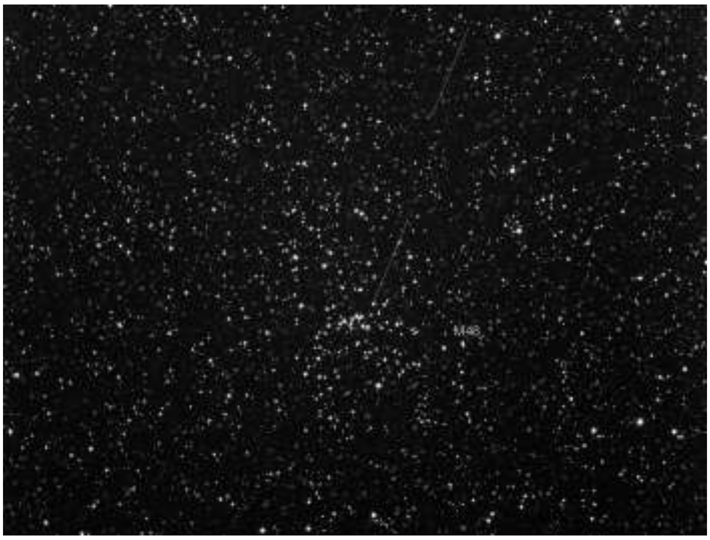


Photo Andy Burns

The next deep sky object deserving of attention is probably one of the most beautiful planetary nebulae in the night sky. This is NGC 3242 at RA 10h 24m 48s Dec -18°38m, an eighth magnitude disc of light that resembles the disc of a planet more than any other planetary in the sky. This object has on occasion been called the "Ghost of Jupiter" due to its uncanny resemblance. It lies over 2000 light years away, and is a marvellous sight in a small telescope, on high powers its lovely blue disc fills the field, and subtle shading indicates the presence of gaseous shells. This planetary can even be seen in binoculars on a good night, as a tiny star like disc.

The real showpiece of Hydra sadly, is not seen very well from Britain. This is the barred spiral galaxy M 83, which shines at eighth magnitude, but due to its southerly declination is extremely faint from these latitudes. It can be seen as an elongated blur of bluish light in a telescope, but binoculars may well provide a better view. M83 is relatively close by, only 10 million light years away, and may be an outlying member of our local group.

There are two globular clusters visible in Hydra, both rather unremarkable objects due to their southern aspect. One is M 68, a bright globular which shows little detail in a small telescope, but can be discerned as a 7th magnitude smudge of white light above the tail of Hydra. The other object is NGC 5694, which at magnitude 11 is beyond the grasp of most amateur instruments. It is another globular of fame, being very distant, and practically outside the confines of our galactic halo, on a par with NGC 2419 in Lynx. Hydra contains many double stars of note, but recourse to an album such as the Webb Deep Sky Society's Binary Star handbook is recommended.

BECKINGTON ASTRONOMICAL SOCIETY

Society Details & Speakers programme can be found on our Website www.beckingtonas.org

General enquiries about the Society can be emailed to chairman@beckingtonas.org.

Our Committee for 2016/2017 is

Chairman: Steve Hill (email chairman@beckingtonas.org)
Treasurer: John Ball
Secretary: Sandy Whitton
Ordinary Member: Mike Witt

People can find out more about us at www.beckingtonas.org

Meetings take place in Beckington Baptist Church Hall in Beckington Village near Frome.

See the location page for details of how to find us on our website…………

Post Code for Sat Nav is BA11 6TB.

Our start time is 7.30pm

Date	**Title**	**Speaker**
20th March	*TBA*	Steve Hill
17th April	*Planetarium in the Bedroom*	Lilian Hobbs
15th May	*It's Not Rocket Science*	Martin Budzynski
19th June	Annual General Meeting *Member Talks*	

STAR QUEST ASTRONOMY CLUB

This young astronomy club meets at the
Sutton Veny Village Hall.
Second Thursday of the Month.

THE MESSIER MARATHON

Messier Marathon is a term describing the attempt to find as many Messier objects as possible in one night. Depending on the location of the observer, and season, there is a different number of them visible, as they are not evenly distributed in the celestial sphere. There are heavily crowded regions in the sky, especially the Virgo Cluster and the region around there, while other regions are virtually empty of them. In particular, there are no Messier objects at all at Right Ascensions 21:40 to 23:20, and only the very northern M52 is between RA 21:40 and 0:40. This chance effect leads, at considerably low northern latitudes on Earth (best around 25 degrees North), to the chance to observe all 110 Messier objects in one night! This opportunity occurs once every year, around mid- to end-March; the best time to try is of course when the Moon is near its new phase. For the upcoming years until 2050, we give best Messier Marathon dates here.

Note: Most Messier Marathoners accept NGC 5866 as M102, either in account of historical evidence, or at least as substitute accepted for the Messier Marathon, and thus arrive at actually 110 different objects. We recommend to do so, but you decide what you want to do.

Messier Marathon was invented independently by several North American (including **Tom Hoffelder**, **Tom Reiland** and **Don Machholz**) and perhaps one Spanish amateur astronomers and groups, in the 1970s. It was probably first in the night of March 23/24, 1985 that **Gerry Rattley** from Dugas, Arizona, completed the list and hunted down all 110 Messier Objects in one night; while he was the first to achieve this goal, it was only about one hour later that **Rick Hull** duplicated this success from Anza, California. This is however possible only under exceptionally good observing conditions, and at a preferred location. Anyway, some Messier Marathon tips may help to be [even] more successful with this endeavor, i.e., see one or a few objects more.

Meanwhile, a number of clubs started to hold more considerable Messier Marathon events, notably in Arizona. In 1981, the **Saguaro Astronomy Club (SAC)** held their first Messier Marathon with about 40 participants, the first in a row of meanwhile 21 events (as of 2009) sponsored by this club; Gerry Rattley's first 110 objects success of 1985 happened on their fourth event. Since 1993, SAC sponsors the famous **All Arizona Messier Marathons** held annually near Arizona City and organized by **A.J. Crayon**. Other clubs throughout the world are also holding their Messier Marathon events semi-annually.

The more complete Messier Marathon history can be found in **Don Machholz**'s booklet, *The Messier Marathon Observer's Guide* (Machholz 1994), or its newer edition or successor, *The Observing Guide to the Messier Marathon* (Machholz 2002), which moreover gives a most useful proposition for the search sequence. It also points out that less complete Messier Marathons may be run at every time in the year, the percentage depending on location and time.

Southerners may prefer other marathons. For the time around September each year, there is another 110-object marathon for mid-northern observers, the Messier Plus Marathon (compiled by Wally Brown and Bob Buckner). Experienced observers have compiled more massive lists for marathoning up to over 500 objects a night; Don Machholz reports that he hunted down 599 deep-sky splendours in one night !

Since their invention, Messier Marathons had to face some opposition. As Don Machholz points out, the major complaint is that "rushing through a Messier [or other] list does not allow to study each" object seriously. However, as nothing prevents you from returning to them, and studying them with more time, in other nights, "such criticism can be ignored, since the Messier Marathon is not designed for everyone. The critic can spend the night looking at a shorter list of wonders. A counterpoint to this resistance is that the Marathoner will see nearly all the Messier Catalogue in one night -- many amateur astronomers [and even more professionals, believe me - hf :-)] never see the whole catalogue in their whole lifetime. Additionally, one's searching and locating skills, necessary in most aspects of astronomy, are sharpened during the Marathon. The benefit of seeing, in one night, the major building blocks of our Galaxy: open and globular clusters, diffuse and planetary nebulae, along with other galaxies, cannot be ignored. Finally, there is a satisfaction of working with others toward a common goal, and then finally achieving it [hopefully !]." Rumours say that there are some hardliners who feel the same satisfaction when they do it alone...

Marathons are of course enriched if other appealing celestial events can fill in the pauses which normally occur if you have hunted down everything you can at a time, and wait for the morning objects to rise. In 1997, the outstanding naked-eye comet Hale-Bopp (C/1995O1) gave an extraordinary spectacle exactly at Messier Marathon time in March and April, to celebrate the Messier Marathon's 20th birthday, similar to 1996's Hyakutake (C/1996B2). In 1998, there was no such bright comet, but a considerable supernova, SN 1998S in NGC 3877 (in Ursa Major), had timely occurred and brightened up to 12th magnitude to enrich the Messier Marathon. In 2002, there occurred two remarkable add-ons just in time: the most remarkable supernova 2002ap occurred in M74 in late January, and comet C/2002 C1 (Ikeya-Zhang) was discovered, and brightened to naked-eye visibility in March and April! In 2006, supernova 2006X flashed up in M100 in early February, as for 2009 did SN 2008in in M61, giving an interesting addition of the marathon. We don't know in advance what extras will give future Messier Marathons additional value, but intend to provide the relevant information here as soon as it is available.

The Messier Marathon Search Sequence

compiled online by Hartmut Frommert, using work of Don Machholz. Depending on geographic location, it may be impossible to find them all, and may be better to slightly modify this list. In case of doubt consult Don Machholz's book. This list should be good for northern latitudes 20 to 40.

Ord	M#	NGC	Con	Type	RA	Dec	Mag	Size	Distance
1.	M77	1068	Cet	5	02 42.7	-00 01	8.9	7x6	60000
2.	M74	628	Psc	5	01 36.7	+15 47	9.4	10.2x9.5	35000
3.	M33	598	Tri	5	01 33.9	+30 39	5.7	73x45	3000
4	M31	224	And	5	00 42.7	+41 16	3.4	178x63	2900
5.	M32	221	And	6	00 42.7	+40 52	8.1	8x6	2900
6.	M110	205	And	6	00 40.4	+41 41	8.5	17x10	2900
7.	M52	7654	Cas	1	23 24.2	+61 35	7.3	13.0	5.0
8.	M103	581	Cas	1	01 33.2	+60 42	7.4	6.0	8.5
9.	M76	650	Per	3	01 42.4	+51 34	10.1	2.7x1.8	3.4
10.	M34	1039	Per	1	02 42.0	+42 47	5.5	35.0	1.4
11.	M45	-	Tau	1	03 47.0	+24 07	1.6	110.0	0.38
12.	M79	1904	Lep	2	05 24.5	-24 33	7.7	8.7	42.1
13.	M42	1976	Ori	4	05 35.4	-05 27	4.0	85x60	1.6
14.	M43	1982	Ori	4	05 35.6	-05 16	9.0	20x15	1.6
15.	M78	2068	Ori	4	05 46.7	+00 03	8.3	8x6	1.6
16.	M1	1952	Tau	9	05 34.5	+22 01	8.4	6x4	6.
17.	M35	2168	Gem	1	06 08.9	+24 20	5.3	28.0	2.8
18.	M37	2099	Aur	1	05 52.4	+32 33	6.2	24.0	4.4
19.	M36	1960	Aur	1	05 36.1	+34 08	6.3	12.0	4.1
20.	M38	1912	Aur	1	05 28.4	+35 50	7.4	21.0	4.2
21.	M41	2287	CMa	1	06 46.0	-20 44	4.6	38.0	2.3
22.	M93	2447	Pup	1	07 44.6	-23 52	6.0	22.0	3.6
23.	M47	2422	Pup	1	07 36.6	-14 30	5.2	30.0	1.6
24.	M46	2437	Pup	1	07 41.8	-14 49	6.0	27.0	5.4
25.	M50	2323	Mon	1	07 03.2	-08 20	6.3	16.0	3
26.	M48	2548	Hya	1	08 13.8	-05 48	5.5	54.0	1.5
27.	M44	2632	Cnc	1	08 40.1	+19 59	3.7	95.0	0.577
28.	M67	2682	Cnc	1	08 50.4	+11 49	6.1	30.0	2.7
29.	M95	3351	Leo	5	10 44.0	+11 42	9.7	4.4x3.3	38000
30.	M96	3368	Leo	5	10 46.8	+11 49	9.2	6x4	38000
31	M105	3379	Leo	6	10 47.8	+12 35	9.3	2.0	38000
32.	M65	3623	Leo	5	11 18.9	+13 05	9.3	8x1.5	35000
33.	M66	3627	Leo	5	11 20.2	+12 59	8.9	8x2.5	35000
34.	M81	3031	UMa	5	09 55.6	+69 04	6.9	21x10	12000
35.	M82	3034	UMa	7	09 55.8	+69 41	8.4	9x4	12000
36.	M97	3587	UMa	3	11 14.8	+55 01	9.9	3.4x3.3	2.
37	M108	3556	UMa	5	11 11.5	+55 40	10.0	8x1	45000
38	M109	3992	UMa	5	11 57.6	+53 23	9.8	7x4	55000
39.	M40	Win4	UMa	C	12 22.4	+58 05	8.4	0.8	0.51
40	M106	4258	CVn	5	12 19.0	+47 18	8.4	19x8	25000
41.	M94	4736	CVn	5	12 50.9	+41 07	8.2	7x3	14500
42.	M63	5055	CVn	5	13 15.8	+42 02	8.6	10x6	37000
43.	M51	5194	CVn	5	13 29.9	+47 12	8.4	11x7	37000
44	M101	5457	UMa	5	14 03.2	+54 21	7.9	22.0	27000
45.	M102?	5866	Dra	8	15 06.5	+55 46	9.9	5.2x2.3	40000
46.	M53	5024	Com	2	13 12.9	+18 10	7.6	12.6	59.7
47.	M64	4826	Com	5	12 56.7	+21 41	8.5	9.3x5.4	19000
48.	M3	5272	CVn	2	13 42.2	+28 23	6.2	16.2	33.9
49.	M98	4192	Com	5	12 13.8	+14 54	10.1	9.5x3.2	60000
50.	M99	4254	Com	5	12 18.8	+14 25	9.9	5.4x4.8	60000
51.	M100	4321	Com	5	12 22.9	+15 49	9.3	7x6	60000
52.	M85	4382	Com	8	12 25.4	+18 11	9.1	7.1x5.2	60000
53.	M84	4374	Vir	8	12 25.1	+12 53	9.1	5.0	60000
54.	M86	4406	Vir	8	12 26.2	+12 57	8.9	7.5x5.5	60000
55.	M87	4486	Vir	6	12 30.8	+12 24	8.6	7.0	60000
56.	M89	4552	Vir	6	12 35.7	+12 33	9.8	4.0	60000
57.	M90	4569	Vir	5	12 36.8	+13 10	9.5	9.5x4.5	60000
58.	M88	4501	Com	5	12 32.0	+14 25	9.6	7x4	60000
59.	M91	4548	Com	5	12 35.4	+14 30	10.2	5.4x4.4	60000
60.	M58	4579	Vir	5	12 37.7	+11 49	9.7	5.5x4.5	60000
61.	M59	4621	Vir	6	12 42.0	+11 39	9.6	5x3.5	60000
62.	M60	4649	Vir	6	12 43.7	+11 33	8.8	7x6	60000
63.	M49	4472	Vir	6	12 29.8	+08 00	8.4	9x7.5	60000
64.	M61	4303	Vir	5	12 21.9	+04 28	9.7	6x5.5	60000
65.	M104	4594	Vir	5	12 40.0	-11 37	8.0	9x4	50000
66.	M68	4590	Hya	2	12 39.5	-26 45	7.8	12.0	33.3
67.	M83	5236	Hya	5	13 37.0	-29 52	7.6	11x10	15000
68.	M5	5904	Ser	2	15 18.6	+02 05	5.6	17.4	24.5
69.	M13	6205	Her	2	16 41.7	+36 28	5.8	16.6	25.1
70.	M92	6341	Her	2	17 17.1	+43 08	6.4	11.2	26.7
71.	M57	6720	Lyr	3	18 53.6	+33 02	8.8	1.4x1.0	2.3
72.	M56	6779	Lyr	2	19 16.6	+30 11	8.3	7.1	32.9
73.	M29	6913	Cyg	1	20 23.9	+38 32	7.1	7.0	4.0
74.	M39	7092	Cyg	1	21 32.2	+48 26	4.6	32.0	0.825
75.	M27	6853	Vul	3	19 59.6	+22 43	7.4	8.0x5.7	1.25
76.	M71	6838	Sge	2	19 53.8	+18 47	8.2	7.2	12.7
77.	M107	6171	Oph	2	16 32.5	-13 03	7.9	10.0	20.9
78.	M12	6218	Oph	2	16 47.2	-01 57	6.7	14.5	16.0
79.	M10	6254	Oph	2	16 57.1	-04 06	6.6	15.1	14.4
80.	M14	6402	Oph	2	17 37.6	-03 15	7.6	11.7	29.0
81.	M9	6333	Oph	2	17 19.2	-18 31	7.7	9.3	26.7
82.	M4	6121	Sco	2	16 23.6	-26 32	5.6	26.3	7.2
83.	M80	6093	Sco	2	16 17.0	-22 59	7.3	8.9	32.6
84.	M19	6273	Oph	2	17 02.6	-26 16	6.8	13.5	28.4
85.	M62	6266	Oph	2	17 01.2	-30 07	6.5	14.1	22.5
86.	M6	6405	Sco	1	17 40.1	-32 13	5.3	25.0	2
87.	M7	6475	Sco	1	17 53.9	-34 49	4.1	80.0	0.8
88.	M11	6705	Sct	1	18 51.1	-06 16	6.3	14.0	6
89.	M26	6694	Sct	1	18 45.2	-09 24	8.0	15.0	5
90.	M16	6611	Ser	1	18 18.8	-13 47	6.4	7.0	7
91.	M17	6618	Sgr	4	18 20.8	-16 11	7.0	11.0	5
92.	M18	6613	Sgr	1	18 19.9	-17 08	7.5	9.0	4.9
93.	M24	>6603	Sgr	B	18 16.9	-18 29	4.6	90	10
94.	M25	I4725	Sgr	1	18 31.6	-19 15	6.5	40.0	2
95.	M23	6494	Sgr	1	17 56.8	-19 01	6.9	27.0	2.15
96.	M21	6531	Sgr	1	18 04.6	-22 30	6.5	13.0	4.25
97.	M20	6514	Sgr	4	18 02.6	-23 02	9.0	28.0	5.2
98.	M8	6523	Sgr	4	18 03.8	-24 23	6.0	90x40	5.2
99.	M28	6626	Sgr	2	18 24.5	-24 52	6.8	11.2	18.6
100.	M22	6656	Sgr	2	18 36.4	-23 54	5.1	24.0	10.4
101.	M69	6637	Sgr	2	18 31.4	-32 21	7.6	7.1	28.0
102.	M70	6681	Sgr	2	18 43.2	-32 18	7.9	7.8	29.4
103.	M54	6715	Sgr	2	18 55.1	-30 29	7.6	9.1	88.7
104.	M55	6809	Sgr	2	19 40.0	-30 58	6.3	19.0	17.6
105.	M75	6864	Sgr	2	20 06.1	-21 55	8.5	6.0	61.3
106.	M15	7078	Peg	2	21 30.0	+12 10	6.2	12.3	33.6
107.	M2	7089	Aqr	2	21 33.5	-00 49	6.5	12.9	37.9
108.	M72	6981	Aqr	2	20 53.5	-12 32	9.3	5.9	55.4
109.	M73	6994	Aqr	A	20 58.9	-12 38	9.0	2.8	2.0
110.	M30	7099	Cap	2	21 40.4	-23 11	7.2	11.0	26.1

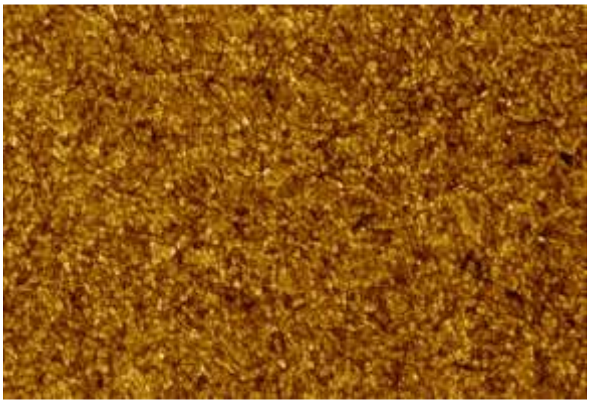
Clear skies and Good Luck

SPACE NEWS FOR March 2020

Our Facebook page carries a lot of these news items throughout the month.

