January, 2013

The Astronomical Society of Las Cruces (ASLC) is dedicated to expanding public awareness and understanding of the wonders"" of the universe. ASLC holds frequent observing sessions and star parties and provides opportunities to work on Society and public educational projects. Members receive the *High Desert Observer*, our monthly newsletter, plus membership to the Astronomical League, which includes their quarterly publication, *Reflector*.

Individual Dues are $30.00 per year

Family Dues are $36.00 per year

Student (full-time) Dues are $24.00

Dues include electronic delivery of the *HDO*. Prorated dues are available for new members. Dues are payable to ASLC with an application form or note to: Treasurer ASLC, PO Box 921, Las Cruces, NM 88004

ASLC members are entitled to a $5.00 (per year) Sky and Telescope *magazine discount.*

ASLC Board of Directors, 2013

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January Meeting

Our January meeting will be held on Friday, January 25, in Room 77 at Doña Ana Community College, with the following schedule:

7:00 pm - 7:30 pm Show & Tell
7:30 pm - 8:00 pm Business Meeting
8:00 pm - 9:00 pm Guest Speaker & Presentation

This month's speaker is Dr. Nancy Chanover, Associate Professor at NMSU. The subject of her presentation is:

Development of In Situ Instrumentation for Biomarker Detection

Events

ASLC hosts deep-sky viewing and imaging at our dark sky location in Upham. We also have public in-town observing sessions at both the International Delights Cafe (1245 El Paseo) and at Tombaugh Observatory (on the NMSU Campus). All sessions begin at dusk.

We frequently offer solar observing at the Farmer's Market on Saturday mornings. For further information please visit our website at www.aslc-nm.org.

Outreach

Outreach is a very important part of ASLC. We are always looking for more volunteers to help us educate the public. Even if you do not have a portable telescope to bring to the events, please consider attending our public outreach programs to help answer questions, share knowledge and point out constellations in the sky.

The President's column-inch...

Having survived the Mayan Apocalypse, aptly predicted by Fred Pilcher a few months ago, we now start a New Year, 2013, able once again to justify buying green bananas with a smile and the expectation of seeing them ripen.

This promises to be another interesting year for ASLC. The observatory at Leasburg State Park, which ASLC has been instrumental in getting constructed, will see First Light this year. Perhaps by the time you receive this newsletter we will have the Meade 16" LX200 (on permanent loan from NMSU) mounted and funneling photons to human eyes. We have some exciting speakers with exciting subjects to present at our meetings this year; I guarantee that you cannot sleep through these and that you will learn something new every time.

We are looking forward to a number of annual events this year, including the Messier Marathon in March, the Texas Star Party May 5 - 12 at the Prude Guest Ranch near Fort Davis, Texas, Astronomy Day on April 20 and October 13, the Okie-Tex Star Party Sept. 28th - Oct. 6th at Camp Billy Joe near Kenton, OK, and the Las Cruces Renaissance Faire on the first weekend of November. I have probably forgotten others…

There is a possibility for a state-wide star party organized by ASLC and to be held during April near Las Cruces, with details still to be worked out.

Our first meeting this year will be January 25 in Room 77 of the Dona Ana Community College main campus complex, with Dr. Nancy Chanover from the New Mexico State University Astronomy Department speaking on "Development of In Situ Instrumentation for Biomarker Detection."

We also have two school star parties currently scheduled for January, the first at Highland Elementary on the 25th (unfortunately conflicting with our meeting, however at least three ASLC members will support this star party event) and the second at Central Elementary on the 30th. We are always looking for volunteers to support these school events, so if you would like to bring a scope and let a bunch of kids have perhaps their first look through an astronomical telescope, just let us know.

Have a Good Year; keep looking UP.

Chuck Sterling

Outreach Events, November and December by Jerry McMahan

Columbia Elementary School, Thursday, November 8

We have had a bad run of cloudy days lately. We haven't exactly struck out (read Darn Yankees), but have had limited success. It was already dark when I got to the school and the clouds were bad enough that Chuck said I should leave the scope in the car.

Several members were in attendance, including Chuck Sterling, Ron Kramer, Tracy Stuart, and Jim Morgan. I had the usual 5-inch in the car, while Chuck had his 10-inch, Tracy had his 8-inch Meade LX90, and Ron had his 5-inch refractor set up, but not used.

For most of the evening the viewing went like the following. Chuck had the 10-inch pointed at Polaris, Tracy was pointed at Polaris, Ron had his laser pointer pointed at (you guessed it) Polaris, while the rest of us discussed

Polaris. Chuck was able to get Mars, early on, near the horizon and later, Jupiter broke through the clouds after most of the kids had left. It was the most attention that Polaris has received at any star party that I can remember.

Moongaze, November 17 and November 24

It was another month that had the Moon in an in-between phase for our monthly Moongaze. It was also advertised in two different places for the two different dates, so it was decided to go to the International Delights on both days.

On the 17th Chuck Sterling brought his 10-inch, which stayed in the car, and his 100mm refractor which he did set up. I set up the 5-inch Maksutov. Steve Shaffer came by later. Again the clouds were a real problem. We had times where the Moon was in the clear, but most of the time it was seen through clouds, or not at all. It disappeared completely well before setting while reappearing just above the horizon. Later, while waiting for Jupiter to show himself, he was well above the building before suddenly shining bright. Jupiter would fade in and out from behind the clouds and was observed by some of the workers in the restaurant.

We didn't have many spectators since there were so many long stretches when there was nothing to see.

