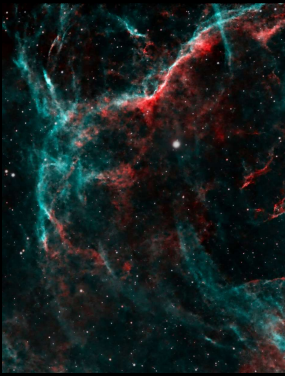


Beginners Astrophotography

Gary Liney


Week 1: Introduction, Basic Concepts



1

Introduction to the Course

- WEEK 1
Introduction to astrophotography, basic concepts
- WEEK 2
Equipment: Lens, cameras & telescopes
- WEEK 3
Equipment: EQ mounts, star-trackers and guiding
- WEEK 4
Imaging the solar system: Moon



2

Introduction to the Course

- WEEK 5
Imaging the solar system: Planets & Sun
- WEEK 6
Deep Sky Objects (DSO)
- WEEK 7
Acquisition and processing software
- WEEK 8
Image processing practical



3

..Be Realistic!

- Avoid internet comparisons
- We do not have the luxury of being in space

AND

- Hubble cost US\$16 billion!



Hubble's pillars of creation

Eagle nebula from Glenfield

4

Persevere...and progress



Basic lens, basic camera Better lens, better PA, more processing Small telescope & dedicated camera

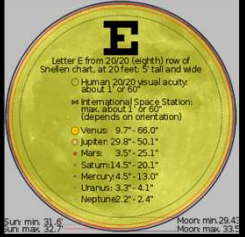
5

Units: Degrees, arc mins & arc secs

- Used since ancient astronomy to describe object size in sky
- 1 degree (°) is 60 arc minutes (')
- 1 arc minute is 60 arc secs (")

Moon is approx. 31' OR 0.52°

We can resolve about 1'



Object	Size (arc minutes)
Letter E from 20/20 (eighth) row of Snellen chart, at 20 feet: 5" tall and wide	1' or 60"
Human: 20/20 visual acuity	about 1' or 60"
International Space Station (size depends on orientation)	9.7" - 66.0"
Venus	29.8" - 50.1"
Jupiter	3.5" - 25.1"
Mars	4.5" - 20.1"
Saturn	4.5" - 13.0"
Mercury	3.3" - 4.1"
Uranus	2.2" - 2.4"
Neptune	2.2" - 2.4"
Sun: min 31.6"	
Sun: max 32.7"	
Moon: min 29.4"	
Moon: max 33.5"	

6

Units: Light Years

- At attempt to express the immense distances in space.
The distance travelled at speed of light in one year, which is:

9460730472580800 km
OR
9.46 trillion km

Note: 1 astronomical unit (au) is distance between earth to sun and is 8.3 light minutes or 150 million km

7

Scale Model

Nearest Star

Sun is 6cm tennis ball

Furthest man has travelled 1.8 cm

Earth is tiny dot 12 m away

8

Some distances

- Moon is 384,000 km away;
- Sun is 400 times further...8 light minutes
- Jupiter is 40 light mins, Neptune is 4 light hours.
- Proxima Centauri is 4 light years away.
- Milky Way centre is 27,000 light years away..
- Other galaxies are many millions of light years away!

9

Units: Magnitude & Colour

- Magnitude**
Logarithmic scale with the lower the number, the brighter the star or object.
e.g. Sun is -27; Venus is -5; Sirius (brightest star) is -1.46, southern cross is 1.25 to 3.55

Each single unit is approx. 2.5 times brighter

10

Units: Magnitude & Colour

- Colour**
Given as magnitude $CI = B - V$
Where B and V is the energy in blue and eye sensitive 'visible' wavelength

Negative values BLUE
Positive values ORANGE

COLOR	EXAMPLE	SURFACE TEMP (K)	MAGNITUDE
Blue	SPICA	28,000 - 11,000	-0.25
White	VEGA	11,000 - 7,500	0
Yellow	THE SUN	6,000 - 5,000	+0.65
Orange	ARCTURUS	5,000 - 3,600	+0.82
Red	ANTARES	3,600 - 2,000	+1.86

11

Popular Astro Targets

<p><u>Either Hemisphere</u></p> <ul style="list-style-type: none"> Moon & planets Orion Nebula Lagoon & Trifid Nebula Eagle Nebula Rosette Nebula Pleiades 	<p><u>Southern Hemisphere only</u></p> <ul style="list-style-type: none"> Alpha & Beta Centauri Southern Cross Coalsack nebula Carina Nebula LMC & SMC Omega Centauri
--	---

