Filters & Video Astronomy

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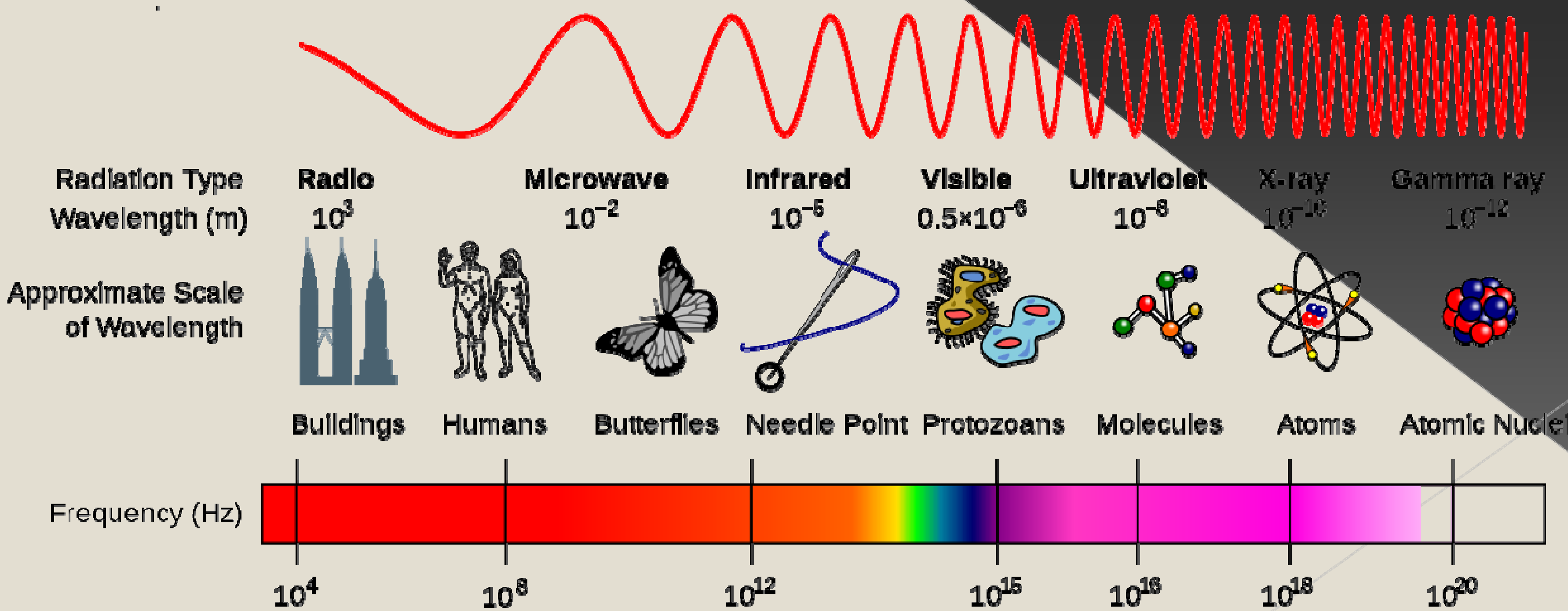
Overview

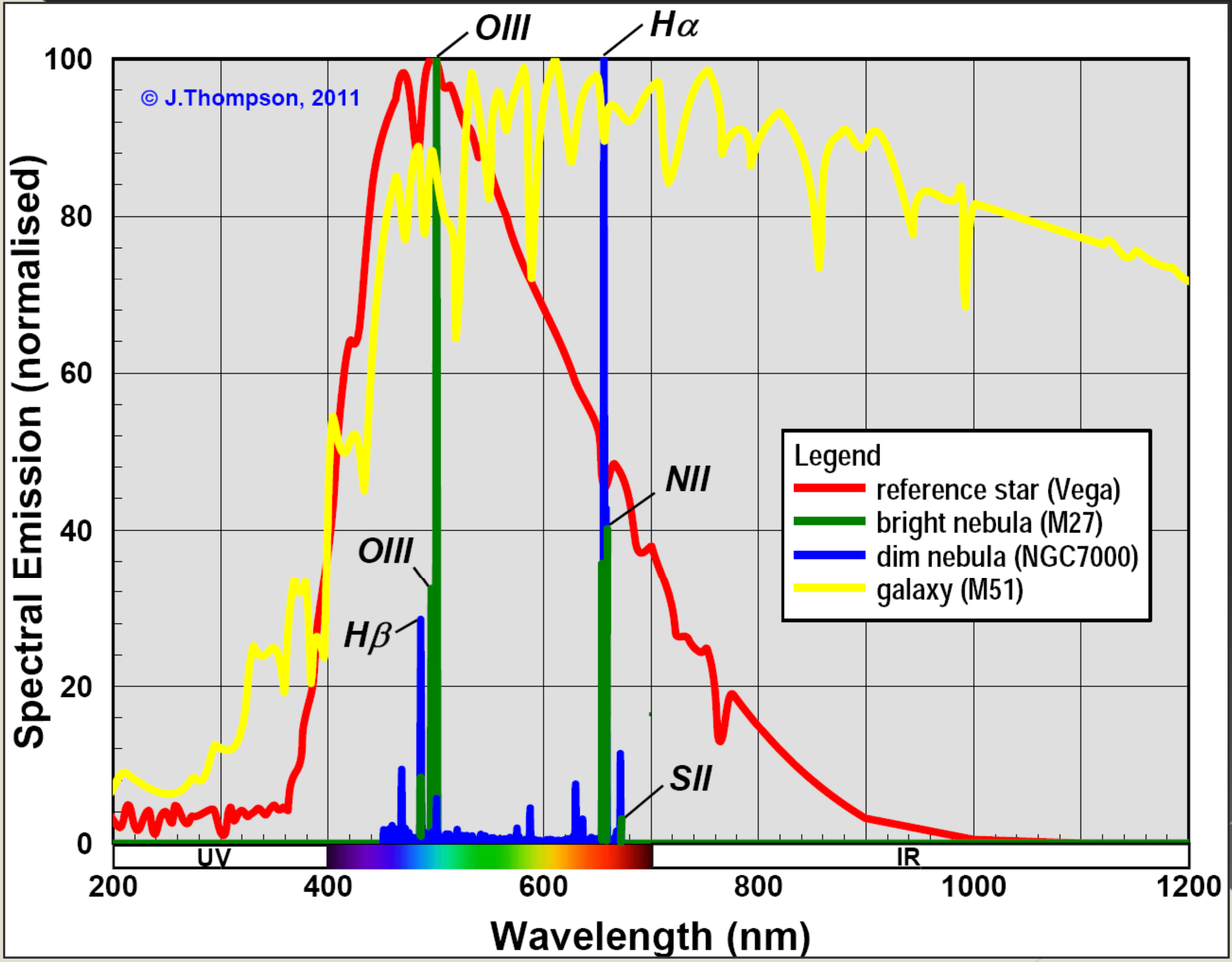
- What are we looking at & how
- Introduction to filters
  - Different types
  - How they work
  - Nomenclature
- Uses of filters in video astronomy
  - Controlling light pollution
  - Enhancing solar system observing
  - Things to remember