WITHOUT SUNSPOTS, THE SUN IS COVERED WITH....

The sun has been blank for 30 consecutive days--a sign that Solar Minimum is underway. Yesterday, amateur astronomer Mike Wise of Trenton, Florida, took a close look at the sun's surface. He couldn't find a single dark core. Instead, there were thousands of granules:



"The sun was covered with them," he says.

The sun is so hot, it literally boils. Bumps on the boiling surface of the sun are called "granules." You can find granules in your kitchen, too, in a pot of hot water boiling on the stove. One difference: While the granules on your stove are only a few centimetres across, granules on the sun are as wide as Texas.

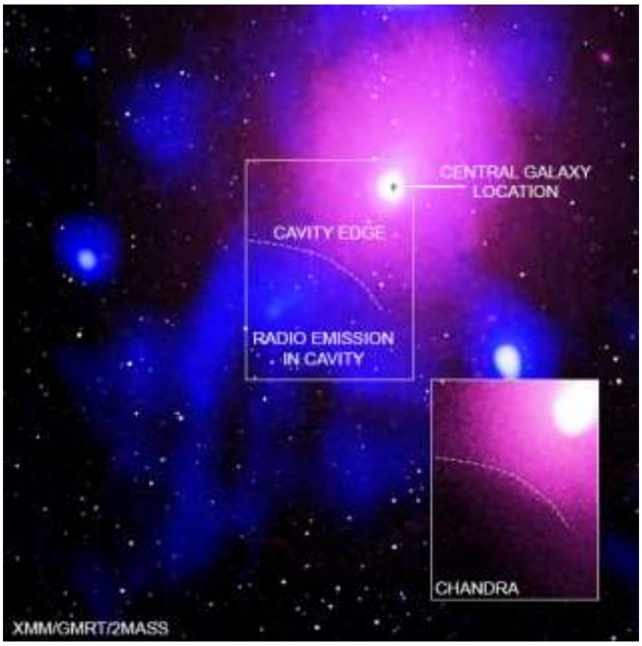
Astronomers Have Recorded the Biggest Explosion Ever Seen in the Universe

Hundreds of millions of light years away, a supermassive black hole sits in the center of a galaxy cluster named Ophiuchus. Though black holes are renowned for sucking in surrounding material, they sometimes expel material in jets. This black hole is the site of an almost unimaginably powerful explosion, created when an enormous amount of material was expelled.

The Ophiuchus galaxy cluster is about 390 million light years away. In the center of the cluster there's a galaxy with a supermassive black hole. Astronomers using data from the Chandra X-Ray Observatory and the ESA's XMM Newton spacecraft saw the black hole's explosion. They also used radio observations from the Murchison Widefield Array (MWA) in Australia and the Giant Metrewave Radio Telescope (GMRT) in India.

The team behind this work published their results in The Astrophysical Journal. Their paper is titled "Discovery of a giant radio fossil in the Ophiuchus galaxy cluster." The paper's lead author is Simona Giacintucci of the Naval Research Laboratory in Washington, DC.

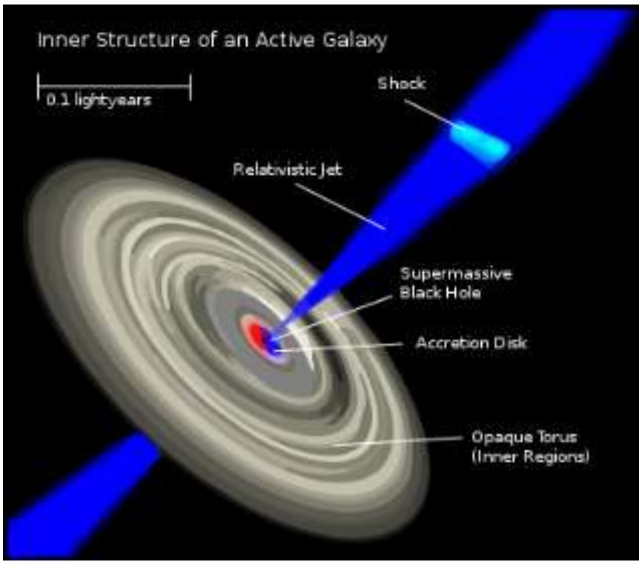
"In some ways, this blast is similar to how the eruption of Mt. St. Helens in 1980 ripped off the top of the mountain," said lead author Giacintucci. "A key difference is that you could fit fifteen Milky Way galaxies in a row into the crater this eruption punched into the cluster's hot gas."



The hole created by the explosion is called a radio fossil. It's carved out of space by the jets or beams of super-heated material that explode out of the black hole and collide with surrounding material. Those jets are the result of what astronomers call an active galactic nuclei, or AGN, which are emitted by black holes that are "feeding." In this case, the carved out area was first spotted in Chandra images of the area as an unusual curved edge. That was first reported in a 2016 paper.

The authors of that paper wondered if a black hole could've produced this curved edge, but discounted that idea, thinking that no black hole could be that powerful. In that paper, they said "We conclude that this feature is most likely due to gas dynamics associated with a merger."

In this new paper, the authors came to a different conclusion. "It thus appears to be a very aged fossil of the most powerful AGN outburst seen in any galaxy cluster."



The inner structure of an Active Galacti Nuclei. By Original: Unknown; Vectorization: Rothwild – Own work based on: Galaxies AGN Inner-Structure-of.jpg,

The amount of energy in the explosion is staggering. It released five times more energy than the previous record holder and hundreds of thousands of times more than typical clusters.

A cross in the labelled version shows where the central galaxy is located. The coolest and densest gas is located about 6500 light years away from the central galaxy. In this image, that corresponds to an area smaller than the cross used to

locate the central galaxy, and the source of the explosion. What's interesting is that if the gas moved that far from the source, then the source black hole would be deprived of fuel for its growth. That in turn would stopped the jets.
According to this new paper, that's exactly what's happened. "The AGN is currently starved of accreting cool gas because the gas density peak is displaced by core sloshing," the authors say. "The sloshing itself could have been set off by this extraordinary explosion if it had occurred in an asymmetric gas core. This dinosaur may be an early example of a new class of sources to be uncovered by low-frequency surveys of galaxy clusters."
Astronomers use the term "sloshing" to describe the displacement of the gas. It's similar to a liquid sloshing around in a container. Sloshing is usually triggered by two galaxy clusters merging, but astronomers think that in this case, the explosion could've caused it.
While the previous 2016 paper was based solely on Chandra X-ray data, the new paper used X-Ray data from the ESA's XMM Newton to spot the unusual curved feature and corroborate it. They also used radio data from two observatories to further examine the region. That data confirmed that the curved edge is indeed the edge of a gigantic radio fossil hole. Key to this are the radio emissions outside the hole, which were accelerated to near-relativistic speeds. A merger couldn't do that; only a massive explosion of material could.
"The radio data fit inside the X-rays like a hand in a glove," said co-author Maxim Markevitch of NASA's Goddard Space Flight Center in Greenbelt, Maryland. "This is the clincher that tells us an eruption of unprecedented size occurred here."
The eruption is in the past now, and astronomers can't see any evidence of continued AGN activity from the black hole. That matches the data which shows the black hole inside a vast bubble of its own making.
"As is often the case in astrophysics we really need multi-wavelength observations to truly understand the physical processes at work," said Melanie Johnston-Hollitt, a co-author from the International Centre for Radio Astronomy in Australia. "Having the combined information from X-ray and radio telescopes has revealed this extraordinary source, but more data will be needed to answer the many remaining questions this object poses."

Another Reminder that Spaceflight is Difficult. Starship Prototype Explodes and Falls Over

SpaceX's *Starship* has been hitting some bumps making its way from the drawing board to space. As the spacecraft element of the Elon Musk's proposed super-heavy launch system, the *Starship* will one day become the workhorse of SpaceX, replacing the *Falcon 9* and *Falcon Heavy* launchers. Unfortunately, another *Starship* prototype recently experienced a structural failure during pressure testing that caused it to explode.
The explosion took place at around 11:00 p.m. EST (0:800 p.m. PST) on Feb. 28th, about an hour after ground crews began loading simulated propellant (liquid nitrogen) into the SN1 prototype. It was here that the liquid oxygen tank violently burst, causing the entire launch vehicle to be tossed a few dozen meters into the air before it came crashing down and burst again on the launch pad.
This was the second time in the past six months that SpaceX lost a prototype vehicle during load testing. This process consists of filling the liquid methane and liquid oxygen (LOX) propellant tanks with a cryogenic liquid to ensure they can withstand being fully-pressurized. The last accident occurred back in November, when the Mk. 1 prototype blew up on the pad, casting its nose cone into the air.
This time around, the SN1 prototype (which had not yet had its nose cone or Raptor engines installed) appeared to have come apart near the bottom. This caused the upper section to be launched into the air and the hull to implode. The top section then came down on its side and experienced a second explosion, this time from the top.
This second explosion was clearly the methane tank (also pressurized with liquid nitrogen), which then shot off and flew about 150 to 300 meters (500 – 1000 ft) from the pad. Several observers who were on the scene captured the explosion on video – including famed NASASpaceFlight member BocaChicaGal, who captured the video shown above.
Mercifully, no injuries have been reported in the area. But the next day, photos taken of the site revealed that very little was left of the SN1 prototype. And while the company did not issue a statement immediately thereafter, Musk responded to the incident on Monday morning (March 2nd) by uploaded a video of the accident on his official Twitter account (shown above).
In true Musk fashion, he also made some cheeky comments that let his followers know that SpaceX was taking this latest setback in stride. In the original Tweet, the video appears with the caption, "So… how was your night?" He later added, "It's fine, we'll just buff it out," and "Where's the Flextape when you need it?"
No word has been given yet how this might affect the overall development of the *Starship* and *Super Heavy* launch system. However, it will mean some changes in terms of time tables. Prior to the accident, Musk had indicated that the SN1 was intended for a full wet dress rehearsal (WDR) with LOX and methane, which was to be followed by a static fire test with a Raptor engine.
Obviously, that won't be happening anymore. However, Musk has also confirmed that his crews are currently focused on finishing work on the next Starship prototype (SN2). If all goes well, SpaceX's ground crews could have the SN2 assembled and ready for testing within a few weeks.

MARCH 1, 2020 BY MATT WILLIAMS

What is the Steady State Hypothesis?

When it comes to our cosmic origins, a number of theories have been advanced throughout the course of history. Literally every culture that's ever existed has had its own mythological tradition, which naturally included a creation story.
With the birth of the scientific tradition, scientists began to understand the Universe in terms of physical laws that could be tested and proven.
With the dawn of the Space Age, scientists began testing cosmological theories in terms of observable phenomena. From all of this, a number of theories emerged by the latter half of the 20th century that attempted to explain how all matter and the physical laws governing it came to be. Of these, the Big Bang Theory remains the most widely accepted while the Steady-State Hypothesis has historically been its greatest challenger.
The Steady-State model states that the density of matter in the expanding universe remains unchanged over time because of the continuous creation of matter. In other words, the observable Universe essentially remains the same regardless of time or place. This places it in sharp contrast to the theory that the majority of matter was created in a single event (the Big Bang) and has been expanding ever since.

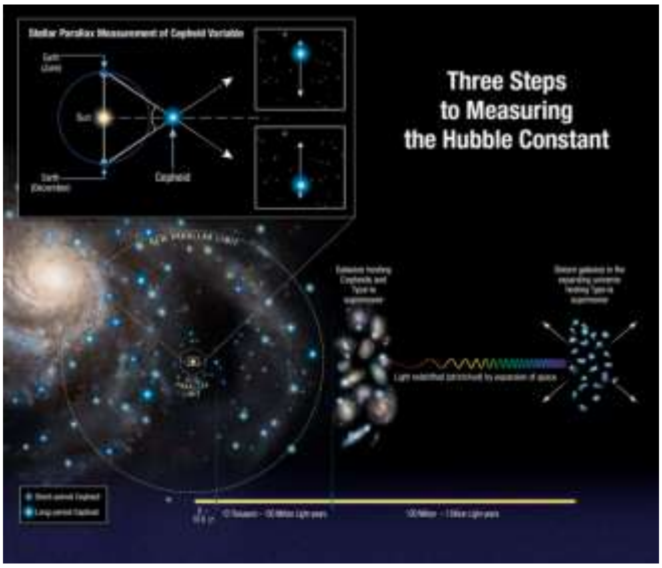


Illustration showing three steps astronomers used to measure the universe's expansion rate (Hubble constant). Credits: NASA, ESA, A. Feild (STScI), and A. Riess (STScI/JHU)

Origins

While the notion of a stable and unchanging Universe has been embraced throughout history, it was not until the early modern period that scientists began to interpret this in astrophysical terms. The first clear example of this being argued in the context of astronomy and cosmology was in Isaac Newton's *Mathematical Principles of Natural Philosophy* (*Philosophiæ Naturalis Principia Mathematica*) published in 1687.

In Newton's magnum opus, he conceptualized the Universe beyond the Solar System as an empty space that extended uniformly in all directions to immeasurable distances. He further explained through mathematical proofs and observations that all motion and dynamics in this system were explained through the single principle of universal gravitation.

However, what would come to be known as the Steady State Hypothesis did not emerge until the early 20th century. This cosmological model was inspired by a number of discoveries, as well as breakthroughs in the field of theoretical physics. These included Albert Einstein's Theory of General Relativity and Edwin Hubble's observations that the Universe is in a state of expansion.

Einstein formalized this theory by 1915 after decided to extend his theory of Special Relativity to incorporate gravity. Ultimately, this theory states that the gravitational force of matter and energy directly alters the curvature of spacetime around it. Or as famed theoretical physicist John Wheeler summarized it, "space-time tells matter how to move; matter tells space-time how to curve."

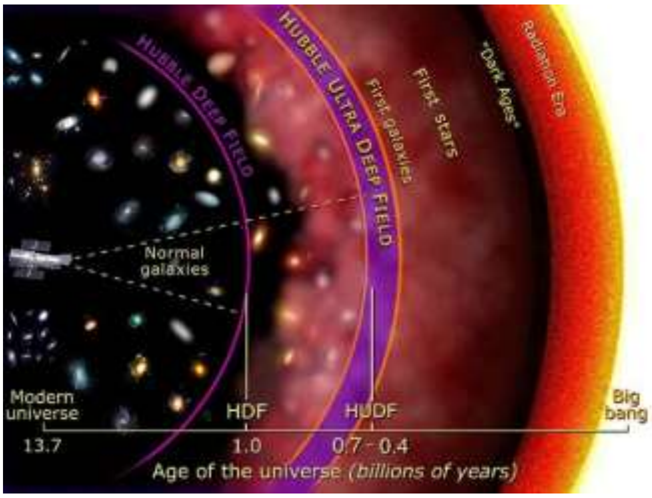


Illustration of the depth by which Hubble imaged galaxies in prior Deep Field initiatives, in units of the Age of the Universe. Credit: NASA and A. Feild (STScI)

By 1917, theoretical calculations based on Einstein's field equations showed that the Universe had to be in either a state of expansion or contraction. By 1929, observations made by George Lemaitre (who proposed the Big Bang Theory) and Edwin Hubble (using the 100-inch Hooker telescope at the Mount Wilson Observatory) demonstrated that the latter was the case.

Based on these revelations, a debate began by the 1930s about the possible origins and true nature of the Universe began. On one side, there were those who asserted that the Universe was finite in age and evolved over time through cooling, expansion and the formation of structures due to gravitational collapse. This theory was satirically named the "Big Bang" by Fred Hoyle, and the name stuck.

Meanwhile, the majority of astronomers at the time held to the theory that while the observable Universe is expanding, it nevertheless does not change in terms of the density of matter. In short, proponents of this theory argued that the Universe has no beginning, no end, and that matter is continuously being created over time – at a rate of one hydrogen atom per cubic meter per 100 billion years.

This theory also extended Einstein's Cosmological Principle, aka. Cosmological Constant (CC), which Einstein proposed in 1931. According to Einstein, this force was responsible for "holding back gravity" and ensuring that the Universe remained steady, homogenous, and isotropic in terms of its large-scale structure.