12

Things that ruin our photos

- 1) Clouds!
- 2) Clouds!!
- 3) Light pollution (direct & indirect)
- 4) Poor 'seeing' conditions
- 5) Poor polar alignment
- 6) Lack of preparation and planning

Clouds also reflect moon and LP

13

Planning your night out

- Use planetarium App (e.g. Stellarium)
- Check moon phase
- Check weather forecast
- Set up gear in daylight
- Plan your shot and don't try to do too much

14

Astro Forecasts

Accuweather stargazing forecast

www.accuweather.com

15

Bintel forecast

www.bintel.com.au/astronomy-weather/

Time	Temp	Clouds	Rain	Humidity	Wind
Tuesday 20th Dec - 2pm to 5pm	19.54 °C	23%	0	55%	20.4 km/h
Tuesday 20th Dec - 5pm to 8pm	17.53 °C	7%	0	61%	14.9 km/h
Tuesday 20th Dec - 8pm to 11pm	15.75 °C	3%	0	68%	10.5 km/h
Tuesday 20th Dec - 11pm to 2am	14.96 °C	7%	0	71%	9.7 km/h

16

ClearOutside forecast

www.clearoutside.com


Day	Weather	Clouds
25	Cloudy	2%
26	Cloudy	7%
27	Cloudy	15%
28	Cloudy	24%
29	Cloudy	35%

17

18

'Seeing'

(right) The brightest star Sirius at low altitude



- Causes stars to twinkle and planets/moon to wobble
- Mars was thought to have canals due to bad seeing
- Seeing reduces the *effective* resolution of telescopes
- Transparency (how clear the air is) also effects astrophotography

19

Astronomy Seeing Sydney

New South Wales, Australia, 33.875 151.875, 3000 m

18 °C

Seeing Forecast

www.meteoblue.com

Date	Clouds			Index		Jet Stream	Bad Layers			Ground		Celestial Bodies
	Low	Mid	High	Arc Sec	2		Bot (km)	Top (km)	K/100m	Temp	Ref. Hum.	
2022-11-24 Thu	11	20	20	1.94	3	30 m/s	08.0	10.0	10.0	20 °C	90%	LW- ---P
12	10	20	0	1.60	3	30 m/s	08.0	10.0	10.0	20 °C	40%	LW-5- -P
13	10	20	0	1.11	4	30 m/s	08.0	10.0	10.0	21 °C	42%	LW-5- -P
14	10	20	0	1.32	4	30 m/s	08.0	10.0	10.0	21 °C	41%	LW-5- -P
15	10	19	0	1.37	4	30 m/s	08.0	10.0	10.0	22 °C	44%	LW-35-NP
16	10	7	0	1.27	4	40 m/s	08.0	10.0	10.0	21 °C	51%	LW-35-NP
17	10	1	0	1.55	4	45 m/s	08.0	10.0	10.0	20 °C	62%	LW-35-NP
18	10	5	0	1.97	4	41 m/s	08.0	10.0	10.0	19 °C	70%	LW-35-NP
19	10	15	0	1.60	4	30 m/s	08.0	10.0	10.0	19 °C	70%	LW-35-NP
20	10	20	0	1.60	4	30 m/s	08.0	10.0	10.0	19 °C	80%	---35LNP
21	10	25	0	1.14	4	31 m/s	08.0	10.0	10.0	18 °C	90%	---35LNP
22	10	45	0	1.20	4	30 m/s	08.0	10.0	10.0	18 °C	91%	---35LNP
23	10	50	0	1.27	4	30 m/s	08.0	10.0	10.0	18 °C	91%	---35LNP

20


Stellarium

- Free planetarium software
- Can be run online or downloaded
- Set time and date to plan photos
- Check moon & any obstructions
- Move telescope from visual display
- Demonstration

21

Light Pollution

- Classed as Bortle scale 1 to 9
- Check light pollution maps (next)
- LP creates a dome up to 30 degrees altitude
- LP may vary in directions at your site
- The moon is also a significant LP source
- LP washes out image and can create significant gradients



