

OBSERVER

Happy Holidays!!



Sister on a Mission

Charles Messier's 31st catalogued object bears an amazing resemblance to our own Milky Way, although with slightly less mass. At an accepted distance of 2.54 million light-years, the Andromeda spiral is headed toward us, approaching at a modest 86 miles per second. We and our sister galaxy, with her family of 14 known dwarf galactic satellites, will likely merge in 2.5 billion years, resulting in a huge elliptical system. Currently though, the condemned Princess' astro-highlight glows high overhead at magnitude 4.36.

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DECEMBER SKIES

Now in late Fall we have a quiet sky of dim constellations, hushed and waiting like a snowbound landscape for momentous events. For instance the election—you remember that one, don't you? And then the holiday time of family get-togethers. Our month culminates with the shortest day of the year and then the Christmas celebration that replaces the old pagan Winter Solstice. If we had a Stonehenge we would sight over the stones to determine that day, and maybe sacrifice a chicken. Instead we will eat a pre-processed chicken and burst into the new year with new telescopes and accessories in hand—maybe even new clothes on our backs!

Meanwhile serenely, predictably, the sky unfolds its patterns, conjunctions and variously timed changes of position. At dusk a planetary skyjam continues with Venus, Jupiter, Mercury and the moon all waiting to be noticed and photographed. The first of this month, which may be after you get this newsletter, is perhaps the best time to see Venus and Jupiter with the moon but in late December Mercury joins the crowd, to schmooze with a very slim crescent moon on the 28th and 29th. By New Year's Eve the waxing lunar crescent is farther up, around Venus. Jupiter will take a dive and disappear until

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PRESIDENT'S CORNER

The Holiday Potluck and the February Elections are just around the corner.

The Potluck will be on December 13th at the Columbine Unitarian Universalist Church starting at 6:00 P.M. This is the same place as last year—a great venue located at 6724 South Webster Street Littleton, Colorado 80128 (See Page 7).

Wayne Kaaz and Dennis Cochran will be serving as the nominating committee this year. Please feel free to volunteer yourself or any other member for high office. The Board is composed of eight members at large, four officers and one ex-president. I will not be running for president this year and I will automatically be on next year's board as part of our bylaws.

We are indeed privileged to have access to the University of Denver's Historic Chamberlin Observatory as the center of our astronomy education outreach efforts. We hold around 140 outreach events per year, reaching over 5,000 people. Our Open House events saturate the facility with eager people seeking to learn about astronomy. While at Chamberlin, we work hard as hosts for our guests. After Open House, the General and E-Board meetings we members get together for a late dinner and some ratchet-jawing.

DAS is making small contributions to Dr. Stencel supporting touch-ups in areas of the observatory that were not part of the recent grant work. The effort is directly coordinated by Aaron Reid. We pitch in and help Aaron on a volunteer basis. Our contributions help keep the Chamberlin venue in great shape for our outreach work.

The recent grant has helped to bring the facility back on-line for research for DU. Dr. Stencel and Aaron are also working on developing the Chamber Room as an office

to facilitate outreach and research. Aaron is also working to bring the observatory's Ready Room back on-line as an area where teachers and scientists can

prepare instrumentation and conduct data collection for approved telescope tasks.



DAS President Wayne Green

The International Year of Astronomy is set to kick off in January of 2009. DAS, the International Astronomical Union (IAU), the American Astronomical Society, and the Astronomical League have a goal to reach as many people as possible and remind them about the significance of science and astronomy on our culture and lives. DAS has an IYA2009 committee and a long list of ideas about exhibits, projects and events we might use to help further all our goals and have some great fun in the process.

With the official close of the restoration grant, DAS is restarting our Amateur Telescope Making group. We have quite a few telescopes to complete from the mirror-making work in 2006. Might as well start some new projects. I'm looking forward to having time to make a few instruments of my own!

I look forward to seeing all of you at the Holiday Potluck. —Wayne Green.



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Wayne Green	(303) 530-1023
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Stuart Hutchins	Bryan Wilburn
Frank Mancini	Dan Wray
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Chamberlin Observatory c/o Wayne Green	
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Denver, Colorado 80210	

The Executive Board conducts the business of the DAS at 7:30 p.m. at Chamberlin Observatory. Please see the Schedule of Events for meeting dates. All members are welcome.

www.denverastro.org

NAOMI PEQUETTE TO SPEAK AT THE JANUARY GENERAL MEETING

by Keith Pool

Naomi Pequette, one of our own DAS members and past Van Nattan-Hansen scholarship awardee will give a talk on Archeo-Astronomy at the January 9th general meeting.