On November 24, it was a very clear night. The Moon was well past first quarter. The terminator was well located for the crater Gassendi and Jupiter was in a good position. Chuck Sterling set up his 10-inch, Steve Shaffer had his 4.5-inch Dobsonian and I brought the usual ETX 125. Mike Zura joined us for most of the evening. He said he intends to join the club.

I was surprised to see that we were observing several belts and bands in Jupiter's atmosphere since the seeing did not seem to be great. I realized, later, that it was because Jupiter was so near opposition.

Saturday, December 8, 2012

A star party was held at Leasburg Dam State Park. Ron Kramer gave us a tour of the new roll-off observatory that we will use for the 16-inch Meade.

Ron brought his 5-inch Meade refractor, Chuck Sterling had his 10-inch Schmidt Cassegrain, Steve Shaffer had the usual 4.5-inch Dob, Sid Webb had his 10-inch Dobsonian, Nils Allen manned his homemade 15-inch Dobsonian and an 8-Inch Schmidt Cassegrain was also present. I did not have the ETX this time. This was my first use of a new Meade LX 80 mount. I had a 120mm Orion refractor mounted on it, thanks to the mounting bars that Chuck Sterling made for me.

We did not have a Moon to observe, so a number of deep sky objects and Jupiter were the targets. They included the galaxies M31, M33, the Pleiades star cluster, the Double Cluster, the Ring Nebula and the Veil Nebula and the double star Alberio. There were probably other objects that were also viewed. Jupiter again showed multiple bands and belts. The moon Io was visible early, but disappeared either in front, or behind the planet.

It was a successful event despite the weather being a bit cold.

Open House at the Clyde Tombaugh Observatory, Friday December 21

Even though the world was supposed to end that night, no one even brought up the Mayan Calender. It seems that Fred was right. School was out for the holidays, so the turnout was below average. The Astronomy Department had the Double Cluster on a 16-inch Dobsonian, Jupiter on one of the 12-inch Schmidt Cassegrains and the Moon on the other. Since there were not many different objects being observed, Steve suggested that since one scope was on the northern hemisphere of the Moon, we should have the club's scope on the rugged southern hemisphere.

Earlier, we had the northern hemisphere of the Moon. The seeing was fairly good and I could fleetingly make out Hadley Rill. The small crater, that it curves around, was easily seen. It has been clear that the 12.5-inch Cassegrain does give a superior view compared to the two 12-inch Schmidt Cassegrains.

Moongaze, December 22, 2012

Chuck Sterling brought his 10-inch, Steve Shaffer brought the 4.5-inch Dobsonian and I had the 120mm refractor. Trish Conley came to help out. Jupiter and the Moon were the main targets, with the Moon's terminator near the crater Copernicus. The hills and volcanic domes were visible near Copernicus.

The last several events had Jupiter's moon Io visible early, only to disappear a short time later. It was pretty cold, so we did not stay as long as we do sometimes and there were not as many customers later in the evening. Since this was the last outreach event before Chuck takes over as President, it brings up the question of what I should call him. Is he President Sterling? President Chuck? President Charles? Charles the First?

Calendar of Events: January 2013 - March 2013 (Mountain Time - 24 hr. clock)

JAN	21	19:57	Moon - Jupiter Conjunction
	22	18:00	OUTREACH EVENT HERMOSA HEIGHTS ELEMENTARY STAR PARTY
	23	18:00	OUTREACH EVENT; J. PAUL TAYLOR ACADEMY STAR PARTY
	25	18:00	HIGHLAND ELEMENTARY STAR PARTY
		19:00	ASLC MONTHLY MEETING
	26	21:38	Full Moon
	30	18:00	OUTREACH EVENT; CENTRAL ELEMENTARY STAR PARTY
FEB	01	18:25	Moon - Spica Conjunction
	03	02:55	Moon - Saturn Conjunction
		06:56	Last Quarter Moon
	08	09:06	Mercury - Mars Conjunction
	10	00:20	New Moon
	15	20:00	OUTREACH EVENT; TOMBAUGH OBSERVATORY Open House
	16	19:00	OUTREACH EVENT; MOONGAZE; International Delights Cafe
	17	13:31	First Quarter Moon
	22	19:00	ASLC MONTHLY MEETING
	25	13:26	Full Moon
	28	18;30	OUTREACH EVENT; DESERT HILLS ELEMENTARY STAR PARTY
		23:56	Moon - Spica Conjunction
MAR	02	08:20	Moon - Saturn Conjunction
	04	14:53	Last Quarter Moon
	11	13:50	New Moon
	16	19:00	OUTREACH EVENT; MOONGAZE; International Delights Cafe
	17	19:15	Jupiter - Aldeberan Conjunction
		19:16	Moon - Jupiter Conjunction
	19	11:27	First Quarter Moon
	20	05:02	Spring Equinox
	22	19:00	ASLC MONTHLY MEETING
		21:00	OUTREACH EVENT; TOMBAUGH OBSERVATORY Open House
	27	03:27	Full Moon
	28	08:29	Moon - Spica Conjunction
	29	14:18	Moon - Saturn Conjunction
	31	15:59	Mercury Western Elongation

Be sure to visit our web site for the latest updates: www.aslc-nm.org

Minutes, November 2012 ASLC Meeting

Show & Tell:

David Anderson started the session by talking about the Society's website and noting that there are video presentations referred to on the site that are not currently accessible. He then demonstrated eyepieces that he is making and discussed par-focal alignment (parallel) for focusing a telescope and camera. Fred Pilcher followed with a description of his problems focusing a CCD for his asteroid light curve measurements. He currently uses a $1000 Op-Tec temperature compensated focuser using a Crawford screw that has no back-lash. The Op-Tec people have been very helpful. Jerry Gaber also talked about compensating for ambient temperature by using heating pads to maintain his telescope at constant temperature.

