Wellington Astronomical Society March 2017 Volume 47 Issue 2
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The next WAS meeting will be held on Wednesday 1st of March 2017 at 7:30 pm at Carter Observatory, Upland Rd, Kelburn, Wellington

ASTROSAT: India's first dedicated multi-wavelength space observatory

Jibu Stephen

With the multi-wavelength astronomy mission ASTROSAT, India became the fifth nation to have an observatory in space. The five instruments on-board the satellite would enable simultaneous observations in optical, ultraviolet and X-ray bands. The mission aims to study high energy processes in binary star systems containing neutron stars and black holes, to estimate magnetic fields of neutron stars and to study star birth regions and high energy processes in star systems lying beyond our galaxy. Early results from the Ultra-Violet Imaging Telescope reveal a hot companion star associated with a blue straggler star in open cluster NGC-188.

Jibu Stephen has a Ph. D. in Physics (Condensed Matter) from Victoria University of Wellington. He worked at the Indian Institute of Astrophysics before moving to New Zealand and was part of the Ultraviolet Imaging Telescope team.

Inside this issue:

2016 — 2017 SUBSCRIPTIONS DUE

The new subscription year began in September, so WAS looks forward to receiving your subscription renewal.

Renewal forms can be found on the website, but a summary follows:

Subscription for Newsletter by Email 2016-2017

Adult/Waged: $ 50.00

Student/Unwaged: $ 30.00

Family: $ 70.00

Payment methods:

Cheque - make out to Wellington Astronomical Society Inc, and mail to PO Box 3181, Wellington 6140

Direct Deposit or Internet Banking - use Acc No: 03-0502-0508656-00, please include reference so WAS knows who is making the payment

Cash - please bring exact amount to meeting

WAS COUNCIL MEMBERS AND CONTACTS

Council Members

The following members were elected to Council at the Nov 2016 AGM

President: Antony Gomez
president@was.org.nz / 021_253_4979

Vice President: Duncan Hall
vice-president@was.org.nz

Secretary/Telescope custodian: Chris Monigatti
secretary@was.org.nz / 021_890_222

Treasurer: John Homes

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Council

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Peter Woods

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WAS ON FACEBOOK

Our Facebook page "Wellington Astronomical Society" is now operational. You can search for it on Facebook or click on this link https://www.facebook.com/WellingtonAstronomicalSociety/.

If you are a Facebook user, please use the page to receive up-to-date notifications of our Society's events and news. This is the easiest way to keep informed as to what is going on in the Society, as well as keeping up with astronomical news.

Remember you will need to interact occasionally with the page by liking or commenting on postings, or indicating whether you are coming to an event. Otherwise Facebook will, after a time, stop sending you new postings. So keep visiting the page as there are a number of Society events coming up in the next few months.

We also have Facebook group "WAS – Wellington Astronomical Society" https://www.facebook.com/groups/96304353012/ which is open for anyone to join by request. The public group is open for discussion or postings on astronomical news. The WAS Astrophotography Group https://www.facebook.com/groups/168473875811214/ is for those interested in astrophotography. It serves as a place to notify others of astrophotography gatherings at short notice and to display images captured by members.

Wellington Astronomical Society March 2017 Events

WAS March Meeting

March's talk is given by Jibu Stephen. He will be taking about ASTROSAT: India's first dedicated multi-wavelength space observatory.

With the multi-wavelength astronomy mission ASTROSAT, India became the fifth nation to have an observatory in space. The five instruments on-board the satellite enable simultaneous observations in optical, ultraviolet and X-ray bands. The mission aims to study high energy processes in binary star systems containing neutron stars and black holes, to estimate magnetic fields of neutron stars and to study star birth regions and high energy processes in star systems lying beyond our galaxy. Early results from the Ultra-Violet Imaging Telescope reveal a hot companion star associated with a blue straggler star in open cluster NGC-188.

Jibu Stephen has a Ph. D. in Physics (Condensed Matter) from Victoria University of Wellington. He worked at the Indian Institute of Astrophysics before moving to New Zealand and was part of the Ultraviolet Imaging Telescope team.

Date: Wednesday, 1st March

Time: 7:30 pm

Venue: Space Place (at Carter Observatory)

WAS Society Observing Evening

Come along and see the many wonderful objects, star clusters, galaxies, dying stars and nebulae around and near the Southern Cross, the spectacular globular cluster 47 Tucanae and the Tarantula Nebula in the Large Magellanic Cloud (LMC). Jupiter rises around 10pm

Date: Saturday 4th March

Time: 7:00 pm

Venue: Tawa College

Astronomy Club Night

A short presentation and observing the night sky.

Date: Thursday 9th March

Time: 7:00pm,

Venue: Hutt International Boys School

Astronomy Night :The Night Sky 2017 by Antony Gomez

Find out what to look forward to in our night sky during 2017!

Antony Gomez, President of the Wellington Astronomical Society, will talk you though the amazing things visible in the sky this year as well as major planetary events.

If the sky is clear, we'll head outside after the talk for a bit of stargazing.

Date: Friday 10th March

Time: 7:00pm,

Venue: Lower Hutt War Memorial Library

WAS Astrophotography Group

Location and updates will be posted on the WAS Astrophotography Group Facebook page closer to the time.

We will aim for a darker location this time to try out our new skills. If the skies are cloudy we will meet indoors and learn more about processing image data.

For further details or cancellations contact Edward 021_08304802 or Chris 021_ 890222.

Date: Saturday 25th March

Time: 7:00pm,

Venue: TBD.

Planetary Accretion

An interesting thing happened for planetary science recently: two papers (Nature, vol 541 (Dauphas, pp 521 – 524; Fischer-Gödde and Kleine, pp 525 – 527) showed that much of how we think planets accreted is wrong. The papers showed that the Earth/Moon system has isotope distributions across a number of elements exactly the same as that found in enstatite chondrites, and that distribution applied over most of the accretion. We know that elements with multiple isotopes have a variation in isotope ratios that depends on the radial distance from the star. Enstatite chondrites have structures consistent with being formed much closer to the sun than, say, Mars. Enstatite chondrites are also very dry.

The standard theory, called oligarchic growth, explains planetary formation in terms of dust accreting to planetesimals by some unknown mechanism, then these collide to form embryos, which in turn formed oligarchs or protoplanets (Mars sized objects) and these collided to form planets. If this happened, they would do a lot of bouncing around and everything would get well-mixed. Standard computer simulations argue that Earth would have formed from a distribution of matter from further out than Mars to inside Mercury's orbit. Dauphas showed that Earth accreted from a reasonably narrow zone throughout its entire accretion time. Also, the standard explanation that Earth's water and biogenetic material came from carbonaceous chondrites must be wrong. The ruthenium isotope analysis falsifies the theory that any significant amount of water arrived from such chondrites.

There is an alternative theory called monarchic growth, but this was abandoned because it cannot explain first why we have the number of planets we have and where they are, and second where our water came from. For those who attended my WAS talk a few years ago, you will recall I gave a mechanism based on chemistry that causes matter to stick together in specific temperature zones, and that places the planets are where they are. The water on Earth was accreted at about 1 AU, where the water set cement that bound the solids.

Maybe one day this will be accepted, but then again, maybe not. If it is, you can say you were the first to hear it and that was at WAS.

Ian Miller

Movie: Hidden Figures

WAS received the following email from John Holmes:

"I'd like to recommend to members that, if they haven't already, they go see the film Hidden Figures. We saw it yesterday night; it is a superb film, and likely to be of interest to many of our members. It is about the lead up to the Mercury spaceflights, and the work done by some people subject to some severe social issues."

Solar Eclipse Provides Coronal Glimpse

This article is provided by NASA Space Place.

With articles, activities, crafts, games, and lesson plans, NASA Space Place encourages everyone to get excited about science and technology.

