

Capturing the heart of our Milky Way Galaxy directly overhead !

A National Science Week 2019
sponsored initiative.



Prepared by Dr John Goldsmith

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- Figure 1 (top left) "Little Planet" projection: South Perth foreshore. Severe urban light pollution.
Figure 2 (top right) "Little Planet" projection: Wave Rock, Western Australia. Dark sky view.
Figure 3 (lower left) "Little Planet" projection: Wave Rock, Western Australia. Dark sky view.
Figure 4 (lower right) "Little Planet" projection: Westonia, Western Australia. Dark sky view with some light pollution.

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1. Introduction

1.1 The opportunity

Did you know that there is one zone on our planet in which it is possible to view the centre of our Milky Way galaxy pass directly overhead? This occurs only in the southern hemisphere, at an approximate latitude of 30° south. Such a remarkable view of our galaxy can be seen at different times of the year, and at different times of the night, but only from the southern latitude of approximately 30° south. Nowhere else in the world is this view possible. This special opportunity gave rise to an astrophotography initiative, put forward by Celestial Visions, Dr John Goldsmith and the Westonia Community Resource Centre.

Our project **Capturing the Heart of our Milky Way Galaxy directly overhead!** set out to record this view, via 360° astrophotography, from the dark sky location of the Goldfields / eastern Wheatbelt region, Western Australia. The project was accomplished via a specialised astrophotography expedition. The results are presented in this project report, and also featured on select web sites including www.celestialvisions.com.au. It is anticipated that the image will feature in subsequent astrophotography exhibitions curated by Dr John Goldsmith, in **“The Universe. Yours to discover. Astrophotography Exhibition”** This collaborative astrophotography exhibition currently features the work of several astrophotographers and was first presented at Westonia, as part of Global Astronomy Month 2019. The exhibition was Australia’s only nominated and registered astronomy initiative for 2009 via Global Astronomy Month, a global initiative coordinated by Astronomers Without Borders. The variety and diversity of Western Australian astrophotography is documented by Goldsmith (2015, 2019). Examples of the use of 360° imaging are provided by Goldsmith & Brocx (2012), Goldsmith (2011, 2014) and Kolor (2009).

1.2 Project participants

Celestial Visions	Project management and co-ordination.
Westonia Community Resource Centre	Exhibition host and collaborative partner
Dr John Goldsmith	Field photography
Luke Busellato	Image processing and additional field photography
Dr Chris Thorne	Virtual Reality coding advice

1.3 Overall aim

Our project aimed to record at least three 360° images of the centre of the Milky Way at or near the zenith, under different sky conditions (1) light polluted urban sky conditions, (2) dark sky conditions at Wave Rock, (3) semi dark sky conditions at Westonia, Western Australia.

1.4 Copyright notice

Please note that all text and image content is copyright to the respective copyright holders. Permission is required for the use and publication of content.

2. General methodology

2.1 360° photography; field method

- Choose photo location.
- Test exposures, focus test.
- Position and level Manfrotto Multirow Spherical Head.
- Prepare camera and conduct test exposures, focus test etc
- Choose an approximate image overlap of 50%.
- Obtain all light frames, 360° lateral, one zenith, one nadir image, plus at least one “dark frame”.
- Complete all photographs as quickly as possible, ideally within a 10 minute period.

2.2 Digital file preparation.

- Download all files, JPEG and RAW.
- Organise into date folders.
- Preserve all original files unmodified.
- Copy relevant files into new folders.
- Folder naming structure: Photo Mosaic. Drive number (D026), Mosaic number (012). Render number (001) = D026 012 001.

2.3 Generic image processing method

- Subtract dark frames from light from light frames to remove hot pixels.
- Manual check of image to assess hot pixel removal. Hand removal of any remaining hot pixels or other image defects such as “cosmic ray” artefacts.
- Complete any pre-processing of images prior to mosaic processing e.g. vignetting.
- Photo mosaic image processing of images, using Auto Pano Giga software.
- Additional processing of 2:1 equi-rectangular 360° image in Photoshop, e.g. colour balance, brightness, shadows highlights etc.
- Generate “Little Planet” projections of equi-rectangular images.

