STELLAR SENTINEL
Grand Traverse Astronomical Society
November 2014

Sleeping Bear Skies for Autumn and Winter

By Bob Moler

Author's Note: I wrote this at the request of Sleeping Bear Dunes National Lakeshore Volunteer Mallory Huizenga for their web page. The original contained a prolog and a writeup for all the seasons. I'm excerpting the prolog plus the autumn and winter seasons, with some additions for the current planets.

The Sleeping Bear Dunes National Lakeshore is a perfect place to observe the heavens and contemplate the universe. It is one of the 10 darkest national parks. What appears as a dome of stars overhead is a vastly deep universe of planets, stars and galaxies.

When one goes out to view the stars, at first the sky appears perfectly black if the moon isn't out and twilight ended, but after 10 to 20 minutes the fainter stars appears and the sky isn't so inky black anymore. This is the period it takes your eyes to be dark adapted. If you must use a flashlight, use one with a red LED or red filter which affects the eyes less. Dress in layers. It can cool down a lot with clear skies. Don't forget the mosquito repellant. Skeeters are a big problem early in the evening, but their threat does taper off later in the evening. If observing meteors or just contemplating the heavens, simply lay back on a blanket. Any kind of binoculars are nice to have to investigate those seemingly fuzzy spots in the sky that can't quite be made out with the naked eye. Of course binoculars are the best instrument for sweeping the Milky Way. Use the star chart in your Stellar Sentinel plus all smart phones and tablets have free star finding apps now.

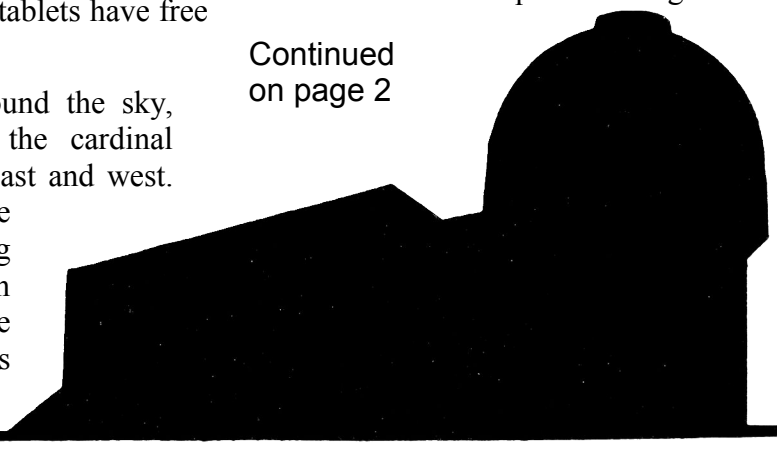
To find your way around the sky, you will need to find the cardinal directions: north, south, east and west. To orient yourself, locate the Big Dipper. On spring evenings it's overhead, in summer its in the northwest, in the fall, it's dipping down near the northern horizon, and in the winter it's standing on its handle in the northeast. At the park, the Big Dipper never sets. The park also straddles the 45th north parallel of latitude, which is half way from the equator to the north pole. The star Polaris, or North Star appears nearly over the north pole of the Earth, so as the Earth rotates it appears to stand still, while all the other stars appear to move around it in a counter clockwise direction once every day.

Polaris can be found using the Big Dipper by extending a line through the stars at the front of the bowl upward from the open face of the bowl to Polaris. It may appear quite alone on all but the darkest nights. A moonless night will reveal the bent handle and small bowl of the Little Dipper, of which Polaris is the star at the end of the handle. By facing north and the star Polaris, south is behind you, east is to to your right and west to your left. If you're facing south, then east is to your left from which the stars, planets, Sun and Moon rise, and west is to your right where all these objects will set.

Autumn

In autumn the Milky Way shifts to run from the northeast, overhead to the southwest. In early autumn the teapot will pour out on the southwestern horizon before it too sets. The Summer Triangle has shifted to the west. Cassiopeia has risen higher in the northeast. A large square of stars dominates the eastern sky, this is the Great Square of Pegasus the

Continued on page 2



Sleeping Bear Skies for Autumn and Winter (From page 1)

winged horse of Greek myth, who's showing off by flying upside down. The Great Square is standing on one corner. From the left corner extend two lines of stars that is Andromeda the chained princess. If these names seen familiar, they are Greek characters in a wonderful story on which the movie Clash of the Titans is loosely based. The Kraken will be released later in the season when the constellation Cetus rises. Astronomers have turned it into a less threatening whale. By then the Milky Way will run roughly east and west.

Look for the beautiful star cluster Pleiades or Seven Sisters rising in the east-northeast. Binoculars are the most you'll need to see them at their best. The Big Dipper is moving toward the horizon in the north as Cassiopeia, opposite Polaris from the dipper ascends to the zenith. The Native Americans around here have a legend regarding the Big Dipper, which besides a bear was the tail end of a weasel-like creature they called Fisher Star, who brought summer to the Earth. He was killed for his trouble by an arrow in his tail. He had, to mix Greek and Indian legends, an Achilles' tail. That was his only vulnerability. Every autumn as his bloody tail, the Big Dipper's handle, brushes the horizon in the north the trees turn their beautiful fall colors of read and yellow.

The planet of autumn this year is the retreating planet Mars seen low in the southwest moving through Scorpius, Ophiuchus, Sagittarius and into Capricornus. Jupiter will rise late in the evening.

Winter

Winter brings a circle of the seven brilliant stars of the season. In the center lies the most famous constellation of all Orion the hunter, with his belt of three bright stars in a distinctive straight line. This is in the center of an upright rectangle of stars. The upper left star of the rectangle is the bright red giant star Betelgeuse (pronounced Beetle Juice, and don't say it three times according to the movie of the same name). The lower right star is the usually slightly brighter blue-white Rigel. The belt stars point in two directions. First down to the left and the brightest night-time star Sirius, in the heart of Orion's great hunting dog Canis Major. That's why Sirius is sometimes called the Dog Star. Sirius, being low to the south, lets our atmosphere sometimes distort its arc light color into a rainbow of sparkles in telescopes. Second the belt pointing to the upper right points to the orange star Aldebaran and the letter V of stars that is the face of Taurus the Bull, who some see as charging toward Orion. In late winter the Big Dipper will be rising high in the northeast. Fisher Star will be announcing the start of the maple sugar season.