Visit **spaceplace.nasa.gov** to explore space and Earth science!

On August 21, 2017, North Americans will enjoy a rare treat: The first total solar eclipse visible from the continent since 1979. The sky will darken and the temperature will drop, in one of the most dramatic cosmic events on Earth. It could be a once-in-a-lifetime show indeed. But it will also be an opportunity to do some science.

Only during an eclipse, when the moon blocks the light from the sun's surface, does the sun's corona fully reveal itself. The corona is the hot and wispy atmosphere of the sun, extending far beyond the solar disk. But it's relatively dim, merely as bright as the full moon at night. The glaring sun, about a million times brighter, renders the corona invisible.

"The beauty of eclipse observations is that they are, at present, the only opportunity where one can observe the corona [in visible light] starting from the solar surface out to several solar radii," says Shadia Habbal, an astronomer at the University of Hawaii. To study the corona, she's traveled the world having experienced 14 total eclipses (she missed only five due to weather). This summer, she and her team will set up identical imaging systems and spectrometers at five locations along the path of totality, collecting data that's normally impossible to get.

Ground-based coronagraphs, instruments designed to study the corona by blocking the sun, can't view the full extent of the corona. Solar space-based telescopes don't have the spectrographs needed to measure how the temperatures vary throughout the corona. These temperature variations show how the sun's chemical composition is distributed—crucial information for solving one of long-standing mysteries about the corona: how it gets so hot.

While the sun's surface is ~9980 Farenheit (~5800 Kelvin), the corona can reach several millions of degrees Farenheit. Researchers have proposed many explanations involving magneto-acoustic waves and the dissipation of magnetic fields, but none can account for the wide-ranging temperature distribution in the corona, Habbal says.

You too can contribute to science through one of several citizen science projects. For example, you can also help study the corona through the Citizen CATE experiment; help produce a high definition, time-expanded video of the eclipse; use your ham radio to probe how an eclipse affects the propagation of radio waves in the ionosphere; or even observe how wildlife responds to such a unique event.

Otherwise, Habbal still encourages everyone to experience the eclipse. Never look directly at the sun, of course (find more safety guidelines here: https://eclipse2017.nasa.gov/safety). But during the approximately 2.5 minutes of totality, you may remove your safety glasses and watch the eclipse directly—only then can you see the glorious corona. So enjoy the show. The next one visible from North America won't be until 2024.

Marcus Woo

For more information about the upcoming eclipse, please see:

NASA Eclipse citizen science https://eclipse2017.nasa.gov/citizen-science

NASA Eclipse safety guidelines https://eclipse2017.nasa.gov/safety

Want to teach kids about eclipses? Go to the NASA Space Place and see our article on solar and lunar eclipses! http://spaceplace.nasa.gov/eclipses/

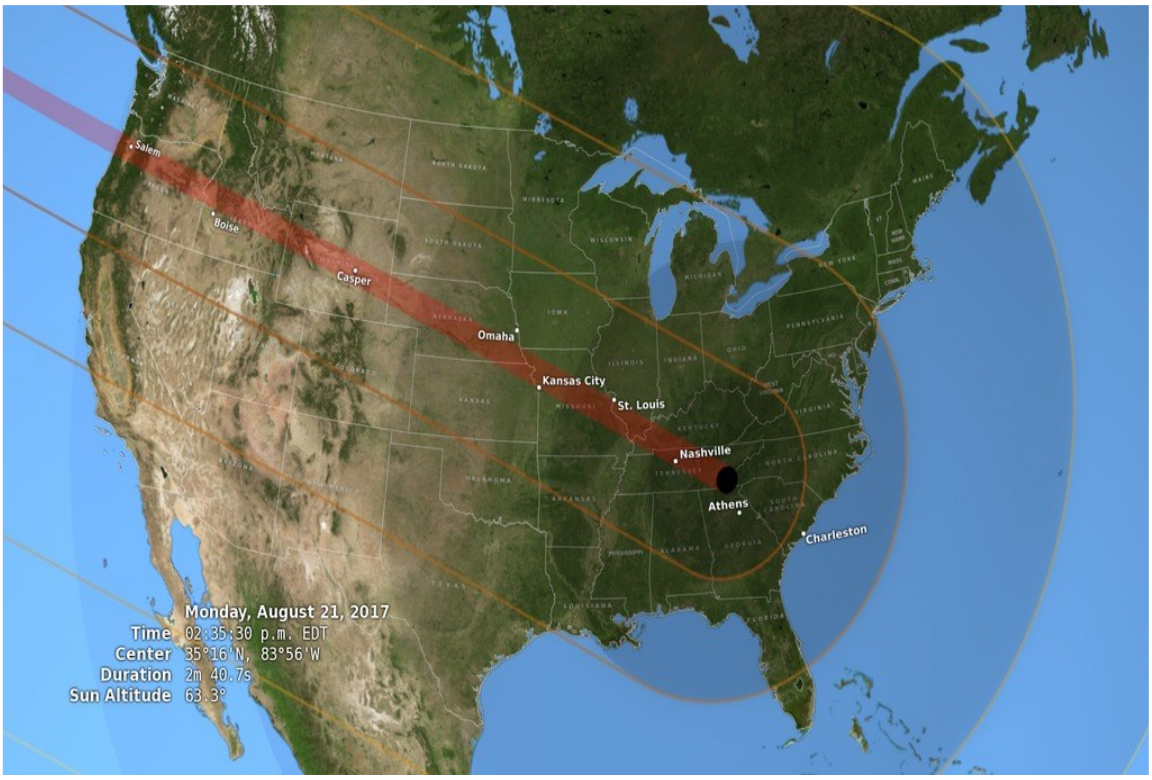


Illustration showing the United States during the total solar eclipse of August 21, 2017, with the umbra (black oval), penumbra (concentric shaded ovals), and path of totality (red) through or very near several major cities. Credit: Goddard Science Visualition Studio, NASA

2017 North American Eclipse Tour

Leading on from the previous article, WAS received the following email: last month

Dear Astronomical Society,

Last year we contacted you regarding an eclipse tour departing Sydney, Australia for the 2017 total solar eclipse in North America that your members might be interested in.
We have now finalised details and flights and are currently taking bookings for the tour.

Details and the finalised itinerary can be downloaded from our website

www.spacetimetravellers.com.au

We will be based in Portland, Oregon for the eclipse and plan to view from either Madras or Salem but it will depend on the weather conditions on the day as to where we watch the eclipse.

Highlights Include:

- *Mt Wilson tour and night viewing on the 60-inch and 100-inch telescopes*
- *Meteor Crater including rim tour*
- *Lowell Observatory tour*
- *Kennedy Space Centre*
- *Smithsonian Museum*

Kind Regards
Mel
SpaceTime Travellers

Addendum:

We have received the following from Murray Forbes:

"I'm planning on going on this tour (and have already paid my deposit) - is anyone else from WAS going?"

L2 Puppis – Is the Puzzle Solved?

I have been thinking a lot about this star over the last couple of years, while we have been analysing some historical and recent data supplied to the Variable Stars South semiregulars project. The results of our analysis are now complete and an article outlining them has been published in two parts in the July 2016 and January 2017 issues of the VSS Newsletter.

I became aware of L2 Puppis when I first started observing variable stars, decided to add it to my observing list and couldn't find it in binoculars or a small telescope even though I was sure I had found the right field. How could you miss a naked eye star week after week? I have tried many times since always with the same result.

The answer is an interesting one. Beginning in the early 1990s L2 Puppis had dimmed over a period of several years to below naked-eye magnitudes and had never recovered. Clearly something quite unprecedented had happened Coincidentally, the data set supplied to the SR project included observations made at Auckland Observatory or by members of the Auckland group that covered the critical period enabling us to independently infer a major episode of dust emission that has not dispersed in the intervening years, so that much of the visible light emitted by the star is now blocked.

