# The Objective View

May 2004

Newsletter of the Northern Colorado Astronomical Society



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**Next Meeting: May 6 7:30 PM**

## How I Spent My Summer Vacation: Launch of SIRTF

## Dr. Andrea Schweitzer
## LTO Astronomer and NASA Consultant

**NCAS Business at 7 PM**
**Meeting directions Discovery Science Center**
**703 East Prospect Rd, Fort Collins**
http://www.dcsm.org/index.html
In Fort Collins, from the intersection of College Ave and Prospect Rd, head East about 1/2 mile. See the Discovery Center sign to the South. Enter the West Wing at the NE corner. From I-25, take Exit 268, West to Lemay Ave, continue West 1/2 mile, see Discovery Center on the left.

**Starwatch at Discovery Science Center**
May 28 7:30 pm

**Rocky Mountain National Park Starwatching 2004**
**A spring date, April 16, will be tried this month.**
Site is the end of the Upper Beaver Meadows road, starting at dusk. Ranger Jeff Maugans plans to add New Moon weekends. Summer 2004 dates: June 11, 18, 25. July 9, 16, 23. August 6, 13, 20. Contact Dan Laszlo if you are interested as a volunteer, djlaszlo@aol.com, 970 498 9226.

**NCAS Dark Sky Star Party Dates**
**May 7, 8, 14, 15**
Cactus Flats site is on undeveloped parcel of prairie about 6 miles West of Briggsdale. Take Colo Hwy 14 East from I-25 (Exit 269). Go 19 miles East to Ault. Continue 18 miles East of Ault. At County Rd 65 (Milepost 170), turn North, go one mile. Site is through the wire gate on the right, no road, close gate and set up. Beware of the cactus. The site is now officially wheelchair accessible, but there are no facilities so bring essentials. Call **Tom Teters,** tomt@starmon.com **,** with questions about star party status or dates, 482-5702.

## Other Events

Little Thompson Observatory Star Night, Berthoud
May 21 Star Night 7 – 10 pm
http://www.starkids.org

Cheyenne Astronomical Society, Cheyenne Botanical Garden
May 21 7 pm Paul Crips Stardust Mission
http://home.bresnan.net/~curranm/

Open House, Chamberlain Observatory, dusk to 10 pm
May 29, Jun 26, Jul 24, Aug 21, Sep 18 303 871 5172
http://www.du.edu/~rstencel/Chamberlin/

Longmont Astronomical Society
May 20 7 pm Longmont Christian School, 550 Coffman St
http://longmontastro.org/

## Global Net of Astronomical Telescopes Needs You

Dr. Culver has short-period variable star candidates which need monitoring. If you can contribute CCD images of selected 15th to 18th magnitude stars, please call Dr. Culver in the Physics Dept, CSU, 491-6206 for more information.

## About Our May 6 Speaker

Andrea will talk about her experiences visiting Kennedy Space Center in Florida for the launch of the Spitzer Space Telescope last August, and what new things this space telescope has already discovered.

Andrea Schweitzer is an astronomer with the Little Thompson Observatory in Berthoud. Andrea grew up in Longmont and received her Ph.D. in Astronomy from the University of Wisconsin. She has authored/co-authored a dozen astronomy articles, helped test one of the cameras for the Hubble Space Telescope, and her research has been written up in publications ranging from the Longmont Times-Call to the New York Times, and Sky & Telescope Magazine. Andrea works from Fort Collins as a consultant for NASA business and for astronomy education. Her clients include NASA Headquarters, Boeing, the Southwest Research Institute and the Space Science Institute.

## April 1 Program
## James Webb Space Telescope, by Dennis Ebbets Ball Aerospace

The Hubble Space Telescope has been the premier instrument of NASA's space astronomy program during the 1990s, and will continue to be for most of this decade. Observations made at the limits of Hubble's capabilities have motivated plans for an even more powerful follow-on mission, the James Webb Space Telescope. The Next Generation Space Telescope workshop at STScI was in 1989. More details emerged in the Dressler Report, 1993-1995. Dan Goldin issued his challenge for an 8