22

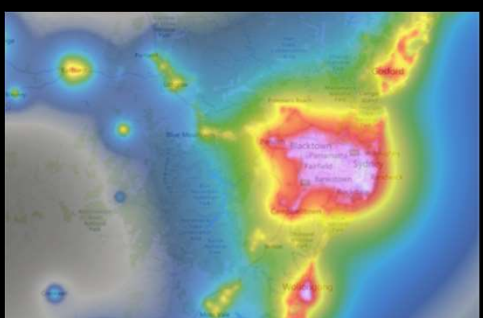
Bortle Scale

7.6 - 8.0	1
7.1 - 7.5	2
6.6 - 7.0	3
6.3 - 6.5	4
6.1 - 6.3	4.5
5.6 - 6.0	5
5.0 - 5.5	6,7
<4.5	8,9

- Introduced in 2001 by John Bortle
- Relates sky conditions to naked eye limiting magnitude
- Also can be related to 'SQM' and description of conditions/appearance of MW

9 (inner city) 'white' zone- only see moon and bright planets- to 1 (true dark sky) 'black' zone

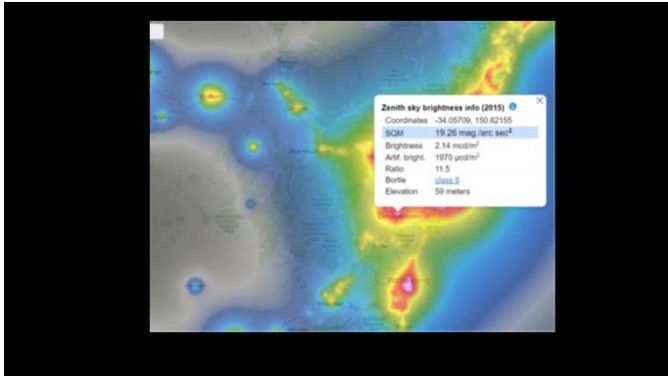
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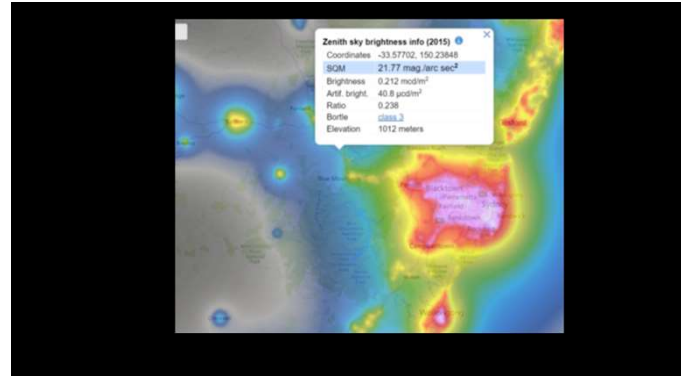
Light Pollution Map

www.lightpollutionmap.info

24



25



26

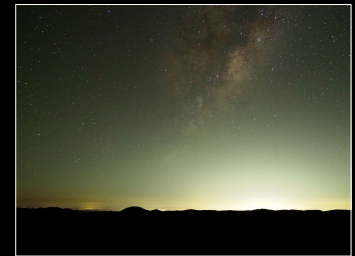
Light Pollution- mitigation

- Go to dark sky site
- OR
- Use lens hood ("dew shield") to avoid direct lighting
- Targets high in sky
- LP filters-poor for modern street lights
- Narrowband filters are very useful for emission nebulae (more later)
- Stacking many subs to reduce 'sky noise'
- Gradient removal in post processing

27

Dark Sky

- Bortle 3 dark sky location
- LP still effects MW in this single shot
- The gradient is extreme and could not be removed



28

Some targets deserve the car journey

- Rho Ophiuchi cloud complex
- 30s sub in backyard vs dark sky site
- Difference is several hours of SNR
- Final image (next) was just 50 mins data



29



30

Position of target is also key

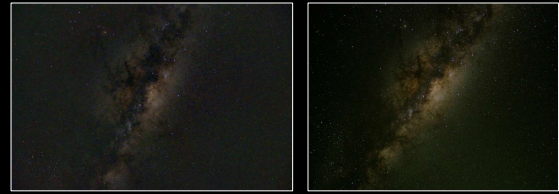


MW low and to west

MW overhead

31

Bortle 6 vs 3



Processed sub (LP backyard)

Raw sub (Dark sky)

32

LP Processing



- Helix Nebula example (left)
- Original has LP gradient
- Apply background correction (Siril)
- Increases noise
- Can be done on raw or stacked data

33

Be creative #1

- Previous data
- Composed of 3 images
 - MW stack high in sky
 - Single foreground
 - Enhanced light dome



34

Be creative #2



Another drive to Blue Mountains potentially wasted..