Call to Order:

Ron Kramer, President, Astronomical Society of Las Cruces (ASLC), called the business meeting to order at 7:30 pm., 16 November 2012, Room 77, Dona Ana Community College, Las Cruces, New Mexico.

President's Comments:

Ron Kramer, President, welcomed the group to tonight's meeting. He noted that this is the last business meeting of the year as the December get-together will be the holiday party. The next business meeting will be in January 2013 with new officers. In mid-March, members will receive their issue of the *Reflector* magazine marking Ron's debut as editor-in-chief. He thanked David for the "Show and Tell" session and the various volunteers for addressing the several problems, questions and dilemmas. There were new members Emere Beegle and his fiancée, Julie Miller, and Rakesh present at tonight's meeting. Emere and Julie are returning to Las Cruces this spring. Emere is interested in the technical side of astronomy while Julie is interested in visual observing and astrophotography; they joined at the 2012 Renaissance ArtsFaire this month. Rakesh is a PhD candidate in astronomy at NMSU and has always been involved in amateur astronomy. There were no guests present, but Ron asked that all members be sure to check in on the roster.

Secretary's Report:

The Secretary, John McCullough, reported that the minutes for the October 2012 meeting were submitted for publication in the November issue of the Society newsletter, the High Desert Observer (HDO). Robert Williams moved the minutes be accepted as published; Chuck Sterling seconded. The motion passed by acclamation. There was not an additional Secretary's report.

Treasurer's Report:

The Treasurer, Trish Conley, reported on the Society's financial balances. She noted that $132 had been received for dues, $66 in renewals. There had been $189 received in donations, mostly at the Renaissance ArtsFaire. There have been some minor expenditures. Nine (9) new members joined in November. Robert Williams moved that the Treasurer's report be accepted, Tracy Stuart seconded. The motion passed by acclamation. There was not an additional Treasurer's report.

Committee Reports:

Apparel Committee:

Ron Kramer, acting Committee chair, reported on apparel sales and noted that jackets, "hoodies" and other items will be available after the meeting. An order for additional items is pending requests for specific items, particularly cool weather items. Ron will continue to fill in as temporary Committee chair, but a new chair is required.

Education:

Rich Richins, Committee Chairman, was not present. There was no committee report.

Fund-Raising and Grants:

Sidney Webb, Committee Chairman, reported that a grant application to the New Mexico Space Consortium had been resubmitted with some corrections/modifications for awarding in April 2013. This is for up to $5000 to support the Leasburg Dam State Park (LDSP) observatory equipment requirements but includes outreach to the local community. Note: computer equipment is not an acceptable expenditure of these grant monies. Any other ideas for fund-raising efforts are welcome.

Society Library:

Brenner Fody, Society Librarian, was not present. There are currently 185 titles in the Society's library published from 1840-1990 and the listing is available on the yahoo group. Volumes are available for checkout by members with advanced notice. The listing may eventually include the book publisher and the publishing date. Additional donations are welcome.

Loaner Telescope Program:

Ron Kramer, acting Committee Chairman, reported the program is doing well. There are currently five (5) telescopes in the program: one (1) each 12" and 10" Dobsonians, two (2) ETX 90s, and a Unitron refractor. The loan agreement is in place, is working well, and has generated some income for the Society. This is a good way for new members to work with a variety of telescope systems if they are uncertain about which type will fit their needs. Cost is $10 per month and members must sign the loan agreement. Members may contact Ron if they have questions about the loaner policy, including how to donate equipment to the program.

Membership:

John McCullough, Committee Chairman, reported that membership for the year is up with the addition of twenty-six (26) new members, some of whom are very active in the Society. However, it was noted that more participation is needed from the longer-term membership.

Leasburg Dam State Park (LDSP) Observatory Committee:

Ron Kramer, Committee Chairman, reported on the progress of construction of the observatory at LDSP. Backyard Observatories will install the roll-off roof structure. The primary structure is complete except for exterior stucco. Note: the roof line blocks a portion of the northern sky. There have been several equipment donations including 19" computer racks, chairs, and bookcases. Ron and Jerry Gaber presented photographs of the construction. Installation of the 16" Meade will begin around 01 December. A Certificate of Occupancy is required. A Cooperative Agreement will be signed on 26 November.

Tombaugh Observatory:

Steve Shaffer, Committee Chairman, reported the next Open House will be 30 November. There are no issues with the telescope, but there is still leakage through the structure's coating (all three structures have this issue).

Outreach Committee:

Chuck Sterling, Outreach Coordinator, reported on recent events. A "cloud" party was held at Columbia Elementary on 08 November. Moon Gazes will be held at International Delights Café (IDC) on 17 and 24 November. A National Public Observatory (NPO) event will take place at LDSP on 08 December. There will be a "Music under the Stars" event at the Franklin Mountains State Park on 17 November; another one will be on 15 December. There will be a star party at Central Elementary on 30 January.

Renaissance ArtsFaire 2012:

Tracy Stuart, Committee Chairman, reported on this year's Faire that was 03-04 November at Young Park. There seemed to be good response from the public and the Society's booth received a $50 prize for Best Costumes.

Publicity:

Daniel Giron, Committee Chairman, was not present.