What are we looking at?

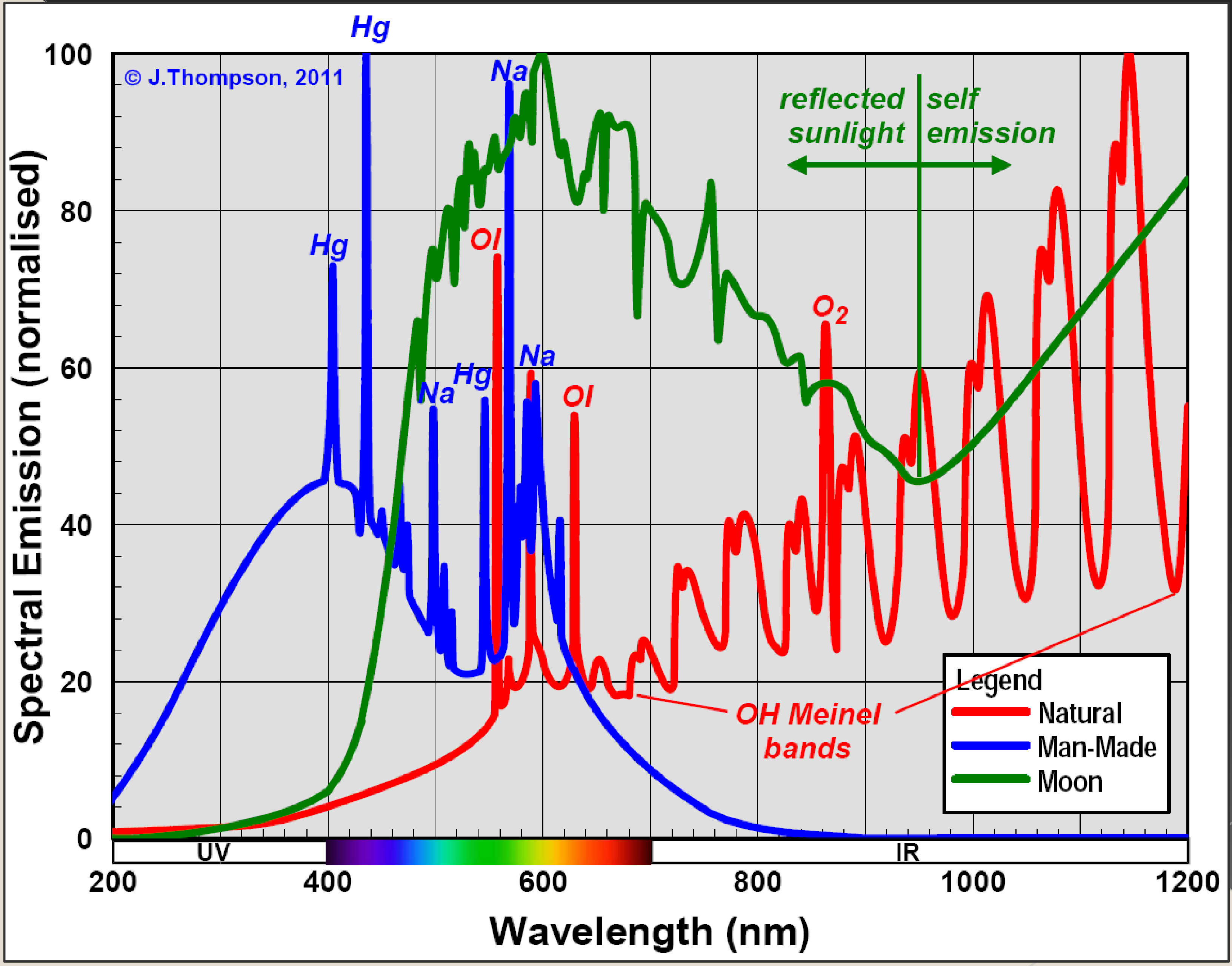
- Photons of different energy levels (wavelengths) excite receptors in our eye – our brain interprets as “colour”
- Whether by eye or camera, only observing a small slice of the Electro-Magnetic spectrum