35

Equipment Level #1: Lens & Tripod

- Assume already have a DSLR or mirrorless camera and tripod
- This will come with 'kit' lenses of various FL
- Additional 'fast' manual focus lenses
- Limited exposure time on FL
- Good for wide angle, single shots of moon, night sky and MW

36

Equipment Level #1: Lens & Tripod


- Olympus MFT camera (second hand \$250)
- Use kit lenses OR buy prime lenses
E.g. f/2 Samyang 12 mm lens (\$400)
- Remote shutter release cable (\$10)

PLUS...reasonable pair of binoculars is very useful tool!!!



37


Examples of single shot photos



Wide angle (12 mm) shots of Southern Cross & Pointers

38

Examples of single shot photos



Moon & Jupiter (135 mm)

Various Moon phases (300 mm)

More on Moon in Week 4

39

Examples of single shot photos




Conjunction of Jupiter & Venus at 12 mm

Alignment of Saturn, Mars, Venus & Jupiter at 12 mm

40

Examples of single shot photos




Orion's belt & nebula (50 mm)

Night sky showing Mars & Pleiades (12 mm)

41

Dark Sky & Single Shots



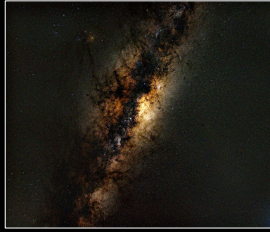
Showing Carina/Crux part of Milky Way

Foreground added with 'light painting'. Can also see LMC.

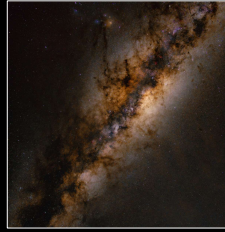
42

Single->Stacked images

Stacked data will always be superior as it significantly reduces LP & increases SNR



Approx 15 min (LP backyard)

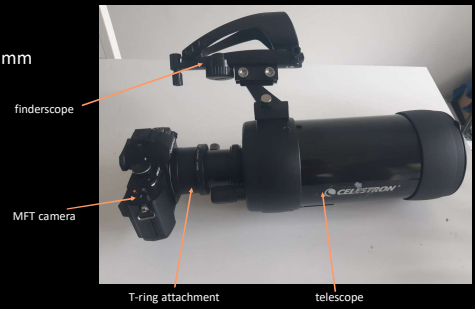


Approx 15 min (Dark sky)

43

Equipment Level #2: Long FL Telescope

- T-ring allows 50 mm backfocus



44

Equipment Level #2: Long FL Telescope

- Example Celestron C90 MAK f/14 90 mm FL = 1250mm
- Cost \$470
- Will need camera specific attachment
- Good for moon & sun (+solar filter!), typically use very short exposures as target is so bright
- Can still be used on fixed tripod
- Not great for DSO as too 'slow' (more in next lecture)

45



Single and stacked (far right) images of the moon... MORE in week 4.

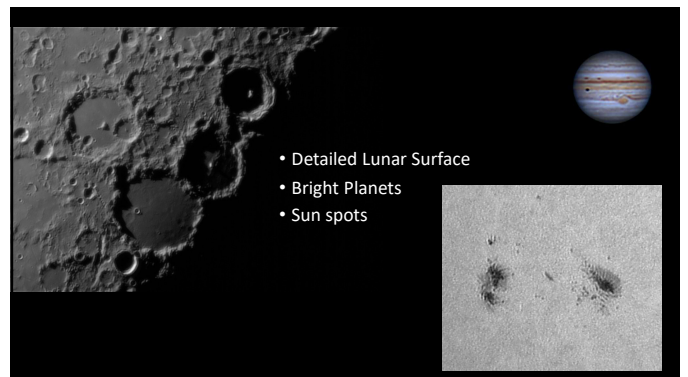
46

Equipment Level #2b: Video Camera

- Camera in fast frame rate video mode
- OR dedicated planetary camera e.g. ZWO ASI220MCS cost \$260
- This can be used as a guidescope camera later*
- Use 'lucky imaging' to select best frames for final photo



47



- Detailed Lunar Surface
- Bright Planets
- Sun spots

48

Equipment Level #3: Star Tracker

- Can be AltAz or EQ (more later)
- May be portable star tracker or heavy duty
- Allows longer exposure subs, also makes planetary/moon easier
- Goto capability needed for non visible DSO targets
- Cost from \$500 upwards