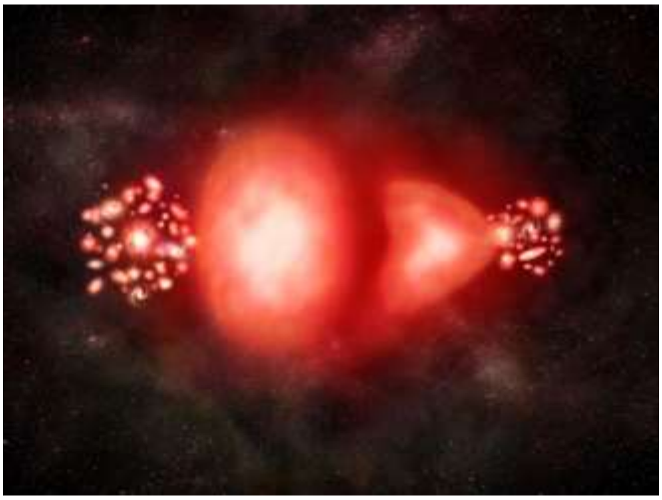
Modifying this principle and extending it, members of the Steady State school of thought argued that it was the continuous creation of matter that ensured that the structure of the Universe remained the same over time. This is otherwise known as the perfect cosmological principle, which unpins the Steady State Hypothesis.

The Steady State theory became widely-known by 1948 with the publication of two papers: "A New Model for an Expanding Universe" by English astronomer Fred Hoyle, and "The Steady-State Theory and the Expanding Universe" by the British-Austrian astrophysicist and cosmologist team of Hermann Bondi and Thomas Gold.

Key Arguments and Predictions

Arguments in favor of the Steady State Hypothesis include the apparent time-scale problem raised by the observed rate of cosmic expansion (aka. the Hubble Constant or the Hubble-Lemaitre law). Based on Hubble's observations of nearby galaxies, he calculated that the Universe was expanding at a velocity that increased systematically with distance.

This gave rise to the idea that the Universe began expanding from a much smaller volume of space. In the absence of acceleration/deceleration – 500 km/s per Megaparsec (310 mps per Mpc) – the Hubble Constant meant that all matter has been expanding for about 2 billion years – which would also be the upper age of the Universe.



What matter and antimatter might look like annihilating one another. Credit: NASA/CXC/M. Weiss

This finding was contradicted by radioactive dating, where scientists measured the rate of decay for deposits of Uranium-238 and Plutonium-205 in rock samples. Using this method, the oldest samples of rock (which were lunar in origin), were estimated to be 4.6 billion years old. Another incongruity emerged as a result of stellar evolution theory.

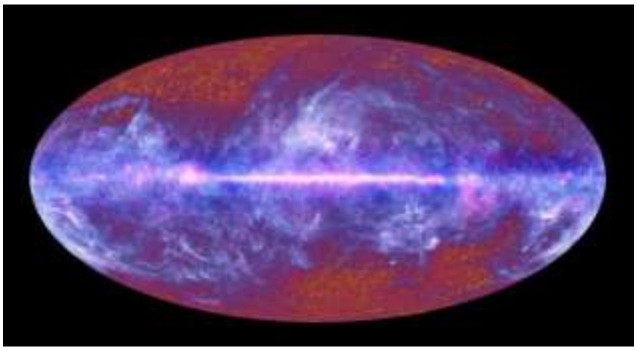
In short, the rate at which hydrogen is fused in the interior of stars (to create helium) yields an upper age estimate of 10 billion years for globular clusters – the oldest stars in the galaxy. What's more, no evolution at great distances could have occurred in this model – which would mean that radio sources – aka. quasars or Active Galactic Nuclei (AGNs) – would be uniform throughout the Universe.

It would also mean that the Hubble Constant (as calculated in the early 20th century) would remain constant. The Steady-State model also predicted that the steady creation of antimatter and neutrons would result in regular annihilations and neutron decay, thus leading to the existence of a gamma-ray background and hot, x-ray emitting gas throughout the Universe.

Big Bang For The Win

However, ongoing observations during the 1950s and 1960s steadily led to a buildup of evidence against the Steady State

Hypothesis. These included the discovery of bright radio sources (aka. quasars and radio galaxies) which were discovered in distant galaxies but not those closest to us – indicating that many galaxies became "radio-quiet" over time.



This single all-sky image, captured by the Planck telescope, simultaneously captured two snapshots of the CMB. Credit: ESA

By 1961, surveys of radio sources allowed for statistical analyses to be made, which ruled out the possibility that bright radio galaxies were uniformly distributed. Another major argument against the Steady State Hypothesis was the discovery of the Cosmic Microwave Background (CMB) in 1964, which the Big Bang model predicted.

Combined with the absence of a gamma-ray background and pervasive clouds of x-ray emitting gas, the Big Bang model became widely accepted by the 1960s. By the 1990s, observations with the *Hubble Space Telescope* and other observatories also discovered that cosmic expansion has not been consistent over time. During the last three billion years, in fact, it has been accelerating.

This has led to several refinements of the Hubble Constant. Based on data collected by the Wilkinson Microwave Anisotropy Probe (WMAP), the rate of cosmic expansion is currently estimated to be between 70 and 73.8 km/s per Mpc (43.5 to 46 mps per Mpc) with a 3% margin of error. These values are far more consistent with observations that place the age of the Universe at around 13.8 billion years.

Modern Variants

Beginning in 1993, Fred Hoyle and astrophysicists Geoffrey Burbidge and Jayant V. Narlikar began publishing a series of studies in which they proposed a new version of the Steady State Hypothesis. Known as the Quasi-Steady-State hypothesis (QSS), this variation attempted to explain cosmological phenomena that the old theory did not account for.

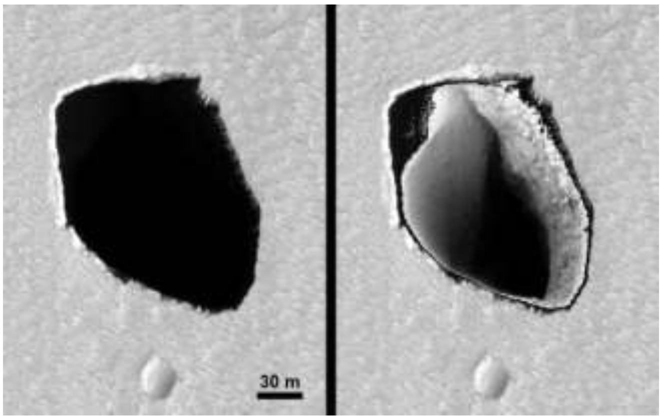
This model suggests that the Universe is the result of pockets of creation (aka. mini-bangs) happening over the course of many billion years. This model was modified in response to data that showed how the Universe's rate of expansion is accelerating. Despite these modifications, the astronomical community still considers the Big Bang to be the best model for explaining all observable phenomena. Today, this model is known as the Lambda-Cold Dark Matter (LCDM) model, which incorporates current theories about Dark Matter and Dark Energy with the Big Bang theory. In spite of that, the Steady State Hypothesis (and variants thereof) are still advocated by some astrophysicists and cosmologists. And it is not the only alternative to Big Bang Cosmology…

Look down into a pit on Mars.

The caved-in roof of a lava tube could be a good place to explore on the Red Planet

Want to look inside a deep, dark pit on Mars? Scientists and engineers using the HiRISE Camera on board NASA's Mars Reconnaissance Orbiter have done just that.

From its orbit about 260 km (160 miles) above the surface, HiRISE can spot something as small as a dinner table, about a meter in size. But can it look *inside* a cave-like feature on the Red Planet and actually resolve any details inside this pit?



In this cutout, the 'normal' view of the HiRISE image on the left, while the right shows what happens when the brightness of the pixels inside the pit is enhanced. Credit: NASA/JPL/University of Arizona.

"Fortunately, HiRISE is sensitive enough to actually see things in this otherwise dark pit," wrote MRO team member Ross Beyer on the HiRISE website. "Since HiRISE turned by almost 30 degrees to capture this image, we can see the rough eastern wall of the pit. The floor of the pit appears to be smooth sand and slopes down to the southeast."

The hope in doing these special maneuvers to take this image, Beyer said, was to determine if this was an isolated pit, or if it was a skylight into a tunnel – similar to skylights in the lava tubes of Hawai'i.

No tunnels are seen in the visible walls, but scientists have ruled out that there could be tunnels in the walls that aren't visible.

Dark pits on Mars are fascinating – probably because they provide mysteries and possibilities. Could anything be inside? Or this could be a place where humans could set up a future base since it would provide shelter from Mars' harsh environment. If a future rover mission were to land nearby, this pit might be worth a look – from a safe distance around the rim, of course.

This pit is located near the Tharsis volcanic rise, a giant region on Mars that includes the three large volcanoes Ascraeus Mons, Pavonis Mons and Arsia Mons. Here's another pit that HiRISE spotted in 2009 that is relatively nearby to this one.

Fraser has a great video about lava tubes and pits, and you can read more about them in this article.

The HiRISE camera has provided incredible images of Mars since its arrival to Mars in 2006. As its name implies, this is a high resolution camera and is the largest ever flown on a planetary mission. HiRISE has allowed the orbiter to identify obstacles such as large rocks that could jeopardize the safety of landers and rovers, like the Curiosity rover or the upcoming Mars 2020 rover.

Future Astronauts Could Enjoy Fresh Vegetables From an Autonomous Orbital Greenhouse

A job for Peter Chappel?

If humanity is going to become a spare-faring and interplanetary species, one of the most important things will be the ability of astronauts to see to their needs independently. Relying on regular shipments of supplies from Earth is not only inelegant; it's also impractical and very expensive. For this reason, scientists are working to create technologies that would allow astronauts to provide for their own food, water, and breathable air.
To this end, a team of researchers from Tomsk Polytechnic University in central Russia – along with scientists from other universities and research institutes in the region – recently developed a prototype for an orbital greenhouse. Known as the Orbital Biological Automatic Module, this device allows plants to be grown and cultivated in space and could be heading to the International Space Station (ISS) in the coming years.

FEBRUARY 26, 2020 BY NANCY ATKINSON

The Life of Katherine Johnson Shows that 'Hidden Figures' Are Important to History

NASA mathematician Katherine Johnson did more than just calculate rocket trajectories for early space missions. Her story, when it was finally told, completely changed people's perceptions about who has been – and who can be — important in history.
Margot Lee Shetterly, who wrote about Johnson's life in the book "Hidden Figures: The American Dream and the Untold Story of the Black Women Mathematicians Who Helped Win the Space Race," called her writing a "recuperative history." She brought the bits and pieces of people's lives together to help tell the full story of NASA's history.
"The women in 'Hidden Figures' upend all our perceptions of what it means to be black, to be female, to be a scientist and to be American," Shetterly said in a speech at the University of Minnesota in 2017. She added that we need to keep finding and telling "these stories until we have the entire spectrum of the experience, not just the tiny slices of the extremes of good experiences or bad experiences, when most of life happens in the middle."
Johnson died this week at the age of 101, and has been lauded an American hero.
"Ms. Johnson helped our nation enlarge the frontiers of space even as she made huge strides that also opened doors for women and people of color in the universal human quest to explore space," NASA administrator Jim Bridenstine said in a statement. "At NASA we will never forget her courage and leadership and the milestones we could not have reached without her."
The "Hidden Figures" book and the 2016 film that followed, tells the stories of Johnson, Dorothy Vaughan and Mary Jackson, Christine Darden and others during a time of Jim Crow laws, when blacks were relegated to the status of second-class citizens and lived under the conditions of legal segregation in the southern United States.
These women worked as mathematicians in the 1940s, 50s and 60s at the all-black West Area Computing section at the Langley Aeronautical Laboratory in Virginia, part of NASA's founding organization, the National Advisory Committee for Aeronautics' (NACA). At that time, doing the tedious mathematical calculations by hand for aeronautics and then the early space missions was considered "women's work," Shetterly said.
"But these women rolled up their sleeves and were really critical to the work that needed to be done," she said. "They were serving our country and serving our country's highest ideals."
The several dozen African American women who were part of the West Area Computing section were well-qualified and well-educated – some had more education than their white counterparts. The women were dedicated, and their high-quality work powered NASA's first successful missions. At the same time, Virginia's segregation laws restricted the women to where they could work and what bathroom they could use.
"Our office computed all the trajectories," Johnson told The Virginian-Pilot newspaper in 2012. "You tell me when and where you want it to come down, and I will tell you where and when and how to launch it."
In 1961, Johnson computed the trajectory analysis for Alan Shepard's Freedom 7 Mission, the first to carry an American into space. The next year, as famously portrayed in the "Hidden Figures" movie, Johnson manually verified the calculations of NASA's IBM 7090 computer, which would control the trajectory of the capsule in John Glenn's Friendship 7 orbital mission. As a part of the preflight checklist, Glenn asked engineers to "get the girl"—Katherine Johnson—to run the same numbers, but by hand, on her desktop mechanical calculating machine.
"If she says they're good,'" Johnson recalled the astronaut saying, "then I'm ready to go." Glenn's flight was a success, and marked a turning point in the competition between the United States and the Soviet Union in space.
Johnson considered her work on the Apollo missions to the Moon to be her greatest contribution to space exploration. Her calculations helped the lunar lander rendezvous with the orbiting Command and Service Module. She also worked on the Space Shuttle program before retiring in 1986.
Before "Hidden Figures" the seminal work done by Johnson and her co-workers went largely unnoticed. Even though the "human computers" – who were later called "math aides" — were a key part in all mission analysis and planning, they were unheralded, even within NASA.

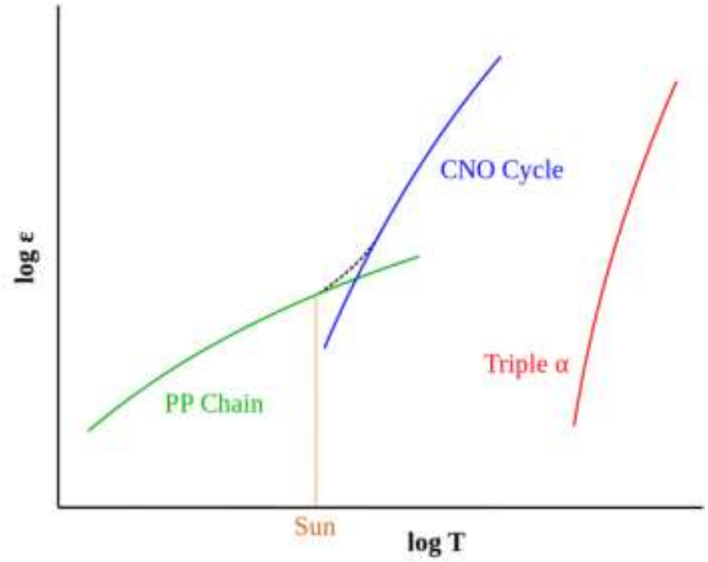
NASA Administrator Charles Bolden presents an award to Katherine Johnson, the African American mathematician, physicist, and space scientist, who calculated flight trajectories for John Glenn's first orbital flight in 1962, at a reception to honor members of the segregated West Area Computers division of Langley Research Center on Thursday, Dec. 1, 2016. Credit: NASA/Aubrey Gemignani

But after the book and movie brought attention to these women mathematicians, NASA renamed a computing facility for Johnson in February 2019, and a street in front of NASA headquarters in Washington DC was renamed "Hidden Figures Way." Johnson received a Presidential Medal of Freedom in 2015, and Christine Darden received Congressional Gold Medal in 2019, while Vaughan and Jackson received theirs posthumously.
Shetterly said this highlights the power of a narrative. "I did not realize how powerful it is to tell a story," she said in 2017. "It's this magical thing when you put everything together — not just as facts — but into a story waiting to be told."
"Hidden Figures" was certainly an inspiration as I researched and wrote the book "Eight Years to the Moon," as it showed me that everyone has a story and that sometimes the untold

stories of people who worked behind the scenes can be as compelling as those in the limelight.
If the telling of Johnson's story has a lasting effect, I hope it shows us how we should always try to use the right equation of looking beyond our differences to find the commonality between us, as well as finding the value in everyone's life and contributions.
And we all should continue to look for and appreciate the 'hidden figures' in our own lives, those who make differences, both large and small.

Betelgeuse Is Brightening Again

The latest observations of Betelgeuse show that the star is now beginning to slowly brighten. No supernova today! Nothing to see, better luck next time.
Despite some of the hype, this behavior is exactly what astronomers expected. Betelgeuse is a very different star from our Sun. While our Sun is a main-sequence star in its prime of life, Betelgeuse is a red giant star on the verge of death. But the death of a star is not a simple process.



The rate of energy production by nuclear fusion in a star. Credit: R J Hall
Stars shine so brightly and for so long because of a delicate balance of gravity and nuclear fusion. Gravity would like to collapse a star under its weight. Without nuclear fusion, gravity would crush a star into a white dwarf, neutron star, or black hole. But the crushing pressure gravity creates allows hydrogen in the star's core to fuse into helium. The process is known as the *proton-proton chain* (or pp-chain) and combines four hydrogen nuclei into one helium nucleus. About 3% of the original mass is converted to energy in the form of gamma rays. This energy heats the core even further, letting it push back against gravity.
For stars larger than the Sun, another fusion process known as the CNO cycle kicks in. CNO stands for Carbon-Nitrogen-Oxygen because the process fuses helium into those three elements. This process is why those three elements are the most abundant in the universe except for hydrogen and helium.

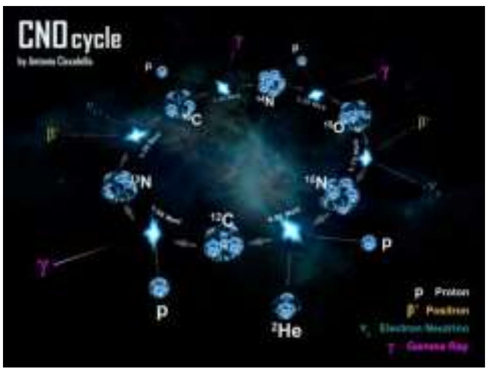
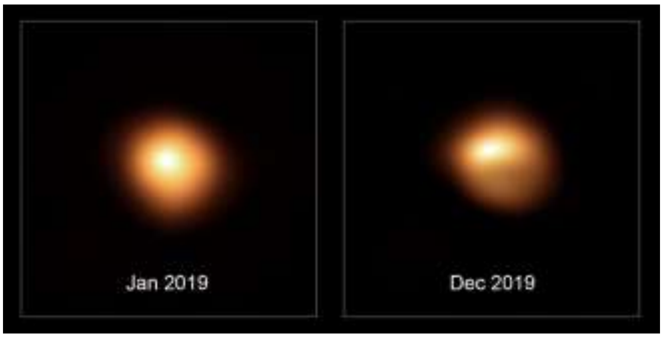
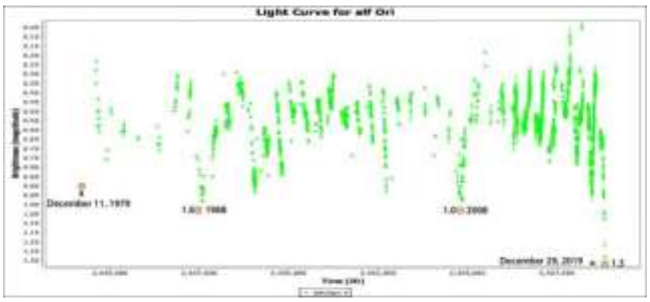


Illustration of a CNO cycle. Credit: Antonio Ciccolella

While both the pp-chain and CNO cycle can occur at the same time within a star, over time the CNO cycle increases as hydrogen become more scarce and helium more abundant. Since the CNO cycle releases more energy at a faster rate than the pp-chain, this means a star's temperature increases over time. We see this gradual heating in our own Sun. By the time the CNO cycle dominates in a star, it's core is so hot that the outer layers of a star swell and expand.
This is the stage Betelgeuse is in now. For millions of years, it was a main-sequence star of about 20 solar masses. But it is now fusing helium so furiously that it has bloomed into a red supergiant. Betelgeuse is running out of fuel, and in the end, gravity will win. It's only a matter of time.