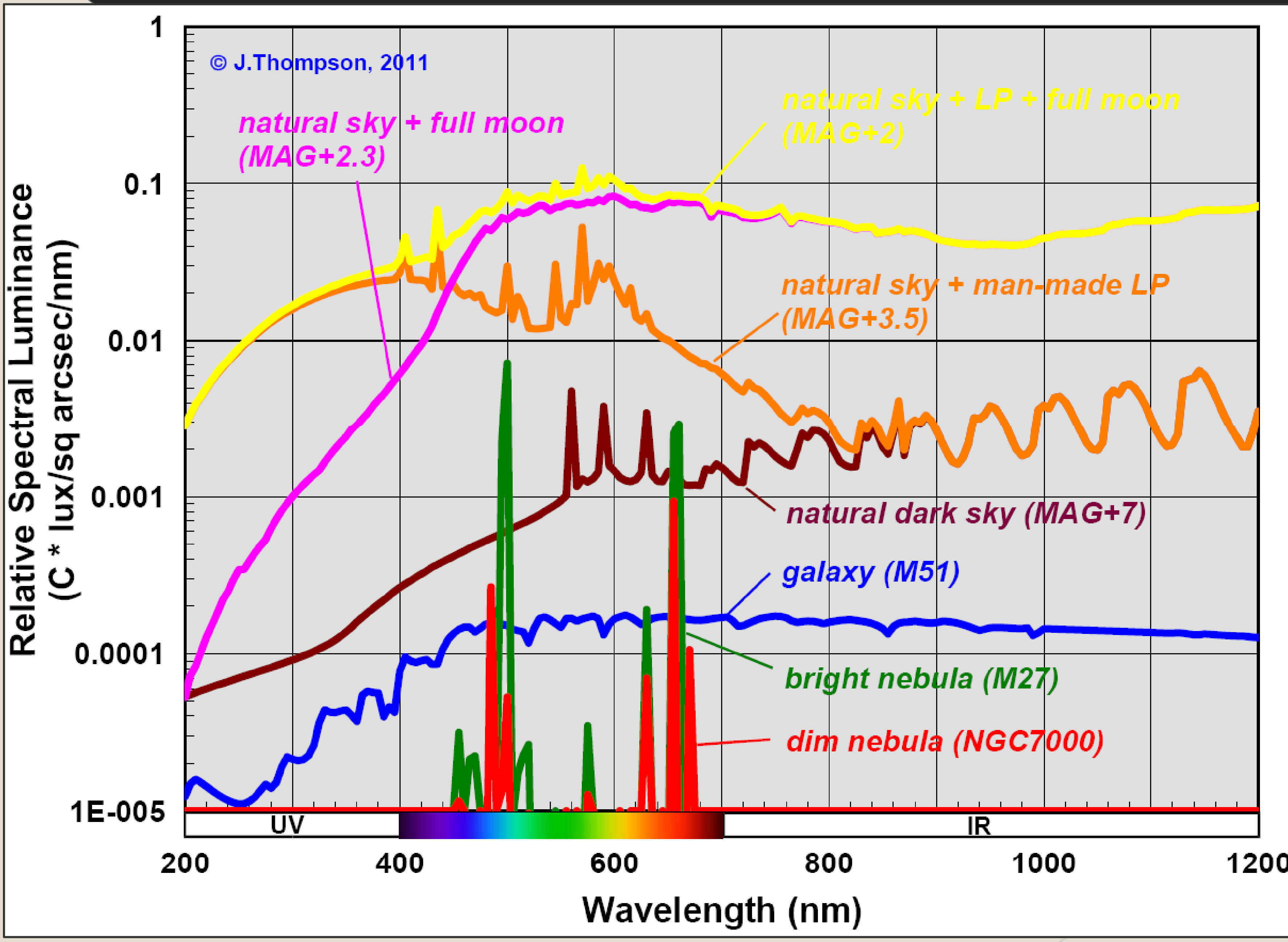
Night sky is full of colours



Including some we don't want



Altogether now…



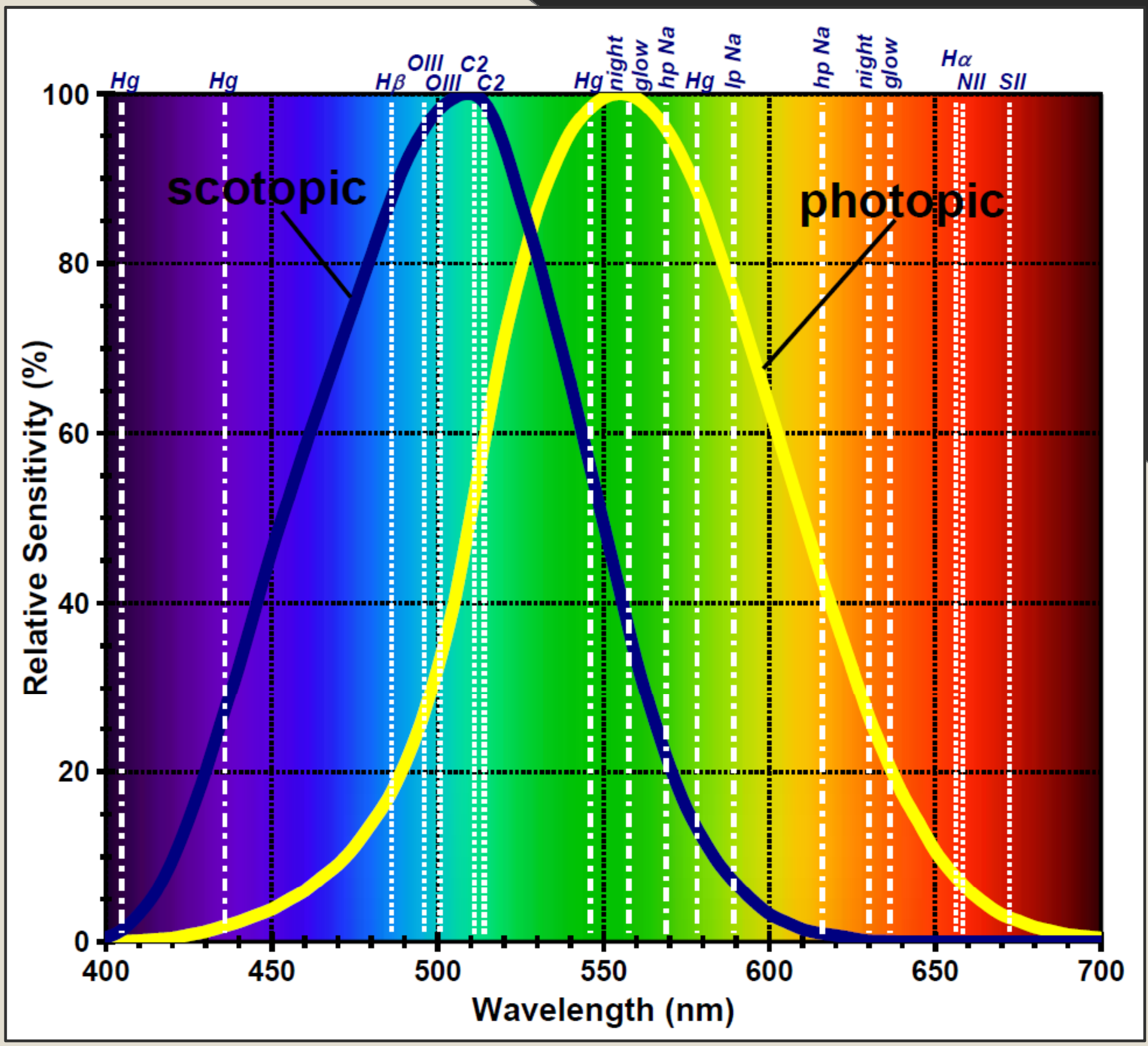
Your eye as a detector

- Billions of years of evolution resulted in eyes that see just the visible light portion of the EM spectrum
- Not by accident – the Sun's energy that makes it to the Earth's surface is centered around the visible & NIR band
- Combined with the visual cortex, the eye-brain system is a very powerful optical data gathering and processing machine

…but how is it for astronomy?