Naomi has been a member of the DAS for the past four years, with three of those being a telescope operator on the Clark Refractor at Chamberlin. A recent graduate (2007) of Littleton High School, Naomi is also a past Galaxy Guide and President of the Teen Astronomy Club at the Denver Museum of Nature and Science. Additionally, she was awarded the 2007 National Young Astronomer Award, presented annually by the Astronomical League.

Currently, Naomi is a sophomore at the University of Denver where she is a student of physics and astronomy. Her main interest lies in the field of galaxies and cosmology. She is working with Dr. Jennifer Hoffman on supernova research and is also a research assistant to Dr. Robert Stencil as well. She is also working at S&S Optika.

When she isn't buried under homework, assisting in research projects, or working at S & S, Naomi enjoys playing the flute, baking and attending ballet classes.



Naomi Pequette

DECEMBER SKIES (CONTINUED FROM PAGE 1)

Summer. Saturn is still an early morning object. By the day before the day before Christmas Saturn's rings are almost edge-on and that night, Tuesday, Titan will be well-placed off to the left while Rhea is farther left and the trio Enceladus, Tethys and Dione are tightly lined up off the right end of the rings, making a nice five-moon photo-op.

Venus is in gibbous phase. I'll say no more since I get a little gibbous myself now and then.

The Seven Sisters are occulted by the moon on Thursday the 11th, and then on the 13th we should have the best night of the Geminid meteor shower. As Saturday night turns into Sunday morning the radiant in Gemini near Castor will be up

all night. On the 21st-22nd the less-known Ursids splash in and may provide a concentrated peak between 2:30-4:40 A.M. The Little Bear radiant is also up all night close to the dipper end of Ursa Minor, to the right of Polaris as you look north.

All of those objects in Cassiopeia we talked about last month will still be there. While you're ogling the Double Cluster look for the loose, wide cluster Stock 2 just north and a bit west of the famous pair. Then east of the pair is Eta Persei (eta looks like an 'n'), the star that I think of as the 'point' of Perseus at its north end. Eta is a wide double of blue stars a half arcminute apart. And remember that last month we were look-

ing at the star cluster M103 just east from Delta Cass, 2nd from left of the W? If you ooze over farther east, a bit below the left-hand arm of the W, there are three NGC clusters: 654, 659 and 663. This area is the north end of the Milky Way.

Remember little Delphinus whose arched shape leaps out of the waters between Altair, himself now diving into the western horizon, and the Great Square of Pegasus? If you draw a line between Altair and the dolphin's back you may find the planetary nebula NGC6891 in its middle, "a bright disk surrounded by a fainter ring" (Menzel and Pasachoff). Finally, it's Open House on the 8th!—
Dennis Cochran

THE ATACAMA LARGE MILLIMETER ARRAY (ALMA)

by Ron Mickle

Due to the length of this excellent article, it will be spread over two issues. Ron has used numerous citations and references. Please contact him if you're interested in seeing them.—Ed.



INTRODUCTION

Since its birth 75 years ago, radio astronomy has made advancements that allow astronomers to probe the mysteries of the Universe all the way back to the Big Bang. While the data captured by optical telescopes present stunning and spectacular images, this is only part of the total picture. Radio images of the Universe yield data that Karl Jansky probably never imagined back in 1933 when he detected radio emissions from the Milky Way galaxy (Burke & Graham-Smith 2002).

Optical and radio astronomy are similar in that they both have atmospheric windows where they operate best. The resolution of both depends on the diameter of the mirror or antenna; the larger the mirror or dish, the better the resolution. And like its optical counterpart, radio dishes are designed to optimize different frequencies, or wavelengths. The millimeter wavelength is particularly challenging, requiring special construction techniques, location and material. While there are several radio telescopes designed to operate at millimeter wavelengths, there are none operated in array configuration to achieve the best resolution. The Atacama Large Millimeter Array (ALMA), which is being constructed in the high Atacama Desert of northern Chile, was designed for the sole purpose of observing in the millimeter/submillimeter regime. The combined signals from multiple radio dishes

through radio interferometry will result in images of very high resolution.

This paper will describe key elements of the ALMA design, including (1) its 64 12-meter antennas, 12 7-m antennas and their high angular resolution and sensitivity, (2) the technical challenges ALMA faces, (3) new science ALMA will provide access to, and (4) ALMA's progress to date.