Our analysis also found other interesting things. The period of the pulsations is rather too regular for a semiregular but amplitude of the variations is a bit too small, by the time you take out the effects of dust-emission, for a classic Mira-type variable. The length of the cycle hasn't undergone any significant change either. Clearly the classification of the star is wrong. Semiregulars are rather young red giants and shouldn't be undergoing any significant mass-loss. Our conclusions, which are in line with those of professionals who have studied the system, are that, far from being young, L2 Puppis is a very old star, close to the end of its life.

Recent professional observations using several instruments on the ESO's Very Large Telescope in Chile, and follow-up studies using a large radio telescope have helped us understand more of what is going on. The images show a dense dust-ring round the star, two polar lobes of ejected material and a previously unsuspected companion, either a super-Jupiter or a low-mass brown dwarf orbiting the red giant at about twice the Earth's distance from the sun, inside the dust-ring. The system is nearly edge-on to us, so no wonder the star has dimmed by so much. The Auckland data captured the start of the formation of this dust-ring.

Has this answered all the questions? Not completely, and it has raised an interesting new one. How old is the companion? Is it a part of the original system, or did it form in the last 20 years or so from dust ejected by the primary? Both are possible. Since the system is more or less edge on, can we detect transits? More observations are needed, and if you are looking for a target, this could be an interesting one to have a crack at.

If you want to find out more about our analysis, you can find our articles on the VSS website:

www.variablestarssouth.org/home

The newsletters are available by going to Latest Downloads and selecting Newsletter July 2016 and Newsletter January 2017.

Aline Homes

Introducing astrometry.net

Last year, Gordon Hudson and I applied an interesting technique for verifying the field of our observation. We submitted one image, in one case even a still image extracted from a digital video, and submitted it to a website capable of identifying the stellar field. We found this an easy, effective and reliable way of getting confirmation that we were indeed observing the correct field.

I no longer have the images from those particular observation runs at Gordon's observatory (KPO), but used an old image I had obtained during the 2010 WAS exercise on RS Chamaeleonis (RS Cha). I did not even bother to calibrate the image and submitted the raw image in JPG format for evaluation. Within a couple of minutes I received a successful identification.

The website is `astrometry.net`, a project is partially supported by the US National Science Foundation, the US National Aeronautics and Space Administration, and the Canadian National Science and Engineering Research Council..

If you have astronomical imaging of the sky with celestial coordinates you do not know—or do not trust—then *Astrometry.net* is for you. Input an image and we'll give you back astrometric calibration meta-data, plus lists of known objects falling inside the field of view.

We have built this astrometric calibration service to create correct, standards-compliant astrometric meta-data for every useful astronomical image ever taken, past and future, in any state of archival disarray. We hope this will help organize, annotate and make searchable all the world's astronomical information.

Fig. 1 Screen shot of the Home page of astrometry.net

The process is fairly simple:

1. In your preferred web browser, go directly to

   nova.astrometry.net

   and click on the Upload link (refer to Fig. 2).
2. On the Upload page, (see Fig. 3) first click on the Select File button and follow the prompts to select your image file. Supported image formats are JPG, GIF, PNG and FITS.
3. Once you have selected your image file, click on the Upload button. The image I submitted for the purpose of describing this process is shown in Fig. 4. The image was obtained on 2010-11-01 at Crows Nest Observatory (CNO) using an SBIG ST6 camera on loan from NASA Ames Research Center.
4. The website confirms the receipt of your submission and initiates the evaluation of the image (see Fig. 5).
5. After the attempted resolution of the image, the website returns a status page with log information, indicating either success or failure to resolve (Fig. 6).
6. Clicking on the Go to results page link then opens a page showing the detailed information on the identified stellar field including image dimensions and pixel scale (see Fig. 7).