meter design in 1995. In 1996, CAN studied "Visiting a Time When Galaxies Were Young," and a need for L2 orbit, deployable primary mirror, and deployable sunshield emerged. Progress on design and technology development continue today. The new telescope is designed to advance cosmology and further show the structure of the Universe. It will address the origin and evolution of galaxies. It will investigate the history of the Milky Way and its neighbors. It will give new vistas on the birth and evolution of stars. It will also further our knowledge of the origin and evolution of planetary systems. The telescope is named for NASA Administrator James Webb. He was recruited by JFK and served from 1961-1968. He infused science into NASA missions. He developed national labs, university and industry involvement. He promoted the peer-review proposal-and-selection process. He promoted Sun, Moon, Mars and Venus missions. He advocated a Large Space Telescope in 1965. The Holy Grail for JWST is detection of the predicted first light in the Universe. This would come from the earliest galaxies or their supernovae. Unprecedented views of the earliest galaxies and their precursors would be obtained. The infrared window of JWST will give views of star and planet formation now obscured by gas and dust clouds. It will also determine the physical and chemical properties of planetary systems. By measuring emission and absorbtion lines, we can infer composition, temperature, and motion. The observed wavelength of a feature can shift due to its motion, the Doppler effect. There is also cosmological redshift, due to expansion of the Universe since light left its source. Cosmological redshift allows us to see the Universe as it existed at much earlier times. The sources for "First Light" likely shone when the Universe was 1/20 its current size, at an age of 180 million years. These are likely stars with several hundred solar masses, several million times the Sun's luminosity. They had very short lifetimes, and ended in supernova explosions, creating black hole remnants. A star could appear as magnitude 30-32, luminosity is better for a supernova, but some luck is involved. Accretion of gas would give an object like a mini-quasar, and these formed the cores of galaxies. Galaxies grew through collisions. The oldest known galaxies are seen when the Universe is 1 billion years old, and mergers apparently started before this. Globular clusters may be fossils of this earliest epoch of galaxy formation. A big galaxy would form from about 1 million primordial objects. Nearby galaxies preserve the history of star formation over cosmic time, and their interstellar clouds would be dissected by JWST. The near environments of stars retain evidence from their formation. Dust disks would be analyzed as both precursors and collision debris. IR spectra contain fingerprints of organic molecules, so they could have biological significance. Scientific requirements are near and mid IR sensitivity, from 1 to 28 micrometers. Imaging and spectroscopy is planned. For high sensitivity to very faint objects, 25 square meter area is needed, 6x HST. A cold telescope and instruments are needed for IR detectors, about 40K. Wide field, 4x4 arcminutes, improves chances to catch rare objects, and study large numbers of common objects. A long lifetime, 5 y minimum with 10 y goal, needs to be accomplished without servicing. The cocktail napkin design phase identified major features of the NGST. A segmented primary mirror was needed to fit in a rocket. Deployment and adjustment in space was dictated by the IR requirements. A large sunshade was needed for heat control. Passive cooling was planned for long life. A design from GSFC, STScI, and later Lockheed-Martin proposed a folding-petal primary linked to a long sunshade, the "yardstick" design. Ball Aerospace proposed a chord-fold primary, and then a hexagonal-segmented primary was promoted successfully by TRW and Ball. At the time of the proposal, TRW became part of Northrop-Grumman, they were renamed Northrop-Grumman Space Technology, NGST, so another name was sought for the telescope. They became the prime contractor. Ball is performing optical design and optics, WFS&C design and algorithms, mirror segment cryogenic testing, OTE and Observatory AI&T support. Kodak is performing OTE ground AI&T support, with a massive vacuum chamber at Plum Brook. They will test configuration and interfaces. An Ariane 5 with its largest fairing will launch JWST. It will settle at the Sun-Earth L-2 point, about 1 million miles from Earth in the antisolar direction. This allows passive cooling, constant distance from Sun and Earth, and a very benign environment. The telescope is a 3 mirror anastigmat. The primary is 6.5 meters, composed of 18 segments, each 1.3 meters. The sunshade is tennis-court sized, with 5 layers. A dihedral angle allows it to compensate for solar photon pressure without reaction wheels. Aiming a 6000 kg observatory with milliarcsecond precision was impractical, so the tertiary mirror feeds a fine-steering mirror on very rapid actuators. The primary can wobble by 1 arcsecond. Individual pickoff mirrors send light to each instrument. Ball advocated beryllium for the primary as best for a cryo instrument. It will get a coat of gold. The structure is a honeycomb with a thin face sheet. It is hyperbolic, f/20. It will sit on 6 actuators which perform location and focus motion, in nanometer steps. The Integrated Science Instrument Module holds ESA's Near IR Spectrometer for 0.6 to 5 uM, over 100 objects simultaneously. The University of Arizona supplies the Near IR Camera with coronagraph imaging capability. The Mid IR Instrument by an international consortium performs imaging and spectroscopy from 5 to 28 uM. The Fine Guidance Sensor incorporates a tunable filter imager. End to end tests will verify optical performance. Daily contact is planned. A dedicated ground station may be built. It was undesirable to operate a gimbal on the cold side of the instrument, so the telescope and sunshade move as a unit. The telescope can angle 5 degrees toward the Sun, but up to 45 degrees away. It can roll 360 degrees around an axis pointing at the Sun. There are therefore a cone-shaped zones of exclusion extending toward and away from the Sun, but all-sky coverage is achieved in the course of the year. The craft's slew speed is like a clock's minute hand. The computer is a 486 class processor, bit rate is 10 megabits/sec. The next generation of craft will use laser transfer to jump to gigabits. Dr. Ebbets then gave some insights into the current HST dilemma. There is little doubt that a robotic mission will be designed to attach a deorbit motor. Proposals are in for more ambitious robotic rescue. Ball would be thrilled to see the Cosmic Origins Spectrograph and WFPC-3 installed.