2.4 Online image upload and coding for “online virtual tour”

- Upload equi-rectangular image to 360° image hosting site (e.g. www.kuula.co)
- Generate applicable embed code (eg. HTML)
- Upload code to specified web sites, eg www.celestialvisions.com.au

2.5 Other presentations options.

- OPTIONAL: Use conversion software to convert from 360° to video format, via rendering process.

3. Specific methodology

3.1 360° field photography

The field photography was accomplished using a Manfrotto Multi-Row Spherical Head. For almost all of the images, a Canon 8-15mm fisheye zoom lens was used, at 15mm, with typically about 12 images used to record in all directions, with a large (approximately 50%) overlap between subsequent images.

3.2 Notes about image processing

Image processing of the 360° images was carried out using software such as Auto Pano Giga and Photoshop. Auto Pano Giga software allows for advanced photomosaic images to be prepared, with advanced blending and image stitching methods.

For each 360° image to be generated, the astrophotographs and dark frames are loaded. Dark frames are separate exposures taken at the time of the field photography, with the lens cap on the lens, and using the same exposure settings as the astrophotography. The purpose of this method is to obtain images that reveal “hot-pixels”. Hot pixels are camera sensor pixels that appear essentially randomly in a digital image, and are image artefacts that should be processed out. They appear as small white, red or blue dots, anywhere in the image. There are two main methods used to remove hot pixels in digital images, one approach is the “dark frame subtraction” method, and the other, either by automated (trained) or manual means, relies on the spot healing or clone tool in Photoshop, to remove hot pixels. When done successfully, these methods produce high quality, artefact free images.

Another image processing issue relates to the nadir image (the image that points directly down). This invariably records part of the tripod head in the image. In most astrophotography 360° images, this also corresponds to un-illuminated and often featureless ground beneath the tripod. Obstructions caused by part of the tripod in the 360° image are usually removed by cloning part of the image. When done with care, this approach does not significantly affect the integrity of the image, and is therefore usually regarded as an acceptable and normal part of 360° image processing.

3.3 Equi-rectangular rendering and preparation.

The stitching of 360° astrophotograph sequences, using software such as Auto Pano Giga, produces a “equi-rectangular” image, with an aspect ratio of 2:1, or expressed in angular ratio, 360°:180°. Rendered images were produced at a scale of 14,000 by 7,000 pixels, or exactly a 2:1 aspect ratio. This type of image, when viewed as a flat image, looks distorted due to the projection of a 360° view in a flat, two-dimensional form. However, the equi-rectangular image is what is used for the generation of 360° Virtual Reality tours. It is in the Virtual Reality (VR) form of viewing these images that a natural looking perspective is achieved. The equi-rectangular images were resized from 14,000 by 7,000 pixels, to 2048 by 1024 pixel resolution. This resolution was chosen as an optimised resolution (based on a power of 2). Image text was added in Photoshop, detailing the project credits. “Little Planet” projections of each 360° image were also generated (see figures 1, 2, 3 & 4).

3.4 Uploading 360° images onto web sites.

Equi-rectangular images were then uploaded to the www.kuula.co online hosting service, which is one of the several 360° image upload platforms available online. HTML code was then generated to incorporate into web sites such as:

<http://www.celestialvisions.com.au/360-degree-milky-way.html>

4. Results

The results include:

- Figure 1. “Little Planet” projection: South Perth foreshore. Severe urban light pollution.
- Figure 2. “Little Planet” projection: Wave Rock, Western Australia. Dark sky view.
- Figure 3. “Little Planet” projection: Wave Rock, Western Australia. Dark sky view.
- Figure 4. “Little Planet” projection: Westonia, Western Australia. Dark sky with some light pollution.
- Figure 5. 180° image (Canon circular fisheye zoom lens, at the 8mm circular fisheye view). Single frame 180° view. Westonia, Western Australia. Dark sky view with some light pollution.
- Figure 6. 360° image: South Perth foreshore. Severe urban light pollution.
- Figure 7. 360° image: Near Hyden, Western Australia. Dark sky view.
- Figure 8. 360° image: Wave Rock, Western Australia. Dark sky view.
- Figure 9. 360° image: Westonia, Western Australia. Dark sky with some light pollution.
- Figure 10. 360° image: Mount Melville, Albany.