Society Website:

Joseph Clower, web master, and his assistant, Steve Barkes, were not present.

There were no additional committee or officer reports.

Old Business:

1. Las Cruces Lighting Ordinance - The new ordinance goes into effect 31 March 2013. The Society can provide a list of offenders through Ron Kramer to the City on a monthly basis. There will be two (2) persons on the City staff to verify complaints and enforce the code. There may be a presentation next year from Codes Enforcement regarding the new ordinance.

2. State-wide Star Party - Ron Kramer has been in communication with the TAAS (The Albuquerque Astronomy Society) president. This event will be postponed until at least March 2013. Participating clubs are expected to include Albuquerque, Silver City, Carlsbad, Socorro, El Paso, Alamogordo, and Las Cruces. This event may also include a Messier Marathon.

3. Holiday party - This year's party will be 01 December (no business meeting, no HDO) at the EAA hangar, Las Cruces airport, with a potluck dinner format. Volunteers will be needed for a gift exchange, food coordination, set-up/decorations (hangar decorating will occur on 30 November), a 2012 Society presentation, and clean-up. Contact Ron Kramer via email to volunteer. More details are forthcoming.

4. Field trip - William Wren, assistant director at McDonald Observatory, has offered the Society a tour of the facility. Details are pending.

There was no additional old business discussed.

New Business:

1. RASC - The Royal Astronomical Society of Canada (RASC) Observer's Handbook and 2013 calendar are available for $25 and $18, respectively. A minimum of ten (10) of each item must be ordered to obtain this price.

There was no additional new business for discussion.

Items for Sale:

- Joseph Clower has purchased a 2.4" Celestron from the Society.
- Various items from the Ken Kile estate will be for sale following the meeting.

No additional items were announced for sale.

Announcements:

The *High Desert Observer* will not be published in December. There will not be a presentation at the December Holiday party.

There were no additional announcements made.

Recognitions/Achievements:

John Kutney has submitted requirements for another certificate from the Astronomical League; award is pending.

There were no other recognitions or achievements announced at tonight's meeting.

Fred Pilcher offered a motion to adjourn and Chuck Sterling seconded. The motion passed by acclamation and the business portion of the meeting was adjourned at 8:20 pm

Presentation:

This month's presentation was made by Society member Fred Pilcher on "Maya Arithmetic, Maya Calendars". The world will end on December 21 2012 - NOT. Maya civilization existed for hundreds of years before the Spanish conquistadors arrived in the New World. The Maya built pyramids and carved stele. Catholic priests destroyed almost all written Mayan records, except for three (3) codices. Where Western math is decimal, Mayan math is bi-decimal (base 20).The Mayans also used a complex series of calendars using several different cycles. It is possible that the current series will complete on or about 21 December, but the Mayan made no known predictions of what would happen then.

This presentation was not recorded for rebroadcast on the Internet. Other meeting presentations have been accessible on the web at http://www.aics research.com/lectures/aslcnm/.

The November meeting of the Astronomical Society of Las Cruces concluded at 9:00 pm.

-Respectfully submitted by John McCullough, ASLC Secretary

Red Stars and their Observation

by John Kutney

Introduction

When one starts observing through a telescope it is easy to be disappointed in the lack of color in Deep Sky Objects (DSOs) as compared to the glossy astrophotos and Hubble Telescope renditions of the objects. However, the stars can give one a sense of the various colors available to the observer from bright blue to deep red. There are even brown stars but the amateur observer may never see them.

The red stars are particularly interesting since they are visually rare but make up the majority of the stars in the night skies. There are three classes of "red" stars to consider: red giants, Carbon stars, and red dwarfs. These are not really red scientific categories but a way to simplify this interesting segment of the stars.

Most of the content of this article is contained in detail from other sources which I will reference in a bibliography for anyone that wants to pursue the wealth of information about this topic. My intentions are to simplify the topic, provide a more in depth overview, and try to bring out the interesting aspects of red star observing.

Why Red Stars?

Observing stars can be accomplished even from light compromised areas with less than ideal transparency and seeing conditions. Typically, I observe DSOs that require a minimal dark site with a Bortle Scale rating of 3/4. This means going to the various dark sites around Las Cruces. On many nights it is not feasible to trek out to the desert due to prevailing conditions. I can observe from my backyard which has a Bortle rating around 5/6. This allows me to run multiple projects simultaneously. Star based projects can be accomplished from Las Cruces such as Double Stars, Carbon Stars, and Open Clusters.

Before starting on Carbon Stars I did not know much about red stars other than about the giants visible in the sky burning up their Hydrogen and boldly expanding. Antares and Betelgeuse are the most obvious examples. Stars have different colors because they are at different temperatures. As stars vary from hottest to coolest, their

colors range from violet-blue to red. A quick review of color, spectra and temperature is in order to classify the star colors.

If one wants to pursue the Carbon List from the Astronomical League[1] it will be necessary to tune up ones planetarium programs or have excellent charts. Several of the 'Carbon stars' are classified only by SAO and HD designations. This will require a good referenced star field. However, the red or orange star will shine through when it enters your field of view.