**NCAS Business, April 1 2003**

President Dan Laszlo called the meeting to order. A motion to sponsor the Clear Sky Clock for Cactus Flats was passed. Membership in the International Dark Sky Association was discussed and approved. Andrea Schweitzer is presenting her experiences at the SIRTF launch at May's NCAS meeting.

Discovery Science Center is hosting guest speaker Carolyn Porco on May 15 on the Cassini Mission. Dan Laszlo announced dates for Rocky Mountain National Park.

**Detection of parasitic microsatellites**
Date: Monday, March 8, 2004 6:59:43 PM
From: fw-nx@xs4all.nl
To: SeeSat-L@satobs.org

Found this thesis by Vincent J. Dabrowski (USAF) published in 2003. "Parasitic" microsatellites rigidly connected to a satellite can be detected with a series of small identical maneuvers. Full text here (PDF, 4.1 MB):
https://research.maxwell.af.mil/papers/ay2003/afit/AFIT-GAE-ENY-03-2.pdf

From the Introduction:
Advances in the miniaturization of space systems technology have, and will continue to, lead to reductions in space vehicle size and cost. These reductions are leading to a world-wide explosion in microsatellite usage. One particularly promising area of research is the use of microsatellites (microsats) as inspection and servicing vehicles for larger satellites. However this same technology can be used to rendezvous and dock with a satellite and disrupt, degrade, disable, or destroy it. Since the UnitedStates (US) is the most space-dependent country on earth it has the most to lose from these types of attacks. Ground-based detection of such threats are insufficient. A 1999, government-sponsored report by the Schafer Corporation concluded that the US Space Object Identification (SOI) capability in Low Earth Orbit (LEO) is inadequate. Worden explains: These sensors are mostly 1960s and 1970s era radar and optical tracking sensors , and the US, cannot detect and track microsatellite-sized objects in Geosynchronous Orbit (GEO). The US Fiscal Year 2000-01 Department of Defense (DoD) Space Technology Guide cites the need for on-orbit diagnostics aboard all satellites. It states that assets must be capable of surveying their own space environment, both for self-protection against natural and man-made threats and to determine if they are under attack. This concept is referred to as Space Situational Awareness.
Regards,
Frits
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Frits Westra -- PE2ATC -- fw-nx#xs4all.nl -- 52.22N 06.38E
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**Cassini Mission Lecture by Dr. Carolyn Porco May 15**
Hi astronomy enthusiasts!
Discovery Science Center is hosting an exciting speaker in May that you won't want to miss. The quick write up is below and I've included the speaker's bio below that. We consider it our pleasure to have such a valuable connection with NCAS and want to invite the members of the club to attend this event free of charge. (The lecture is included with regular admission to Discovery Center.) When you come to the front desk please just mention that you are with NCAS and we will waive the admission for you and a guest. Hope to see you there!