KEYELEMENTS

The key element of ALMA's design are the 64 Cassegrain geometry antennas (ALMA Construction) that will allow ALMA to search the wavelengths between 0.3 to 9.6 mm, divided into 10 bands (Fig. 1) (De Breuck 2004). The antennas will be arranged in an array whose baseline is reconfigurable, from 0.15 km to 18 km wide at its largest, with a total projected collecting area of 7240 m². In its largest configuration, the predicted spatial resolution of 0.005" (Tarengi 2008) will be better than Hubble by a factor of ten (ALMA brochure).

An integral part of ALMA is the Atacama Compact Array (ACA) being built by the consortium of Japan and their East Asian partners. ACA consists of 12 7-m antennas and 4 12-m antennas, for a total collection area of 910 m² in Bands 4, 8, and 10 (Fig. 1). According to De

ALMA Band	Frequency Range
1	31.3 - 45 GHz
2	67 - 90 GHz
3	84 - 116 GHz
4	125 - 169 GHz
5	163 - 211 GHz
6	211 - 275 GHz
7	275 - 373 GHz
8	385 - 500 GHz
9	602 - 720 GHz
10	787 - 950 GHz

Figure 1. De Breuk (ESO), presentation on requirements of ALMA. BOLD indicates ACA bands.

Breuck (2004), the ALMA array cannot measure the smallest spatial frequencies, therefore, the four secondary mirrors of the ACA 12-m antennas will be steered (nutating secondaries) through small angles to optimize power measurements. The 4 12-m antennas functioning as a single-dish array, is referred to as the “ACA Total Power Array” (Takakuwa et al. 2008). The 12 7-m antennas will complete the gap in the u,v-plane.

The surface accuracies of the antenna dish are manufactured to 25 microns rms, with a goal of 20 microns, including the subreflector. These surface

specifications will provide efficiencies of 91% at 300GHz (1 mm) at the 25 micron tolerance and 41% at 900GHz (0.3 mm), and are to be achieved at night in 9 ms-1 wind. One specification requirement is that calibration and adjustments of the dish surfaces take no more than 16 person-hours of work (ALMA Construction).

The ALMA site is in the high desert of Chajnantor plain in northern Chile at an altitude of 5000 m, more than 750 meters higher than Mauna Kea. This altitude provides an atmospheric window comparable to, or better than Mauna Kea and the South Pole and with more than adequate space to accommodate the footprints of the antenna and supporting structures (ALMA brochure).

The ALMA antennas are elevation over azimuth mount, with a design lifetime of 30 years. Features include 270,000 cycles of elevation and not less than 200,000 degrees of motion about each axis. Voltage will be 230v European standard and will operate on either 50 Hz or 60 Hz (ALMA Construction).

At the heart of the ALMA antenna is the detector, covering the entire electromagnetic spectrum between 31.3 GHz /9.6 mm wavelength to 950 GHz/0.3 mm wavelength. The antenna will use superconducting mixers (Fig. 2) cooled to 4 K (-269° C), providing the receivers with the lowest possible noise level (Tarenghi 2008). The receivers are located at the secondary focus of the Cassegrain geometry (De Breuck 2004). According to the ALMA information brochure, the receivers will be the largest superconducting electronics system in the world. Processing data from the receivers is the correlator that will handle 16 GHz bandwidth per baseline, up to 2016 baselines. The correlator, located in the Array Operations Facility, will digitize and process data at a rate of over 1.6×10^{16} floating point operations per second (ALMA NA).

(Continued in the January issue of The Observer)