Harvard spectral classification[2]

The Harvard classification system is a one-dimensional classification scheme. Stars vary in surface temperature from about 2,000 to 40,000 Kelvin. Physically, the classes indicate the temperature of the star's atmosphere and are normally listed from hottest to coldest, as is done in the following table:

Class	Surface Temperature (Kelvin)	Conventional Color	Apparent Color	Mass (Solar Masses)	Radius (Solar Radii)	Luminosity (Total Wave)	H Lines	Fraction of all Main-Sequence Stars (%)
O	≥ 33,000	blue	blue	≥ 16	≥ 6.6	≥ 30,000	weak	.00003
B	10,000-33,000	white to blue white	blue white	2.1 - 16	1.8 - 6.6	25 - 30,000	medium	0.13
A	7,500-10,000	white	white to blue white	1.4 - 2.1	1.4 - 1.8	5 - 25	strong	0.6
F	6,000-7,500	yellowish white	white	1.04 - 1.4	1.15 - 1.4	1.5 - 5	medium	3
G	5,200-6,000	yellow	yellow white	0.8 - 1.04	0.96 - 1.15	0.6 - 1.5	weak	7.6
K	3,700-5,200	orange	yellow orange	0.45 - 0.8	0.7 - 0.96	0.08 - 0.6	very weak	12.1
M	2,000-3,700	red	orange red	≤ 0.45	≤ 0.7	≤ 0.08	very weak	76.45
L	1,300-2,000	purple-red	red	unknown	unknown	unknown	extremely weak	≥ 100.00
T	7,000-1,300	brown	purple-red	unknown	unknown	unknown	extremely weak	≥ 100.00
Y	≤ 700	dark brown	brown	unknown	unknown	unknown	extremely weak	≥ 100.00

The mass, radius, and luminosity listed for each class are appropriate only for stars on the Main Sequence portion of their lives and so are not appropriate for red giants. The spectral classes O through M are subdivided by numerals (0–9). For example, A0 denotes the hottest stars in the A class and A9 denotes the coolest ones. The Sun is classified as G2.

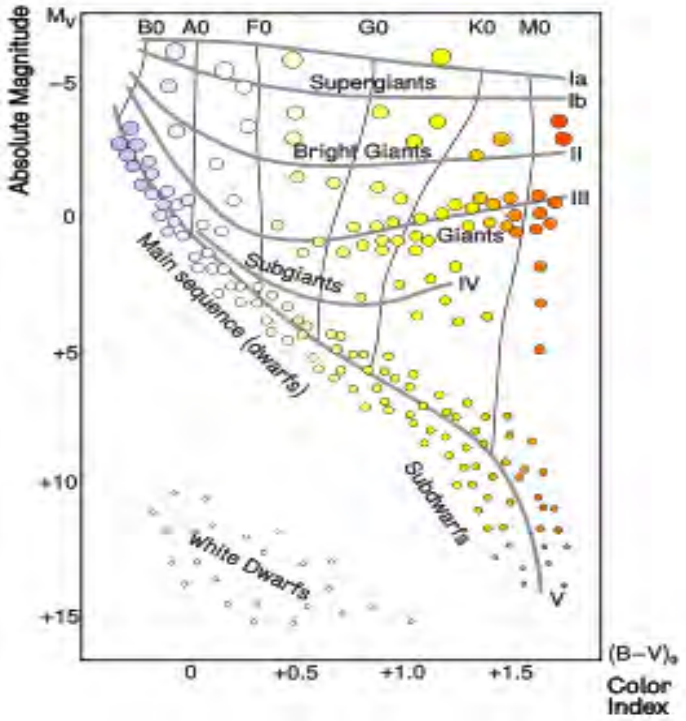
Hertzsprung-Russell Diagram[3]

The Hertzsprung-Russell diagram relates stellar classification with absolute magnitude, luminosity, and surface temperature as seen in the following chart:

- **0** Hyper-giants
- **I** Super-giants
  - **Ia-0** (hypergiants Example: Eta Carina
  - **Ia** (luminous supergiants), Examples: Deneb; Betelgeuse
  - **Ib** (less luminous supergiants)
- **II** Bright giants

[1] www.astroleague.org [2] Wikipedia.org [3] ibid.

  - o **IIa**, Example: β Scutum
- **III** Normal giants
  - o **IIIa** Example: ρ Perseus
  - o **IIIb** Example: Pollux
- **IV** Subgiants
- **V** Main sequence stars (dwarfs)
  - o **Va** Example: AD Leo
  - o **Vb** Example: 85 Pegasus A
- **VI** Subdwarfs.
- **VII** White dwarfs.



Red dwarfs and Carbon stars would be located at the lower right near class M and possibly in class K. Most stars in the sky, except the brightest ones, appear white or bluish white to the unaided eye because they are too dim for color vision to work.

Class **K** are orange colored stars that are slightly cooler than our Sun. Some K stars are giants and super-giants, such as Arcturus, while orange dwarfs, like Alpha Centauri B, are main-sequence stars.

Class M is by far the most common class. About 76.02% of the main-sequence stars in the Solar neighborhood are Class M stars. However, because main sequence stars of spectral class M have such low luminosities, there are few bright enough to see with the unaided eye.

Although most Class M stars are red dwarfs, the class also hosts most giants and some super-giants such as Antares and Betelgeuse, as well as Mira variables. Mira variables, named after the star Mira, are a class of pulsating variable stars characterized by very red colors and pulsation periods longer than 100 days. They are red giant stars in the very late stages of stellar evolution.

Red Dwarf Examples: Proxima Centauri, Barnard's star, Gliese 581, AD Leonis

The late-M group holds hotter brown dwarfs that are above the L spectrum.

The new spectral types L and T were created to classify infrared spectra of cool stars. This included both red dwarfs and brown dwarfs which are very faint in the visual spectrum. These are most likely not visible to the amateur observer.