Sincerely, Corey Radman Museum Educator
Discovery Science Center

May 15, 2004 1:00
Guest Lecturer: Saturn Expert, Dr. Carolyn Porco

Discovery Science Center is honored to host Dr. Carolyn Porco, Cassini Mission Imaging Team Leader and Adjunct Professor at the University of Colorado and Sr. Research Scientist at the Space Science Institute, in Boulder. She will address the history and latest updates in the Cassini mission. The Cassini mission is an international effort to place a spacecraft in orbit around Saturn, and deploy an atmospheric probe to Saturn's largest satellite, Titan, in the year 2004.

Saturday, May 15, 1:00-2:00 lecture. 2:00-2:30 Q&A
Talk will be appropriate for older students and adults.

Dr. Porco's Bio:

Dr. Carolyn C. Porco received her PhD degree in 1983 from the California Institute of Technology in the Division of Geological and Planetary Sciences, having completed her doctoral dissertation on Voyager discoveries in the rings of Saturn. In the fall of 1983, she joined the faculty in the Department of Planetary Sciences within the University of Arizona; the same year she was made a member of the Voyager Imaging Team. In the latter capacity, she participated heavily in the Voyager encounters with Uranus in 1986 and Neptune in 1989, leading the Rings Working Group within the Voyager Imaging Team during the latter encounter. In November 1990, she was selected as the leader of the Imaging Team for the Cassini mission to Saturn, an international mission to place a spacecraft in orbit around Saturn, and deploy an atmospheric probe to Saturn's largest satellite, Titan, in the year 2004. She is also the Imaging Science lead on the recently-selected Pluto/Kuiper Belt mission called New Horizons, which will launch to Pluto in 2006.

She is currently a Sr. Research Scientist at the Space Science Institute in Boulder, Colorado, an Adjunct Professor in the Department of Planetary Sciences at the University of Arizona, and an Adjunct Professor at the University of Colorado in Boulder. She has taught both graduates and undergraduates and was one of 5 finalists for the University of Arizona Honors Center `Five Star Faculty Award', a campus-wide student-nominated, student-judged award for outstanding undergraduate teaching.

Her research specialty is the study of the ring systems which gird all 4 giant planets in the outer solar system. She has made major scientific contributions in the understanding of the structure and phenomenology of planetary rings and the gravitational interactions between ring particles and the natural satellites which orbit the outer planets. Her doctoral work on the rings of Saturn includes the discovery of the connection between Saturn's ring spokes and its magnetic field. Using Voyager Uranus data, she did the defining research on the shepherding of the Uranian rings; with Voyager Neptune

data, she proposed a dynamical explanation for the confinement of the Neptune ring arcs. Since then, she has been involved in elucidating the possible role of acoustic oscillations within Saturn in creating ring features and in modeling the light scattering behavior of Saturn's rings -- ideas that will be tested when Cassini arrives at Saturn in 2004. The Cassini Imaging Science results from the December 2000 Cassini Jupiter flyby were just recently featured on the cover of SCIENCE.

She has been an active participant in guiding the American planetary exploration program through membership on several important NASA advisory committees, including the Solar System Exploration Subcommittee, the Mars Observer Recovery Study Team, and the Solar System Road Map Development Team. She served as the chairperson for a small NASA advisory working group to study and develop future outer solar system missions and she recently served as the Vice Chair of the Steering Group for the Solar System Decadal Survey, sponsored by the National Academy of Sciences and NASA.

Dr. Porco has made many radio and television appearances, explaining science to the layman, including two MacNeil/Lehrer Newshour interviews in 1989, and many TV programs and documentaries on planetary exploration. She was a strong and visible defendant of the usage of radioactive materials on the Cassini spacecraft; in particular, she participated in a nationally aired radio debate with Karl Grossman, a leader among anti-nuclear activists, in October 1997. She was a consultant on the movie `Contact' and participated in a series of panel discussions at the American Film Institute in Hollywood to discuss `Creating Network Television About Scientists and Engineers' and `Portraying Real Science and Technology in the Movies'.