Human eye spectral response

- Eye optimized for "eat or be eaten" world that is illuminated by the Sun



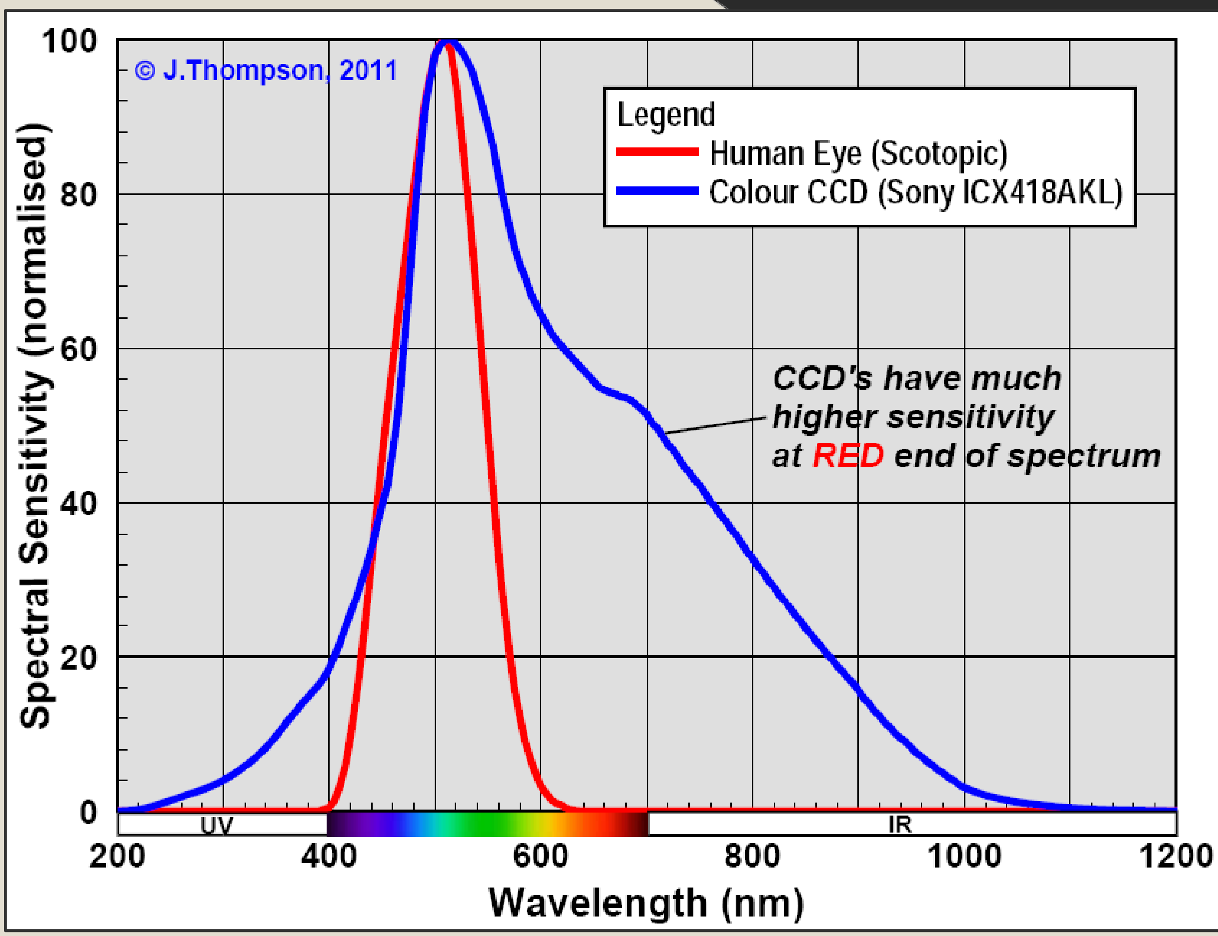
› no colour if dark

› lower limit to sensitivity

› overall spectral sensitivity

Colour CCD spectral response

- CCD's used in video have wider response, but designed as surrogate for human eye – produce "pleasing" image



- much better response to red and NIR
- more sensitive than human eye but less dynamic range
- net result: more red + more sensitivity = awesome!

Astronomical Filters

- Piece of glass designed to make what we don't want to see darker
- Makes what we want to see easier to see (but not brighter)

Planetary (Colour)