Recap

Now we know from the above charts that most red stars are in the M Class. In fact we know that red giants and Carbon stars are very similar. We also know that red stars denote "cool" stars relative to other star colors (except brown). We also may infer that red dwarfs are cooler than Carbon stars and much more difficult to observe. We shall review more details about the three types of red stars to distinguish them further.

Red Giants[4]

A red giant is a luminous giant star of low or intermediate mass in a late phase of stellar evolution. The outer atmosphere is expanded which makes the radius immense and the surface temperature low, somewhere from 5,000 K and lower. The appearance of the red giant is from yellow orange to red, including the spectral types K and M, and most carbon stars.

Prominent bright red giants in the night sky include Aldebaran, Arcturus, and Mira, while the even larger Antares and Betelgeuse are red supergiants. Betelgeuse is one of the largest stars known. It is a stalwart of the winter sky in Orion.

[4] ibid.

The most common red giants are the so-called red giant branch stars whose shells are still fusing Hydrogen into Helium while the core is inactive Helium. Another case of red giants are the Asymptotic Giant Branch stars (AGB) that produce Carbon from Helium.

Over its Main Sequence life, the star slowly converts the Hydrogen in the core into Helium; its Main Sequence life ends when nearly all the Hydrogen in the core has been used. When the star exhausts the Hydrogen fuel in its core, nuclear reactions in the core stop, so the core begins to contract due to its gravity. This heats a shell just outside the core, where Hydrogen remains, and initiating fusion of Hydrogen to Helium in the shell. The higher temperatures lead to increasing reaction rates, producing enough energy to increase the star's luminosity by a factor of 1,000–10,000. The outer layers of the star then expand greatly, beginning the red giant phase of the star's life. Due to the expansion of the outer layers of the star, the energy produced in the core of the star is spread over a much larger surface area, resulting in a lower surface temperature and a shift in the star's visible light output towards the red – hence red giant, even though the color usually is orange. At this time, the star is said to be ascending the red giant branch of the Hertzsprung-Russell (H-R) diagram.

The red giant star will continue to heat until it reaches a temperature of roughly 10^8 K, hot enough to begin fusing Helium to Carbon. Once the degenerate core reaches this temperature, the entire core will begin Helium fusion nearly simultaneously. In more massive stars, the collapsing core will reach 10^8 K before it is dense enough to be degenerate, so Helium fusion will begin much more smoothly. Once the star is fusing Helium in its core, it contracts and is no longer considered a red giant.

In stars massive enough to ignite Helium fusion, an analogous process occurs when central Helium is exhausted and the star switches to fusing Helium in a shell, although with the additional complication that in many cases Hydrogen fusion will continue in a shell at lesser depth. This puts stars onto the asymptotic giant branch (AGB), a second red giant phase. More massive stars continue to repeat this cycle, fusing heavier elements in successive phases, each lasting more briefly than the previous.

A solar mass star will never fuse Carbon. Instead, at the end of the asymptotic giant branch phase the star will eject its outer layers, forming a planetary nebula with the core of the star exposed, ultimately becoming a white dwarf. The ejection of the planetary nebula finally ends the red giant phase of the star's evolution.

The red giant phase typically lasts only a few million years and hence is very brief compared to the billions of years that stars of roughly solar mass will spend on the main sequence.

Carbon Stars[5]

Carbon stars are part of the phase in the red giants' evolution. It is a star in the late stage in the process on its way to extinction. When the core stops fusing Hydrogen into Helium, the Helium begins fusing due to gravitation forces and one of the products is Carbon. It is somewhat similar to a red giant but its atmosphere contains more Carbon than Oxygen. The two elements combine in the upper layers of the star which consumes all the Oxygen in the atmosphere, leaving Carbon atoms free to form other Carbon compounds, giving the star a "Carbon filled" atmosphere and a red appearance. Visually, M-class red giants such as Antares and Betelgeuse appear more orange with a hint of red. Carbon stars have a more obvious red hue.

There are two reasons for Carbon stars to be redder. Their surface temperature is relatively cool at less than 4000 degrees Kelvin. In comparison, white to blue stars have surface temperatures of 7500 to more than 30000 degrees Kelvin. Their atmospheres are full of Carbon and Carbon compounds. These Carbon particles reflect and scatter the shorter wavelengths of blue light but allow the longer red wavelengths to pass through.

Carbon stars have quite distinctive spectral characteristics, and they were first recognized by their spectra by Angelo Secchi in the 1860s. Carbon stars were given a separate classification. Secchi created the "Secchi class IV" for the carbon stars, which in the late 1890s were reclassified as N class stars. Harvard improved the classification. The N class was later enhanced by an R class for less deeply red stars sharing the characteristic carbon bands of the spectrum. Morgan-Keenan C system classification replaced the older R-N classifications.

[5] ibid.

This Morgan-Keenan C system classification replaced the older R-N classifications from 1960–1993 as follows:

MK-type	C0	C1	C2	C3	C4	C5	C6	C7
giant equiv.	G4-G6	G7-G8	G9-K0	K1-K2	K3-K4	K5-M0	M1-M2	M3-M4
Temp (K)	4500	4300	4100	3900	3650	3450	---	---

A new revised Morgan-Keenan classification was published in 1993 by Philip Keenan, defining the classes: C-N, C-R and C-H. Later the classes C-J and C-Hd were added. It gradually occurred that the old R and N stars actually were two distinct types of Carbon stars, having real astrophysical significance.