She has also given many newspaper and magazine interviews, and has been profiled seven times in print, beginning in 1989 (Boston Globe, October, 1989) and recently in the New York Times (August 1999). In late 1999, she was selected by the Sunday London Times as one of 18 scientific leaders of the 21st century.

Dr. Porco has been, and continues to be, active in the presentation of science to the public. She was a member of a committee chaired by Carl Sagan in 1994 entitled `Public Communication of NASA's Science.' Her popular scientific writings have been published in the London Sunday Times, the Guardian, Astronomy Magazine and the Arizona Daily Star.

Her contributions to the exploration of the outer solar system were recently recognized with the naming of Asteroid (7231) Porco: `Named in honor of Carolyn C. Porco, a pioneer in the study of planetary ring systems...and a leader in spacecraft exploration of the outer solar system.'

Finally, Dr. Porco was responsible for the proposal to honor the late renowned planetary geologist, Eugene Shoemaker, by sending his cremains to the Moon aboard the Lunar Prospector spacecraft launched from Cape Canaveral on January 6, 1998. Accompanying this unprecedented payload was a tribute designed and produced by Dr. Porco which may be viewed at: http://ciclops.lpl.arizona.edu/tribute.html

**Binoculars for Sale**
11x80 binoculars in excellent condition, with caps and case. $145. Contact REScline@aol.com

**URL for Clear Sky Clocks for Colorado**
http://cleardarksky.com/csk/prov/Colorado_clocks.shtml

**Best Looks**

| | |
|---|---|
| Moon | By Mercury 5/16 |
| | By Venus 5/20, 21 |
| | By Mars and Saturn 5/22 |
| | By Jupiter 5/26 |
| Mercury | Very low in East at dawn, midmonth |
| Venus | In West at sunset, look before midmonth |
| Mars | In West at sunset, look before midmonth |
| Jupiter | High in S evenings |
| Saturn | In West at sunset, look before midmonth |

From: Dan Laszlo
2001 S Shields St Building H
Fort Collins CO 80526

**TO:**

**Comet Bradfield 2004 F4 from Cactus Flats, 4-27-2004 from Tom T**

Well I did see Bradfield this morning. Got setup about 2:30am at Cactus Flats. (Bradfield rose at 3:31am). After I found M31 & Mirach I aimed my Pentax MX SLR w/100mm lens using Kodak 400 slide film (remember that technology?) to the south and shot a 15 min exposure. after the first shot, I did find the comet and was on track, so I reframed a little, to include M31 in the second shot, another 15 min. Now it was about 4:30am & I could just see some lightening of the horizon. The next 2 shots were through the 80mm refractor at f/5, 7 minutes long. The 3rd exposure may have a bit of a jet & contrail on it's south side. After the 4th. shot, it the horizon was obviously brighter. So I observed Bradfield visually. Comet Bradfield it difficult to view naked eye, with a combination of slight haze on the horizon & it's proximity to the Sun, I only captured it visually once at about 4:50am with averted vision. In both the 80mm & the C-14 it is very striking. The wider field showed a slender linear tail 5*-6*, I noticed no knots of dust/gas and the coma was almost pinpoint and the most beautiful Azure blue, almost pastel. In the C-14 with a 14mm eyepiece (279x) it appeared that the coma was oblong, not round.

Date: Wednesday, April 28, 2004 5:51:31 AM
From: dwolford@atcjet.net
To: front-range-tac@seds.org

Hi all,
Got out about 3:30am this morning. Great views of Bradfield this morning. The best with 8X50 Binoculars about 4:15am. Could see visually naked eye for a few minutes from 4:15 - 4:30. Tail covers nearly full FOV in 8X50's. Striking blue coma through 7" Mead Mak w/40 MM (67X). Look forward to seeing anyone's images of Bradfield. Could not locate LINEAR
Doug

Date: Tuesday, April 27, 2004 6:49:50 PM
From: kimon@deepskymarines.org
To: front-range-tac@seds.org

I saw Bradfield through binoculars at 4:40. I tried again at 5:05 and it was too bright. It's pretty faint, but then so was M31...
Kimon

Subj: [FRAC] More Comet Bradfield
Date: Wednesday, April 28, 2004 6:13:44 AM
From: street@juno.com
To: front-range-tac@seds.org

Another observation/view from Frederick, CO:
Tried to locate Comet Bradfield by n*ked eye at 4:30am this morning, but was unsuccessful. Sky was beginning to noticeably lighten, altho' all stars in Little Dipper were still visible.