49

Equipment Level #3: Star Tracker

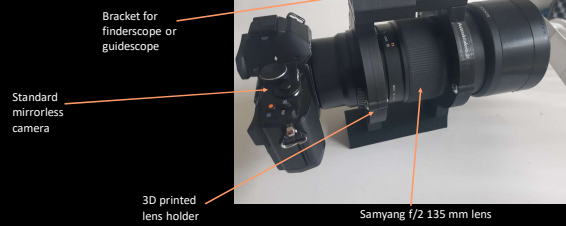
- Skywatcher AZGTi



50

Example Set-up for Star Tracker

- This is what I use for max portability



51

- Examples taken at 135 mm



52

Equipment Level #4: Small Refractor

- Quality medium FL (360 mm) scope cost \$700
- Add guiding capability for even longer subs (re-use planetary camera)
- Can still use digital camera
- May want to add dedicated 'Astro' camera in future cost \$1000-\$2000
- ✓ Computer control allows full EAA capability

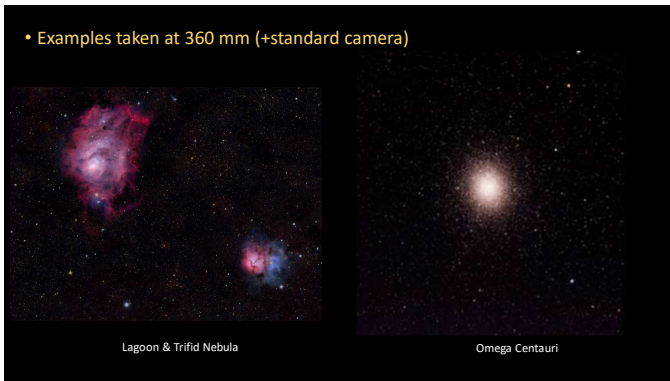
53

Equipment Level #4: Small Refractor

- Size & weight limited by mount/tracker



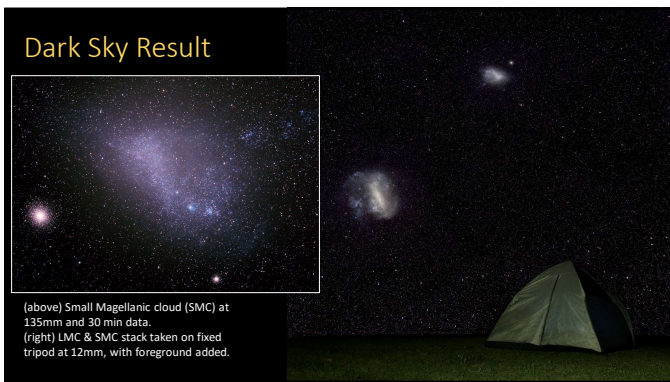
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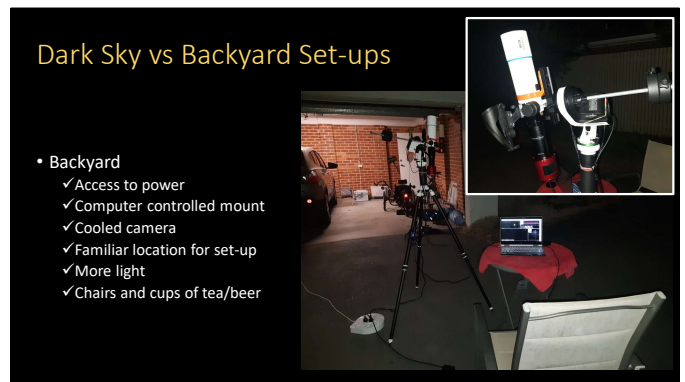
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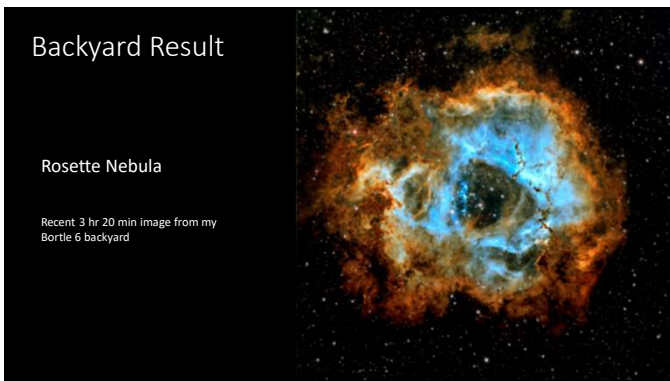
56



57



58



59



60