This comparison image shows the star Betelgeuse before and after its unprecedented dimming. The observations, taken with the SPHERE instrument on ESO's Very Large Telescope in January and December 2019, show how much the star has faded and how its apparent shape has changed.
But that time isn't necessarily soon. Betelgeuse has enough helium to stay in the red supergiant stage for about 100,000 years. Even after it runs out of helium, it will be able to fuse carbon into heavier elements for about a millennium. After that things will change fairly quickly. When it runs out of carbon it will try fusing heavier and heavier elements for about a year. Then its core will collapse, Betelgeuse will become a supernova, and we will finally get our show.
As best we can tell, Betelgeuse is still deep in the red supergiant phase of its life. Even though it has dimmed significantly of recent, it isn't on the verge of exploding. The gradual dimming and brightening we see suggest that it won't be exploding in our lifetimes. It suggests that the core of Betelgeuse is still chugging away at a steady pace.



The brightness of Betelgeuse over the years. Credit: AAVSO
The changing brightness of Betelgeuse is due to a process known as convection. The upper layers of the star are heated by the core, and this generates a flow of hotter and cooler regions. Material in the interior is heated and rises to the surface. It then cools and sinks into the star, and the cycle continues. Convection happens in the outer regions of most stars, including our Sun. On the surface of the Sun, these convection regions are known as granules, and they are typically the size of Texas. That sounds large, but for the Sun that's smaller than most sunspots. So even though the Sun has bright hot regions and dimmer cool regions, they are so small compared to the Sun's surface there isn't an overall change in solar luminosity.
A simulation of convection in Betelgeuse.
But the outer layer of Betelgeuse is much less dense than that of the Sun. It is even less dense than Earth's atmosphere. It's basically a thin soup of glowing gas. That means the convection regions on Betelgeuse can be huge. A single

region can cover a large part of the star. When one of those regions rises to the top, Betelgeuse gets brighter, and when it cools the star dims. Betelgeuse is starting to brighten because hot material is convecting to its surface. This is normal for Betelgeuse and is likely the way things will be for millennia.
So no boom today. But boom someday. Sooner or later…Boom!

After a Challenging First Year on Mars, InSight Shows Us that Mars is Seismically Active

The NASA and DLR InSight lander has been on Mars for over a year now. The mission has faced significant challenges getting its HP^3 (Heat Flow and Physical Properties Package) into the subsurface, but the spacecraft's other instruments are working as intended. Now, researchers have published six papers outlining some of the mission's scientific results.
NASA's Viking landers were the first to investigate Martian seismology. Both landers carried a seismometer to the surface, but they weren't as sophisticated as InSight's. Separate seismometers that could be placed on the surface of the planet were too massive, required too much electricity, and also took up too much bandwidth. So the Viking seismometers were attached to the landers, and were negatively affected by wind and the activity of the lander itself.

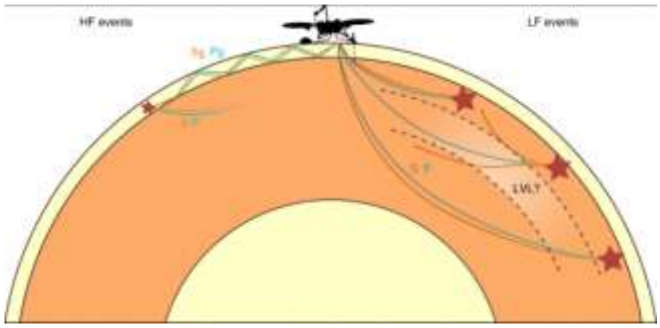
The Viking 2 lander on Mars, at Utopia Planitia. The seismometer is the small box between the color calibration targets left of center on the top of the lander's equipment bay. (NASA/JPL)

Viking 1's seismometer never deployed properly and produced no usable data. Viking 2's seismometer was deployed properly, and produced lots of data, but no definitive Marsquakes were detected. The Martian winds made detection difficult.
Now InSight is giving us our first real look at Martian seismology. InSight was launched in May 2018 and landed on Mars on November 26th 2018. Its full name is Interior Exploration using Seismic Investigations, Geodesy and Heat Transport. Its mission is to study Mars' deep interior by measuring heat flow, seismic activity, and the wobble of Mars' north pole as the Sun's gravity pulls on the planet.
The lander carries three primary science instruments:
SEIS, the Seismic Experiment for Internal Structure, measure Marsquakes and other internal activity.
Heat Flow and Physical Properties Package (HP^3) which measures the transfer of heat from the planet's interior to its surface.
RISE: the Rotation and Interior Structure Experiment which measures the planet's wobble which in turn reveals the size and density of Mars' core and mantle.
InSight also carries a laser retroreflector, weather monitoring equipment, an instrument deployment arm, and cameras.
InSight has been struggling to get the HP^3 instrument, also known as "the mole," into position to take measurements, and Universe Today has covered those struggles and the ongoing effort to overcome them. But even with the mole not contributing much, the lander has delivered some solid science. A total of six papers were just published outlining that science. Five are in the journal Nature and one is in Nature Communications:

The atmosphere of Mars as observed by InSightInitial results from the InSight mission on Mars Geology of the InSight landing site on Mars

The seismicity of Mars InSight searches high to see below Constraints on the shallow elastic and anelastic structure of Mars from InSight seismic data

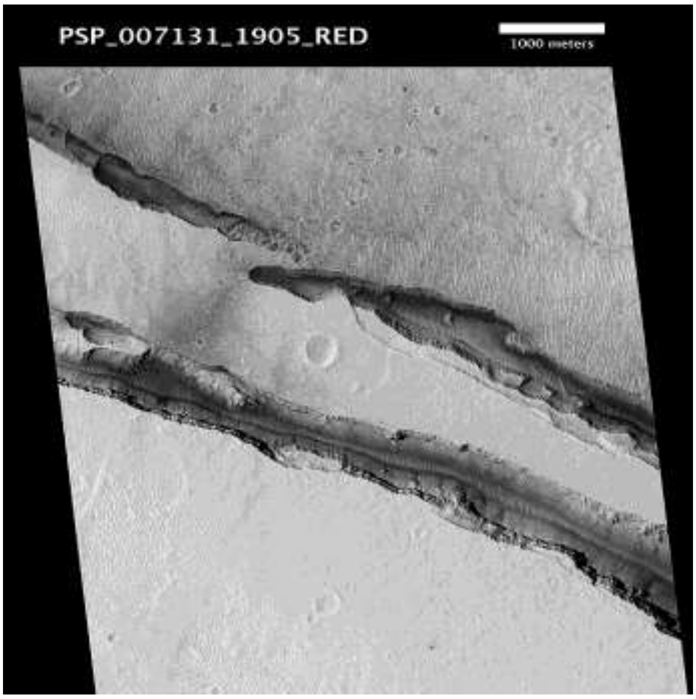
In "The seismicity of Mars," lead author D. Giardini and co-authors paint a picture of Mars as a seismically active planet. InSight has measured over 450 seismic signals, much more than expected, although only 174 were detected in the mission's first 10 months and covered in these results. The quakes are relatively weak compared to Earthquakes.
On Earth, quakes are caused by the tectonic plates grinding against one another. Mars has no tectonic plates, so its quakes have another cause. The planet is cooling down, and contracting at the same time. As it contracts, the surface has to fracture, leading to Marsquakes.
There are two broad categories of Marsquakes in the data. 150 of them were shallow, relatively weak quakes that propagated through the crust. 24 of them were more powerful, and deeper. They originated at different locations in the planet's crust. They were all weaker compared to Earthquakes, though. The most powerful ones detected by InSight were between 3 and 4 on the Richter scale. An Earthquake has to be at least 5.5 to damage structures.
The data also shows that while the frequency of weaker quakes stayed the same throughout the time period the data was collected, the frequency of stronger quakes increased. The researchers have no explanation for this, but they could be related to seasonal orbital and/or thermal effects.



A schematic of the two types of seismic waves detected on Mars. Weaker high frequency events are mostly confined to the crust, while the stronger low frequency events propagate across the mantle. The LVL is a hypothesized Low Velocity Layer which may signal the presence of melted rock or water. Image Credit: Giardini et al, 2020.

When the mission was planned, there was some concern that SEIS would measure meteorite impacts which would complicate the data. But according to the InSight team, all of the seismic activity detected by SEIS came from the interior of Mars.
The most powerful quake that InSight detected was about magnitude 4. It was not powerful enough to penetrate below the crust, deeper into the mantle and the core. According to Bruce Banerdt, InSight principal investigator at JPL, those are "the juiciest parts of the apple" when it comes to studying the interior or Mars. Scientists are still waiting for a more powerful Marsquake to propagate that deeply, and to tell them more about the deeper interior of the planet.
Some of the strongest seismic activity was centered on the Cerberus Fossae region. The two strongest quakes originated there. The Cerberus Fossae region is a series of mostly-

parallel faults in the Martian crust, in the Cerberus region.

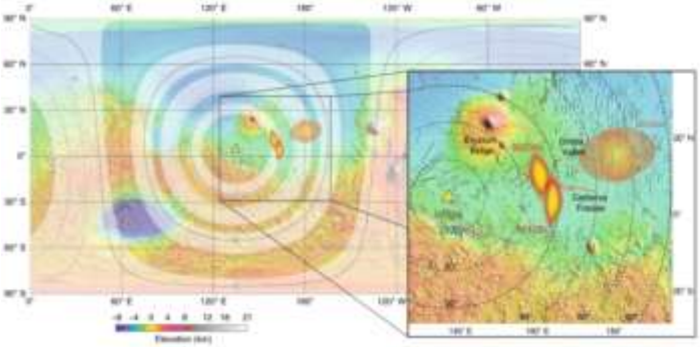


The HiRise instrument on the Mars Reconnaissance Orbiter captured this image of some faults in the Cerberus Fossae Region. The two strongest Marsquakes that InSight detected originated in the Cerberus Fossae Region. Image Credit: By Jim Secosky / WolfmanSF modified NASA / JPL / University of Arizona image – Cerberus Fossae faults are associated with possible recent volcanic activity, and possible recent tectonic activity. The region also shows recent boulder traces, which hints at seismic activity.

HiRise image of boulders on the floor of Cerberus Fossae. Image Credit: NASA/JPL/UArizona

Cerberus Fossae also contains ancient water channels, which were more recently partially filled with lava, perhaps as little as 10 million years ago. As little as 2 million years ago, seismic activity fractured some of those flows.

"It's just about the youngest tectonic feature on the planet," said planetary geologist Matt Golombek of JPL. "The fact that we're seeing evidence of shaking in this region isn't a surprise, but it's very cool."



The yellow triangle marks InSight's location. The white bands show the range of epicentral distances, because the exact epicenters of most quakes aren't determined. Some epicenters are known, however, especially two of the strongest which were located in the Cerberus Fossae Region. Image Credit: Giardini et al; 2020

"Over 44 years since the first attempt by the Viking missions[27], the InSight SEIS instrument has revealed that Mars is seismically active," the authors say in their paper. "In the first 207 sols of data continuously recorded on Mars we detected 174 events that cannot be explained by local atmospheric- or lander-induced vibrations; these are interpreted as marsquakes."

There's much more data to come from InSight, especially if the HP^3 instrument can be successfully deployed. The mission will last about one more year, and by that time the RISE instrument will have two years worth of data. All of that data, along with HP^3 and the seismometer, will paint an even clearer picture of the interior of Mars.

A New Kind of Rocket that's Lightweight and Easier to Construct: a Rotating Detonating Engine. Unfortunately, it's Also Completely Unpredictable

In the current era of space exploration, the name of the game is "cost-effective." By reducing the costs associated with individual launches, space agencies and private aerospace companies (aka. NewSpace) are ensuring that access to space is greater. And when it comes to the cost of launches, the single-greatest expense is that of propellant. To put it simply, breaking free to Earth's gravity takes a lot of rocket fuel!

To address this, researchers at the University of Washington recently developed a mathematical model that describes the workings of a new launch mechanism: the rotating detonation engine (RDE). This lightweight design offers greater fuel-efficiency and is less complicated to construct. However, it comes with the rather large trade-off of being too unpredictable to be put into service right now.

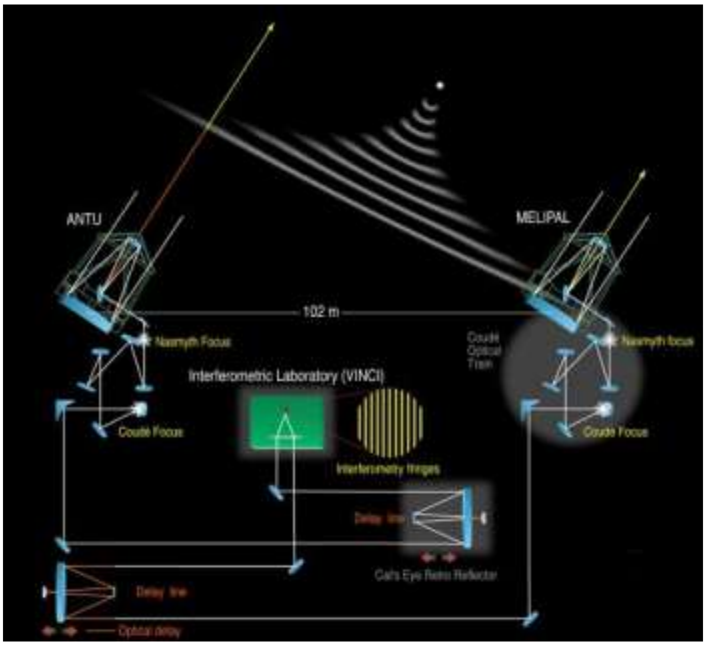
Not a manned mission I'd sign up for.

How Interferometry Works, and Why it's so Powerful for Astronomy

When astronomers talk about an optical telescope, they often mention the size of its mirror. That's because the larger your mirror, the sharper your view of the heavens can be. It's known as resolving power, and it is due to a property of light known as diffraction. When light passes through an opening, such as the opening of the telescope, it will tend to spread out or diffract. The smaller the opening, the more the light spreads making your image more blurry. This is why larger telescopes can capture a sharper image than smaller ones. Diffraction doesn't just depend on the size of your telescope, it also depends on the wavelength of light you observe. The longer the wavelength, the more light diffracts for a given opening size. The wavelength of visible light is very small, less than a millionth of a meter in length. But radio light has a wavelength that is a thousand times longer. If you want to capture images as sharp as those of optical telescopes, you need a radio telescope that is a thousand times larger than an optical one. Fortunately, we can build radio telescopes this large thanks to a technique known as interferometry.

The Five-hundred-metre Aperture Spherical Telescope (FAST) has just finished construction in the southwestern province of Guizhou. Credit: FAST

To build a high-resolution radio telescope, you can't simply build a huge radio dish. You would need a dish more than 10 kilometers across. Even the largest radio dish, China's FAST telescope, is only 500 meters across. So instead of building a single large dish, you build dozens or hundreds of smaller dishes that can work together. It is a bit like using only parts of a great big mirror instead of the whole thing. If you did this with an optical telescope your image wouldn't be as bright, but it would be almost as sharp.



Light from a distant object strikes one antenna before another. Credit: ESO

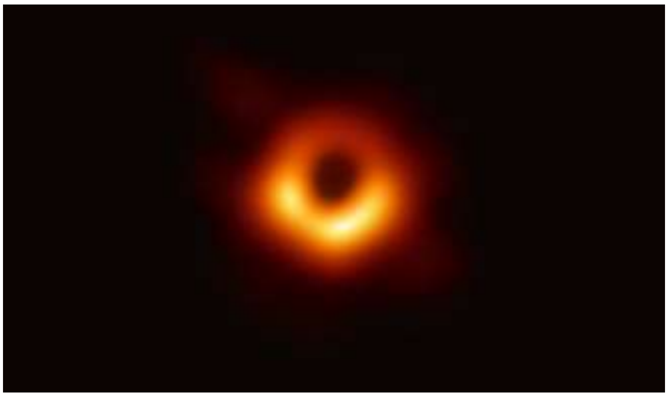
But it's not as simple as building lots of little antenna dishes. With a single telescope, the light from a distant object enters the telescope and is focused by the mirror or lens onto a detector. The light that left the object at the same time reaches the detector at the same time, so your image is in sync. When you have an array of radio dishes, each with their own detector, the light from your object will reach some antenna detectors sooner than others. If you just combined all your data you would have a jumbled mess. This is where interferometry comes in.

Each antenna in your array observes the same object, and as they do they each mark the time of the observation very precisely. This way you have dozens or hundreds of streams of data, each with unique timestamps. From the timestamps, you can put all the data back in sync. If you know that dish B gets a single 2 microseconds after dish A, you know signal B has to be shifted forward 2 microseconds to be in sync.

The correlator computer at ALMA Observatory. Credit: ALMA (ESO/NAOJ/NRAO), S. Argandoña.

The math for this gets really complicated. In order for interferometry to work, you have to know the time difference between each pair of antenna dishes. For 5 dishes that's 15 pairs. But the VLA has 27 active dishes or 351 pairs. ALMA has 66 dishes, which makes for 2,145 pairs. Not only that, as the Earth rotates the direction of your object shifts relative to the antenna dishes, which means the time between the signals changes as you make observations. You have to keep track of all of it in order to correlate the signals. This is done with a specialized supercomputer known as a correlator. It is specifically designed to do this one computation. It is the correlator that lets dozens of antenna dishes act as a single telescope.