Deepsky (Interference)*

* also known as: nebula filters or light pollution filters

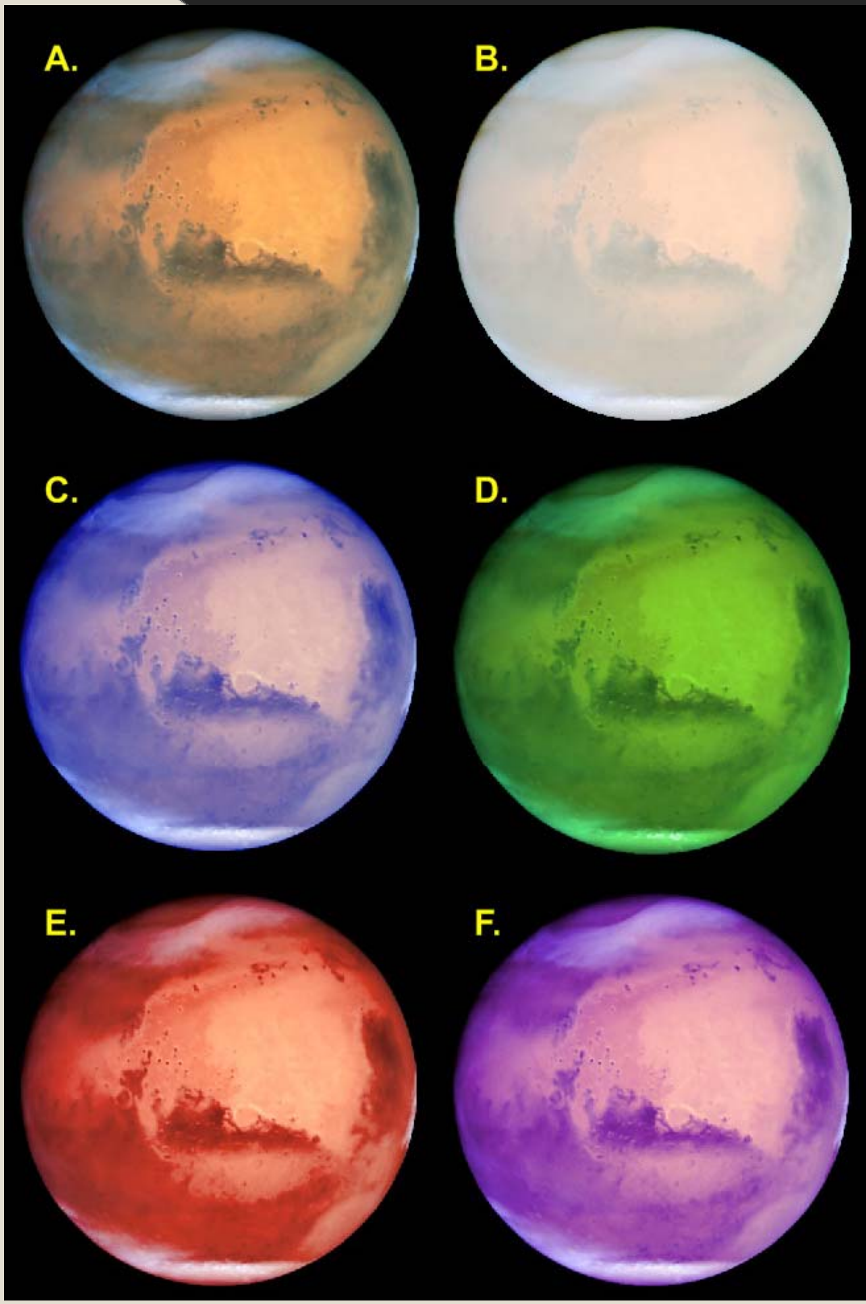
Special Filters

- Some special interference type filters also exist for:
  - Planetary observing
  - Chromatic aberration correction
  - Solar observing

- Let's ignore for now

Special Filters

Example Application - Planets



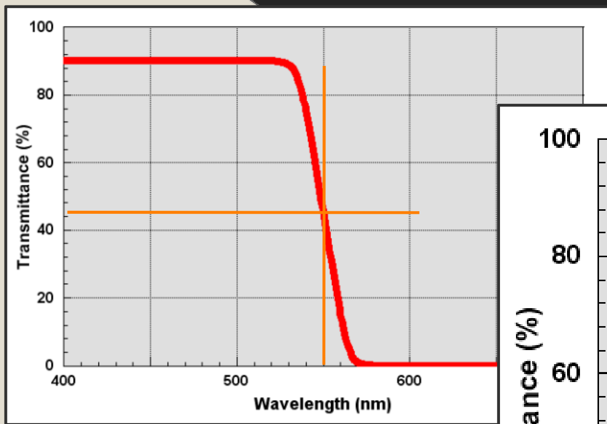
A. from orbit
B. from Earth
C. add Blue filter
D. add Green filter
E. add Red filter
F. add Magenta filter

Planetary (Colour)

Example Application - Nebulae

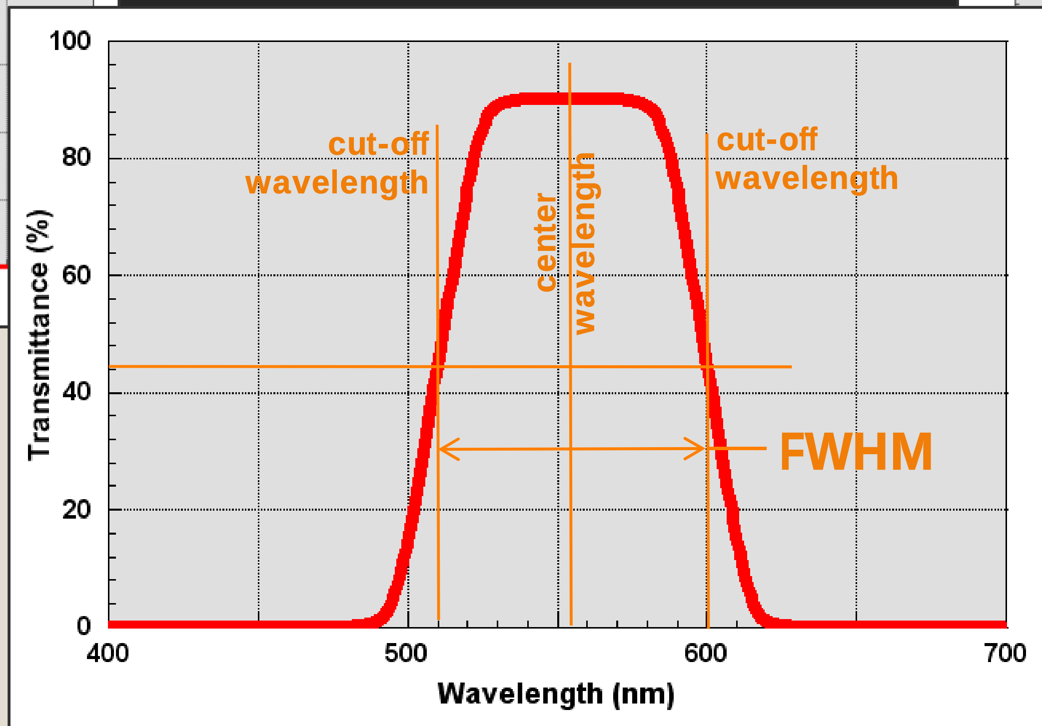
Deepsky (Interference)