The following table constitutes the established classification system used today:

Class	Spectrum	Theory	Temp (K)	Example	Est .# Known
Classical Carbon Stars					
C-R	the old Harvard class R reborn; are still visible at the blue end of the spectrum, strong isotopic bands, no enhanced Ba line	Red giants	5100-2800	S Cam	25
C-N	the old Harvard class N reborn; heavy diffuse blue absorption, sometimes invisible in blue, s-process elements enhanced over solar abundance, weak isotopic bands	Asymptotic Giant Branch (produce Carbon from Helium in core)	3100-2600	R Lep	90
Non-Classical Carbon Stars					
C-J	very strong isotopic bands of C_2 and CN	unknown	3900-2800	Y CVn	20
C-H	very strong CH absorption	bright giants, mass transfer (all C-H are binary)	5000-4100	V Ari TT CVn	20
C-Hd	Hydrogen lines and CH bands weak or absent	unknown	?	HD 137613	7

Carbon stars are explained by more than one astrophysical mechanism. **Classical Carbon stars** are distinguished from **non-classical** ones on the grounds of mass, with classical Carbon stars being the more massive. Most classical Carbon stars are variable stars of the long period variable types.

In the **classical Carbon stars** which belong to the modern spectral types C-R and C-N, the abundance of Carbon is thought to be a product of Helium fusion, which giants reach near the end of their lives in the asymptotic giant branch (AGB). These fusion products have been brought to the stellar surface after the Carbon and other products were made. The star transforms to burning Helium in a shell, while the Hydrogen fusion temporarily ceases. In this phase, the star's luminosity rises, and material from the interior of the star (notably Carbon) moves to the outer shells.

The **non-classical** kinds of Carbon stars, belonging to the types C-J and C-H, are believed to be binary stars, where one star is observed to be a giant star (or occasionally a red dwarf) and the other a white dwarf. The star observed to be a giant star siphoned Carbon-rich material when it was still a main sequence star from its companion when the latter was still a classical Carbon star. We are now seeing these systems a comparatively long time after the mass transfer event, so the extra Carbon observed in the present red giant was not produced within that star. Sometimes the stars whose excess Carbon came from this mass transfer are called "extrinsic" Carbon stars to distinguish them from the "intrinsic" AGB stars which produce the Carbon internally. Many of these extrinsic Carbon stars are not luminous or cool enough to have made their own Carbon, which was a puzzle until their binary nature was discovered.

One is likely to only see the old designations as "**C or N**" classification when reviewing lists or determining

star classifications. I will provide some examples of Carbon Star classifications from Carbon stars I have observed.

Red Dwarfs[6]

A **red dwarf** is a small and relatively cool star on the Main Sequence, either late K or M spectral type. A red dwarf has a mass of less than half that of the Sun (down to about 0.075 solar masses, below which stellar objects are brown dwarfs) and a surface temperature of less than 4,000 Kelvin. Red dwarfs are by far the most common type of star in the Galaxy in the neighborhood of the Sun. Proxima Centauri, a red dwarf, is the nearest star to the Sun. However, due to their low luminosity, individual red dwarfs cannot easily be observed. No red dwarfs are visible to the naked eye.

Red Dwarf Typical Characteristics				
Stellar Class	**Mass (% of Sun)**	**Radius (of Sun)**	**Luminosity (of Sun)**	**Temp. (K)**
M0V	60	62	7.2	3800
M1V	49	49	3.5	3600
M2V	44	44	2.3	3400
M3V	36	39	1.5	3250
M4V	20	26	0.55	3100
M5V	14	20	0.22	2800
M6V	10	15	0.09	2600
M7V	9	12	0.05	2500
M8V	8	11	0.03	2400
M9V	7.5	8	0.015	2300

Stellar models indicate that red dwarfs with less than 35% of the Sun's mass constantly remix the Helium produced by the fusion of Hydrogen throughout the star. This avoids a buildup at the core. Red dwarfs therefore develop very slowly, having a constant luminosity and spectral type for some hundreds of billions of years, until their fuel is depleted. The lower the mass of a red dwarf, the longer the lifespan.

The following are the three brightest Red Dwarfs. All of them should be observable from southern New Mexico.

Red Dwarf Name	***Constellation***	***Spectral Type***	***Visual Magnitude***	***Other Names***
Lacaille 8760	Microscopium	M0	6.69	Gilese 825, HD 202560, AX Microscopii
Lacaille 9352	Piscis Austrinus	M0.5	7.34	Gilese 887, HD 217987
Lalande 21185	Ursa Major	M2	7.49	Gilese 411, HD 95735

Observation Process

Let's take a look at a typical observation list for Carbon Stars. The following is the information provided to classify and locate the star; it is a revised partial list of the 100 Carbon Stars from the Astronomical League:

Name	Other Names	CON	RA	Dec	V	B-V	Spec.	Notes
WZ Cas	SAO21002, STT 254, EsB 764	CAS	00 00.3	+60 21	6.9	2.84	N1p	Period 106 days; 8.0-11.0m; 2 min from 9m Blue-Wh star

[6] ibid.