It has taken decades to refine and improve radio interferometry, but it has become a common tool for radio astronomy. From the inauguration of the VLA in 1980 to the first light of ALMA in 2013, interferometry has given us extraordinarily high-resolution images. The technique is now so powerful that it can be used to connect telescopes all over the world.



The Event Horizon Telescope (EHT) — a planet-scale array of eight ground-based radio telescopes forged through international collaboration — was designed to capture images of a black hole. In coordinated press conferences across the globe, EHT researchers revealed that they succeeded, unveiling the first direct visual evidence of the supermassive black hole in the centre of Messier 87 and its shadow. The shadow of a black hole seen here is the closest we can come to an image of the black hole itself, a completely dark object from which light cannot escape. The black hole's boundary — the event horizon from which the EHT takes its name — is around 2.5 times smaller than the shadow it casts and measures just under 40 billion km across. While this may sound large, this ring is only about 40 microarcseconds across — equivalent to measuring the length of a credit card on the surface of the Moon. Although the telescopes making up the EHT are not physically connected, they are able to synchronize their recorded data with atomic clocks — hydrogen masers — which precisely time their observations. These observations were collected at a wavelength of 1.3 mm during a 2017 global campaign. Each telescope of the EHT produced enormous amounts of data – roughly 350 terabytes per day – which was stored on high-performance helium-filled hard drives. These data were flown to highly specialised supercomputers — known as correlators — at the Max Planck Institute for Radio Astronomy and MIT Haystack Observatory to be combined. They were then painstakingly converted into an image using novel computational tools developed by the collaboration. Credit: Event Horizon Telescope Collaboration

In 2009 radio observatories across the world agreed to work together on an ambitious project. They used interferometry to combine their telescopes to create a virtual telescope as large as a planet. It is known as the Event Horizon Telescope, and in 2019 it gave us our first image of a black hole.

With teamwork and interferometry, we can now study one of the most mysterious and extreme objects in the universe.

FEBRUARY 19, 2020 BY MATT WILLIAMS

Salt Water Might Still be Able to Collect on the Surface of Mars a Few Days a Year

Billions of years ago, Mars had liquid water on its surface in the form of lakes, streams, and even an ocean that covered much of its northern hemisphere. The evidence of this warmer, wetter past is written in many places across the landscape in the form of alluvial fans, deltas, and mineral-rich clay deposits. However, for over half a century, scientists have been debating whether or not liquid water exists on Mars today.

According to new research by Norbert Schorghofer – the Senior Scientist at the Planetary Science Institute – briny water may form intermittently on the surface of Mars. While very short-lived (just a few days a year), the potential presence of seasonal brines on the Martian surface would tell us much about the seasonal cycles of the Red Planet, as well as help to resolve one of its most enduring mysteries.

Schorghofer's study, titled "Mars: Quantitative Evaluation of Crocus Melting behind Boulders", recently appeared in *The Astrophysical Journal*. To address the question of whether seasonal water frost can melt, thus producing liquid water, Schorghofer considered a suite of quantitative models, as well as updated info on heat convection and a three-dimensional surface energy balance model.

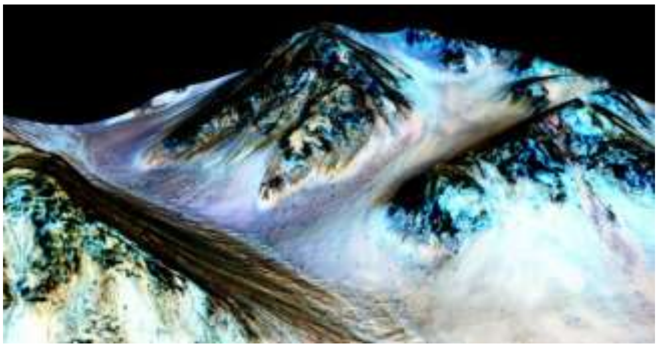
A possible 'Recurring Slope Lineae (RSL), dark streaks on slopes that appeared to ebb and flow over time, in Ceraunius Fossae. Credit: NASA/JPL/University of Arizona.

While much of the water that once existed on Mars' has been preserved in the form of its polar ice caps, the presence of liquid water is very difficult to determine. The planet undergoes seasonal cycles like Earth, which would lead one to conclude that this ice periodically melts. However, the low-pressure environment and rapid temperature changes on Mars cause this ice to sublimate long before it reaches its melting point.

On Mars, atmospheric pressure ranges from 0.4 to 0.87 kilopascals (kPa), which is the equivalent of less than 1% of Earth's at sea level. This places it close to the triple point pressure of H_2O – the minimum pressure necessary for liquid water to exist. Meanwhile, the surface heats very quickly when exposed to sunshine, which results in massive changes in temperature throughout the day.

As Schorghofer explained in a recent PSI press release: *"Mars has plenty of cold ice-rich regions and plenty of warm ice-free regions, but icy regions where the temperature rises above the melting point are a sweet spot that is nearly impossible to find. That sweet spot is where liquid water would form."*

Schorghofer envisions these "sweet spots" as being located in the mid-latitudes around protruding topography (e.g. boulders and tall rock formations). During the winter, these regions would cast shadows continually, creating very cold temperature environments where water frost could accumulate.



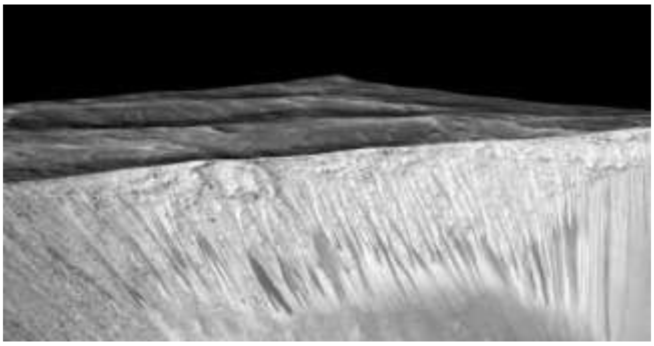
These dark, narrow, 100 meter-long streaks called recurring slope lineae flowing downhill on Mars could be formed by flowing water. Credits: NASA/JPL/University of Arizona

When Spring comes, these same spots would become exposed to direct sunlight. This would cause the water frosts to be heated to close to the melting point of water after one or two Martian days (aka. sols). According to Schorghofer's detailed model calculations, the temperature would change very rapidly, rising from -128 °C (-200 °F) in the morning to -10 °C (14 °F) by noon.

Wherever these water frost deposits formed on salt-rich ground, their melting point would be depressed to the point where it would melt at -10 °C. This means that not all of the frost would sublimate and become gaseous. Some of it would turn into brines that would endure until all of the ice has either melted or turned to vapor. This seasonal pattern would repeat again the following year.

Much like what happens in the southern polar region, carbon dioxide frosts could also build up during the winter in the shadowed areas behind protruding topography. The melting of water frosts would therefore only take place after the dry ice had vaporized – a point that scientists refer to as the "crocus date." One or two sols after this date has passed, liquid water ice will begin to thaw to create water – known as "crocus melting."

These findings build on previous experiments conducted by NASA that showed how chlorate-rich environments on Mars would be the most likely place to find water. Similar research has been conducted by numerous science teams that have questioned whether seasonal features around Mars' equatorial regions – known as Recurring Slope Lineae (RSL) or "slope streaks" – are the result of brines forming.



Dark narrow streaks called recurring slope lineae emanating out of the walls of Garni crater on Mars. Credits: NASA/JPL/University of Arizona

So far, there is conflicting evidence as to what causes these features and whether they are the result of sand avalanches ("dry" mechanisms) or liquid water from groundwater springs, melting surface ice, or the formation of brines ("wet" mechanisms). As Schorghofer explained, his research and modeling are an additional indication that the “wet” school of thought is correct.

“Answering the question whether crocus melting of seasonal water ice actually occurs on Mars required a slew of detailed quantitative calculations – the numbers really matter. It took decades to develop the necessary quantitative models.”

This summer, NASA’s *Mars 2020* rover will launch from Cape Canaveral to begin its six-month-long journey to Mars. Once there, it will join *Curiosity* and a host of other missions that are currently looking for evidence of Mars’ watery past. With any luck, some direct evidence that liquid water exists there today will also be found! Aside from settling a decades-long debate, it would be good news for all those hoping to go there in the future!

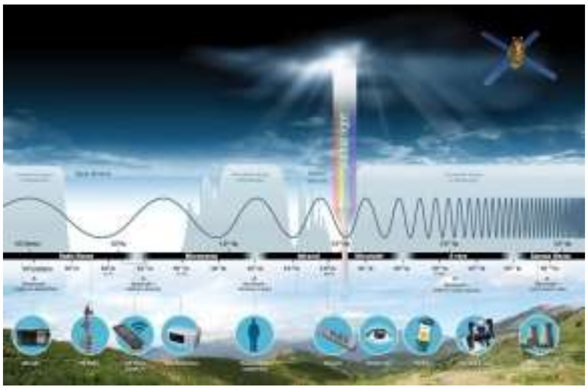
FEBRUARY 19, 2020 BY MATT WILLIAMS

A New Technique to Make Lighter Radiation Shielding For Spacecraft: Rust.

One of the biggest challenges of working and living in space is the threat posed by radiation. In addition to solar and cosmic rays that are hazardous to astronauts’ health, there is also ionizing radiation that threatens their electronic equipment. This requires that all spacecraft, satellites, and space stations that are sent to orbit be shielded using materials that are often quite heavy and/or expensive.

Looking to create alternatives, a team of engineers came up with a new technique for producing radiation shielding that is lightweight and more cost-effective than existing methods. The secret ingredient, according to their recently-published research, is metal oxides (aka. rust). This new method could have numerous applications and lead to a significant drop in the costs associated with space launches and spaceflight.

The research team’s study appeared online and will be included in the June 2020 issue of the scientific journal *Radiation Physics and Chemistry*. The study was conducted by Michael DeVanzo, a senior systems engineer at Lockheed Martin Space, and Robert B.Hayes, an associate professor of nuclear engineering at North Carolina State University.



The Electromagnetic Spectrum visualized. Credit: NASA

Put simply, ionizing radiation deposits energy onto the atoms and molecules with which it interacts, causing electrons to be lost and producing ions. On Earth, this type of radiation is not an issue, thanks to Earth’s protective magnetic field and dense atmosphere. In space, however, ionizing radiation is very common and comes from three sources – galactic cosmic rays (GCRs), solar flare particles, and Earth’s radiation belts (aka. Van Allen Belts).

To protect against this type of radiation, space agencies and commercial aerospace manufacturers will typically encase sensitive electronics in metal boxes. While metals like lead or depleted uranium provide the most protection, this kind of shielding would add a significant amount of weight to a spacecraft.

Hence why aluminum boxes are preferred, since they are believed to provide the best tradeoff between a shield’s weight and the protection it will provide. As Prof. Hayes explained, he and DeVanzo sought to investigate materials that could provide better protection and reduce the overall weight of spacecraft further:

“Our approach can be used to maintain the same level of radiation shielding and reduce the weight by 30% or more, or you could maintain the same weight and improve shielding by 30% or more – compared to the most widely used shielding techniques. Either way, our approach reduces the volume of space taken up by shielding.”

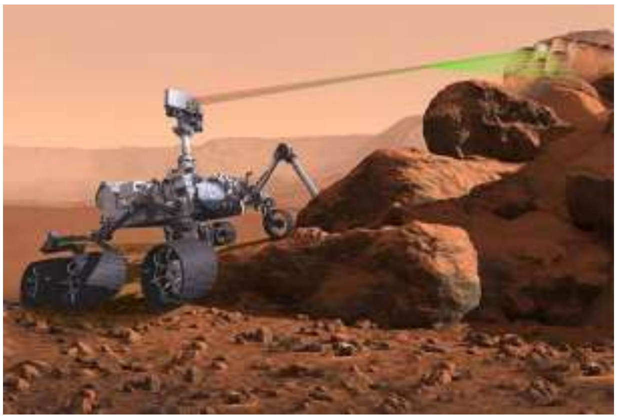
The technique he and DeVanzo developed relies on mixing powdered oxidized metal (rust) into a polymer and then incorporating it into a common coating that is then applied to electronics. Compared to metal powders, metal oxides offer less shielding, but are also less toxic and don’t pose the same electromagnetic issues that could interfere with a spacecraft’s electronics. As DeVanzo explained:

“Radiation transport calculations show that inclusion of the metal oxide powder provides shielding comparable to a conventional shield. At low energies, the metal oxide powder reduces both gamma radiation to the electronics by a factor of 300 and the neutron radiation damage by 225%.”

“At the same time, the coating is less bulky than a shielding box,” Hayes added. “And in computational simulations, the worst performance of the oxide coating still absorbed 30% more radiation than a conventional shield of the same weight. On top of that, the oxide particulate is much less expensive than the same amount of the pure metal.”

In addition to reducing the weight and cost of space-based electronics, this new method could potentially reduce the need for conventional shielding on space missions. Looking ahead, DeVanzo and Hayes will continue to fine-tune and test their shielding technique for various applications and are looking for industry partners to help them develop the technology for industry use

Mars 2020 Will be The Third Time That NASA Has Tried to Send a Microphone to Mars



This summer, between mid-July and early August, the *Mars 2020* rover will launch, reaching Mars by February of 2021. Once it touched down in the Jezero Crater, it will carry on in the footsteps of its predecessor – the *Curiosity* rover. This will include searching for evidence of Mars’ past habitability and the possible existence of life (past and present), as well as a sample-return mission.

To accomplish these tasks, the Mars 2020 rover will be relying on an advanced suite of instruments. One of these is the SuperCam, which includes a camera, a laser, and spectrometers and is mounted to the rover’s mast (or “head”). Once operational, this instrument will be used to study the chemistry and mineralogy of Martian rocks and (with any luck) find evidence of fossilized microbial life on Mars.

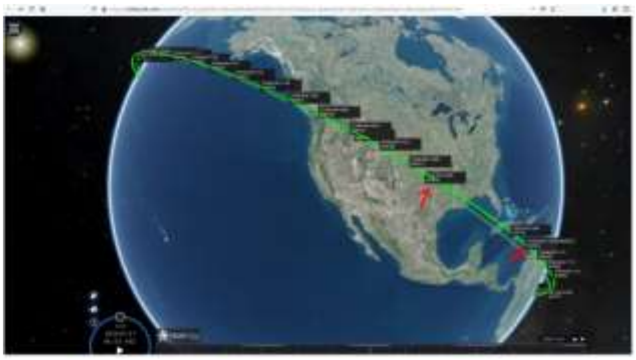
Astronomers Have Some Serious Concerns About Starlink and Other Satellite Constellations

Picture the space around Earth filled with tens of thousands of communications satellites. That scenario is slowly coming into being, and it has astronomers concerned. Now a group of astronomers have written a paper outlining their detailed concerns, and how all of these satellites could have a severe, negative impact on ground-based astronomy.

SpaceX and other companies are casting their keen capitalist eyes on the space around Earth. SpaceX and One-Web are the only companies—so far—to launch any portions of their satellite constellations. But a number of other companies have plans to do the same, and eventually all of those satellites will number in the tens of thousands.

60 Starlink satellites stacked together just after being launched on 24 May 2019. Image Credit: By Official SpaceX Photos – Starlink Mission, CC0

The astronomy community has raised some concerns about these satellite constellations. The Royal Astronomical Society and the American Astronomical Society have both released statements expressing their concern and desire to work with companies in the satellite constellation business. Those statements are polite, cautious in their criticism, and written in the spirit of cooperation.



This is what the first 240 of Starlink satellites look like in Celestrak. Image Credit: Gallozzi et all 2020/Celestrak.

But this new paper lays out all of the astronomical community's concerns, backed up with data, and presses their point more insistently.

"For centuries ground based astronomical observations have led to exceptional progresses in our scientific understanding of the Laws of Nature."

From "Concerns about ground based astronomical observations: A step to Safeguard the Astronomical Sky"

A satellite constellation is a group of artificial satellites that work together to provide global or near-global communications coverage. They have the potential to make high-speed internet available almost anywhere. Obviously, there are a lot of benefits to that.

But there are criticisms, too, and three astronomers from Italy have presented these criticisms in detail. The three are Stefano Gallozzi, Marco Scardia, and Michele Maris. Their paper is titled "Concerns about ground based astronomical observations: A step to Safeguard the Astronomical Sky."

When you add up all the satellites that companies want to launch as part of their constellations, you get somewhere around 50,000 satellites. The question is, what effect will of those satellites have on ground-based astronomy? The authors of the report claim that all of these satellites will inevitably damage astronomical observing.

A note to readers: English is not the first language of the authors of the paper, so some of the quotes contain small inconsistencies, but the meaning is clear.

"Depending on their altitude and surface reflectivity, their contribution to the sky brightness is not negligible for professional ground based observations," the report says in the introduction. "With the huge amount of about 50,000 new artificial satellites for telecommunications planned to be launched in Medium and Low Earth Orbit, the mean density of artificial objects will be of >1 satellite for square sky degree; this will inevitably harm professional astronomical images."

Visible to typical human eye	Apparent magnitude	Brightness relative to Vega	Number of stars (other than Sun) brighter than apparent magnitude in the night sky
Yes	−1.0	251%	1 (Sirius)
	0.0	100%	4
	1.0	40%	15
	2.0	16%	48
	3.0	6.3%	171
	4.0	2.5%	513
	5.0	1.0%	1602
	6.0	0.4%	4800
	6.5	0.25%	9100[4]
No	7.0	0.16%	14 000
	8.0	0.063%	42 000
	9.0	0.025%	121 000
	10.0	0.010%	340 000

There are only 172 stars in the whole sky exceeding the expected brightness of Starlink satellites. Higher altitude LEO satellites (e.g. over 1000km-altitude) will be visible all the night reaching approximately the 8th magnitude. Image Credit: Gallozzi et al, 2020

Since SpaceX is the furthest along in deploying their constellation, and their name pops up frequently in the paper. SpaceX's Starlink system has already launched almost 250 of their satellites, and they plan to deploy up to 42,000 satellites in total. According to the paper, these satellites "will shine from the 3rd to the 7th magnitude in sky after sunset and before sun dawn."

The authors say that all of those satellites will inevitably leave trails in astronomical images, and may inhibit the search for Near Earth Objects. There's some degree of risk that we might not spot a potential impact because of all these satellites.