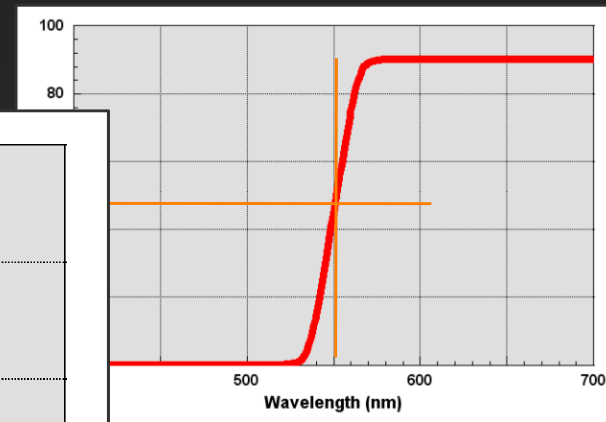
Filter response nomenclature



low pass

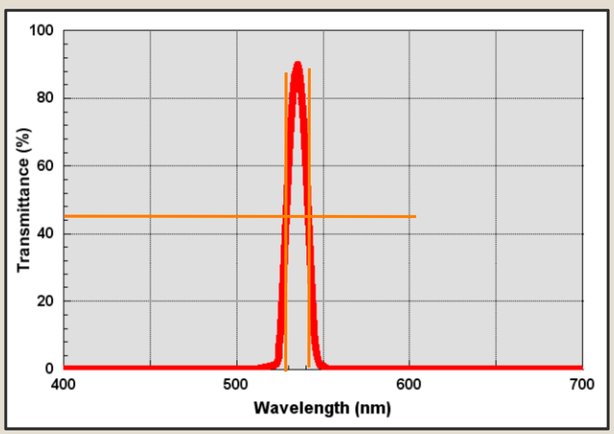
wide band pass



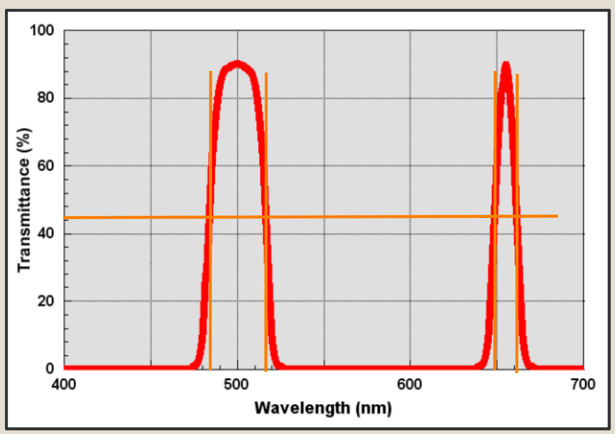


high pass

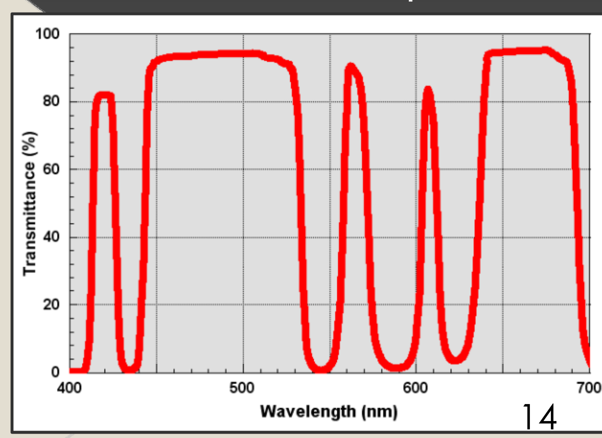
narrow band pass



dual band pass

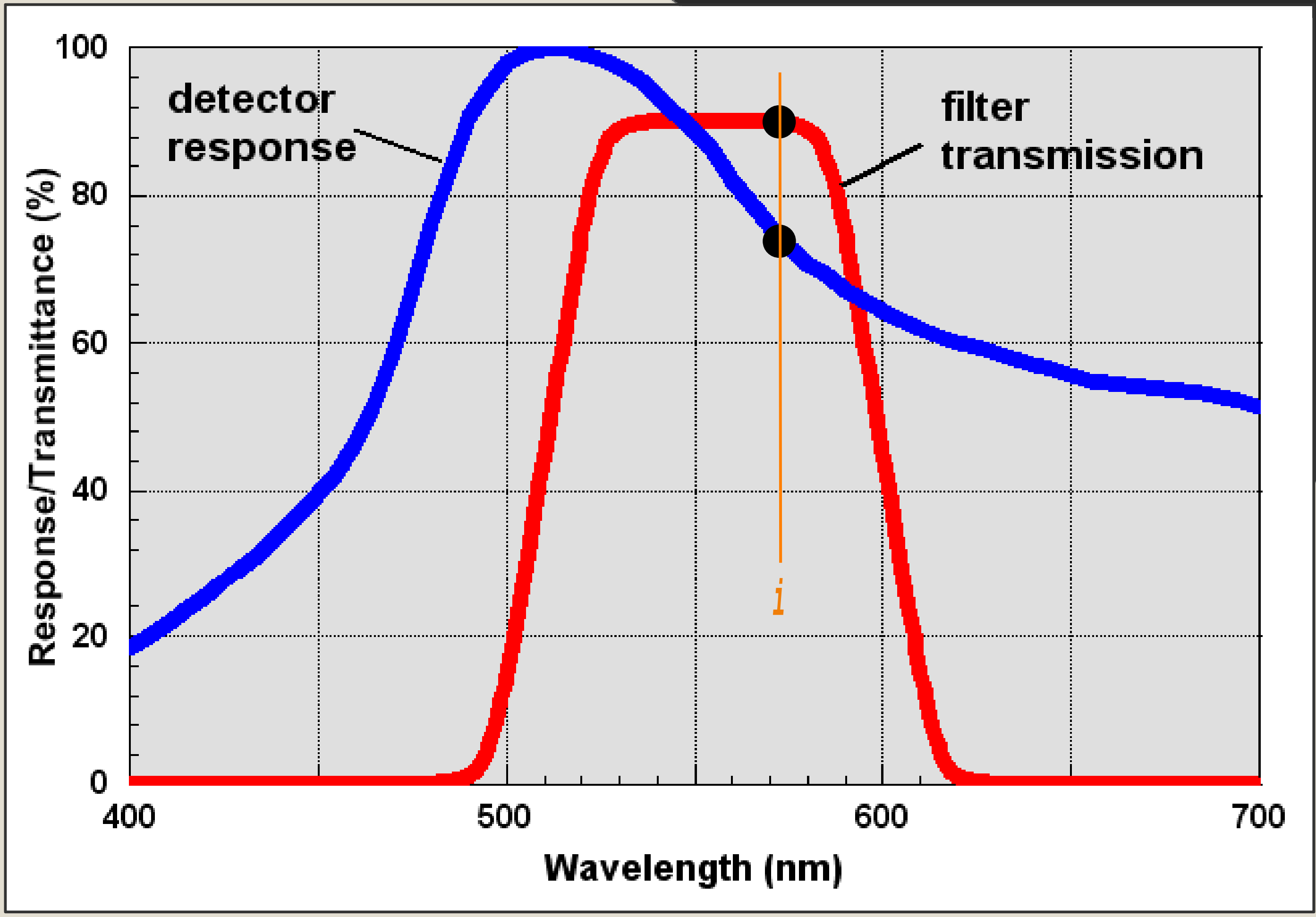


multi-band pass



Luminous Transmissivity (%LT)

- A measure of generally how “dark” a filter is (how much light it blocks), with 100% = clear
- Calculated based on response of detector
- Most often quoted assuming daytime use!