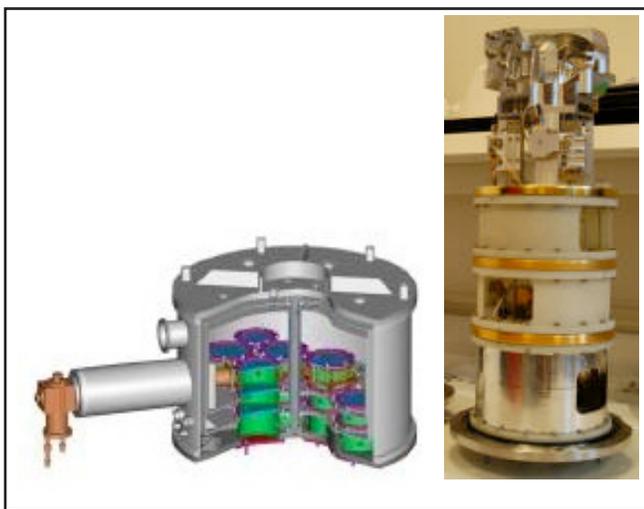
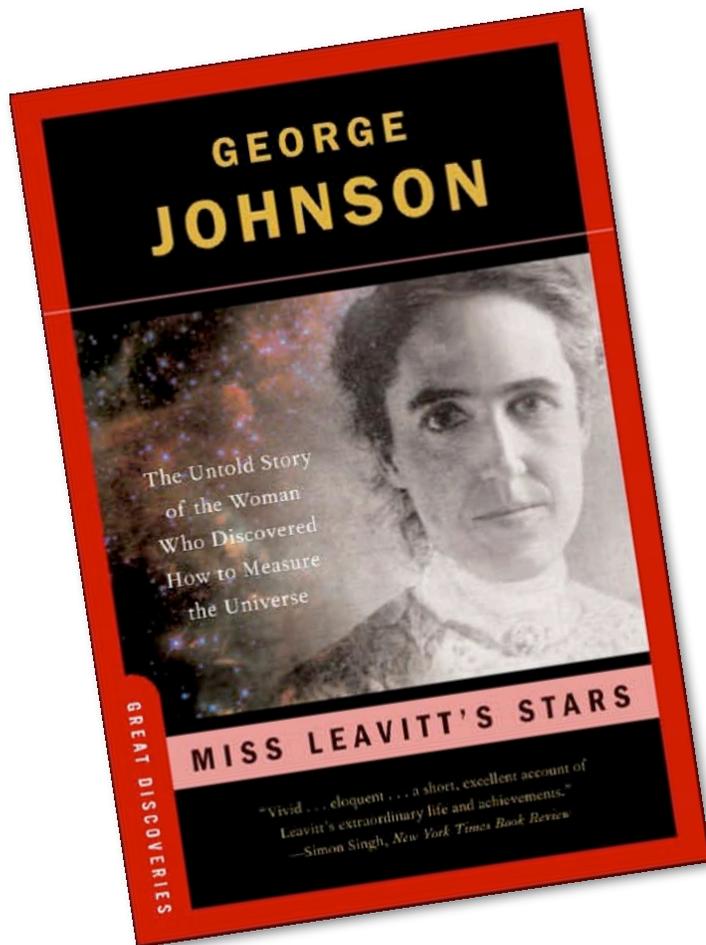


Figure 2. The frequency Band 9 receiver cartridge (right) contains two receivers. Receivers for each antenna utilize superconducting mixers operating at 4 K. The receivers are housed in the cryostat (left) which is located at the Cassegrain focus of each antenna (Tarenghi 2008).

MISS LEAVITT'S STARS

by Jerry M. Sherlin



A century ago a quiet, unassuming lady, Henrietta Swan Leavitt (1868-1921), was working as a “computer” at Harvard College Observatory. In the course of her many analyses she discovered something that would quickly help revolutionize understanding of the structure and size of the universe. Science writer George Johnson has written an interesting little book entitled *Miss Leavitt's Stars* (W. W. Norton, ISBN 0393051285)—an easy evening’s read, that I would recommend to you.

Given the dynamic role of women astronomers today, it may be hard to imagine a time when women’s contributions to astronomy consisted of measuring the positions of stars on photograph plates for 25 cents an hour—yet that is exactly what Henrietta Leavitt, a Radcliffe graduate, had to put up with (she did later get a raise to 60 cents an hour). A hundred years ago access to academic advancement for women was limited, and the first Ph.D. in astronomy awarded to a woman by either Radcliffe or Harvard was to Cecilia Payne (later Payne-Gaposchkin) in 1925. Miss Leavitt never saw that happen.

But what was Miss Leavitt’s monumental discovery? Well, you first have to realize that at the turn of the 20th century, the cosmic yardstick was not very accurate. Fact is the very structure of the universe was in question. Some astronomers (among them Harlow

ABOUT THE DAS

Membership in the Denver Astronomical Society is open to anyone wishing to join. The DAS provides trained volunteers who host educational and public outreach events at the **University of Denver’s Historic Chamberlin Observatory**, which the DAS helped place on the National Register of Historic Places. First light at Chamberlin in 1894 was a public night of viewing, a tradi-



tion the DAS has helped maintain since its founding in 1952.

The DAS is a long-time member in good standing of the **Astronomical League** and the **International Dark Sky Association**. The DAS’ mission is to provide its members a forum for increasing and sharing their knowledge of astronomy, to promote astronomical education to the public, and to preserve Historic Chamberlin Observatory and its telescope in cooperation with the University of Denver.

The DAS is 501 (c)(3) tax-exempt corporation and has established three tax-deductible funds: the Van Nattan-Hansen Scholarship Fund, the Public Outreach Fund and the Edmund G. Kline Dark Site Fund. To contribute, please see the bottom of the membership form for details (found on the DAS website: thedas.org).