But it's not just images that will be negatively affected, according to the report. "Serious concerns are common also to other wavelengths eligible for ground based investigation, in particular for radio-astronomy, whose detectors are already saturated by the ubiquitous irradiation of satellites communication from space stations as well as from the ground."

Back in May 2019, Elon Musk tried to dismiss any astronomical con-

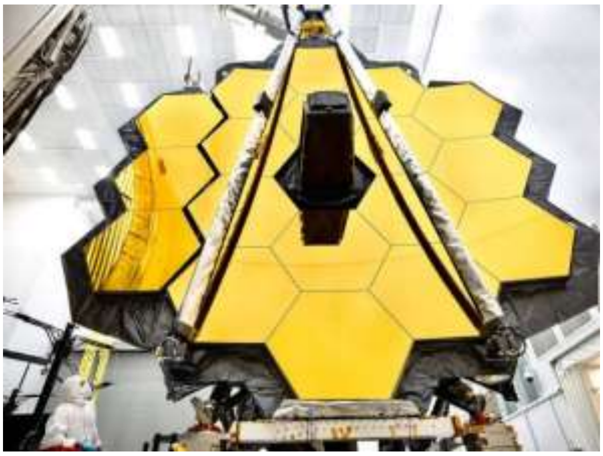
cerns about Starlink. Among his rather brusque dismissal of criticisms was his statement that “We need to move telelscopes <sic> to orbit anyway. Atmospheric attenuation is terrible.”
Musk has a huge profile in the space community, so his words might have convinced some that there are no problems between Starlink and astronomy. But Musk is an entrepreneur, not a scientist.
For all his accomplishments, Musk is not an expert in astronomy or astronomical observing. Is his statement that Starlink “will have ~0% impact on advancements in astronomy,” accurate and informed?
The three authors of the new paper don’t seem to think so. They outline the risks that satellite constellations pose to astronomy, and it’s not all about whether they’re visible in optical light. They point out that there are “dangerous effects arising from such changes in the population of small satellites. A dedicated strategy for urgent intervention to safeguard and protect each astronomical band observable from the ground is outlined.”
“Without ground based observations most of current space based astronomy would be useless or impossible.”

From “CONCERNS ABOUT GROUND BASED ASTRONOMICAL OBSERVATIONS: A STEP TO SAFEGUARD THE ASTRONOMICAL SKY”

The authors start at the beginning, by pointing out the enormous advances in understanding made by ground-based observations. “For centuries ground based astronomical observations have led to exceptional progresses in our scientific understanding of the Laws of Nature.” That’s hard to argue with.
In the paper’s first section, they talk about how space-based astronomy, or space telescopes, have contributed to knowledge. But they point out that ground-based and space-based astronomy need each other and produce the best science when they work together. “Without ground based observations most of current space based astronomy would be useless or impossible.”
It’s safe to say that the authors don’t agree with Musk’s glib assertion that “We need to move telelscopes <sic> to orbit anyway. Atmospheric attenuation is terrible.”
Maybe Musk has never heard of adaptive optics. Adaptive optics allow modern ground-based telescopes to overcome the effect of the atmosphere on observations. Upcoming telescopes like the European Extremely Large Telescope and the Thirty Meter Telescope feature adaptive optics at the heart of their designs.

An illustration of the segmented primary mirror of the Thirty Meter Telescope. Image Courtesy TMT International Observatory

The authors also point out what should be clear to anyone who thinks about it for very long: compared to ground-based astronomy, space-based telescopes are enormously expensive. And risky.
Advances in telescope technology are made here on Earth. Their deployment is the risky part, but the technologies have already been tested and developed here on Earth. As the authors of the paper point out, testing and developing new telescope technologies is not feasible in space.
“A major limitation of space based telescopes is that they can not be maintained, refurbished or repaired after launch.” The Hubble is an exception, and other space telescopes have not been maintained. Once they’re done, they’re done.



The James Webb Space Telescope inside a cleanroom at NASA’s Johnson Space Center in Houston. The astronomy community is eagerly awaiting the launch of the JWST, but space telescopes can never replace ground-based telescopes. Credit: NASA/JSC

“Compared to ground based observatories, the average life-time of space based telescopes is of the order of a couple of decades or less. On the contrary ground based observatories lasts for several decades, with telescopes installed at the beginning of the space era again working in a profitable manner.” In short, space telescopes become technologically obsolete, while their ground-based counterparts keep on working.
We can see this with the European Southern Observatory’s (ESO) Very Large Telescope (VLT). The VLT is made up of four primary units, and the first one saw first light in 1998. Over the years its been upgraded multiple times, each time increasing its observing capabilities. Two of its instruments, SPHERE (first light June 2014) and ESPRESSO (first light September 2016), are designed to study exoplanets, something that wasn’t important when the VLT was designed. Other instruments, like VISIR (VLT Imager and Spectrometer for mid-Infrared) were upgraded to study exoplanets.

ESO’s Very Large Telescope (VLT) has recently received an upgraded addition to its suite of advanced instruments. On 21 May 2019 the newly modified instrument VISIR (VLT Imager and Spectrometer for mid-Infrared) made its first observations since being modified to aid in the search for potentially habitable planets in the Alpha Centauri system, the closest star system to Earth. This stunning image of the VLT is painted with the colours of sunset and reflected in water on the platform. While inclement weather at Cerro Paranal is unfortunate for the astronomers using it, it lets us see ESO's flagship telescope in a new light. Space telescopes are also costly when compared to ground-based telescopes. The James Webb Space Telescope has been in development for 20 years, and it will cost $10 billion US. But the next generation of ground-based telescopes, like the Giant Magellan Telescope and the European Extremely Large Telescope, will cost about $1 billion each. And they will likely outlive the JWST by decades.

The nitty-gritty part of the paper deals with the actual problems that ground-based astronomy will face from satellite constellations. In some electromagnetic wavelengths, space telescopes are much more effective than ground-based telescopes. In the far Infrared for example, the atmosphere blocks much of it. But that doesn't tell the whole tale.

In the paper the authors talk about sky degradation. This degradation comes not only from light pollution on the ground, but "it is also due to artificial satellite fleets crossing and scarring observations with bright parallel streaks/trails at all latitudes."

Starlink alone would like to place up to 40,000 satellites into orbit. That's just one company out of several with plans to launch satellite constellations. Nobody knows how many there will eventually be, but it's fair to use a 50,000 satellite figure for discussion.

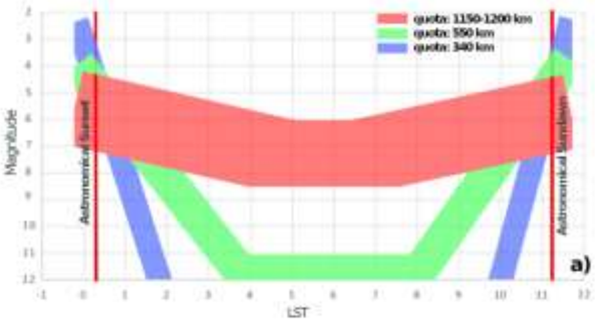
Constellation Name	n. Satellites	Altitude [km]	Bands	Serv.Start
SpaceX - Starlink (USA)	42,000	1150, 550, 340	Ku, Ka, V	2020
OneWeb (UK)	5,260	1200	Ku	2020
Telesat (CAN)	512	~1000	Ka	2022
Amazon - Kuiper (USA)	3236	590, 630, 610	?	2021
Lynk (USA)	thousands		?	2023
Facebook (USA)	thousands	500-550	?	2021
Roscosmos (RU)	640	870	?	2022-2026
Aerospace Sci.Corp. (CHI)	156	~1000	?	2022

Table 1: Satellite-Constellation projects comparison.

A table from the paper "Concerns about ground based astronomical observations: A step to Safeguard the Astronomical Sky." Image Credit: Gallozzi et al, 2020.

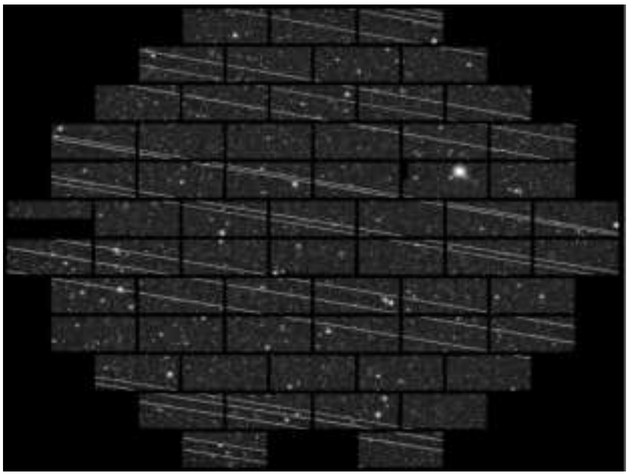
"Astronomers are extremely concerned by the possibility that sky seen from Earth may be blanketed by tens of thousands of satellites, which will greatly outnumber the approximately 9,000 stars that are visible to the unaided human eye," the authors say. "This is not some distant threat: it is already happening."

The three astronomers break down all the numbers for Earth's growing fleet of satellites. Taking into account viewing angles, altitude, and brightness leads them to this conclusion: "Thus with 50k satellites the "normality" will be a sky crowded with artificial objects: every square degree of the sky will have a satellite crawling in it along the whole observing night accessible and visible by astronomical cameras and not only by professional instrumentation."



Apparent magnitude of satellites during an observing night depending on the altitude. Image Credit: Gallozzi et al; 2020

According to the authors, all of this light pollution will be a serious detriment to astronomical observing. They acknowledge that SpaceX is experimenting with one "dark" satellite which is painted black to reduce reflectivity. But they point out that 75% of the satellite's surface is solar panels, which obviously cannot be painted. They also point out problems with painting a satellite black: "If the satellite body will be inhibited to reflect the sun light, it will absorb radiation warming too much with possible failures, thus will probably increase the risk management for the whole fleet and make the dark-coating solution ineffective or even counterproductive."



This is what astronomers are concerned about. Few Starlink satellites visible in a mosaic of an astronomical image (courtesy of NSF's National Optical-Infrared Astronomy Research Laboratory/NSF/AURA/CTIO/DELVE)

Then there's the whole problem of radio-band interference. "Even with best coating and mitigation procedures to decrease the impact on visual astronomical observations, what it is often omitted or forgotten is that telecommunication constellations will shine in the radio wavelengths bands, observable from the ground."

There are decades old agreements from the beginning of the space age that reserve certain radio frequencies for certain uses. The frequencies of certain atoms and molecules in space are reserved for radio astronomy. These include carbon monoxide and its isotopes, and H2O.

Radio astronomers already have to contend with all kinds of interference. According to the authors, this will get much worse. "What is not widely acknowledged is that the development of the latest generation telecommunication networks (both from space and from Earth) already has a profound impact on radio-astronomical observations (at all sub-bands): with LEO satellite fleets it is quite sure that the situation could become unbearable."

"Persons belonging to future generations have the right to an uncontaminated and undamaged Earth, including pure skies;"

UNESCO's Universal Declaration of Human Rights for Future Generations.

Then there's the question of legality, and which bodies can authorize the deployment of satellite constellations. The authors draw our attention to the 1994 statement from UNESCO (United Nations Educational, Scientific and Cultural Organization). That statement says "Persons belonging to future generations have the right to an uncontaminated and undamaged Earth, including pure skies; they are entitled to its enjoyment as the ground of human history of culture and social bonds that make each generation and individual a member of one human family."

That same statement from UNESCO also says "Here, World Heritage is the property of all humankind, and while there may be protective laws, enforcing this is another matter, as only States can sue other States under this type of international treaty. A State is responsible for the activities that occur within its jurisdiction – whether they are authorized or unauthorized."

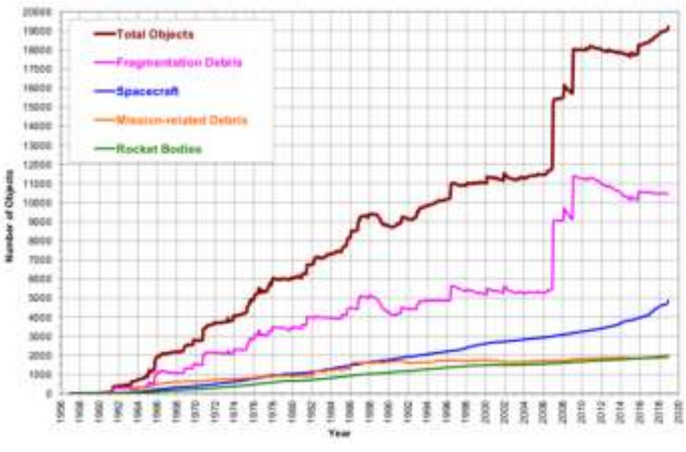
STS61 was the first servicing mission to the Hubble Space Telescope. The Hubble is the only space telescope to have been serviced after launch. Credit: NASA

The three astronomers point out that since the FCC and other bodies in the United States have given approval to Starlink, they may be able to halt Starlink, too. They may even be obligated to under international law.

They also mention the Outer Space Treaty, and say "And the legal process is that the state government, this time the USA government, is legally responsible for all objects sent into outer space that launch from USA borders. That means, that it is the USA government that is responsible for the harm caused by its corporation, Starlink, sending objects into orbit that cause harm."

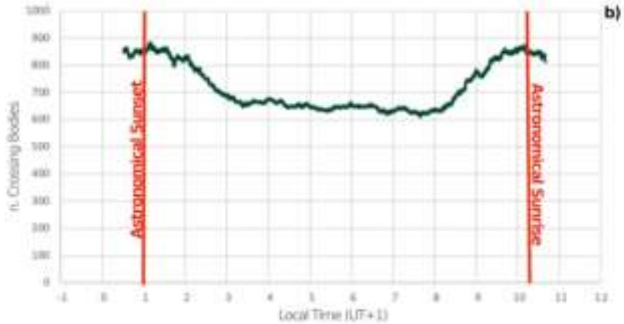
The paper draws to a close by pointing out possible legal actions that the international community could take to stop satellite constellations.

They could sue the FCC because in their approval they didn't take light pollution into account, which violates the National Environmental Policy Act. That act requires any federal agency to consider the environmental impact of the projects they approve. The authors claim that the FCC didn't adequately consider the light pollution from Starlink.



The number of objects around Earth is growing rapidly. Image Credit: Gallozzi et al; 2020

The international astronomy community could "sue in court for lack of jurisdiction and jurisprudence of US FCC to authorize private not geostationary satellites over other states and nations." This calls into question the FCC's right to even authorize satellite constellations that travel over other nations.



The number of crossing bodies during an evening of observing will grow rapidly with the deployment of satellite constellation. Image Credit: Gallozzi et al; 2020

Then there's the International Court of Justice (ICJ). The three authors say the international community could sue the US government at the ICJ "… to put on hold further Starlink launches to quantify the loss of public finances in damaging national and international astronomical projects."

The international astronomy community started a petition in January 2020. The community wants a hold put on Starlink and others, they want legal protections put in place for astronomical observing, and they want to limit the number of satellite constellations to a minimum.

"All of these requests come from the heartfelt concern of scientists arising from threatens to be barred from accessing the full knowledge of the Cosmos and the loss of an intangible asset of immeasurable value for humanity," the authors say.

Space is becoming more of a legal morass as time goes on. Exactly which types of activities will be allowed is unclear. Decades ago, near the beginning of the space age, laws and agreements were put in place to keep things under control.

But nobody foresaw anything like satellite constellations, and the legal framework governing space is likely going to come under a lot of pressure.

E Mails Viewings Logs and Images from Members.

Hi Andy,

Viewing Log plus conjunction of Moon and Venus recently and closer view of the Moon.

Moon phase: 4.1 days old or 14.4 % lit at a distance of 402,181 km.

Pete

Hi Andy,
Here are my submissions for the WAS March Newsletter.
Here are two images of Venus and Mercury at the Teide National Park, Tenerife.
The first shows Venus and Mercury just as the Sun was setting. Mercury is bottom centre of image just above the orange glow of the sunset.

Canon G16, 28mm, ISO 400, F1.8, 6 sec

The second is of Venus framed by the Rogues de Garcia.
Canon G16, 28mm, ISO 800, F1.8, 10 sec.

The final image is a stack of 27 images stacked in Starstax showing Venus setting among the bright lights of Puerto Cruz and being lost among the clouds over the sea. These were imaged from the hotel balcony!

Clear Skies,
John Dartnell

Hello Andy,

I have renewed the above with the FAS the total price was £53. Alarmingly the FAS have uprated their system into the 21st century thus making it easy to use. I have also added our Website details to their new and improved system.

See you Tuesday

Bob J

Viewing Log for 20th of February

Had a free evening and the skies were clear, so really this meant only one thing to me, a viewing session ☺?

After being out with the Sky Watcher EQ3-2 Pro Mount last time I thought I would go back to my normal set up and use the Meade LX90 8 inch (203 mm) GOTO telescope with the 14 mm Pentax XW eye piece giving a magnification of about 143? I arrived and had everything set up by 19:38, while setting up I had three cars go past me and the flood lights in the nearby farm were on! With a temperature of + 4 °C and a light wind it should be a reasonable experience for viewing?

With Venus coming to nearly half phase, I thought I would have a go at finding this planet. I was surprised but delighted to find Venus just in the field of view of the eye piece (in previous months I had found the planets to be nowhere near the eye piece and had to adjust quite a bit to centre them yet deep sky objects were in the eye piece?), I could make out the gibbous planet quite well. Would not be the same for my next target and Uranus, I noticed a blueish 'star' on the edge of finder scope, moving this 'star' to the centre, it turned out to be Uranus, nice!