However, using 10 x 50 binoculars, easily located M31 and Comet Bradfield (about 10 degrees below and to the right of M31). "Pinpoint" coma and a very nice tail extended across the bino's field (about 5 degrees?).

Definitely a "looker", but would suggest an earlier look (e.g., 4:10-4:20am). Unfortunately, the weather report for tomorrow morning doesn't sound encouraging. Good luck!

Till later...
---> Dave

International Space Station Passes for Loveland – Fort Collins May 2004

| Date | Mag | Starts | | | Max. Altitude | | | Ends | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Time | Alt. | Az. | Time | Alt. | Az. | Time | Alt. | Az. |
| 05 May | 2.4 | 05:26:34 | 10 | NNW | 05:28:04 | 13 | NNE | 05:29:34 | 10 | NE |
| 06 May | 2.7 | 04:21:00 | 10 | N | 04:21:30 | 10 | N | 04:22:00 | 10 | NNE |
| 07 May | 2.4 | 04:49:40 | 10 | NNW | 04:51:23 | 14 | NNE | 04:53:07 | 10 | NE |
| 08 May | 1.5 | 05:18:27 | 10 | NW | 05:21:04 | 27 | NNE | 05:23:39 | 10 | E |
| 09 May | 2.4 | 04:12:37 | 10 | NNW | 04:14:34 | 16 | NNE | 04:16:30 | 10 | ENE |
| 10 May | 1.1 | 04:41:23 | 10 | NW | 04:44:08 | 32 | NNE | 04:46:49 | 10 | E |
| 11 May | 2.2 | 03:35:26 | 10 | NNW | 03:37:35 | 18 | NNE | 03:39:43 | 10 | ENE |
| 11 May | -0.9 | 05:10:25 | 10 | WNW | 05:13:22 | 71 | SW | 05:16:17 | 10 | SE |
| 12 May | 0.6 | 04:04:11 | 10 | NW | 04:06:58 | 40 | NNE | 04:09:49 | 10 | ESE |
| 12 May | 1.4 | 20:35:48 | 10 | SE | 20:36:30 | 11 | SE | 20:37:13 | 10 | ESE |
| 12 May | -0.6 | 22:08:38 | 10 | WSW | 22:11:35 | 69 | NW | 22:11:35 | 69 | NW |
| 13 May | -0.7 | 04:33:14 | 10 | WNW | 04:36:07 | 53 | SW | 04:39:00 | 10 | SE |
| 13 May | -0.3 | 21:02:28 | 10 | SSW | 21:05:16 | 38 | SE | 21:08:05 | 10 | ENE |
| 13 May | 1.7 | 22:38:20 | 10 | W | 22:40:52 | 24 | NNW | 22:43:22 | 10 | NNE |
| 14 May | 0.1 | 03:29:52 | 50 | NE | 03:29:52 | 50 | NE | 03:32:38 | 10 | ESE |
| 14 May | 1.0 | 05:03:17 | 10 | W | 05:04:56 | 14 | SW | 05:06:35 | 10 | SSW |
| 14 May | 0.0 | 21:31:20 | 10 | WSW | 21:34:17 | 53 | NNW | 21:37:13 | 10 | NE |
| 14 May | 2.7 | 23:08:42 | 10 | NW | 23:10:18 | 13 | NNW | 23:11:54 | 10 | NNE |
| 15 May | 2.0 | 22:01:08 | 10 | WNW | 22:03:30 | 21 | NNW | 22:05:52 | 10 | NNE |
| 15 May | 3.0 | 23:39:28 | 10 | NNW | 23:39:52 | 10 | N | 23:40:16 | 10 | N |
| 16 May | 0.6 | 20:53:56 | 10 | WSW | 20:56:49 | 42 | NNW | 20:59:41 | 10 | NE |