Jupiter will shine brightly between the constellations Cancer and Leo. Venus as the Evening Star will begin to make its appearance low in the southwest after sunset in December. By the end of winter it will be low in the west, outshone by only the bright Moon.

The Stellar Sentinel is Available by Email

If you receive the Stellar Sentinel via email you will receive an Adobe Acrobat (PDF) copy of the newsletter. It can be printed, or viewed on the computer screen. Hyperlinks like the ones above can be clicked on to directly link to the page. If you email your email address to info@gtastro you will receive the pdf copy of this issue to start you off plus be enrolled to receive better quality issues with even more content that can be squeezed into 8 pages.

Grand Traverse Astronomical Society - Est. June 1982 – 32 years of service

-----Officers-----		*Directors*	*S.S Staff*	*----------Patrons----------*
President	Ron Uthe	Jerry Dobek	Bill Renis	Mick Glasser HG & Autumn Smith Bill Hathaway Ronald & Jan Uthe Nancy Hammond Charles Bell Judy Moler
Vice President	Dave Kane	Bill Renis	Lee Renis	
Secretary	Don Flegel	Joe Brooks	Bernadette Farrell	
Treasurer	Gary Carlisle	Richard Kuschell		
Editor	Bob Moler			

Society Events

Check http://www.gtastro.org for late breaking events.

November

7 Friday **Board of Directors** – 7 p.m. - NMC Rogers Observatory
General Meeting – 8 p.m. - NMC Rogers Observatory.
Program: Hitchhiker's Guide to the Solar System
Star Party: 9 p.m. - 11 p.m. - NMC Rogers Observatory.

15 Saturday **Star Party –** 9 p.m. - 11 p.m. - NMC Rogers Observatory.

December

5 Friday **Board of Directors** – 7 p.m. - NMC Rogers Observatory
General Meeting – 8 p.m. - NMC Rogers Observatory.
Program: Bob Moler – In Search of the Star of Bethlehem
Star Party – 9 p.m. - 11 p.m. - NMC Rogers Observatory.

---------- Star Parties ----------

Rogers Observatory star parties for the rest of 2014: 11/7, 11/15, 12/5. 2015: To be announced

Sleeping Bear Dunes star parties for 2015 To be announced

---------- Some of the best objects for public viewing in November ----------

Planetary Object(s): Mars

Deep Sky Object, description, constellation, distance	Rt. Asc. hr. min.	Declin. ° '
M 13: Great Hercules globular cluster, Her, 25k l.y.	16 41.7	+36 28
M 57: Ring Nebula (planetary), Lyr, 1500 l.y.	18 53.6	+33 02
Alberio (β Cygni): Gold and blue double star, Cyg, 160 l.y., actual separation = 400b miles	19 30.3	+27 43
M 11: A great open (galactic) star cluster, Sct, 5.5k l.y.	18 50.0	-06 16
M 27: Dumbbell nebula (planetary), Vul, 900 l.y.	19 58.8	+22 43
M 31: Great Andromeda Galaxy, And, 2.3m l.y.	00 42.7	+41 16
M52: Rich open cluster, Cas,5.5k l.y.	23 24.2	+61 35
Almach (γ Andromedae): Yellow and greenish-blue double star, And, 260 l.y.	02 03.2	+42 17
χ & h Persei: Double Cluster, Per, 7k l.y.; χ Per, 8.1k l.y.	02 20.0	+57 08