Figure 5. 360° image: Heart of the Milky Way directly overhead. Circular fisheye astrophotography.

Camera: Canon 5D Mk II

Lens: 8 to 15mm Canon fisheye at 8mm, f4.

Exposure: 45 seconds

ISO: 5000 ISO

Date: 1 August 2019

Location: Westonia, Western Australia.

Photographer: Dr John Goldsmith.

Image processing: Luke Busellato / Dr John Goldsmith.

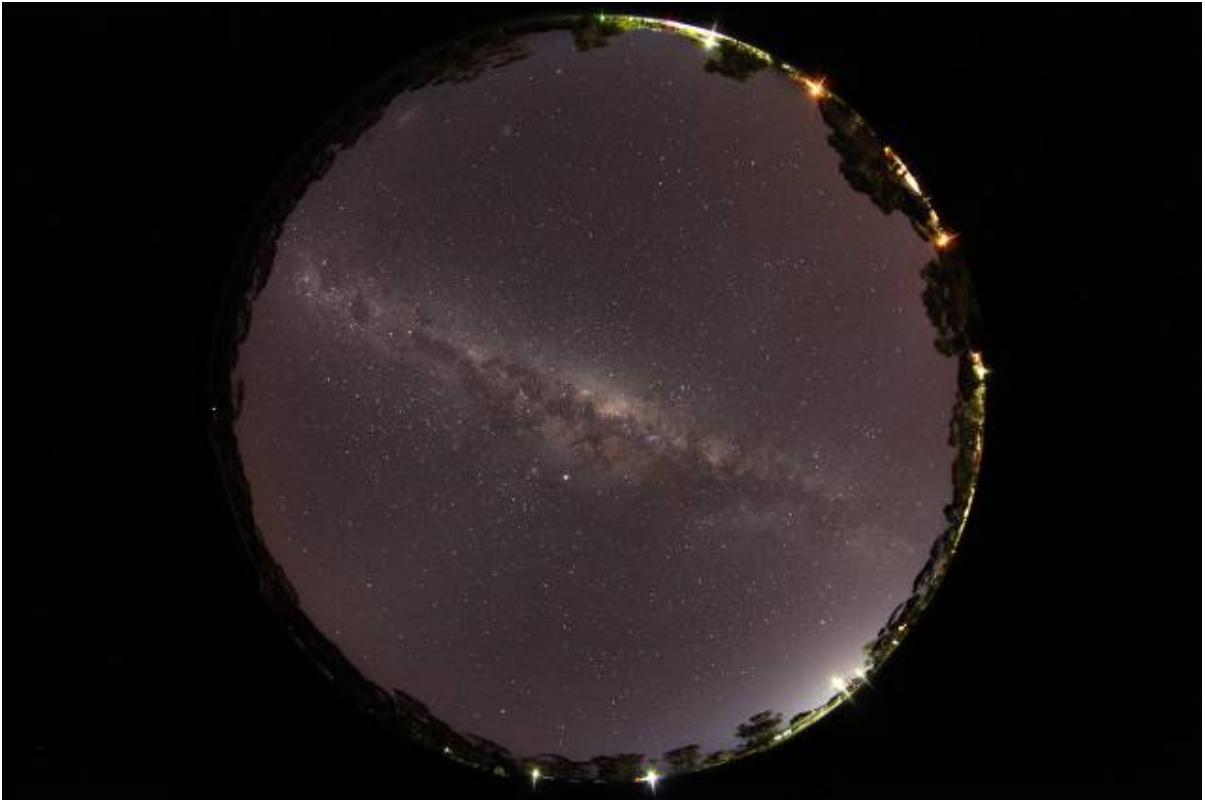


Figure 6. 360° image: South Perth foreshore. Severe urban light pollution.