| 16 May | 2.8 | 22:31:32 | 10 | NW | 22:32:54 | 12 | NNW | 22:34:18 | 10 | NNE |
| 17 May | 2.9 | 00:08:37 | 10 | N | 00:09:02 | 11 | N | 00:09:02 | 11 | N |
| 17 May | 2.2 | 21:23:48 | 10 | WNW | 21:26:01 | 18 | NNW | 21:28:13 | 10 | NNE |
| 17 May | 2.9 | 23:02:14 | 10 | N | 23:02:26 | 10 | N | 23:02:37 | 10 | N |
| 18 May | 2.8 | 21:54:13 | 10 | NNW | 21:55:23 | 12 | N | 21:56:33 | 10 | NNE |
| 18 May | 2.6 | 23:30:50 | 10 | NNW | 23:31:55 | 11 | N | 23:32:23 | 11 | NNE |
| 19 May | 2.3 | 20:46:21 | 10 | WNW | 20:48:23 | 17 | NNW | 20:50:25 | 10 | NNE |
| 19 May | 2.8 | 22:24:39 | 10 | N | 22:24:50 | 10 | N | 22:25:02 | 10 | N |
| 19 May | 2.7 | 23:59:07 | 10 | NNW | 23:59:48 | 13 | NNW | 23:59:48 | 13 | NNW |
| 20 May | 2.7 | 21:16:46 | 10 | NNW | 21:17:43 | 11 | N | 21:18:40 | 10 | N |
| 20 May | 2.5 | 22:52:56 | 10 | NNW | 22:54:14 | 12 | NNE | 22:55:28 | 10 | NE |
| 21 May | 2.7 | 21:46:43 | 10 | N | 21:47:06 | 10 | N | 21:47:30 | 10 | N |
| 21 May | 2.0 | 23:21:10 | 10 | NNW | 23:22:48 | 19 | N | 23:22:48 | 19 | N |
| 22 May | 2.3 | 22:14:54 | 10 | NNW | 22:16:25 | 13 | NNE | 22:17:57 | 10 | NE |
| 22 May | 2.4 | 23:49:33 | 10 | NW | 23:50:07 | 14 | NW | 23:50:07 | 14 | NW |
| 23 May | 2.5 | 21:08:37 | 10 | N | 21:09:14 | 10 | N | 21:09:50 | 10 | NNE |
| 23 May | 1.3 | 22:43:05 | 10 | NNW | 22:45:33 | 23 | NNE | 22:45:42 | 23 | NNE |
| 24 May | 2.0 | 21:36:43 | 10 | NNW | 21:38:27 | 14 | NNE | 21:40:11 | 10 | NE |
| 24 May | 1.4 | 23:11:27 | 10 | NW | 23:12:59 | 27 | NW | 23:12:59 | 27 | NW |
| 25 May | 1.0 | 22:04:52 | 10 | NW | 22:07:28 | 26 | NNE | 22:08:33 | 21 | ENE |
| 25 May | 2.5 | 23:40:15 | 10 | WNW | 23:40:16 | 10 | WNW | 23:40:16 | 10 | WNW |
| 26 May | 1.8 | 20:58:24 | 10 | NNW | 21:00:20 | 16 | NNE | 21:02:15 | 10 | ENE |
| 26 May | -0.4 | 22:33:13 | 10 | NW | 22:35:50 | 64 | NNW | 22:35:50 | 64 | NNW |
| 27 May | 0.6 | 21:26:31 | 10 | NW | 21:29:15 | 31 | NNE | 21:31:24 | 14 | E |
| 27 May | 1.7 | 23:02:05 | 10 | WNW | 23:03:06 | 17 | W | 23:03:06 | 17 | W |
| 28 May | -0.9 | 21:54:51 | 10 | NW | 21:57:52 | 80 | SSW | 21:58:41 | 42 | SE |
| 29 May | 0.3 | 20:48:01 | 10 | NW | 20:50:48 | 37 | NNE | 20:53:38 | 10 | E |
| 29 May | 1.2 | 22:23:51 | 10 | W | 22:26:00 | 20 | SW | 22:26:00 | 20 | SW |
| 30 May | -0.6 | 21:16:22 | 10 | WNW | 21:19:20 | 62 | SW | 21:21:37 | 15 | SE |
| 31 May | 1.5 | 21:45:32 | 10 | W | 21:47:30 | 16 | SW | 21:48:58 | 12 | SSW |