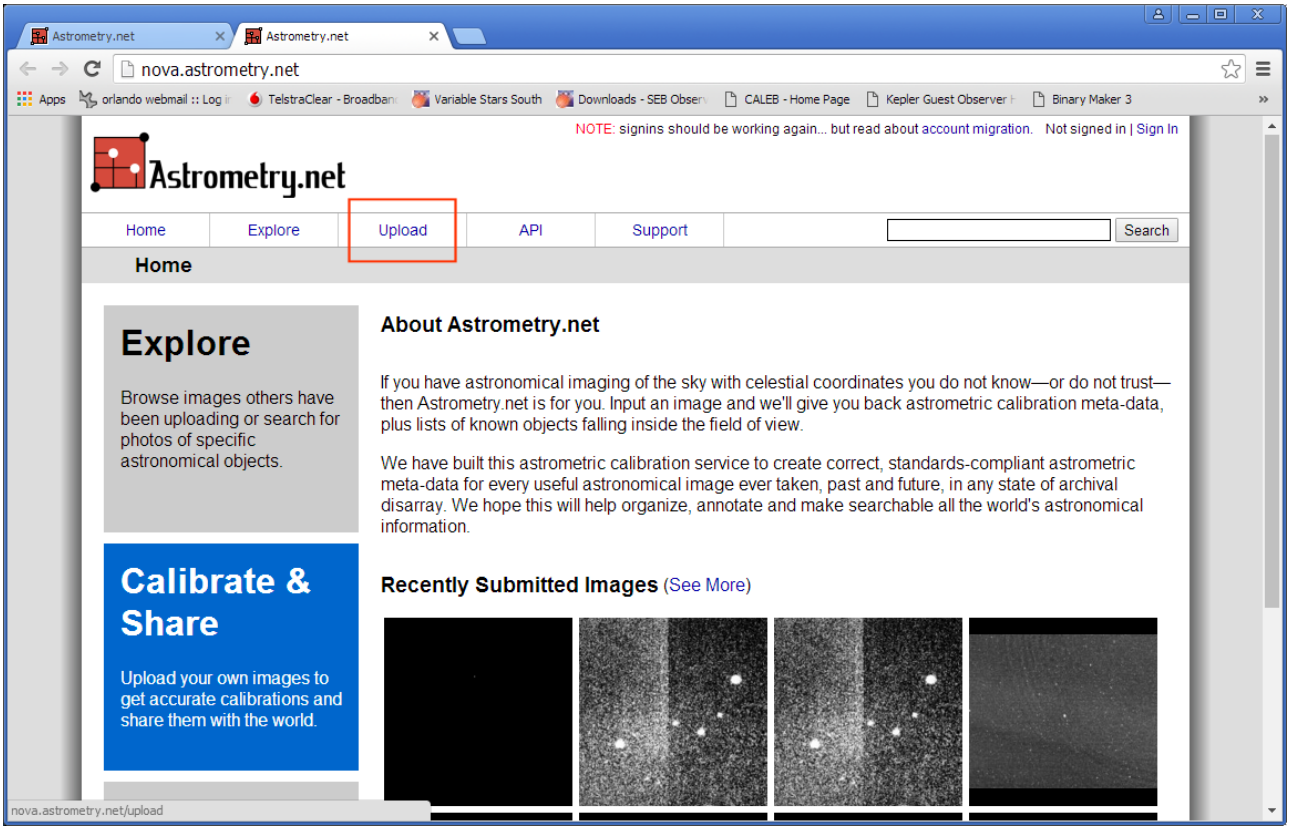


Fig. 2 Screen shot of the Home page of nova.astrometry.net

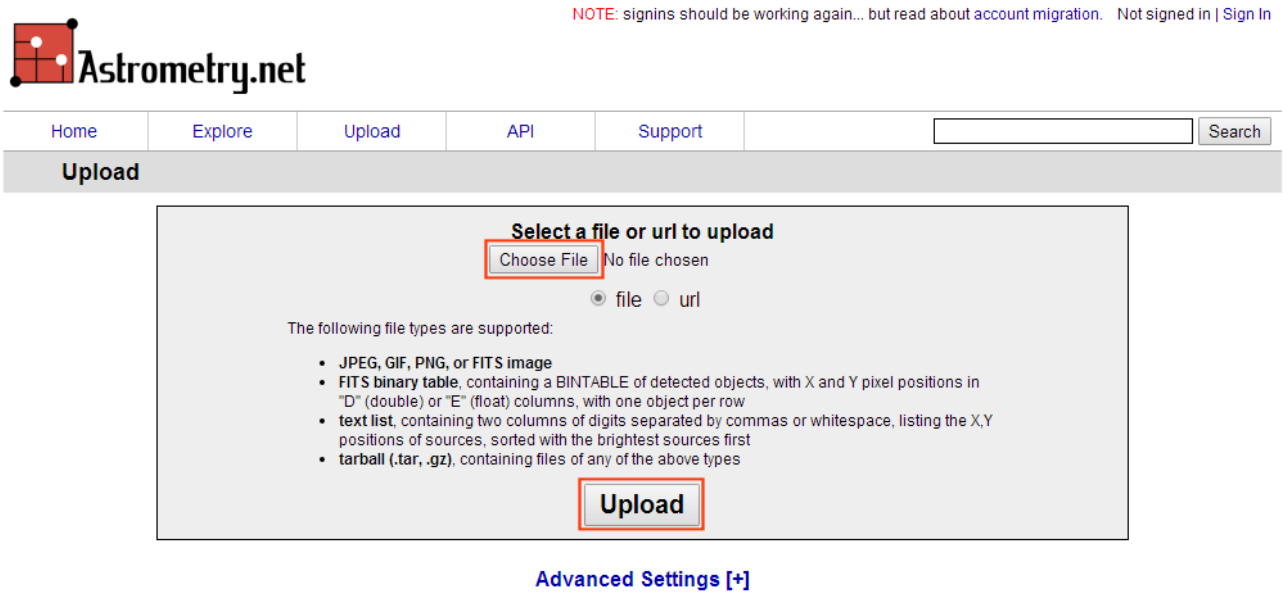


Fig. 3 Screen shot of the Upload page of astrometry.net

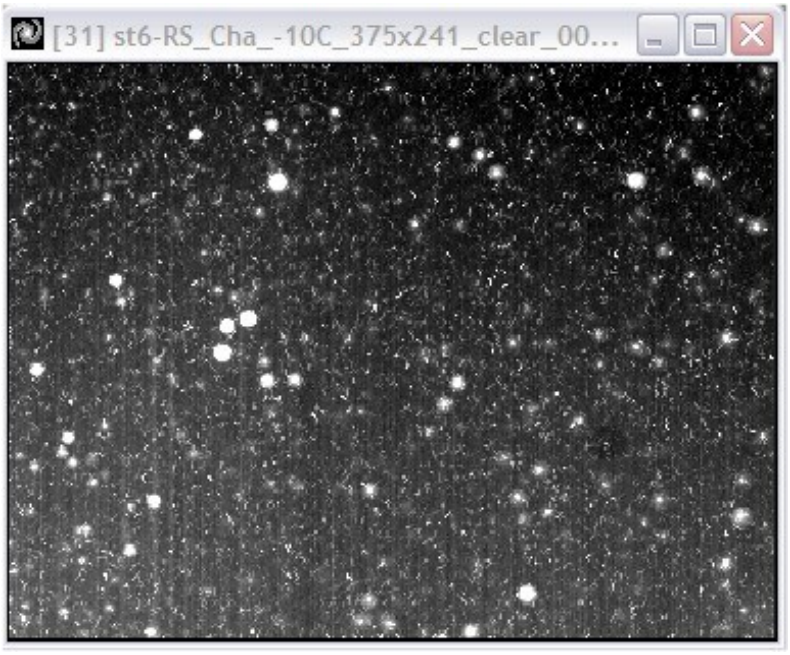


Fig. 4 The raw image submitted to astrometry.net

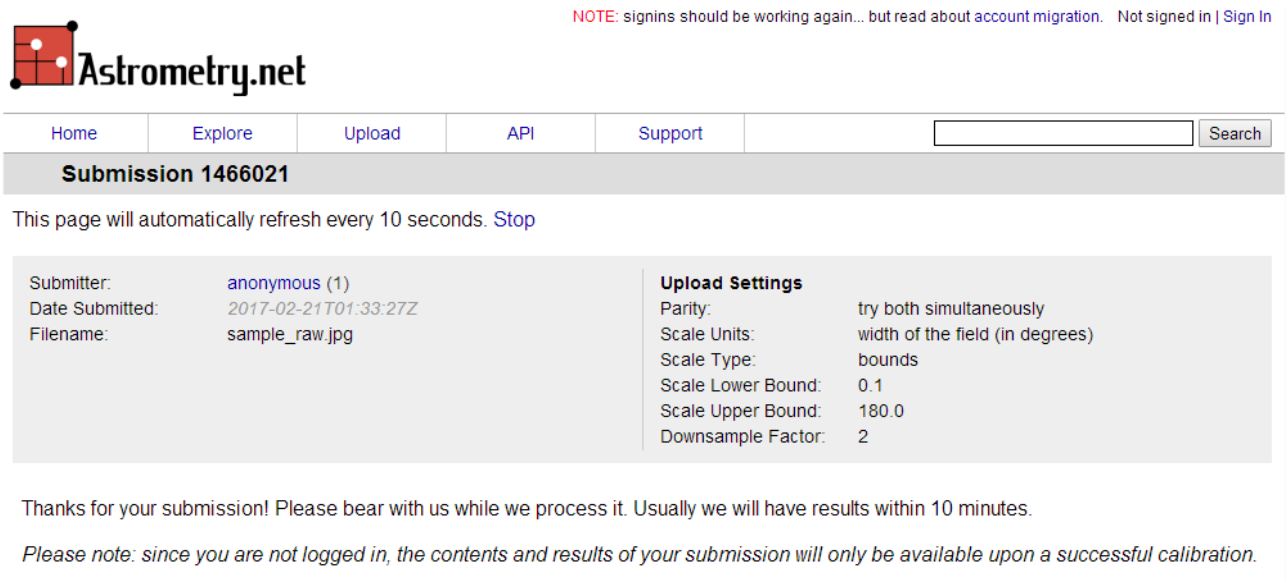


Fig. 5 Confirmation that the submission has been received and is being processed

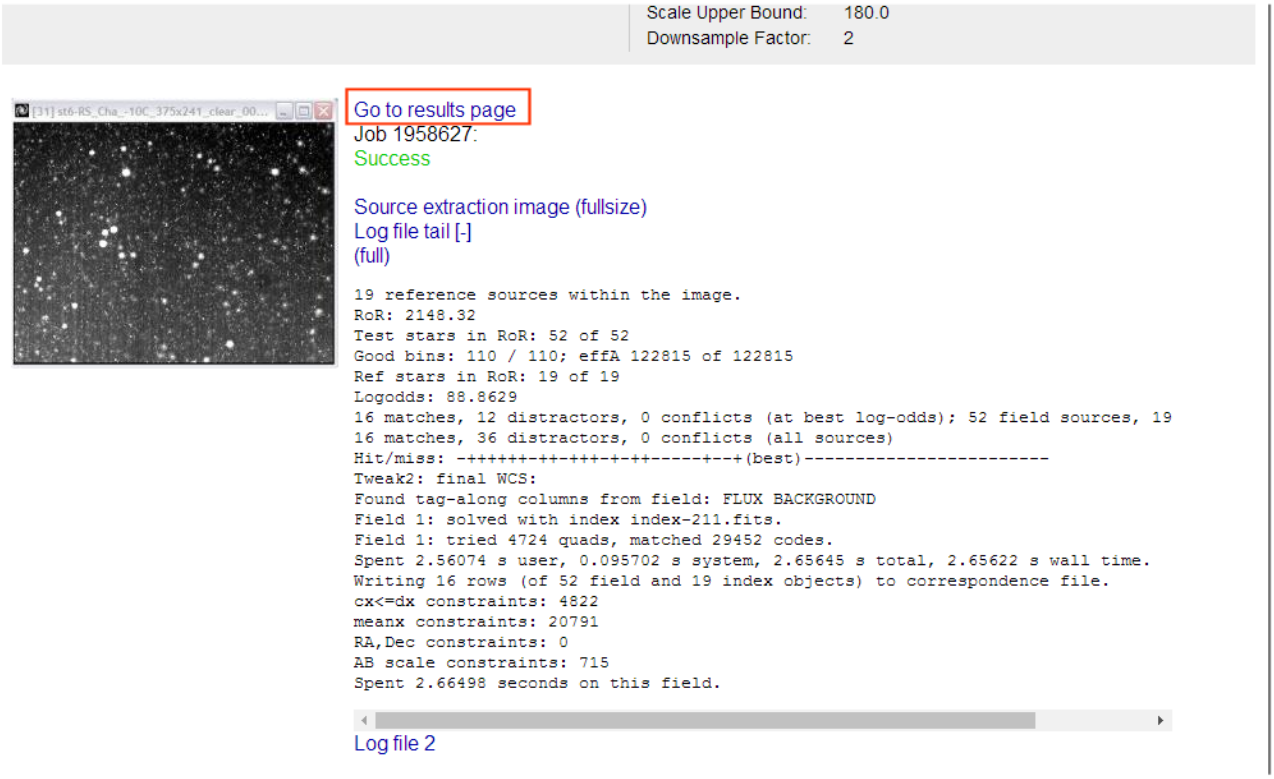


Fig. 6 Success page with processing log

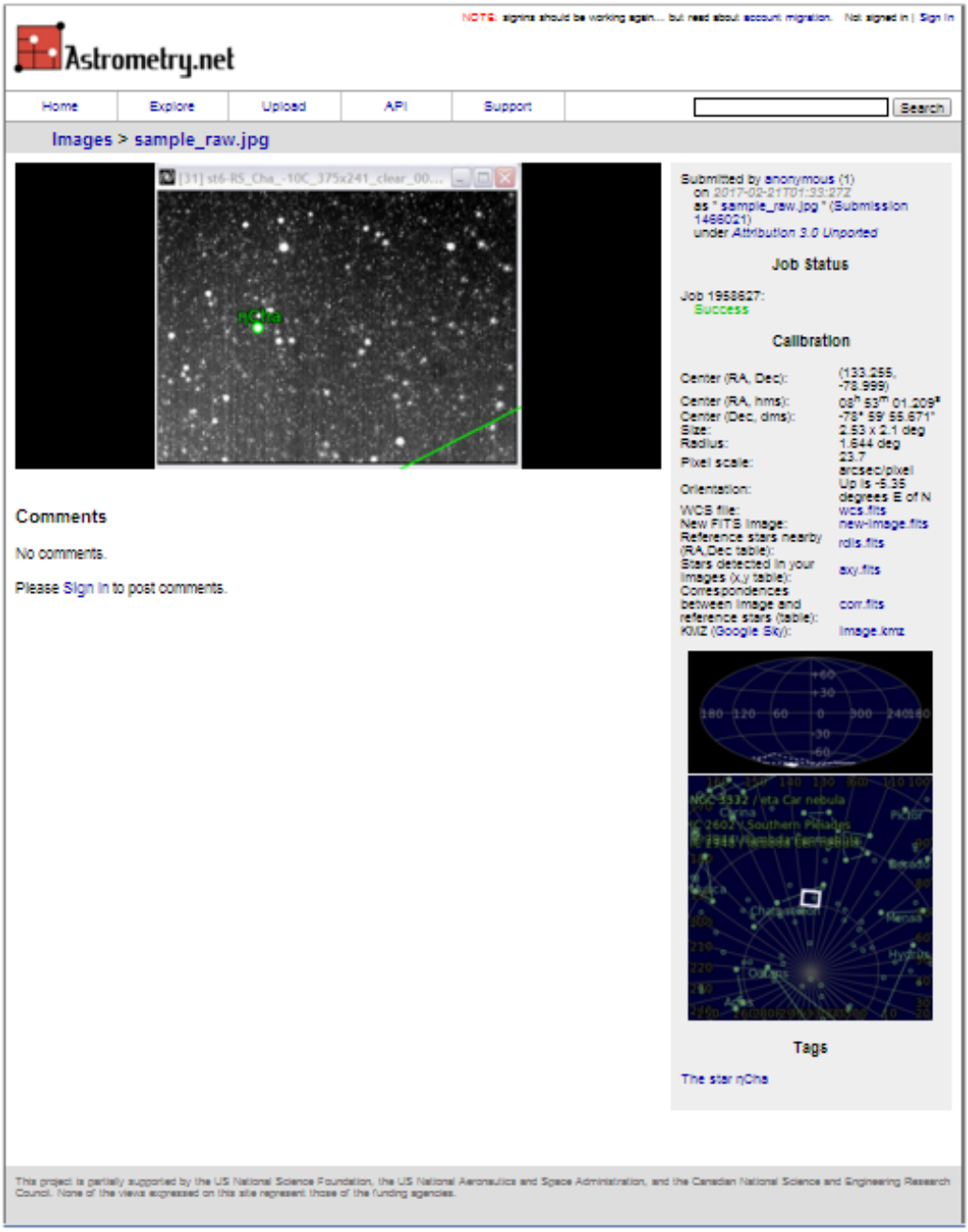


Fig. 7 The results page identifying the field position

The brightest neighbour of RS Cha has clearly been identified and labelled as η Cha (eta Cha). RS Cha is the bright star right on top of the "ha" in Cha.

I encourage everyone involved with imaging, be it for minor planet occultations or the monitoring of variable stars, to give it a go and to "test-drive" astrometry.net to familiarise themselves with the process well before they may need it for their research work.

Roland Idaczyk

Crows Nest Observatory

Occultations for March 2017

Total Lunar Occultations

Unfortunately there are only two worthwhile lunar occultations during March:

- ZC1175 is occulted by the moon on Wednesday 8th March at approximately 09:24 NZDST. ZC1175 is a K5 spectral type which means it is a very red star, and so you may be able to improve the contrast between the star and the (bluer) sky by using a red filter. This could also help reduce the glare from the 80% illuminated moon. The star is also suspected to be a double, so your observation might be the one that confirms this. If it is a double, then the predicted difference in disappearance times of the two components (0.19 seconds) should give us a double-step event in the video measurements over 4-5 frames.