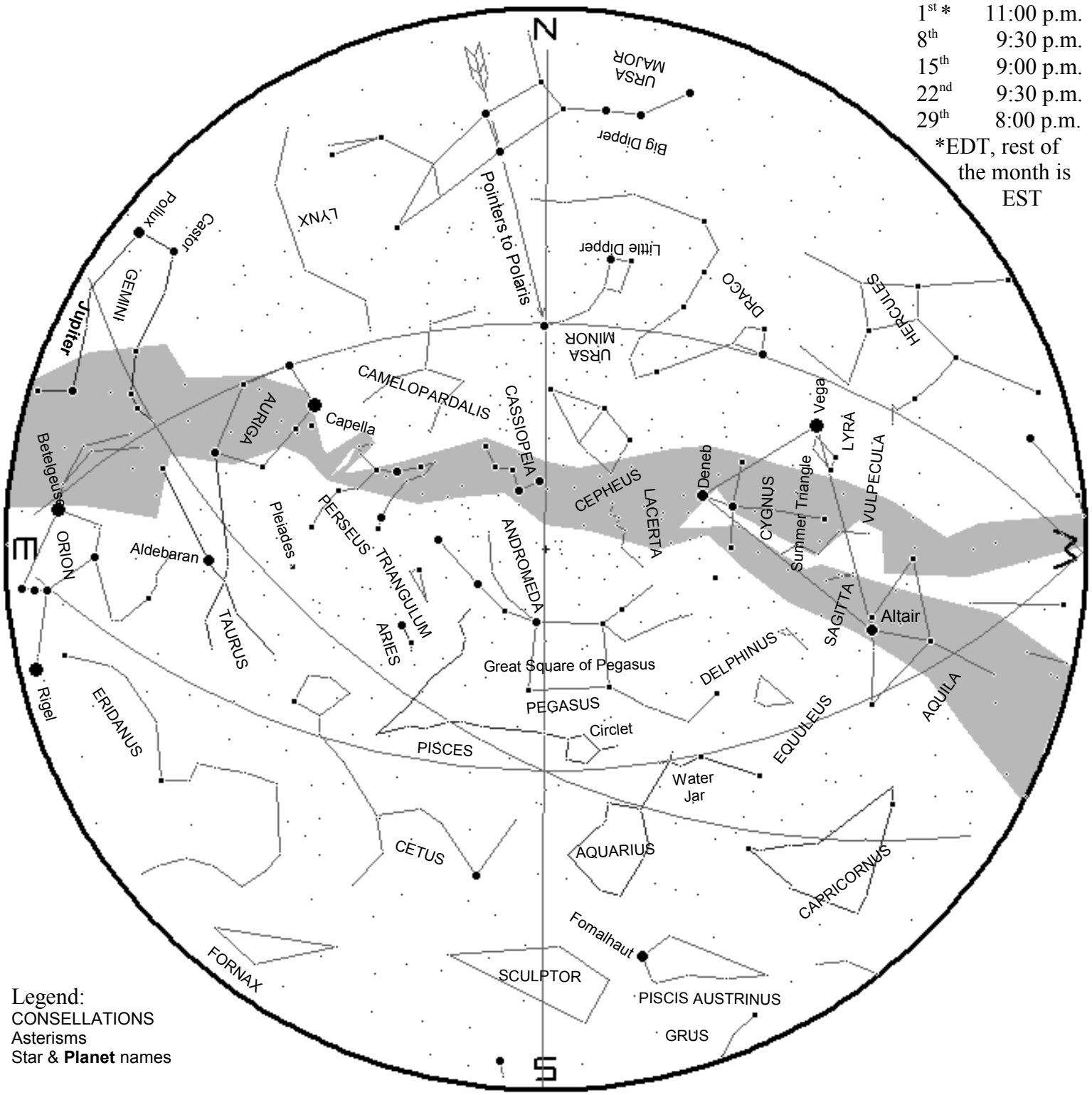
The Stars and Planets for November 2014

By Bob Moler

Planets are plotted for mid month. The star positions are correct for:

1st *	11:00 p.m.
8th	9:30 p.m.
15th	9:00 p.m.
22nd	9:30 p.m.
29th	8:00 p.m.

*EDT, rest of the month is EST



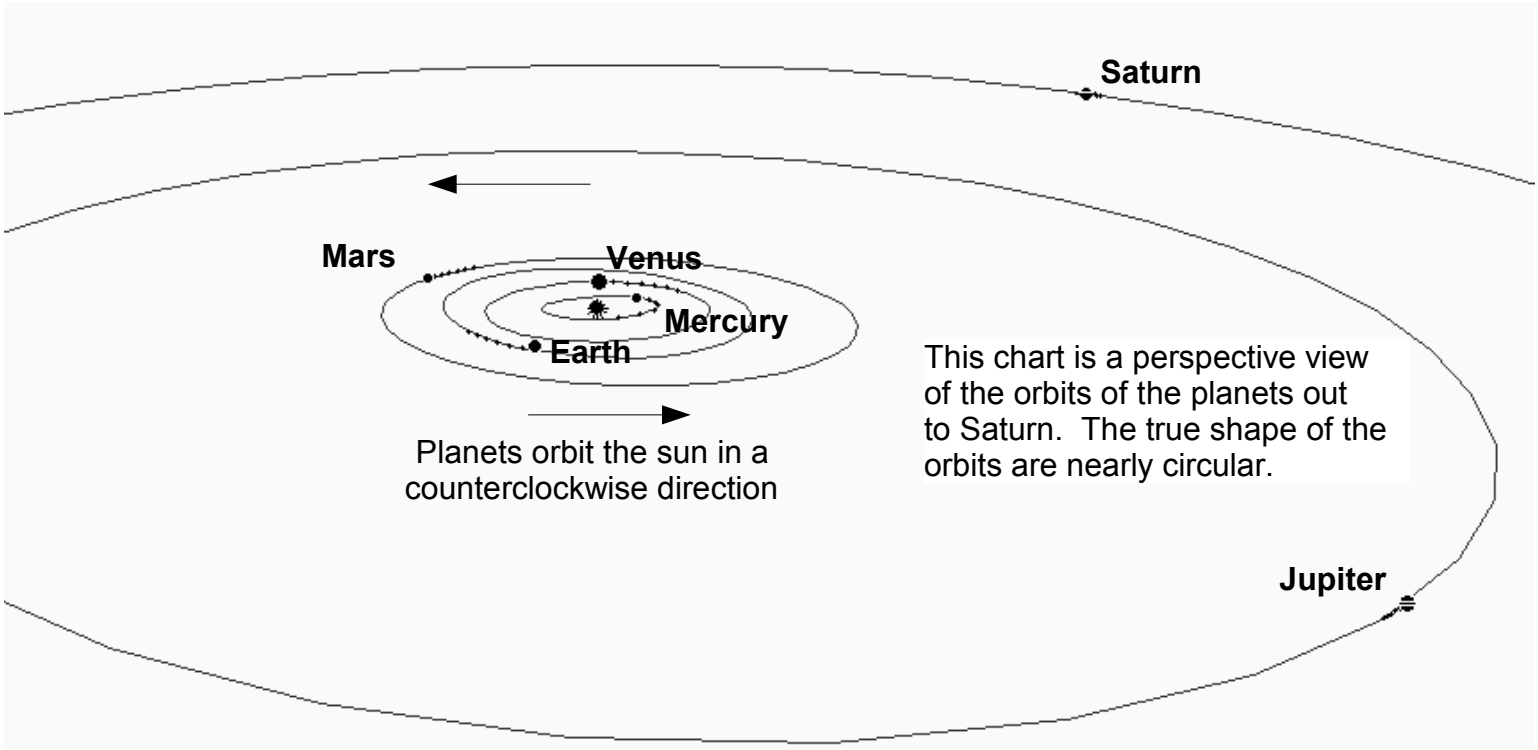
Legend:
CONSELLATIONS
Asterisms
Star & **Planet** names

November brings the autumn constellations to center stage in the south. The northernmost of the summer constellations are still hanging on in the western sky. There are no bright planets visible at chart time although Uranus and Neptune are visible. The northernmost of the winter sky rise in the northeast. Even the central winter constellation Orion is seen throwing a leg over the horizon in the east. Pegasus the aerobatic flying horse is flying upside down nearly overhead in the south at chart time. It rides high along with Cassiopeia the queen, Cepheus the king, Andromeda the princess, Perseus the hero and Cetus the sea monster, of that wonderful autumn story. Venus is in the evening sky, but won't be really visible until next month.