- Average brightness weighted by detector sensitivity

$$\%LT = \frac{avg(\%DR_i * \%FT_i)}{avg(\%DR_i)}$$

, where $I = \lambda1$ to $\lambda2$

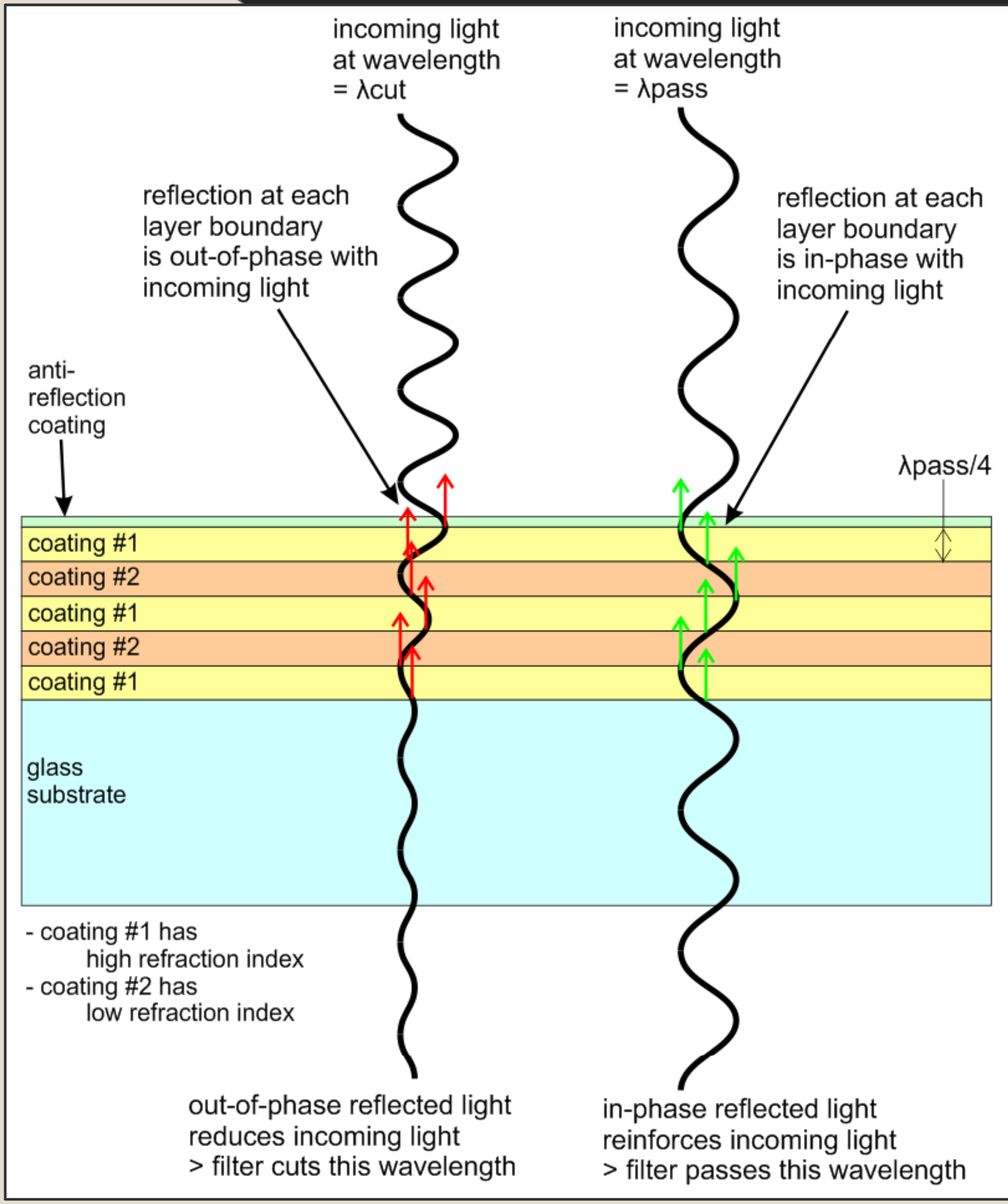
How do they work?

- Piece of glass held in an aluminum cell that screws to your eyepiece/camera
  - 1.25" (M28) or 2" (M48) standard sizes available

- Planetary filters:
  - glass is either infused with a dye or dyed gelatin is sandwiched between layers of glass
  - dye molecules absorb some wavelengths of light and not others
  - dye technology around since Stone Age!