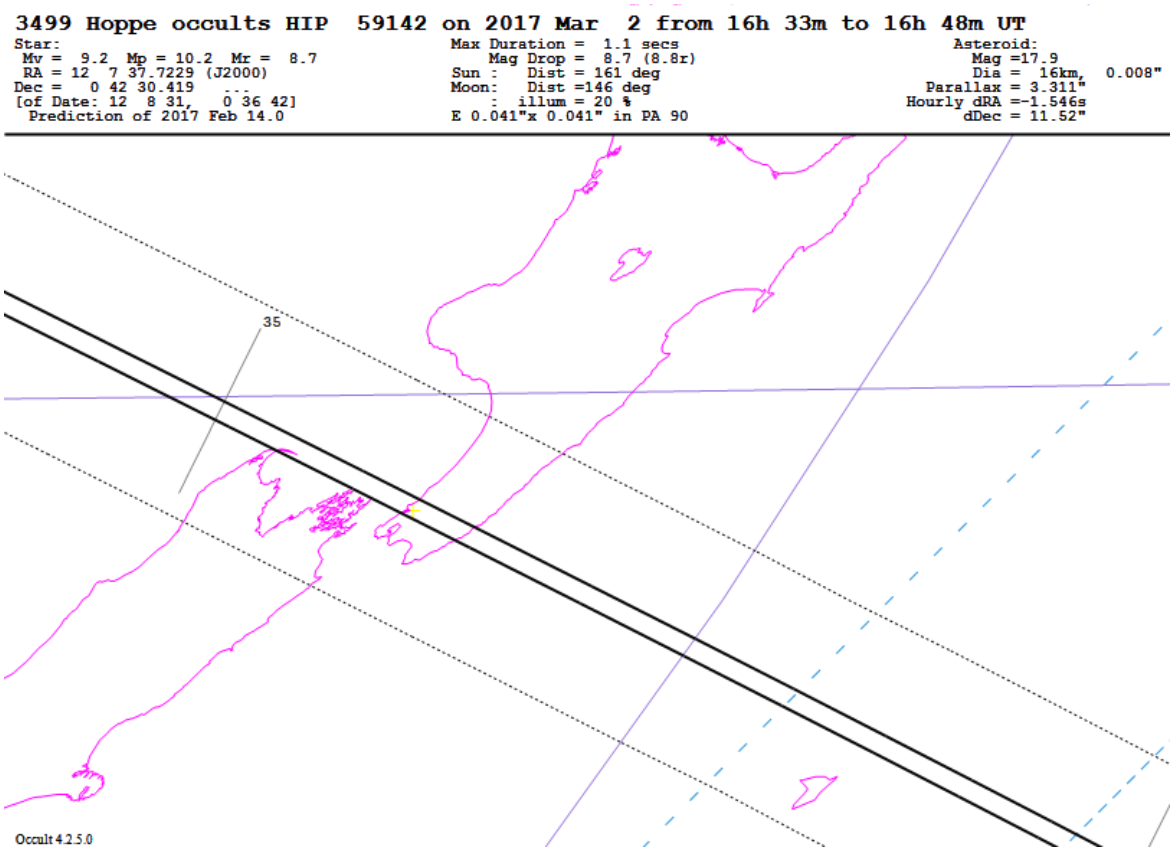
- ZC2198 is occulted by the moon on Friday 17th March, reappearing at approximately 11:14 NZDST. I don't normally include reappearances as they usually take place in the early morning but this one is at a more civilised hour. The down-side is that the moon (and star) will be due east at only 10° altitude – which may be below the hills from where I live in the Hutt Valley. Further, as the moon is 78% illuminated then any nearby thin cloud will cause severe problems with glare from the moon.

day			Time			P	Star		Sp	Mag	Mag		%	Elo n	Sun	Moo n	
y	m	d	h	m	s		No	D		v	r	V	ill		Alt	Alt	Az
17	Mar	08	08	24	30.3	D	1175	c	K5	4.9	4.1		80+	127		30	010
Double: 5.8 5.8 0.10" 90.0, dT = +0.19sec																	
17	Mar	17	10	14	03.3	R	2198		G8	5.7	5.2		78-	125		10	098

Minor Planet Occultations

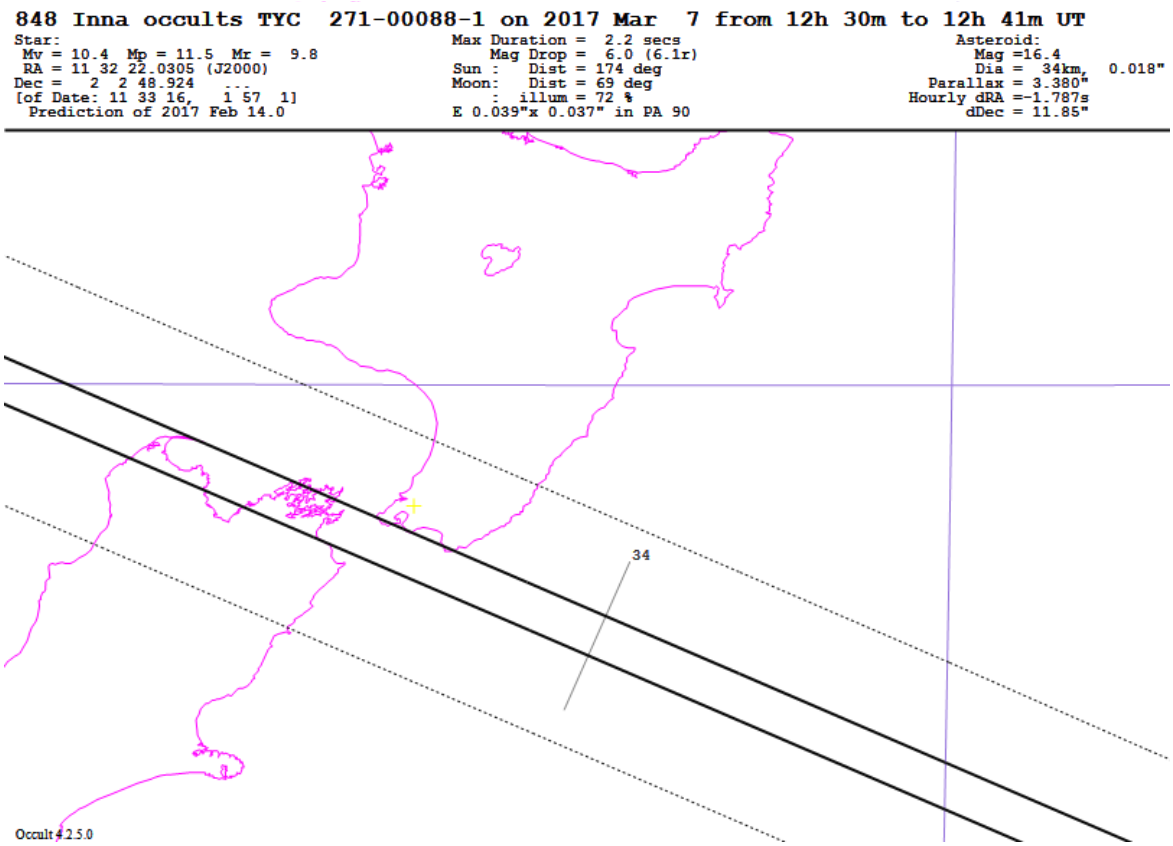
The first minor planet occultation for March is on Thursday 2nd (the night after our meeting) at UT 16h 34m 48s. This is actually at 5:34 am NZDST on Friday morning just before twilight. The event is very quick (at most 1.1 seconds long) so you need to be using a video camera/recorder system (rather than observing visually). If you have an 8" scope or bigger, you should be able to see the magnitude 9.2 star without needing to use integration on your video camera. With a large drop in magnitude (8.7) during the event, the star will seem to completely disappear when occulted. Although my observatory is on the southern edge of the shadow's predicted track, the uncertainty in the prediction is large enough that it is worthwhile for our Wellington based observers to also attempt this event. The moon is only 20% illuminated and 146° away from the minor planet. Most of the pre-point stars are a bit on the faint side (6-7 magnitude), while the two bright pre-point stars will appear together in your cameras field of view.