With this month's speaker talking about the Messier Marathon, I thought I would start with the first object in this marathon and M

74, this is the classical faint fuzzy blob (FFB) to me and yes it is a spiral galaxy (SG) coming in at mag 9.2? No way would I be able to find this FFB using star hopping method? During the day we did have a few rain showers (now that is not rare for February?) and this cleared the sky a lot, as my next target M 79 in Lepus had a bright core to this globular cluster (GC). With M 79 being quite low from the UK it has never been that good to me, yet tonight I thought it was very good to look at. While in Lepus I had a look at the stars Arneb and Nihal (alpha and beta stars for the constellation), both of them looked white? Instead of just looking at the usual objects tonight (mainly Messier objects) I would have a look at my Star Atlas and seek out some others as well, starting with these two stars. Across the border and into Canis Major and look at M 41 a loose open cluster (OC) about 4 ° south of Sirius. Looking at the atlas I noticed a few other OC's in Canis Major, starting off with NGC 2354, a dim and small OC. Next was NGC 2360 which turned out to be Caldwell 58 (according to my hand controller), this was a small but pretty OC to view? Next target NGC 2345, an OC did not have many stars in it? Back to the Messier's and M 47, this is a large spread out OC. Right next door is M 46, another large OC which filled the eye piece with stars? Also in the OC there is a planetary nebula (PN), NGC 2438 which can be easy to miss, I think I saw it, but…….. M 50 is a large and loose OC, if I thought M 50 was large I was looking thru M 48. Really need a smaller eye piece for this object? While all this viewing Venus had been shining brightly in the western sky even with it getting lower, yet now I noticed it was being filtered out? Yes a cloud bank was coming in so my session but get stopped fairly soon (turns out this was one cloud only and was quite thin and did not affect my viewing too much later on).

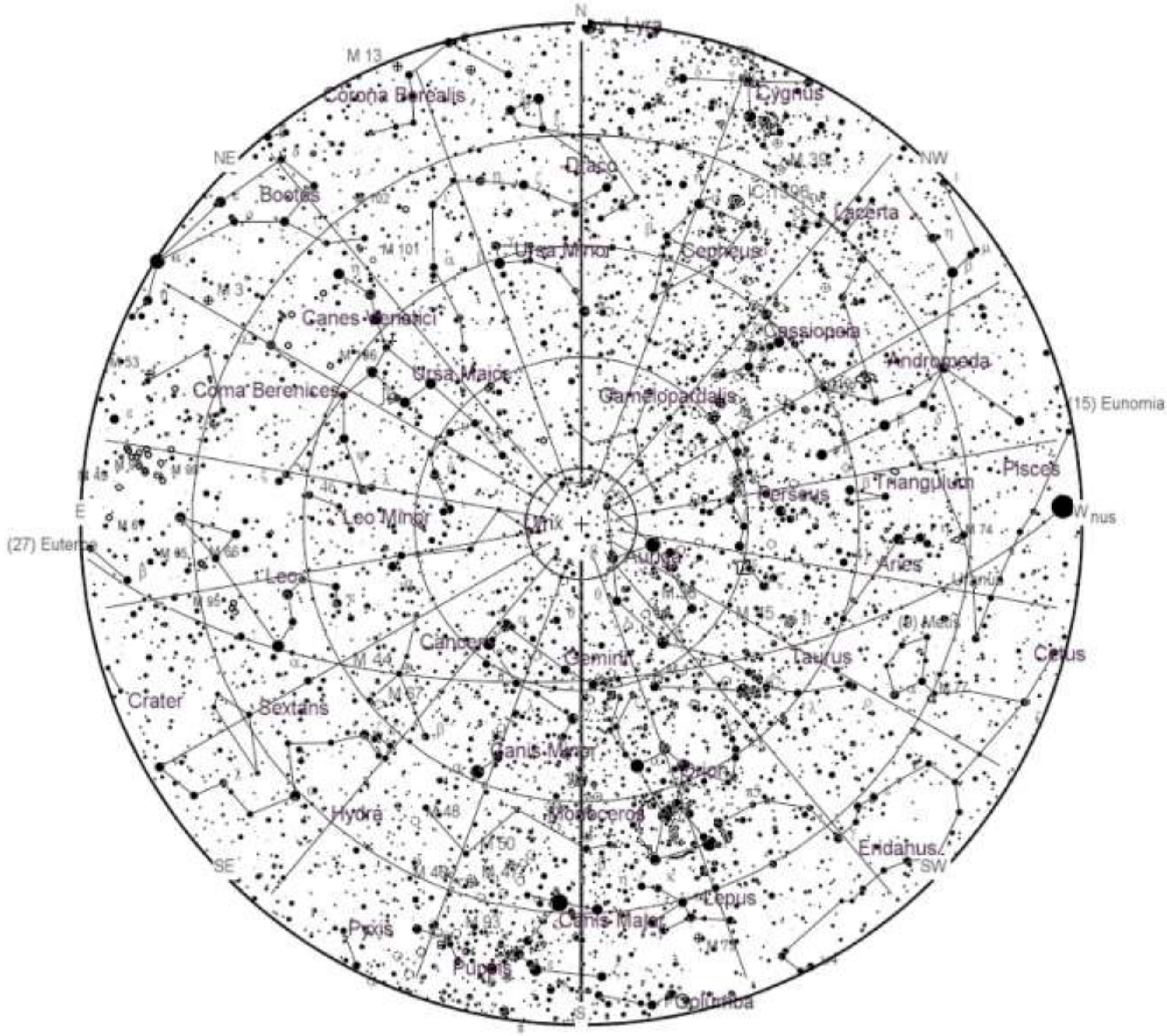
Back to the sky and M 45, this looked truly beautiful in the finder scope, again the sky condition helped?

Around to another PN and an object I rarely look at and M 76, just a faint blob (FB) and no real detail to see? At this time of year Andromeda is quite low in the northern sky, M 31 the great nebula of Andromeda had a bright core, close by is M 32, this also had a bright core but much smaller than M 31. The other close by galaxy is M 110 turned out to be a FFB! Time to have a quick look at the Ursa Major area and the glow of Swindon below it! Started with M 51, the Whirlpool galaxy, I had to use averted vision to find this object, the glow probably did not help? M 101 and M 109 were both FFB's to look at. Noticed Venus was about 30 minutes from setting and starting to go behind some trees, had another quick look at this planet, it seemed to have a few colours to it now? With it being that low, I think the atmosphere was having some effect on it? Back to Ursa Major area and my once nemesis and M 97 the Owl nebula, could only find this PN using adverted vision. M 108 could not be found at all, wonder if that cloud was having some effect on my viewing conditions? Tried M 81, a nice bright galaxy, I could make this out but not very clear? M 82 nearby was much better to look at. One of the less interesting objects on Messier's list is M 40, a double star not much else can be said about this! The cloud had now cleared Orion and I was thinking about packing up as I had been hit by several car lights recently! As usual, M 42 looked good, thought I would try with an OIII filter and see what that did. The OIII filter enhanced the dust lanes but I lost the four stars of the trapezium? Tried with a Deep Sky filter and the stars came back again. Thought I would try this filter on M 97 and it was much easier to find, of course the thin cloud might have now gone and made this area much easy to look at?

Yet another car went past me, so I decided to call it time after doing a two hour session, in that time 10 cars went pass me which is a lot. Noticed there was no dew on any parts of the gear used this evening. I would still leave them out overnight in the lounge to dry properly before storing them ready for the next session.

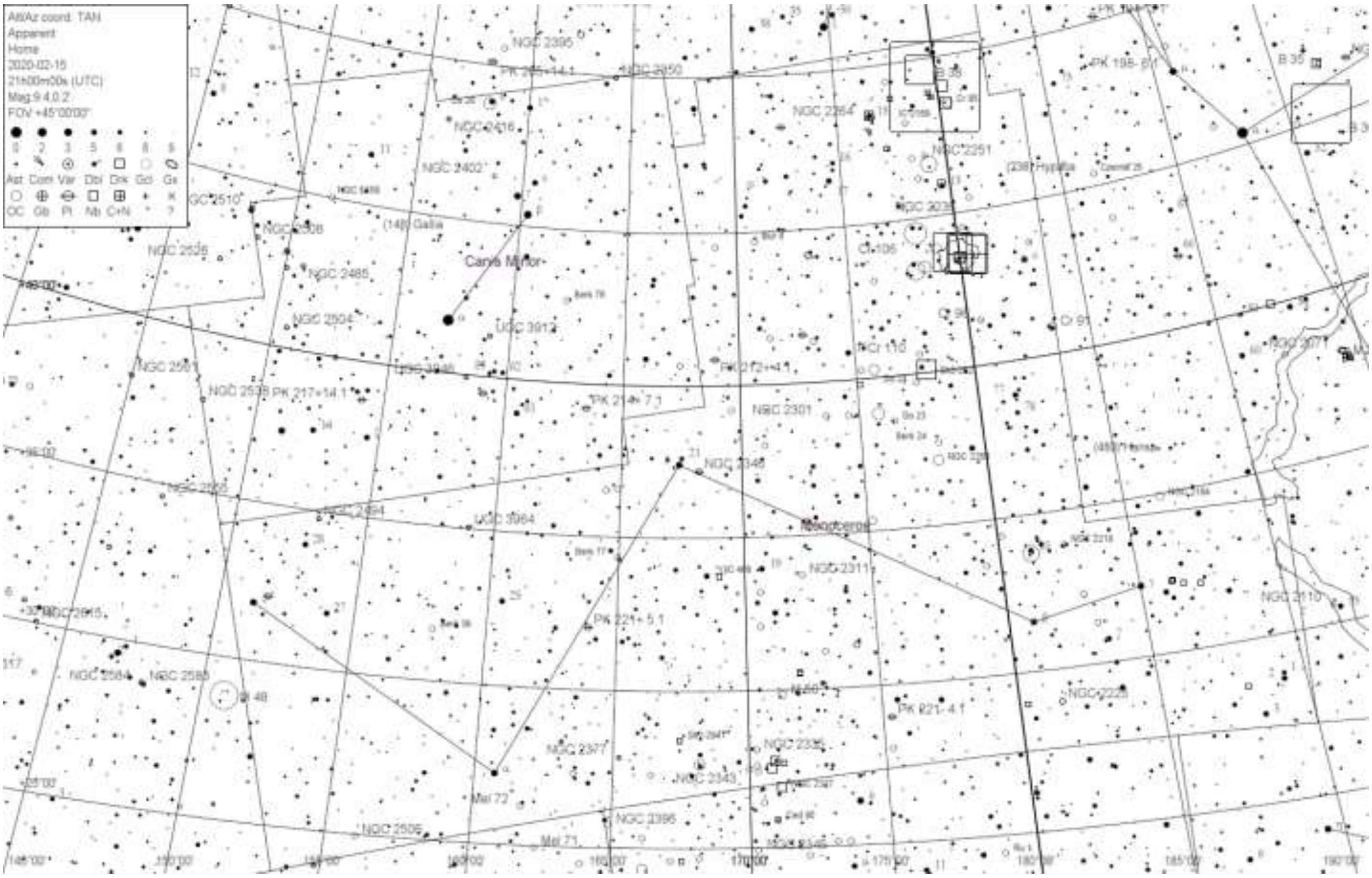
Clear skies.

Peter Chappell



March 9 - **Full Moon, Supermoon.** The Moon will be located on the opposite side of the Earth as the Sun and its face will be will be fully illuminated. This phase occurs at 17:48 UTC. This full moon was known by early Native American tribes as the Full Worm Moon because this was the time of year when the ground would begin to soften and the earthworms would reappear. This moon has also been known as the Full Crow Moon, the Full Crust Moon, the Full Sap Moon, and the Lenten Moon. This is also the second of four supermoons for 2020. The Moon will be at its closest approach to the Earth and may look slightly larger and brighter than usual.
March 20 - **March Equinox.** The March equinox occurs at 03:50 UTC. The Sun will shine directly on the equator and there will be nearly equal amounts of day and night throughout the world. This is also the first day of spring (vernal equinox) in the Northern Hemisphere and the first day of fall (autumnal equinox) in the Southern Hemisphere.
March 24 - **New Moon.** The Moon will located on the same side of the Earth as the Sun and will not be visible in the night sky. This phase occurs at 09:29 UTC. This is the best time of the month to observe faint objects such as galaxies and star clusters because there is no moonlight to interfere.
March 24 - **Mercury at Greatest Western Elongation.** The planet Mercury reaches greatest western elongation of 27.8 degrees from the Sun. This is the best time to view Mercury since it will be at its highest point above the horizon in the morning sky. Look for the planet low in the eastern sky just before sunrise.
March 24 - **Venus at Greatest Eastern Elongation.** The planet Venus reaches greatest eastern elongation of 46.1 degrees from the Sun. This is the best time to view Venus since it will be at its highest point above the horizon in the evening sky. Look for the bright planet in the western sky after sunset.

CONSTELLATIONS OF THE MONTH: Canis Minor and Monocerous



The Canis Minor and Monocerous Constellations

In the 2nd century CE, Greek-Egyptian astronomer Claudius Ptolemaeus (aka. Ptolemy) compiled a list of all the then-known 48 constellations. This treatise, known as the *Almagest*, would be used by medieval European and Islamic scholars for over a thousand years to come, effectively becoming astrological and astronomical canon until the early Modern Age.

One of these constellations was Canis Minor, a small constellation in the northern hemisphere. As a relatively dim collection of stars, it contains only two particularly bright stars and only faint Deep Sky Objects. Today, it is one of the 88 constellations recognized by the International Astronomical Union, and is bordered by the Monoceros, Gemini, Cancer and Hydra constellation.

Like most asterisms named by the Greeks and Romans, the first recorded mention of this constellation goes back to ancient Mesopotamia. Specifically, Canis Minor's brightest stars – Procyon and Gomeisa – were mentioned in the *Three Stars Each* tablets (ca. 1100 BCE), where they were referred to as *MASH.TAB.BA* (or "twins").

In the later texts that belong to the *MUL.APIN*, the constellation was given the name *DAR.LUGAL* ("the star which stands behind it") and represented a rooster. According to ancient Greco-Roman mythology, Canis Minor represented the smaller of Orion's two hunting dogs, though they did not recognize it as its own constellation.

In Greek mythology, Canis Minor is also connected with the Teumessian Fox, a beast turned into stone with its hunter (Laelaps) by Zeus. He then placed them in heaven as Canis Major (Laelaps) and Canis Minor (Teumessian Fox). According to English astronomer and biographer of constellation history Ian Ridpath:

"Canis Minor is usually identified as one of the dogs of Orion. But in a famous legend from Attica (the area around Athens), recounted by the mythographer Hyginus, the constellation represents Maera, dog of Icarius, the man whom the god Dionysus first taught to make wine. When Icarius gave his wine to some shepherds for tasting, they rapidly became drunk. Suspecting that Icarius had poisoned them, they killed him. Maera the dog ran howling to Icarius's daughter Erigone, caught hold of her dress with his teeth and led her to her father's body. Both Erigone and the dog took their own lives where Icarius lay.

"Zeus placed their images among the stars as a reminder of the unfortunate affair. To atone for their tragic mistake, the people of Athens instituted a yearly celebration in honour of Icarius and Erigone. In this story, Icarius is identified with the constellation Boötes, Erigone is Virgo and Maera is Canis Minor."

To the ancient Egyptians, this constellation represented Anubis, the jackal god. To the ancient Aztecs, the stars of Canis Minor were incorporated along with stars from Orion and Gemini into as asterism known as "Water", which was associated with the day. Procyon was also significant in the cultural traditions of the Polynesians, the Maori people of New Zealand, and the Aborigines of Australia.

In Chinese astronomy, the stars corresponding to Canis Minor were part of the The Vermilion Bird of the South. Along with stars from Cancer and Gemini, they formed the asterisms known as the Northern and Southern River, as well as the asterism *Shuiwei* ("water level"), which represented an official who managed floodwaters or a marker of the water level.

Canis Minor was one of the original 48 constellations included by Ptolemy in his the *Almagest.* Though not recognized as its own asterism by the Ancient Greeks, it was added by the Romans as the smaller of Orion's hunting dogs. Thanks to Ptolemy's inclusion of it in his 2nd century treatise, it would go on to become part of astrological and astronomical traditions for a thousand years to come.

For medieval Arabic astronomers, Canis Minor continued to be depicted as a dog, and was known as "*al-Kalb al-Asghar*". It was included in the Book of Fixed Stars by Abd al-Rahman al-Sufi, who assigned a canine figure to his stellar diagram. Procyon and Gomeisa were also named for their proximity to Sirius; Procyon being named the "Syrian Sirius ("*ash-Shi'ra ash-Shamiya*") and Gomeisa the "Sirius with bleary eyes" ("*ash-Shira al-Ghamisa*").

The constellation Canis Minor, shown alongside Monoceros and the obsolete constellation Atelier Typographique. Credit: Library of Congress

The constellation was included in Syndey Hall's *Urania's Mirror* (1825) alongside Monoceros and the now obsolete constellation Atelier Typographique. Many alternate names were suggested between the 17th and 19th centuries in an attempt to simplify celestial charts. However, Canis Minor has endured; and in 1922, it became one the 88 modern constellations to be recognized by the IAU.

Notable Features:

Canis Minor contains two primary stars and 14 Bayer/ Flamsteed designated stars. It's brightest star, Procyon (Alpha Canis Minoris), is also the seventh brightest star in the sky. With an apparent visual magnitude of 0.34, Procyon is not extraordinarily bright in itself. But it's proximity to the Sun – 11.41 light years from Earth – ensures that it appears bright in the night sky.

The star's name is derived from the Greek word which means "before the dog", a reference to the fact that it appears to rise before Sirius (the "Dog Star") when observed from northern latitudes. Procyon is a binary star system, composed of a white main sequence star (Procyon A) and Procyon B, a DA-type faint white dwarf as the companion.

Procyon is part of the Winter Triangle asterism, along with Sirius in Canis Major and Betelgeuse in the constellation Orion. It is also part of the Winter Hexagon, along with the stars Capella in Auriga, Aldebaran in Taurus, Castor and Pollux in Gemini, Rigel in Orion and Sirius in Canis Major.

Next up is Gomeisa, the second brightest star in Canis Minor. This hot, B8-type main sequence star is classified as a Gamma Cassiopeiae variable, which means that it rotates rapidly and exhibits irregular variations in luminosity because of the outflow of matter. Gomeisa is approximately 170 light years from Earth and the name is derived from the Arabic "*al-ghumaisa"* (*"*the bleary-eyed woman").

Canis Minor also has a number of Deep Sky Objects located within it, but all are very faint and difficult to observe. The brightest is the spiral galaxy NGC 2485 (apparent magnitude of 12.4), which is located 3.5 degrees northeast of Procyon. There is one meteor shower associated with this constellation, which are the Canis-Minorids

Though it is relatively faint, Canis Minor and its stars can be viewed using binoculars. Start with the brightest, Procyon – aka. Alpha Canis Minoris (Alpha CMi). If you're unsure of which bright star is, you'll find it in the center of the diamond shape grouping in the southwest area. Known to the ancients as Procyon – "The Little Dog Star" – it's the seventh brightest star in the night sky and the 13th nearest to our solar system.