Camera: Canon 5D Mk II

Lens: 8 to 15mm Canon fisheye at 15mm, f4.

Image processing: Auto Pano Giga

Exposure: 10 seconds

ISO: 640 ISO

Date: 28 July 2019

Location: South Perth, Western Australia.

Photographer: Dr John Goldsmith

Image processing: Luke Busellato / Dr John Goldsmith.



Figure 7. 360° image: Near Hyden, Western Australia. Dark sky view.

Camera: Canon 5D Mk II

Lens: 8 to 15mm Canon fisheye at 15mm, f4.

Image processing: Auto Pano Giga

Exposure: 45 seconds

ISO: 5000 ISO

Date: 31 July 2019

Location: Wave Rock, Western Australia

Photographer: Dr John Goldsmith.

Image processing: Luke Busellato / Dr John Goldsmith.



Figure 8. 360° image: Wave Rock, Western Australia. Dark sky view.

Camera: Canon 5D Mk II

Lens: 8 to 15mm Canon fisheye at 15mm, f4.

Image processing: Auto Pano Giga

Exposure: 45 seconds

ISO: 5000 ISO

Date: 31 July 2019

Location: Wave Rock, Western Australia

Photographer: Dr John Goldsmith.

Image processing: Luke Busellato / Dr John Goldsmith.



Figure 9. 360° image: Westonia, Western Australia. Dark sky with some light pollution.

Camera: Canon 5D Mk II

Lens: 8 to 15mm Canon fisheye at 15mm, f4.

Image processing: Auto Pano Giga

Exposure: 45 seconds

ISO: 5000 ISO

Date: 1 August 2019

Location: Westonia, Western Australia.

Photographer: Dr John Goldsmith.

Image processing: Luke Busellato / Dr John Goldsmith.



Figure 10. 360° image: Mount Melville, Albany.

Camera: Canon 6D (astro modified)

Lens: Samyang 14mm f2.8

Image processing: Auto Pano Giga

Exposure: 15 seconds

ISO: 1600 ISO

Date: 20 August 2019

Location: Albany, Western Australia

Photographer: Luke Busellato

Image processing: Luke Busellato / Dr John Goldsmith



5. Discussion & conclusions

The astrophotography and 360° imaging successfully achieved our objective of recording the centre of our galaxy at or near the zenith. Figures 1 to 10 all show the centre of the galaxy at or very close to the zenith.

A comparison of figures 1 & 2 (and 11 & 12) provide an example of the effect of urban light pollution relative to dark sky conditions. The photographic exposures were:

Figure 1 & 11: 10 second exposure, 640 ISO, f4 (8 to 15mm Canon fisheye at 15mm)

Figure 2 & 12: 45 second exposure, 5000 ISO, f4 (8 to 15mm Canon fisheye at 15mm)

These images show the impact of urban light pollution and its impact on our ability to view the night sky. Figure 1 was photographed from the South Perth foreshore, overlooking the Swan River and the centre of Perth. Due to the very bright night-time ambient lighting, figure 1 was exposed approximately five "f" stops LESS exposure than figure 2, which is correctly exposed for dark-sky conditions. If both images were photographed with the same exposure, the city image would be completely over-exposed due to the bright ambient light. In the city, the Milky Way is barely visible, in contrast to the spectacular view of the Milky Way from the dark-sky location.