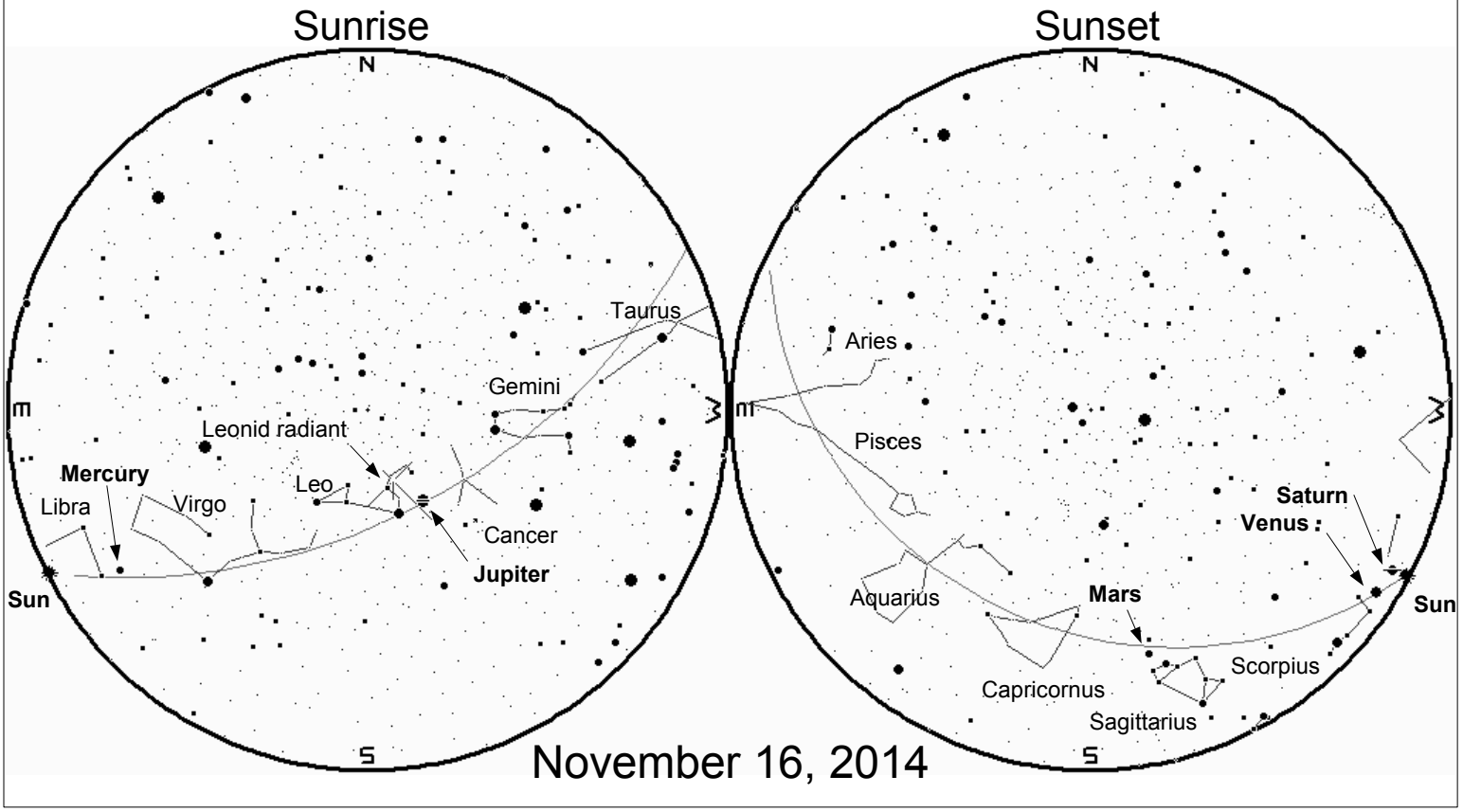
For more information on planets and stars each month:
http://ephemeris.bjmoler.org

The Naked Eye Planets

November 1st, 6th, 11th, 16th, 21st, 26th, December 1st



The Planets as Seen From Northern Michigan



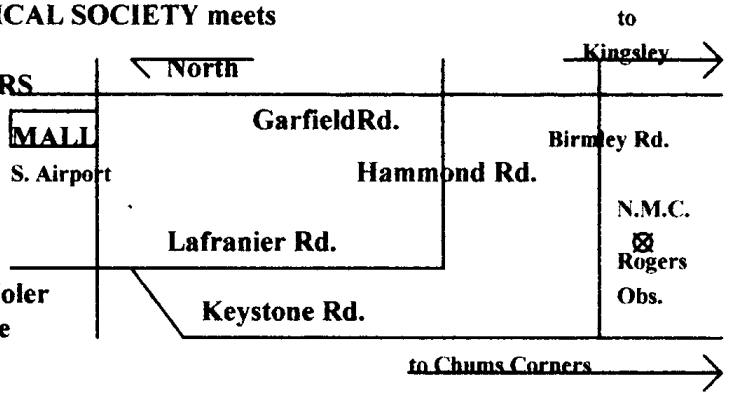
November 16, 2014

CELESTIAL CALENDAR

Nov 01	8 a.m.	Mercury at Greatest Elong: 18.7°W
02	**2:00 a.m.**	**Eastern Standard Time Returns. Turn clocks back 1 hr.**
02	7:21 p.m.	Moon at Perigee: 367871 km
04	7:10 a.m.	Mercury 3.9°N of Spica
04	10:13 p.m.	Moon at Descending Node
05	12 noon	S Taurid Meteor Shower
06	5:23 p.m.	FULL MOON
07	**8 p.m.**	**GTAS Monthly Meeting – NMC Observatory**
		Program: Hitchhiker's Guide to the Solar System
07	**9 p.m.**	**Star Party - NMC Observatory**
08	2:41 p.m.	Aldebaran 1.4°S of Moon
12	11 a.m.	N Taurid Meteor Shower
14	10:16 a.m.	LAST QUARTER MOON
14	12:39 p.m.	Jupiter 5.2°N of Moon
14	20:56 p.m.	Moon at Apogee: 404338 km
15	5:05 a.m.	Regulus 4.6°N of Moon
15	**9 p.m.**	**Star Party - NMC Observatory**
17	5 p.m.	Leonid Meteor Shower
18	3 a.m.	Saturn in Conjunction with Sun
19	3:18 a.m.	Moon at Ascending Node
19	11:01 a.m.	Spica 2.6°S of Moon
22	7:32 a.m.	NEW MOON
27	6:11 p.m.	Moon at Perigee: 369825 km
29	5:06 a.m.	FIRST QUARTER MOON

Calendar of Astronomical Events Courtesy of Fred Espenak, www.AstroPixels.com

The GRAND TRAVERSE ASTRONOMICAL SOCIETY meets on the first Friday of each month at the NORTHWESTERN MICHIGAN ROGERS OBSERVATORY at 8 p.m. The public is invited to attend all Society functions as our guests. We are a non-profit group dedicated to the study of astronomy and the sky above us. If you would like more information on GTAS, please call Bob Moler at 946-8649, or write to the address on the last page of this publication.