For over 100 years, astronomers have known this brilliant star had a companion. Being 15,000 times fainter than the parent star, Procyon B is an example of a white dwarf whose diameter is only about twice that of Earth. But its density exceeds two tons per cubic inch! (Or, a third of a metric ton per cubic centimeter). While only very large telescopes can resolve this second closest of the white dwarf stars, even the moonlight can't dim its beauty.

The Winter Triangle. Credit: constellation-guide.com/ Stellarium software

Now hop over to Beta CMi. Known by the very strange name of Gomeisa ("bleary-eyed woman"), it refers to the weeping sister left behind when Sirius and Canopus ran to the south to save their lives. Located about 170 light years away from our Solar System, Beta is a blue-white class B main sequence dwarf star with around 3 times the mass of our Sun and a stellar luminosity over 250 times that of Sol.

Gomeisa is a fast rotator, spinning at its equator with a speed of at least 250 kilometers per second (125 times our Sun's rotation speed) giving the star a rotation period of about a day. Sunspots would appear to move very quickly there! According to Jim Kaler, Professor Emeritus of Astronomy at the University of Illinois:

"Since we may be looking more at the star's pole than at its equator, it may be spinning much faster, and indeed is rotating so quickly that it is surrounded by a disk of matter that emits radiation, rendering Gomeisa a "B-emission" star rather like Gamma Cassiopeiae and Alcyone. Like these two, Gomeisa is distinguished by having the size of its disk directly measured, the disk's diameter almost four times larger than the star. Like quite a number of hot stars (including Adhara, Nunki, and many others), Gomeisa is also surrounded by a thin cloud of dusty interstellar gas that it helps to heat."

Now hop over to Gamma Canis Minoris, an orange K-type giant with an apparent magnitude of +4.33. It is a spectroscopic binary, has an unresolved companion which has an orbital period of 389 days, and is approximately 398 light years from Earth. And next is Epsilon Canis Minoris, a yellow G-type bright giant (apparent magnitude of +4.99) which is approximately 990 light years from Earth.

For smaller telescopes, the double star Struve 1149 is a lovely sight, consisting of a yellow primary star and a faintly blue companion. For larger telescopes and GoTo telescopes, try NGC 2485 (RA 07 56.7 Dec +07 29), a magnitude 13 spiral galaxy that has a small, round glow, sharp edges and a very bright, stellar nucleus. If you want one that's even more challenging, try NGC 2508 (RA 08 02 0 Dec +08 34).

Canis Minor lies in the second quadrant of the northern hemisphere (NQ2) and can be seen at latitudes between +90° and -75°. The neighboring constellations are Cancer, Gemini, Hydra, and Monoceros, and it is best visible during the month of March.

Monoceros

The constellation of Monoceros was originally charted on a work done by Petrus Plancius in the early 1600s for its biblical references, but its first historical reference appears in Jakob Bartsch's star charts created of 1624 where it was listed as Unicornu. There is also a possibility, according to Heinrich Wilhelm Olbers and Ludwig Ideler's work with older astrological charts, that Monoceros could have been referred to as "the Second Horse" – while historian Joseph Justus Scaliger also makes reference to it in his (mid 1500s) work with Persian astrological records. Regards of its origins, Monoceros was adopted as one of the 88 modern constellations by the International Astronomical Union in 1930 and remains on the charts today. It is a relatively dim constellation that consists of 4 main stars in its primary asterism and contains 32 Bayer Flamsteed designated stars within its confines. Monoceros spans approximately 482 square degrees of sky and is bordered by the constellations of Canis Minor, Gemini, Hydra, Lepus, Orion and Puppis. It is visible to all observers located at latitudes between +75° and ?85° and is best seen at culmination during the month of February.

There is one annual meteor shower associated with Monoceros which peaks on or about December 10 of each year – the Monocerids: The radiant for this meteor shower occurs near the border of Gemini and averages about 12 meteors per hour at maximum fall rate. It is best viewed when there is little to no Moon to interfere with the faint streaks and activity is at its most when the constellation reaches the zenith.

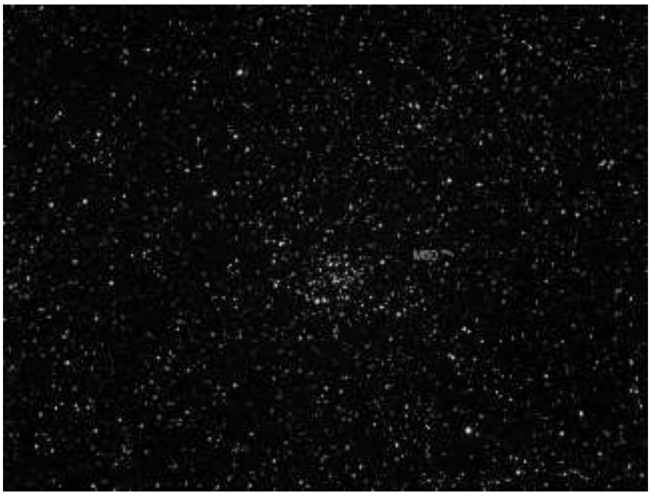
Because Monoceros is a relatively "new" constellation, there isn't any mythology associated with it – but the Unicorn itself has a long history of mystery. You'll not find this creature mention anywhere in mythology, but everywhere else! The unicorn is mention in the Bible, in accounts of natural history, in Chinese lore, Ethiopian artwork, medieval stories and religious art. It is depicted as a one-horned horse, thought to have existed somewhere at the edge of the known Earth.. and it still exists roaming the edges of the celestial sphere just between the northern and southern ecliptic plane. Fable or folklore? No matter which, it's filled with many great and starry delights!

Let's begin our binocular tour of Monoceros with its primary star – Alpha Monocerotis – the "a" symbol on our map. Hanging out in space some 144 light years from Earth, it's not the brightest star in the constellation, nor is it particular special. Alpha is just another orange/yellow helium-fusing giant star, not a whole lot different than ours. Averaging about 11 times larger than our Sun and putting out about 60 times more light, Alpha's hydrogen fuel tank went to empty about 250 million years ago. Now it just waits quiety, waiting for its helium shell to fade away… ready to spend the rest of its life as just another dense white dwarf star.

Now, take a look at Beta Monocerotis – the "B" symbol on our map. If you think it's slightly brighter – you're right. That's because Beta has some help from two other stars, too! Put your telescope Beta's way and discover what Sir William Herschel called "one of the most beautiful sights in the heavens". This fantastic triple star star system is located about 690 light years from our solar system. As you watch it slowly drift by the eyepiece, you'll know the names of the stars by which leave sight first… from west to east they are A, B and C. In this circumstance, it is believed the B and C stars orbit each other and the A star orbits this pair. All three are about 34 million years old and all three are dwarf stars. Close to each other in magnitude, this trio of hot, blue/white B3 stars each run a temperature of about 18,500 Kelvin and shine anywhere from 3200 down t0 1300 times brighter than our own Sun and spinning on their axis up to 150 times faster. A real triple treat!

For binoculars, have a look at visual double star Delta Monocerotis – the "8" symbol on our map. Located 115 light years from our solar system, this cool pair is worth stopping by – just to see if you can resolve it with your eyes alone! Don't forget to try Epsilon Monocerotis, too. The backwards "3" on our map. Larger, steady binoculars may separate it and it's easy for a smaller telescope. This is a very pretty gold and yellow combination binary star, seperated by about two magnitudes. You'll find it on a number of observing lists. While there, take a look just two degrees northwest of Epsilon for T Moncerotis. This is a great Cepheid variable star with a period of 27 days and a magnitude range of 6.4 to 8.0. Those are the kinds of changes you can easily notice!

Our first deep sky binocular and telescope target will be magnificent Messier 50 (RA 07:03.2 Dec -08:20). This splendid open star cluster averages around magnitude 6 and was logged on April 5, 1772 by Charles Messier in his catalog on deep sky objects. Located about about 3,200 light years from Earth, it spans about 20 light years of space and contains about 200 stars. Inside this 78 million year old cloud is at least one red giant star – located just a little bit south of central. Can you spot it? How about the smattering of yellows amid the blue/whites?



Now head for equally bright NGC 2301 (6:51.8 Dec +00:28). This easily resolvable chain of stars can be seen in binoculars, but requires a telescope to resolve its individual members. Smaller telescopes will notice at least 30 members, while larger aperture can detect many more from this 80 member galactic star cluster. Located about 2500 light years away, be sure to see if you notice color in the stars here, too. This intermediate age open cluster has been studied for short-term variable stars and chemically peculiar stars. You'll find this one on many challenging observing lists, too!

Time to hop to NGC 2244 (RA 6:32.4 Dec +04:52). The "Rosette Nebula" is a fine target for either telescopes or larger binoculars at a combined magnitude of 5. But, remember, combined magnitude isn't true brightness! You'll find the nebula here is quite faint and requires a good, dark, Moon-less sky. NGC 2244 is a star cluster embroiled in a reflection nebula spanning 55 light-years and most commonly called "The Rosette." Located about 2500 light-years away, the cluster heats the gas within the nebula to nearly 18,000 degrees Fahrenheit, causing it to emit light in a process similar to that of a fluorescent tube. A huge

percentage of this light is hydrogen-alpha, which is scattered back from its dusty shell and becomes polarized. While you won't see any red hues in visible light, a large pair of binoculars from a dark sky site can make out a vague nebulosity associated with this open cluster. Even if you can't, it is still a wonderful cluster of stars crowned by the yellow jewel of 12 Monocerotis. With good seeing, small telescopes can easily spot the broken, patchy wreath of nebulosity around a well-resolved symmetrical concentration of stars. Larger scopes, and those with filters, will make out separate areas of the nebula which also bear their own distinctive NGC labels. No matter how you view it, the entire region is one of the best for winter skies.

Now for NGC 2264 (RA 6:41.1 Dec +09:53). Larger binoculars and small telescopes will easily pick out a distinct wedge of stars. This is most commonly known as the "Christmas Tree Cluster," its name given by Lowell Observatory astronomer Carl Lampland.

With its peak pointing due south, this triangular group is believed to be around 2600 light-years away and spans about 20 light-years. Look closely at its brightest star – S Monocerotis is not only a variable, but also has an 8th magnitude companion. The group itself is believed to be almost 2 million years old. The nebulosity is beyond the reach of a small telescope, but the brightest portion illuminated by one of its stars is the home of the Cone Nebula. Larger telescopes can see a visible V-like thread of nebulosity in this area which completes the outer edge of the dark cone. To the north is a photographic only region known as the Foxfur Nebula, part of a vast complex of nebulae that extends from Gemini to Orion.

Northwest of the complex are several regions of bright nebulae, such as NGC 2247, NGC 2245, IC 446 and IC 2169. Of these regions, the one most suited to the average scope is NGC 2245 (RA 6:32.7 Dec +10:10), which is fairly large, but faint, and accompanies an 11th magnitude star. NGC 2247 is a circular patch of nebulosity around an 8th magnitude star, and it will appear much like a slight fog. IC 446 is indeed a smile to larger aperture, for it will appear much like a small comet with the nebulosity fanning away to the southwest. IC 2169 is the most difficult of all. Even with a large scope a "hint" is all!

Now, get out there and capture NGC 2261 (RA 6:39.2 Dec +08:44). You'll find it about 2 degrees northeast of star 13 in Monoceros. Perhaps you know it better as "Hubble's Variable Nebula"? Named for Edwin Hubble, this 10th magnitude object is very blue in appearance through larger apertures, and a true enigma. The fueling star, the variable R Monocerotis, does not display a normal stellar spectrum and may be a proto-planetary system. R is usually lost in the high surface brightness of the "comet-like" structure of the nebula, yet the nebula itself varies with no predictable timetable – perhaps due to dark masses shadowing the star. We do not even know how far away it is, because there is no detectable parallax!

There are many other wonderful objects in Monoceros just waiting for you to discover them… So get a good star atlas and go hunting the Unicorn!

ISS PASSES For March 2020 From Heavens Above website maintained by Chris Peat

Date	Brightness	Start			Highest point			End		
	(mag)	Time	Alt.	Az.	Time	Alt.	Az.	Time	Alt.	Az.
03 Mar	-2.3	04:16:26	37°	E	04:16:26	37°	E	04:18:39	10°	E
03 Mar	-3.8	05:49:22	15°	W	05:52:06	86°	N	05:55:30	10°	E
04 Mar	-0.5	03:30:34	13°	E	03:30:34	13°	E	03:30:59	10°	E
04 Mar	-3.8	05:03:30	46°	W	05:04:24	85°	N	05:07:48	10°	E
05 Mar	-2.7	04:17:37	46°	E	04:17:37	46°	E	04:20:06	10°	E
05 Mar	-3.7	05:50:34	13°	W	05:53:32	76°	SSW	05:56:55	10°	ESE
06 Mar	-0.7	03:31:44	15°	E	03:31:44	15°	E	03:32:24	10°	E
06 Mar	-3.8	05:04:41	38°	W	05:05:51	88°	S	05:09:14	10°	E
07 Mar	-3.1	04:18:49	54°	E	04:18:49	54°	E	04:21:32	10°	E
07 Mar	-3.3	05:51:46	11°	W	05:54:51	47°	SSW	05:58:07	10°	SE
08 Mar	-0.9	03:32:59	16°	E	03:32:59	16°	E	03:33:48	10°	E
08 Mar	-3.7	05:05:56	34°	W	05:07:12	62°	SSW	05:10:32	10°	ESE
09 Mar	-3.2	04:20:08	54°	ESE	04:20:08	54°	ESE	04:22:52	10°	ESE
09 Mar	-2.4	05:53:07	10°	W	05:55:59	26°	SSW	05:58:50	10°	SSE
10 Mar	-0.9	03:34:25	15°	E	03:34:25	15°	E	03:35:09	10°	E
10 Mar	-3.0	05:07:22	28°	WSW	05:08:23	35°	SSW	05:11:29	10°	SE
11 Mar	-2.6	04:21:44	34°	SSE	04:21:44	34°	SSE	04:23:58	10°	SE
11 Mar	-1.6	05:55:19	10°	WSW	05:56:54	13°	SW	05:58:30	10°	SSW
12 Mar	-0.7	03:36:13	11°	ESE	03:36:13	11°	ESE	03:36:21	10°	ESE
12 Mar	-2.1	05:09:11	18°	SW	05:09:22	19°	SW	05:11:47	10°	S
13 Mar	-1.4	04:23:49	15°	SSE	04:23:49	15°	SSE	04:24:37	10°	SSE
19 Mar	-1.8	19:32:30	10°	S	19:34:10	14°	SE	19:34:10	14°	SE
20 Mar	-2.6	20:19:43	10°	SW	20:21:57	31°	SSW	20:21:57	31°	SSW
21 Mar	-2.7	19:32:12	10°	SSW	19:35:08	28°	SSE	19:36:32	21°	ESE
21 Mar	-1.5	21:08:18	10°	WSW	21:09:31	21°	WSW	21:09:31	21°	WSW
22 Mar	-3.9	20:20:28	10°	WSW	20:23:48	67°	SSE	20:23:56	66°	SE
23 Mar	-3.5	19:32:43	10°	SW	19:35:58	52°	SSE	19:38:14	18°	E
23 Mar	-2.0	21:09:19	10°	W	21:11:11	30°	W	21:11:11	30°	W
24 Mar	-3.9	20:21:25	10°	W	20:24:47	90°	ENE	20:25:22	58°	E
24 Mar	-0.5	21:58:14	10°	W	21:58:18	10°	W	21:58:18	10°	W
25 Mar	-3.8	19:33:32	10°	WSW	19:36:53	80°	S	19:39:28	16°	E
25 Mar	-2.3	21:10:20	10°	W	21:12:25	35°	W	21:12:25	35°	W
26 Mar	-3.8	20:22:24	10°	W	20:25:46	85°	N	20:26:28	53°	E
26 Mar	-0.5	21:59:13	10°	W	21:59:24	11°	W	21:59:24	11°	W
27 Mar	-3.8	19:34:28	10°	W	19:37:50	85°	N	19:40:28	16°	E
27 Mar	-2.3	21:11:16	10°	W	21:13:24	35°	W	21:13:24	35°	W
28 Mar	-3.9	20:23:20	10°	W	20:26:41	79°	SSW	20:27:23	53°	ESE
28 Mar	-0.5	22:00:17	10°	W	22:00:18	10°	W	22:00:18	10°	W
29 Mar	-3.8	20:35:23	10°	W	20:38:45	90°	S	20:41:20	16°	E
29 Mar	-2.1	22:12:13	10°	W	22:14:16	28°	WSW	22:14:16	28°	WSW
30 Mar	-3.4	21:24:13	10°	W	21:27:30	51°	SSW	21:28:14	41°	SSE
31 Mar	-3.6	20:36:15	10°	W	20:39:35	66°	SSW	20:42:12	15°	ESE
31 Mar	-1.5	22:13:25	10°	W	22:15:08	18°	WSW	22:15:08	18°	WSW
01 Apr	-2.3	21:25:12	10°	W	21:28:08	28°	SSW	21:29:08	24°	S
02 Apr	-2.8	20:37:07	10°	W	20:40:15	38°	SSW	20:43:09	12°	SE
03 Apr	-1.3	21:26:41	10°	WSW	21:28:34	14°	SW	21:30:09	11°	S
04 Apr	-1.6	20:38:11	10°	W	20:40:45	20°	SW	20:43:19	10°	SSE

END IMAGES, OBSERVING AND OUTREACH

The Moon and Venus on 2nd March, using 2x Barlow lens on 127mm Esprit telescope, D7200 DSLR.
The angle from the Earth to the Moon and the Sun meant 60% of illumination.
This matches the view of Venus on the same night, though Venus is 132 million km away.

Andy

Wiltshire Astronomical Society	Observing Sessions 2019/20	
Date	**Moon Phase (%)**	**Moonrise/Targets**
2020		
27th March	6% 2.3day set before start	Venus, Milky Way South to North
24th April not dark until 9:30pm	0%	Venus high, galaxies of Leo and Virgo clusters
22nd May not dark until 10pm	0%	Summer triangle rising

OUTREACH

After our last meeting I was suddenly inundated by requests for help from scouts, beavers and schools.

Westbury Leigh and Wellington Academy at Ludgershall were visited for talks.

Excellent session at Stonar.

Work with Dark Skies Wales for 14th February at Dunstable Downs, then 12 hour days on Wednesday to Saturday 20th to 24th February very windy.

We still need to get some viewing sessions in at Chippenham Beavers on Wednesdays and Chippenham scouts on a Thursday.