Point Time			Star	J2000 RA		Dec		Dec Offset	SAO
h	m	s	mag	h	m	o	'	ArcMin	
15	23	05	5.9	10	55.7	0	44	-1.9	
13	44	18	6.7	9	16.7	0	44	-2.6	
11	50	26	6.4	7	22.5	0	42	-3.2	
10	27	00	5.2	5	58.8	0	33	3.6	
10	00	15	3.8	5	32.0	-0	18	54.0	
10	00	15	2.3	5	32.0	-0	18	54.0	
09	54	03	6.2	5	25.8	0	31	4.7	
09	42	06	6.3	5	13.8	0	34	2.0	
09	40	00	6.7	5	11.7	0	31	4.7	
09	30	11	5.9	5	01.8	0	43	-8.0	
09	23	12	6.0	4	54.8	0	28	7.1	



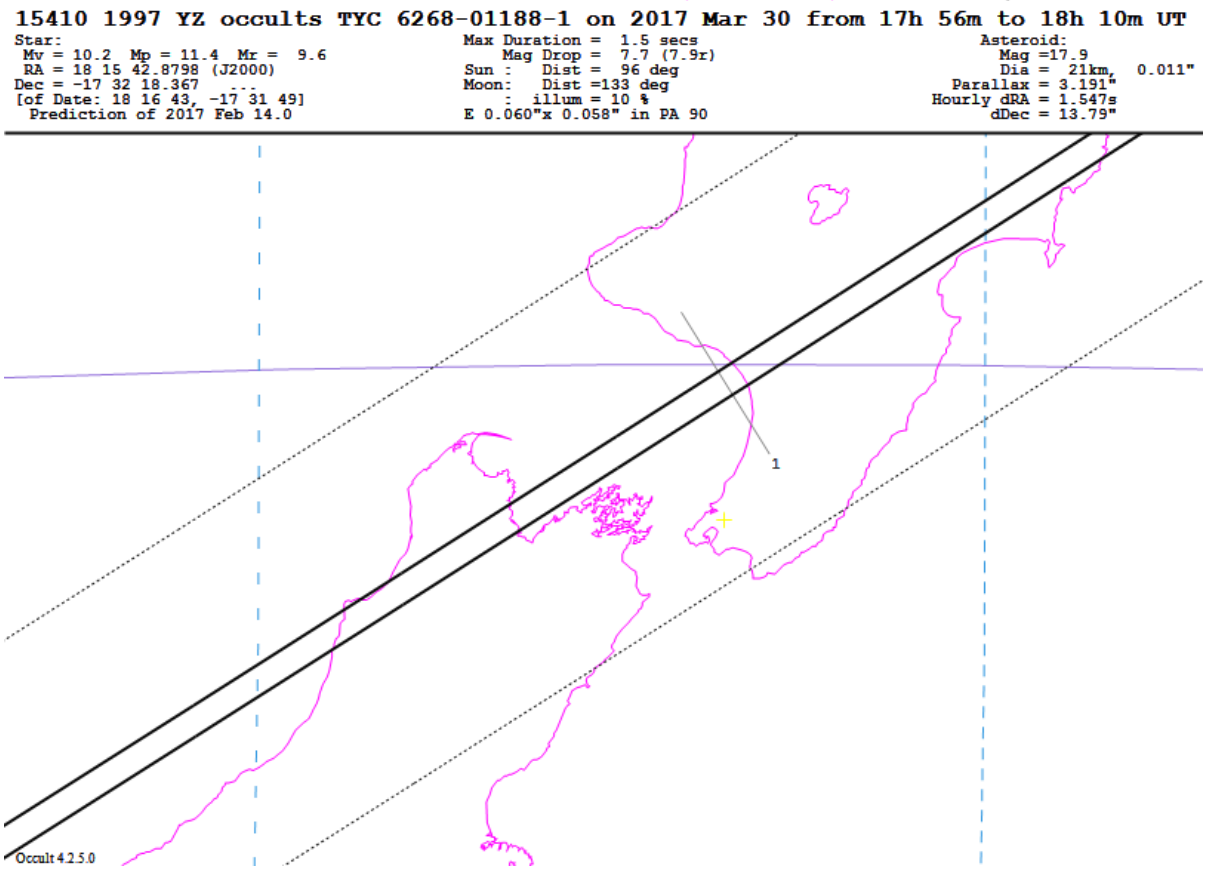
The next event is at UT 12h 34m 12s on Tuesday 7th March, or 1:34 am NZDST on Wednesday. The star is a bit fainter (magnitude 10.4) than the previous occultation but it lasts a bit longer (at most 2.2 seconds). With a drop in magnitude of 6, the star will seem to completely disappear. The northern edge of the shadow is predicted to pass over the south coast of Wellington. However the uncertainty of the prediction means there is a reasonable chance (16% for my observatory in the Hutt Valley) that Wellington observers could see the occultation. Unfortunately the moon is 72% illuminated and only 69° away in the sky from the minor planet so it will probably be easier to find the target star using a pre-point star.

Point Time			Star	J2000 RA		Dec		Dec Offset	SAO
h	m	s	mag	h	m	o	'	ArcMin	
12	19	10	5.2	11	17.3	2	01	2.1	
12	08	48	5.5	11	06.9	1	57	5.4	
11	32	31	7.0	10	30.5	2	09	-6.6	
10	19	25	6.8	09	17.2	1	56	5.7	
10	16	35	3.9	09	14.4	2	19	-17.4	
09	42	37	6.8	08	40.3	1	55	5.6	
09	27	57	5.7	08	25.6	2	06	-5.6	



The third event for the month is another morning event, at UT 18h 0m 54s on Thursday 30th March. This is actually on Friday morning at 6 am NZDST during twilight. The star is again quite faint at magnitude 10.2 and the occultation only lasts at most 1.5 seconds. Fortunately the moon is only 10% illuminated and quite some way in the sky (133°) from the target star. The predicted path of the shadow is to the NW of Wellington, but the uncertainty about this prediction is large enough that there is still a chance that Wellington observers could see the occultation (5% at my observatory).

Point Time			Star	J2000 RA		Dec		Dec Offset	SAO
h	m	s	mag	h	m	o	'	ArcMin	
17	18	17	6.8	17	33.0	-17	30	-1.5	
16	53	37	6.0	17	08.2	-17	37	5.9	
15	15	12	6.7	15	29.6	-17	26	-1.9	
14	43	47	6.6	14	58.1	-17	22	-5.9	
13	48	53	6.3	14	03.1	-17	22	-4.9	
12	01	52	2.6	12	15.8	-17	33	6.4	
10	12	23	3.8	10	26.1	-16	50	-36.4	
09	53	14	6.7	10	06.9	-17	27	-0.2	
09	41	57	6.9	09	55.6	-17	28	1.2	