Ephemeris of Sky Events for NMC Observatory										
November, 2014 - Local time zone: EDT										
Date		**Sun**			**Twilight***		**Moon**			**Illum**
		Rise	**Set**	**Hours**	**End**	**Start**	**Phase**	**R/S****	**Time**	**Fractn**
Sat	1	08:20a	06:31p	10:11	08:10p	06:41a		Set	03:11a	71%
*** Time Change - **EST** - Time Change ***										
Sun	2	07:21a	05:29p	10:08	07:08p	05:42a		Set	03:23a	81%
Mon	3	07:22a	05:28p	10:05	07:07p	05:43a		Set	04:35a	89%
Tue	4	07:24a	05:27p	10:03	07:06p	05:44a		Set	05:46a	95%
Wed	5	07:25a	05:26p	10:00	07:05p	05:46a		Set	06:56a	99%
Thu	6	07:26a	05:24p	09:57	07:04p	05:47a	Full	Rise	05:32p	100%
Fri	7	07:28a	05:23p	09:55	07:03p	05:48a		Rise	06:15p	99%
Sat	8	07:29a	05:22p	09:52	07:02p	05:49a		Rise	07:01p	95%
Sun	9	07:31a	05:21p	09:50	07:01p	05:50a		Rise	07:51p	89%
Mon	10	07:32a	05:19p	09:47	07:00p	05:52a		Rise	08:45p	82%
Tue	11	07:33a	05:18p	09:45	06:59p	05:53a		Rise	09:41p	74%
Wed	12	07:35a	05:17p	09:42	06:58p	05:54a		Rise	10:38p	65%
Thu	13	07:36a	05:16p	09:40	06:57p	05:55a		Rise	11:36p	56%
Fri	14	07:37a	05:15p	09:37	06:56p	05:56a	L Qtr	Rise	12:33a	47%
Sat	15	07:39a	05:14p	09:35	06:55p	05:57a		Rise	01:31a	37%
Sun	16	07:40a	05:13p	09:33	06:55p	05:58a		Rise	02:30a	28%
Mon	17	07:41a	05:12p	09:30	06:54p	06:00a		Rise	03:30a	20%
Tue	18	07:43a	05:11p	09:28	06:53p	06:01a		Rise	04:31a	13%
Wed	19	07:44a	05:10p	09:26	06:53p	06:02a		Rise	05:34a	7%
Thu	20	07:45a	05:10p	09:24	06:52p	06:03a		Rise	06:38a	3%
Fri	21	07:47a	05:09p	09:22	06:51p	06:04a		Rise	07:42a	0%
Sat	22	07:48a	05:08p	09:20	06:51p	06:05a	New	Set	05:40p	0%
Sun	23	07:49a	05:07p	09:18	06:50p	06:06a		Set	06:31p	3%
Mon	24	07:50a	05:07p	09:16	06:50p	06:07a		Set	07:29p	8%
Tue	25	07:52a	05:06p	09:14	06:49p	06:08a		Set	08:33p	15%
Wed	26	07:53a	05:06p	09:12	06:49p	06:09a		Set	09:41p	24%
Thu	27	07:54a	05:05p	09:10	06:49p	06:10a		Set	10:51p	34%
Fri	28	07:55a	05:04p	09:09	06:48p	06:11a		Set	12:01a	45%
Sat	29	07:56a	05:04p	09:07	06:48p	06:12a	F Qtr	Set	01:12a	57%
Sun	30	07:58a	05:04p	09:06	06:48p	06:13a		Set	02:22a	68%
* Astronomical Twilight										
** Moonrise or moonset, whichever occurs between sunset and sunrise										

Grand Traverse Astronomical Society – Membership Application 2014

___ I am interested, please send me more information about the next GTAS meeting.

___ I'll join, payment enclosed Email Address:_____

___ Membership renewal **Newsletter Delivery: ___ Email ___ Mail**

Interests: _____

Name: _____ Telephone: _____

Address: _____

Street City State ZIP

Dues: ___ Single Membership $25.00/yr

___ Family.....$30.00/yr

___ Student (up to 18 years age)....$15.00/yr

Mail check to: G.T.A.S.

Gary Carlisle, Treasurer

1473 Birmley Road

Traverse City, MI 49686

WANTED: Astronomers interested in working with Project ASTRO POLARIS.
Willingness to work with K-12 students and teachers. Visiting classrooms and conducting experiments, discussing astronomy interests and events. Sharing your love of astronomy with others. Will provide; training, materials, instuctionals and support.
Please contact: Jerry Dobek Site Coordinator Project ASTRO POLARIS NMC Science & Math 1701 East Front Street Traverse City, MI 49686 email jdobek@nmc.edu phone 946-1787 obsv. 223-4545 home

The Stellar Sentinel
Bob Moler, Editor
6003 Secor Rd.
Traverse City, MI 49685

GRAND TRAVERSE ASTRONOMICAL SOCIETY
GTAS

Extras – November 2014

Contents:

In Memoriam – Judy Moler

My wife, Judy, who was one of the founding members of the GTAS passed away suddenly September 13th. I will cull some of my comments from my blog and other sources that I have written about her.

Addendum to the bobmoler.wordpress.com post for September 16, 2014

Judith Ann Moler 1943-2014

The love of my life, Judy passed away last Saturday, September 13, 2014 at the age of 71, after we'd been married 48 years. I met her, arranged, by my sister Shirley, who herself succumbed to cancer last month. It was kind of a mercy dinner to take this guy (me) out before he entered Air Force for basic training. Shirley said I pretty much ignored her on previous occasions, but this time I was smitten. I'm a pretty much buttoned down guy with the ladies, but it was maybe because I was going to change my life by entering the Air Force that opened me up.
After a few dates I told her I had this, um, problem. I liked to go out on dark nights and observe the heavenly bodies. She could join me or stay inside where it's warm. She gamely joined me. I suspect it was to make sure these heavenly bodies were celestial and not terrestrial. (Just kidding). Judy didn't know much about astronomy when we met, about the same as we see from our schools today. I was working at the Planetarium of the Grand Rapids Public Museum at the time and we went in after hours and viewed the sky. Judy got to make up her own constellations. Later, using flash cards I made up, she learned many of the brighter real constellations.