SU And	BD+42 4827, CCCS 3219, EsB 765	AND	00 04.6	+43 33	8.5	2.53	C6	Period is irr; 8.0-8.5m; in asterism
SAO 109003	GCS 594:778	PSC	00 05.4	+08 46	8.2		C(G4V)	
VX And	HD 1546, CCCS 11, EsB 4	AND	00 19.9	+44 43	7.8	1.6	N7;C4	Period is 367 days; 8.0-9.5m
AQ And	BD +34:56, CCCS 16	AND	00 27.5	+35 36	8.6	2.1	N;C5	Period is 332 days; 6.9-8.2m; deep red
NSV 15196	Sao 74353	AND	00 54 13	+24 04 01	8.3		Cl (Rp)	Period is 755 days

Name: the prefix WZ in "WZ Cas" refers to variable star designation using letters; after the letter pairs are exhausted then the variable stars in a constellation start with V such as V 1369 Aql. Other designations that are typically used for identification are[7]: Bayer uses Greek letters; BD for *Bonner Durchmusterung*, a catalog that covers the northern sky to magnitude 9; CCCS for *Catalog of Cool Carbon Stars*, by Stephenson; CD for *Cape Durchmusterung*, an extension of the BD, completed in South Africa; HD is the *Henry Draper Catalog*; SAO is the *Smithsonian Astrophysical Observatory Catalog*, a catalog of stars to 9th magnitude; STF for *F.G.W. Struve*; TYC is the *Tycho Catalog*, taken from the Tycho satellite: EsB is the *Epsin-Bimingham ' Red Star Catalogue.*'

CON, **RA**, and **Dec** are self-explanatory. **V** is the visual magnitude; variable stars typically will have a range associated with them.

B-V is the numeric value of the color appearance. Plus (+) numbers tend to the red, "0" is white, and minus (-) numbers tend to the blue. The higher the value, one expects to see a redder star. For example Sirius is -1.04 (blue/white), Betelgeuse is 1.85 (orange looking), R Lepus is 5.74 (very red).

Spec.: Because the spectrum of Carbon stars is different from stars on the main sequence, they received their own spectral type by A. Secchi that evolved into "Type C." Other researchers added Class R to include the G and K giant stars and then Class N to combine the K and M cool giant stars. This was mentioned previously when introducing the revised Morgan-Keenan classification. Most likely one will see a "Cn" designation for a Carbon star.

NOTES: These are additions from previous observers or other databases.

Finding a red or orange star in a sparse field of stars was very rewarding and fun. Some of the objects on the list were just SAO or HD numbers that made it interesting and challenging to find them on a chart and then to locate them in the sky. Of course the really red stars such as R Lepus, V Aquila, and T Lyra were all spectacular. My 120mm ED Apochromatic telescope was utilized for observing the Carbon stars. This gives very clear and crisp views of the star fields without any chromatic aberrations. I used a template that was fashioned from viewing "flat galaxies" attached to my eyepiece to locate west for the star field by letting the stars drift. Also, I am aware of the fact that I am color ignorant at times (teal vs. blue, etc.), especially if you ask my wife. In fact some call it color blindness but I can distinguish red from green. The problem is mostly in the tan areas but some of my observations may have mixed up shades of the reds and oranges of the Carbon Stars. I could clearly see that they were in the red/orange color to distinguish them from the surrounding star field. The following template was used to record my observations and to draw the star field:

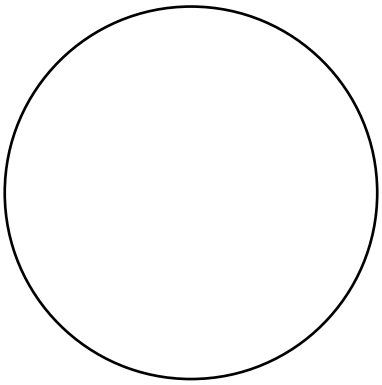
OBJECT: _____ DATE: _____ TIME: _____

SEEING: _____ EYEPIECE: _____ FOV:_____

SITE :_____ TRANS : _____ MAGNIFICATION : _____

MOON : _____ TELESCOPE:_____

NOTES:



[7] Steve Coe; cloudynights.com

Really RED Stars

One always has to distinguish some observations and what better way than to list some of the reddest stars observed. The following is a short list of red Carbon stars that I observed:

Star	*Location*	*Spec.*	*Mag. Range*	*B-V*	*Notes*
T Lyr	18h 32m; +36 59 56.0	C6	7.5-9.3	3.67	Very red
R Lep	04h 59m 36.30; -14 48 23.0	N6	5.5-11.7	5.74	Dim, deep red
W Cas	00h 54m 53; +58 33 49.0	C7	7.8-12.5	2.7	Deep red/orange
V Cyg	20h 41m 18; +48 08 28.0	C5-7	7.7-13.9	4.04	Red
V Aql	19h 04m 24; -05 41 05.0	C5 (N6)	6.6-8.4	4.2	Red

Some other notable Carbon stars are: CW Leo; the most studied Carbon star, and is also the brightest star in the sky at N-band; and Y Canes Venatici (La Superba) one of the brighter Carbon stars.

A Special Carbon Star

WZ Cassiopeia [00h 01'; +60 21'] is both a Carbon star and a double star. If one wanted to see both types of these categories in one star in a constellation that is circumpolar (therefore available every night of the year), WZ Cas fits that requirement. WZ Cas has a B-V rating of 3 and magnitude of 7-9 but it is a variable star. Its double is white (B-V = 0) about 58 arc seconds at a position angle of 156 degrees with a magnitude of 8.3. This pair is worth a look and possibly an image. It should be viewable with binoculars and is just 1.5 degrees NNW of Caph.

Summary

Carbon stars have been a great project since it was easy and rewarding. I will be trying for some of those bright "red dwarfs" since they should be available in the southern skies. Remember, the colors you may see are very subjective but you can't miss a bright Carbon star when it gets into your FOV.

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