Murray Forbes

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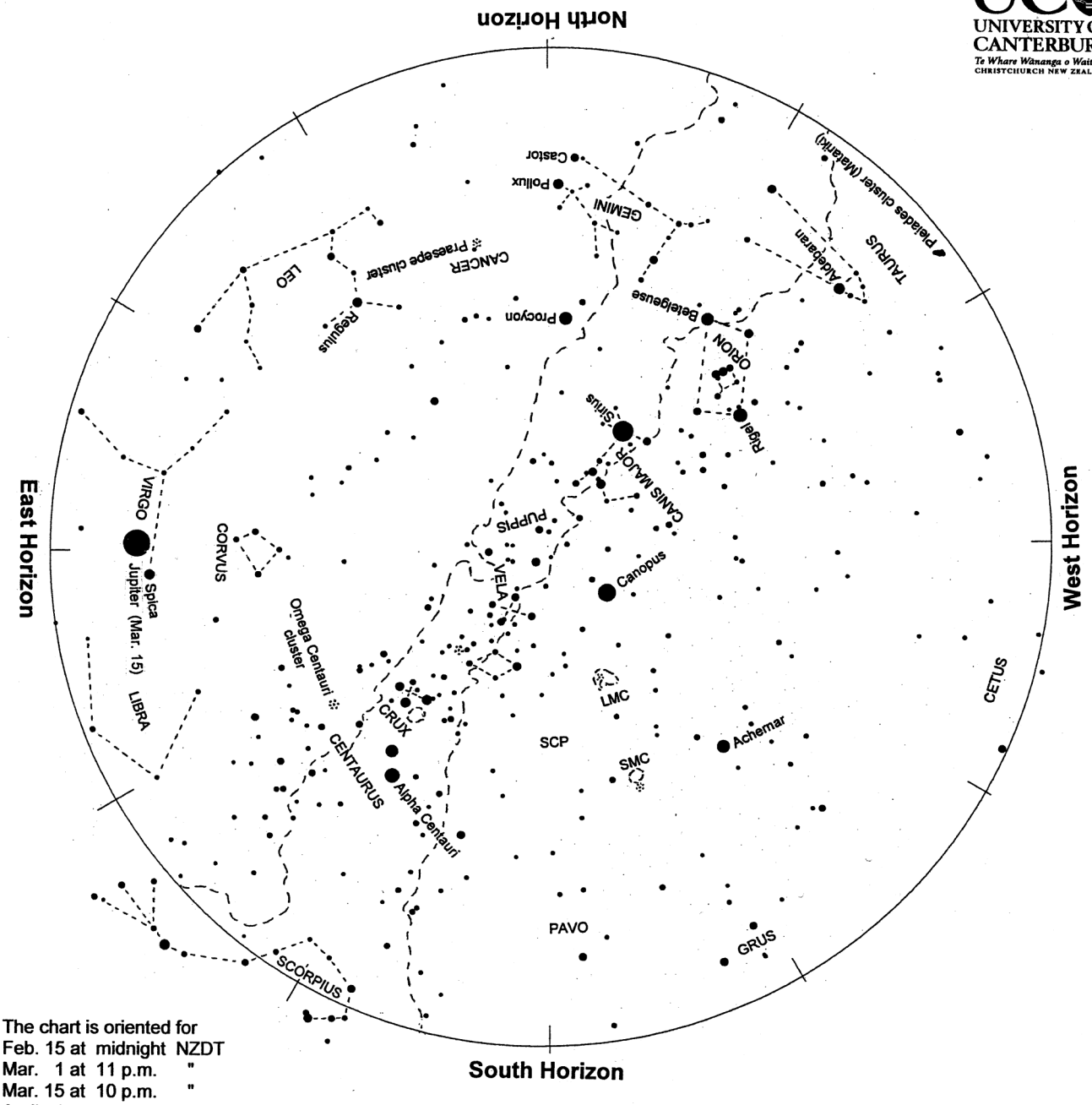
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND



The chart is oriented for
Feb. 15 at midnight NZDT
Mar. 1 at 11 p.m. "
Mar. 15 at 10 p.m. "
April 1 at 9 p.m. "

Evening sky in March 2017

To use the chart, hold it up to the sky. Turn the chart so the direction you are looking is at the bottom of the chart. If you are looking to the south then have 'South horizon' at the lower edge. As the earth turns the sky appears to rotate clockwise around the south celestial pole (SCP on the chart). Stars rise in the east and set in the west, just like the sun. The sky makes a small extra westward shift each night as we orbit the sun.

Venus (not shown on the chart) might be seen low on the western skyline soon after sunset at the start of the month. It sets steadily earlier, disappearing mid-month. Golden Jupiter rises in the east around 9:30 pm at the beginning of the month. By mid-month it is up at dusk. Sirius is the brightest true star, northwest of overhead. Canopus, the second brightest star, is southwest of overhead. Orion, containing 'The Pot', is below Sirius in the northwest sky. The Southern Cross and Pointers are midway up the southeast sky. Nearby galaxies the Clouds of Magellan, LMC and SMC, are high in the southern sky. The Scorpion rises in the southeast later. Saturn is below it.

Chart produced by Guide 8 software; www.projectpluto.com. Labels and text added by Alan Gilmore,
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The Night Sky in March

Bright planets are low in the east and west at the beginning of the month. Venus (not shown on the chart) might be seen from places with a low western skyline, setting 40 minutes after the Sun at the start of the month. It sets steadily earlier, disappearing by mid-March. Golden Jupiter rises in the east around 9:30 pm at the beginning of the month. By mid-month it is up at dusk. The near-full Moon will be near Jupiter on the 14th and 15th. Less obvious is Mars (not shown), looking like a medium-brightness red star above the western skyline at dusk. It sets about 80 minutes after the sun throughout the month. On March 1st the thin crescent Moon will be level with Mars and above Venus. The Moon is by Mars again on the 30th.

Jupiter is the biggest planet by far. Its mass is greater than all the other planets put together. In a telescope it shows parallel stripes. These are zones of warm and cold clouds, made narrow by Jupiter's rapid rotation. Any telescope shows Jupiter's disk with its four bright 'Galilean' moons lined up on either side. They are roughly the size of our moon. Sometimes one or two moons can be seen in binoculars, looking like faint stars close to the planet. Io, the smallest and closest to Jupiter, has massive volcanoes. The other moons have crusts of ice, some with oceans beneath, around rocky cores. Jupiter is 680 million km from us in March.

Northwest of overhead is Sirius the brightest star in the sky. It is fainter than star-like Venus and Jupiter. Southwest of the zenith is Canopus, the second brightest star. Below Sirius are Rigel and Betelgeuse, the brightest stars in Orion. Between them is a line of three stars: Orion's belt. To southern hemisphere star watchers, the line of three makes the bottom of 'The Pot'. Orion's belt points down and left to a V-shaped pattern of stars. These make the face of Taurus the Bull. The orange star is Aldebaran, Arabic for the eye of the bull. Continuing the line from Orion down and left finds the Pleiades or Matariki star cluster.

Sirius is the brightest star in the sky both because it is relatively close, nine light years* away, and 23 times brighter than the sun. Rigel, above and left of Orion's belt, is a bluish supergiant star, 40 000 times brighter than the sun and much hotter. It is 800 light years away. Orange Betelgeuse, below and right of the line of three, is a red-giant star, cooler than the sun but much bigger and 9000 times brighter. It is 400 light years from us. The handle of "The Pot", or Orion's sword, has the Orion Nebula at its centre; a glowing gas cloud many light-years across and 1300 light years away.

Near the north skyline are Pollux and Castor marking the heads of Gemini the twins. Left of Jupiter is the star cluster Praesepe, marking the shell of Cancer the crab. Praesepe is also called the Beehive cluster, the reason obvious when it is viewed in binoculars. The cluster is some 500 light years from us.

Crux, the Southern Cross, is in the southeast. Below it are Beta and Alpha Centauri, often called 'The Pointers'. Alpha Centauri is the closest naked-eye star, 4.3 light years away. Beta Centauri, like most of the stars in Crux, is a blue-giant star hundreds of light years away. Canopus is also a very luminous distant star; 13 000 times brighter than the sun and 300 light years away.

The Milky Way is brightest in the southeast toward Crux. It becomes broader lower in the southeast toward Scorpius. Above Crux the Milky Way can be traced to nearly overhead where it fades. It becomes very faint in the north, right of Orion. The Milky Way is our edgewise view of the galaxy, the pancake of billions of stars of which the sun is just one. We are 30,000 light years from the galaxy's centre.

The Clouds of Magellan, LMC and SMC are high in the south sky, easily seen by eye on a dark moonless night. They are two small galaxies about 160 000 and 200 000 light years away.

Saturn rises in the southeast around 1 a.m. at the beginning of the month; at 11 pm by the end. It looks like a lone bright star, cream-coloured, shining with a steady light. Well above it is Scorpius with orange Antares, marking Scorpio's body. A telescope magnifying 20x shows Saturn's rings. The rings are at their most 'open' now. Saturn is 1500 million km away in mid-March. The Moon is below Saturn on the 20th.

*A light year (l.y.) is the distance that light travels in one year: nearly 10 million million km or 1013 km. Sunlight takes

eight minutes to get here; moonlight about one second. Sunlight reaches Neptune, the outermost major planet, in four hours. It takes four years to reach the nearest star, Alpha Centauri.

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