After we were married and I got out of the Air Force we came back to Grand Rapids I got a job with NCR and Judy got a job as the planetarium director's secretary and sales clerk. By then the planetarium had a name, the Roger B. Chaffee Planetarium, named for the Grand Rapids astronaut who died in the Apollo 1 fire in 1967. Judy took the college Astronomy 101 course, and even produced a planetarium

show for young kids using kids drawings projected on the dome for illustration.

She joined with us in trips to view the total solar eclipses of 1970 and 1972, but gave up her seat on the small plane we chartered in 1979 to view the total solar eclipse in February that year, being not too keen on flying, especially in small planes. She even found a pilot we nicknamed, “Crash” LaMar, to fly the 5 of us brave souls to North Dakota to view this eclipse. He could fly just fine, but had a problem keeping the wing tips from hitting the high snow banks when taxiing at the Bottineau, ND airport. I recall that once we had to get out and push, or was that my imagination?

We moved to the Traverse City area in 1971 to follow my job at the time working for NCR. Around 1980 I was approached by the head of the Science and Math department Joe Rogers, at Northwestern Michigan College (NMC) to teach their 100 level astronomy course. By then I had programs on the public radio station WIAA for 5 years, so my name was out there as an astronomical expert. The problem was that I had never had any formal astronomical training*, despite that they hired me. My other problem was that I frequently had to work out of town, so Judy stepped in to substitute teach on those nights I was out of town. Actually she had more “formal” astronomy training than I did.

Judy was an instrumental part of the founding and operation of the Grand Traverse Astronomical Society (GTAS), started in 1982 and many years thereafter. She held down the fort at the NMC Observatory with other members of the GTAS on the night in May 1983 when Comet IRAS-Araki-Alcock buzzed 3 million miles from the Earth and the public wanted to see it because Paul Harvey featured it on his newscast, when I abandoned them and snuck out to the less known Leelanau School's Lanphier Observatory in Glen Arbor to photograph the comet in peace. I know, it wasn't nice of me.

In 1986 our family flew down to Miami and drove down to Key Largo to join the teacher and students from the Leelanau School to observe Halley's Comet at its closest to the Earth, which was too far south to see from Traverse City. I had the brilliant or cockamamie idea of splitting our 24 hour days into two 12 hour days. A daytime day to explore and enjoy the Keys and a night time day to observe the comet. Judy gamely went along with it: 8 hours up and 4 hours of sleep then repeat. I found that it worked for me, at least for the 6 days we tried it. Judy, at least, didn't complain, but our daughter couldn't handle it. She went on our day trips, but stayed at our resort sleeping all night. Beside viewing and photographing Halley's Comet, which lost its tail that week (bummer), we visited Theater of the Sea, Key West and toured the coral reefs in a glass bottomed boat, and the Everglades.

We had many more adventures, but these have come to mind now.

** I’m not self taught. My astronomy education comes via the members of the Grand Rapids Junior Astronomy Club and my close association with John Wesley, a true genius, and Donn Cuson, and members of the Grand Rapids Amateur Astronomical Association, and one of its founding members the late Evelyn Grebel, who let me tinker with the planetarium in its early days, and countless others including my still good friends Jim and Evie Marron at whose home Judy and I watched Neil*

Armstrong and Buzz Aldrin of Apollo 11 work on the Moon's surface, and my friend and sometimes antagonist Dave DeBruyn, now Emeritus Director of the Roger B. Chaffee Planetarium.

From her Tribute Wall on the Reynolds Jonkhoff website

Judy was the love of my life.

She had a long slow decline. She worked at her job as a CSR for an independent insurance company until this spring, when her boss folded the company. That job, at the end down to two days a week, helped keep her somewhat active.

For over a month starting in July she became my sister Shirley Burnham's 24/7 caregiver along with daily visits from the hospice nurses. Shirley had a form of pancreatic cancer. We were staying at Shirley's condo in Walker, MI. I helped out staying there about half the time, coming back to TC for a few days weekly for various things I had to do. My big job was filling syringes with the drugs Shirley had to take every 4 and 6 hours, and woke up to give it to her, or got Judy up by phone, if I wasn't there to give Shirley the dose. After a few weeks Shirley became too weak to stay at home, but Judy stayed to visit her at least twice a day to bring mail and clothes, whatever she needed, until the end on August 8th.

Shirley wasn't just a sister-in-law to Judy. They were best friends all the way back to high school. And actually Shirley introduced Judy to me.

It was after we got back to TC after trying to organize Shirley's condo that Judy really started to get worse, with infections and rashes on her legs. It was a blood clot Saturday morning that probably moved up from her legs to her lungs that stopped her heart.

Judy, maybe your final job, nursing my sister through her final days, was completed; but your passing leaves a big hole in our lives. That goes for Stef, Chris, Coley, Bea and myself plus our dogs Pepper, and (Clara and Phoebe who always slept on you), and our cats Flash, Junior, and our latest acquisition from Shirley's condo, Lily.

I love you Judy.