The impact of urban light pollution is demonstrated in the images below;

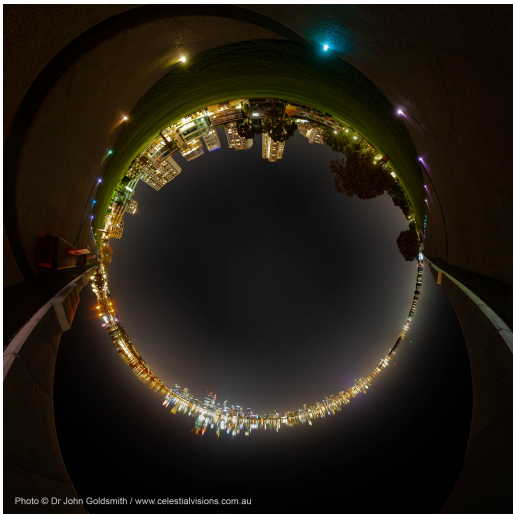


Figure 11



Figure 12

Some differences are apparent between figure 10 and all other images, due to the different camera used for figure 10 (Canon 6D astro-modified) as compared to the Canon 5D Mk II. Astro-modified cameras are those cameras that have had their infra-red filter (located immediately above the sensor), removed. This modification has the effect of increasing the spectral range recorded by the camera (further into the red end of the spectrum), and as a result, such images tend to look redder than images obtained from unmodified cameras.

The astrophotography accomplished for this project has successfully recorded the appearance of the Milky Way at or near the zenith, from approximately 30° South latitude. The project also demonstrates how 360° imaging can be used to document and illustrate the effect of urban light pollution and dark sky conditions.

6. Acknowledgments

The funding support provided by National Science Week 2019 (Australia) is gratefully acknowledged, in addition to the administrative support by Westonia Community Resource Centre, Western Australia. This project is an initiative of Celestial Visions and Dr John Goldsmith. Project collaborative partners are gratefully thanked for their involvement, including Luke Busellato (image processing and additional field photography) and Dr Chris Thorne (web site / Virtual Reality coding advice).

7. Profiles

Profile: Dr John Goldsmith

Dr John Goldsmith is an astrophotographer, writer, researcher, exhibition developer and curator based in Western Australia. His life-long fascination with the cosmos has found expression through his photography, exhibitions, writings and research. His PhD research “Cosmos, Culture and Landscape”, at the International Centre for Radio Astronomy Research, Curtin University, focussed on cultural astronomy and the documentation, communication



and sharing of Aboriginal sky knowledge, associated with Wolfe Creek Crater and radio astronomy initiatives in the Murchison region of Western Australia. His research applied a suite of digital imaging for site documentation, including astronomical timelapse and 360° spherical imaging. Dr Goldsmith is a member of The World at Night (www.twanight.org), a leading global network of astronomical landscape photographers. He is the creative developer behind Celestial Visions (www.celestialvisions.com.au) and his astro-imaging is exhibited worldwide. He served as the curator for the Astrofest astrophotography exhibition, from 2009 to 2019. In 2011, John was awarded the inaugural De Laeter Science Engagement Scholarship, (Gravity Discovery Centre, Western Australia). In 2017, John featured in “The Borderless Sky, The Aboriginal Sky of Australia” episode, screened in Europe via ARTE.

Dr Chris Thorne. Chris's long-term goal is to move the digital world to high-resolution spaces and positionally invariant accuracy by applying origin-centric techniques. This approach leads to greater fidelity and scalability. The sub-goal is to promulgate high-fidelity motion, interaction and calculation, an optimising simulation architecture, code and practices. Chris is best known for the floating origin software design concept, an idea aptly mirrored a Futurama episode when the Planet Express space ship was described as moving by staying still and shifting the Universe around itself.



Research profile: https://www.researchgate.net/profile/Chris_Thorne3

Project and research: <https://www.floatingorigin.com/>

Luke Busellato

Luke Busellato is an Information Technology professional and network engineer, based in Albany, Western Australia. He began astrophotography in 2012 and specialises in 360° virtual reality, panoramic imaging and astro-landscape photography. Luke uses a Canon 6D camera with variety of lenses, most often a Samyang 14mm. A sample of his images can be viewed online at facebook.com/LBusPhoto



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