More information about the DAS, its activities and the special tax-deductible funds is available on the DAS website at www.denverastro.org.

Shapley) believed that the Milky Way galaxy encompassed the “spiral nebulae”, globular clusters, etc. while others believed that the universe included many “spiral nebulae” far beyond our Milky Way system. In 1920 Shapley participated in a debate with Heber Curtis (Lick Observatory) on the scale of the universe.

Key to determining the scale of the universe was a reliable yardstick and Miss Leavitt, in 1908, had stumbled on it. During her analyses of a special class of pulsating variable stars called Cepheids (named after the first such star discovered, Delta Cephei, in 1784) in the Large and Small Magellanic Clouds, she observed that changes in size of Cepheid variables could be linked to their luminosity; the longer period Cepheids were brighter (or more luminous) than the shorter period ones. Upon plotting her findings, she found a distinct relationship between the Cepheid’s period and its

brightness and this became known as the period-luminosity relationship. One of the first to seize on this appears to have been Shapley who used the period-luminosity relationship to measure the distance to globular clusters. Later, Edwin Hubble, using the new 100-inch reflector on Mt. Wilson, would discover a Cepheid in the Andromeda galaxy (M31). Using the period-luminosity relationship he showed that M31 was outside our Milky Way galaxy.

Henrietta Leavitt left little personal record of her life but her discovery would eventually lead to a radical new understanding of size and distance of the universe. Johnson makes up for the paucity of details about Miss Leavitt’s life by detailing the search for the size of the universe—which was set in motion by Henrietta Leavitt’s discovery.

BRYAN WHITE’S AURORAE HIGHLIGHT DAS ANNUAL HOLIDAY POTLUCK AND BASH

Come one, come all!!! . . . to the annual DAS Holiday Potluck, to be held this year on Saturday evening, December 13th from 6-9 P.M. We will again be meeting at the Columbine Unitarian Universalist Church, 6724 South Webster Street, Littleton, Colorado.

Bring your best culinary potluck creations (salads, casseroles, vegetable dishes, light meat dishes, desserts, and breads) to our traditional end-of-year gathering. DAS will provide liquid refreshment (wine, soda and juices), eating utensils, and ham and turkey meat servings. You’ll experience the very best of company, view the photo review of the year’s highlights, and see the latest edition of Bryan White’s spectacular 3-D comet and aurora multimedia presentation.

The DAS participation prize drawing will also be held at the potluck, covering the last 3 months of DAS

outreach and volunteer activities during 2008.

We had a wonderful time last year and hope to see more of you there this year.

The church is located several blocks east of Wadsworth Boulevard, on the south side of Coal Mine Road.

VOLUNTEERS NEEDED

Volunteers are needed to help set-up before (starting at 4 P.M.) and clean-up after the potluck. E-mail Darrell Dodge at

dmdodge@aol.com. If you get lost driving to the church, call (303) 668-1630.



S&S OPTIKA HAS MOVED TO:

6579 SO. BROADWAY
LITTLETON, CO. 80121
(~1 1/2 blocks NORTH of
Arapahoe Road on the
WEST side of South
Broadway)

(303) 789-1089
www.sandsoptika.com

DAS SCHEDULE

DECEMBER

- 6 Open House at Chamberlin Observatory (Begins at 5:00 P.M.)
- 13 DAS Holiday Potluck (Begins at 6:00 P.M.)
- 19 E-Board meeting at Chamberlin Observatory (Begins at 7:30 P.M.)
- 22 Hannukah Begins
- 25 Christmas Day—No Public Night
- 26-28 EGK Dark Sky weekend

JANUARY

- 3 Open House at Chamberlin Observatory (Begins at 5:00 P.M.)
- 9 General Meeting at D.U.'s Olin Hall (Begins at 7:30 P.M.)
- 16 E-Board meeting at Chamberlin Observatory (Begins at 7:30 P.M.)
- 23-25 EGK Dark Sky weekend
- 31 Open House at Chamberlin Observatory (Begins at 7:30 P.M.)

Public nights are held at Chamberlin Observatory every Tuesday and Thursday evenings

beginning at the following times:

March 9 - April 14 at 8:00 p.m.

April 15 - September 1 at 8:30 p.m.

September 2 - March 8 at 7:00 p.m.

Costs to non-members are: \$3.00 adults, \$2.00 children.

Please make reservations via our website (www.denverastro.org) or call (303) 871-5172.



The Denver Astronomical Society
C/O Chamberlin Observatory
2930 E. Warren Ave.
Denver, Colorado 80210