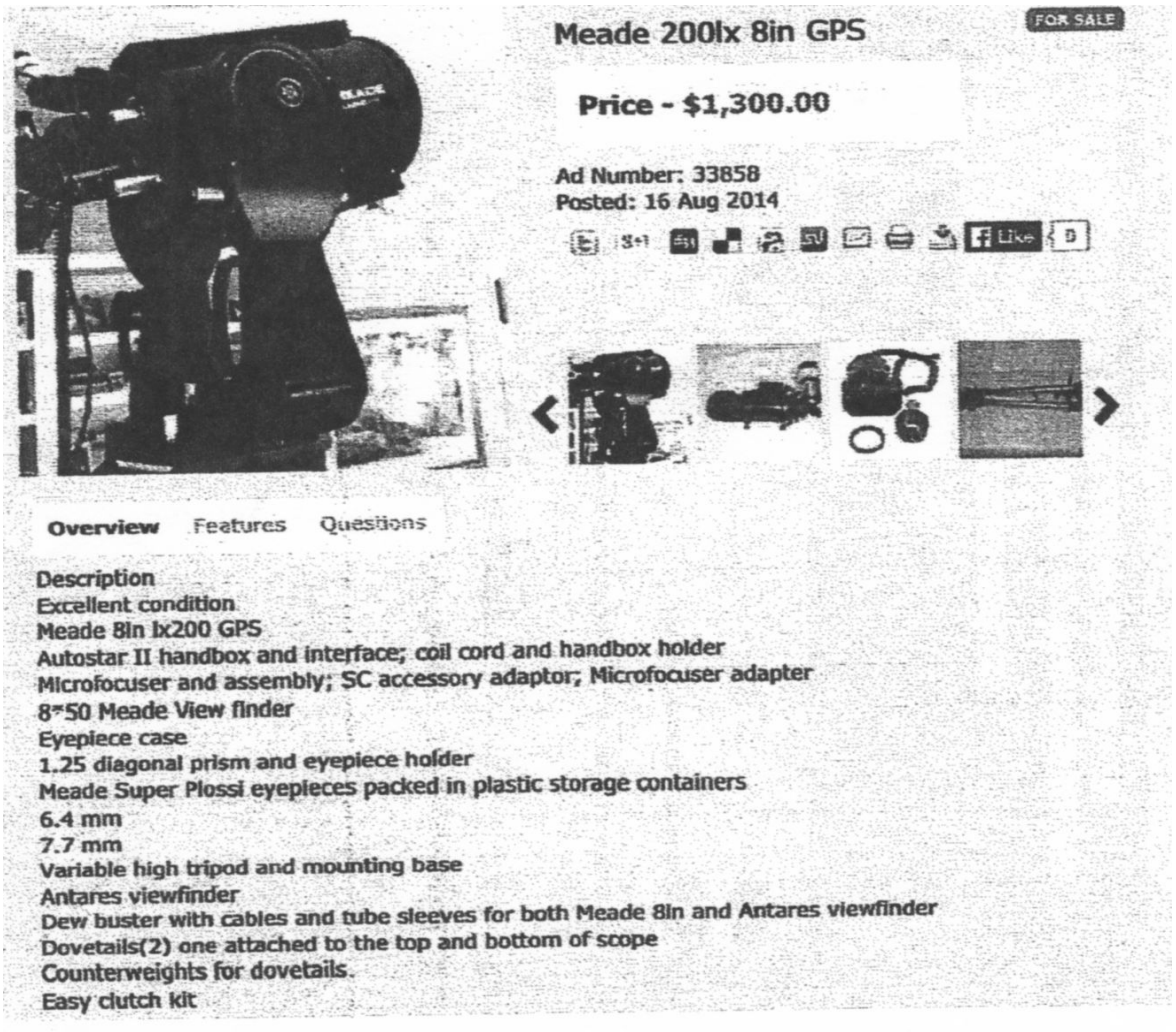
Your husband Bob

Telescope for Sale

From time to time we have been approached by folks wanting to buy or sell telescopes. I have checked with our member Dave Kane who has some experience with telescope buying and selling on the Internet. He suggests Craig's List or the Cloudy Nights classifieds section.

We will occasionally post a telescope for sale. However we do not know the condition of the equipment and we make no representation about its fitness for your purposes.

This picture was handed us at the Acme Fall Festival by John Stoll, phone (231) 620-0006, email jostolliii@gmail.com.



Editors note: It comes with a steel tripod. However it need some good low power eyepieces: 40 mm, 32 mm, 18 mm and maybe a 2X Barlow. The listed eyepieces are way too powerful to be useful, in my opinion.

Editor's Note: This month NASA's Space Place sent over an infographic on how the Sun generates its energy. It's on the last page of this issue. While it's set up to print on 8 ½ X 11 paper it can be scaled up to print posters. Wee are also including a Space Place post from earlier this year that explains it in depth. Along with the infographic, here's a link to a short video: Space Place in a Snap: Where Does the Sun's Energy Come From?

The Power of the Sun's Engines

By Dr. Ethan Siegel

Here on Earth, the sun provides us with the vast majority of our energy, striking the top of the atmosphere with up to 1,000 Watts of power per square meter, albeit highly dependent on the sunlight's angle-of-incidence. But remember that the sun is a whopping 150 million kilometers away, and sends an equal amount of radiation in all directions; the Earth-facing direction is nothing special. Even considering sunspots, solar flares, and long-and-short term variations in solar irradiance, the sun's energy output is always constant to about one-part-in-1,000. All told, our parent star consistently outputs an estimated 4×10^{26} Watts of power; one *second* of the sun's emissions could power all the world's energy needs for over 700,000 years.

That's a literally astronomical amount of energy, and it comes about thanks to the hugeness of the sun. With a radius of 700,000 kilometers, it would take 109 Earths, lined up from end-to-end, just to go across the diameter of the sun once. Unlike our Earth, however, the sun is made up of around 70% hydrogen by mass, and it's the individual protons — or the nuclei of hydrogen atoms — that fuse together, eventually becoming helium-4 and releasing a tremendous amount of energy. All told, for every four protons that wind up becoming helium-4, a tiny bit of mass — just 0.7% of the original amount — gets converted into energy by $E=mc^2$, and that's where the sun's power originates.

You'd be correct in thinking that fusing $\sim 4 \times 10^{38}$ protons-per-second gives off a tremendous amount of energy, but remember that nuclear fusion occurs in a *huge* region of the sun: about the innermost quarter (in radius) is where 99% of it is actively taking place. So there might be 4×10^{26} Watts of power put out, but that's spread out over 2.2×10^{25} cubic meters, meaning the sun's energy output *per-unit-volume* is just 18 W / m^3. Compare this to the average human being, whose basal metabolic rate is equivalent to around 100 Watts, yet takes up just 0.06 cubic meters of space. In other words, **you emit 100 times as much energy-per-unit-volume as the sun**! It's only because the sun is so large and massive that its power is so great.

It's this slow process, releasing huge amounts of energy *per reaction* over an incredibly large volume, that has powered life on our world throughout its entire history. It may not appear so impressive if you look at just a tiny region, but — at least for our sun — that huge size really adds up!

Check out these "10 Need-to-Know Things About the Sun":
http://solarsystem.nasa.gov/planets/profile.cfm?Object=Sun.

Kids can learn more about an intriguing solar mystery at NASA's Space Place:
http://spaceplace.nasa.gov/sun-corona.

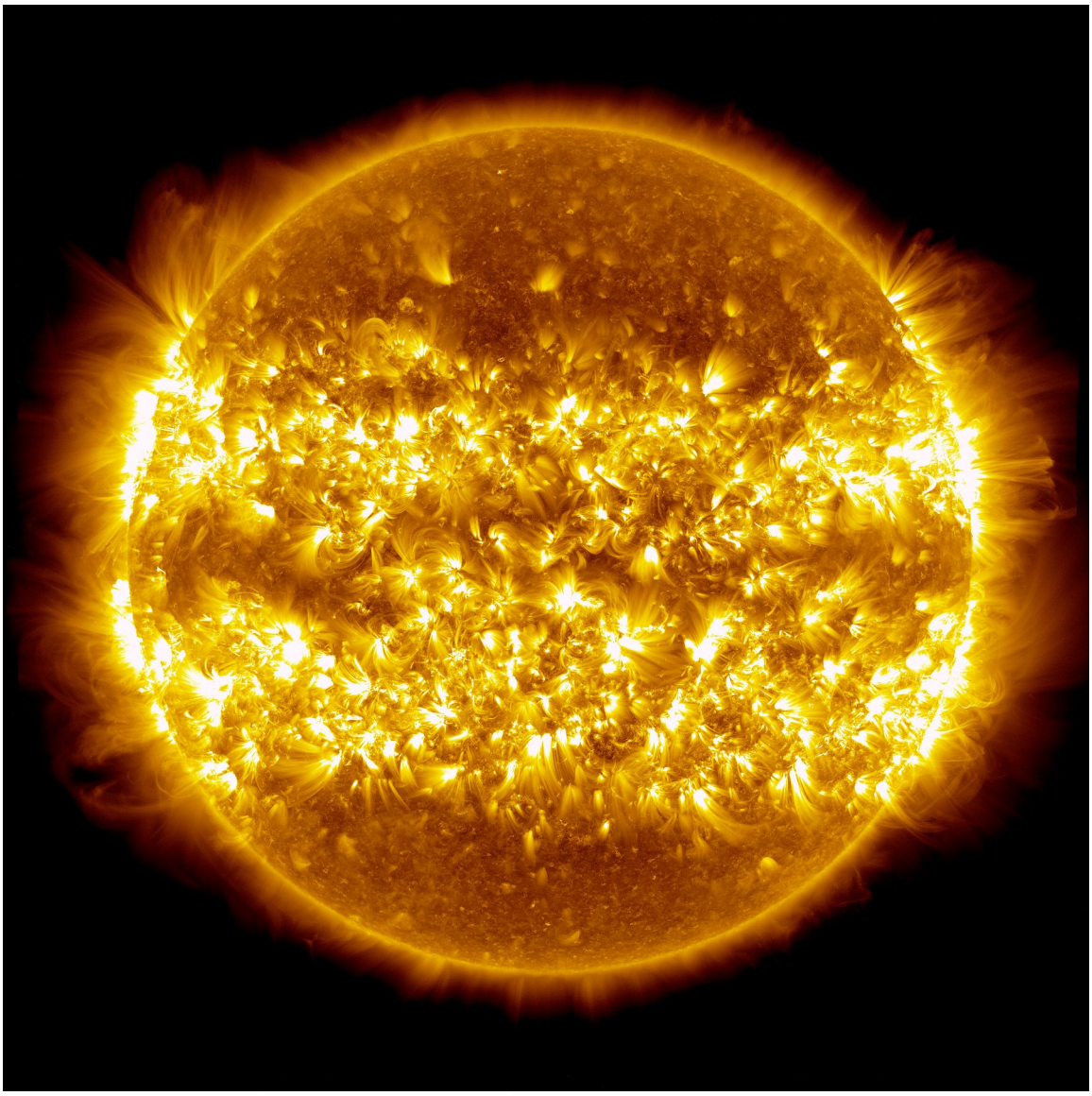


Image credit: composite of 25 images of the sun, showing solar outburst/activity over a 365 day period; NASA / Solar Dynamics Observatory / Atmospheric Imaging Assembly / S. Wiessinger; post-processing by E. Siegel.

Where does the sun's energy come from?

National Aeronautics and Space Administration

Every 1.5 millionths of a second, the sun releases more energy than all humans consume in an entire year. Its heat influences the environments of all the planets, dwarf planets, moons, asteroids, and comets in our solar system.

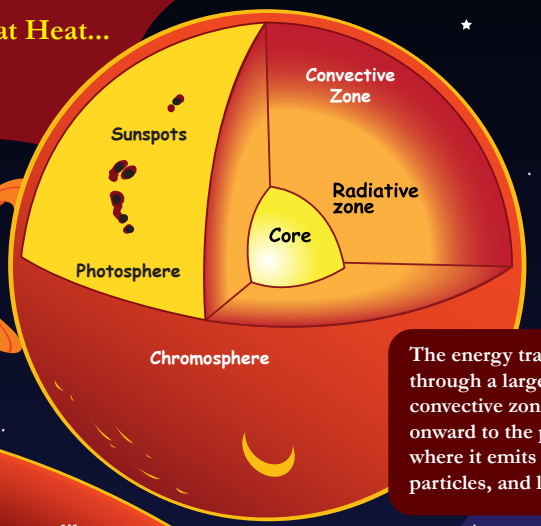
And that light travels far out into the cosmos—just one star among billions and billions.

Create a 'solar wind' that pushes against the fabric of interstellar space billions of miles away.

Allows gases and liquids to exist on many planets and moons, and causes icy comets to form fiery halos.

Powers the chemical reactions that make life possible on Earth.

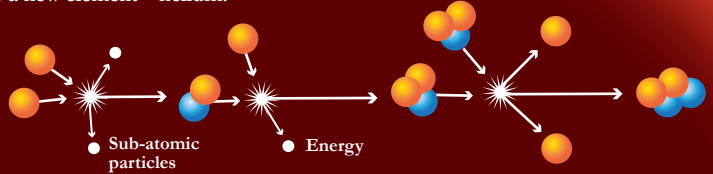
That Heat...



The energy travels outward through a large area called the convective zone. Then it travels onward to the photosphere, where it emits heat, charged particles, and light.

How does a big ball of hydrogen create all that heat? The short answer is that it is big. If it were smaller, it would be just be a sphere of hydrogen, like Jupiter. But the sun is much bigger than Jupiter. It would take 433,333 Jupiters to fill it up!

That's a lot of hydrogen. That means it's held together by a whole lot of gravity. And THAT means there is a whole lot of pressure inside of it. There is so much pressure that the hydrogen atoms collide with enough force that they literally meld into a new element—helium.



Nuclear Fusion

This process—called nuclear fusion—releases energy while creating a chain reaction that allows it to occur over and over and over again. That energy builds up. It gets as hot as 15 million degrees Fahrenheit in the sun's core.

Space Place in a Snap!