- Deepsky filters:
  - more complex – use wave property of light

Interference filters



- 10's to 100's of alternating coatings on a glass substrate
- each coating has different refractive index
- light partly reflects at each boundary
- by design all undesired wavelength reflections are out-of-phase – null each other out

Overwhelming choices

- Planetary filters:
  - originate with Wratten series of colour filters for film photography (circa 1910)
  - are still produced today by a myriad of manufacturers
  - my research alone considered 56 different filters
  - generally low cost
- Deepsky filters:
  - technology to manufacture is relatively new so cost to purchase is still high
  - due to complexity in design, filters vary widely in performance from manuf. to manuf.
  - my research alone considered 101 different filters (does not include narrow band filters for astrophotography)
- How does one choose?

How use…Planetary*

- Want to increase contrast of details
- Colour filters can help – IN THEORY
- More can be done adjusting video settings
- I do recommend:
  - UV/IR cut filter to sharpen focus (all scope types)
  - “Moon & Skyglow” w/ IR cut (eg. Baader)
  - Red or IR (high) pass filter when seeing is bad or daytime Lunar

Also good for white light Solar

* including Lunar

How use…Deepsky

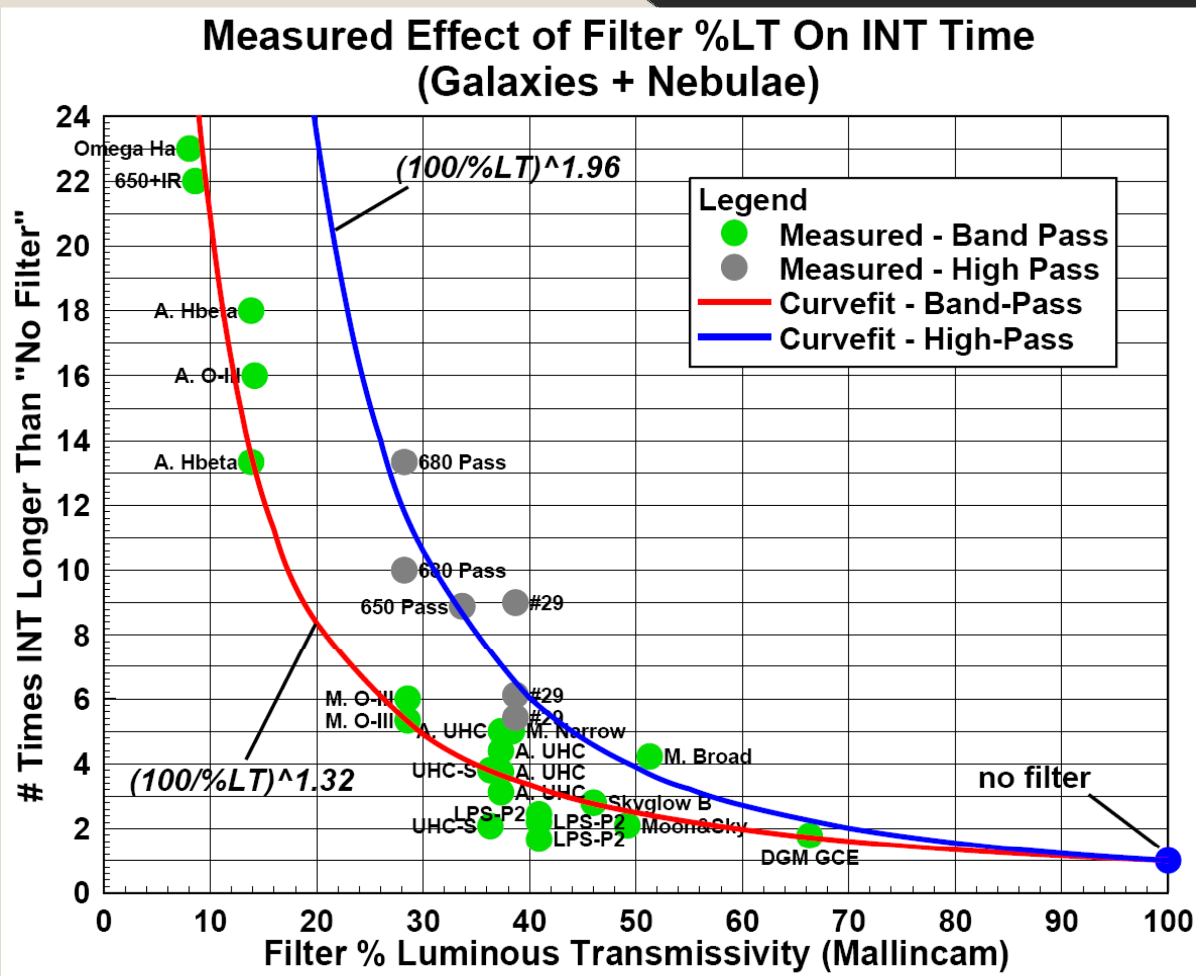
- Like Planetary, want to increase contrast

- Best filter to use depends on:
  - object type (galaxies/clusters, emission nebulae, or both)
  - amount and type of light pollution
  - type of optics
  - <u>tracking capability</u>

In general best contrast comes from using narrowest filter – but at the cost of longer INT

How filters affect exposure

- Deepsky filter makes background darker, but emission nebula is the same…net result is nebula easier to see



- Darker background allows you to use a longer INT to further increase image contrast
- Filters make galaxies & reflection nebulae darker, but not as much as the background

Selecting a filter for deepsky

Object Type	Dark Sky	Light Polluted Sky
Emission Nebulae (incl. planetary neb. & supernova remnants)	Best contrast comes from using the narrowest deepsky filter your scope setup tracking will support, with Halpha being the best. Adding an IR cut will also help improve contrast.	
Galaxies, globular clusters, open clusters, reflection nebulae	Adding an IR cut can help improve contrast.	Deepsky filters that also pass IR are required, with wide to medium-wide band pass filters working best. Even more contrast on galaxies from IR high pass filters, if scope tracking will support.

- Unfocused IR in refractors:
  - Most ED doublets and APO triplets not a problem
  - Commercial camera lenses (esp. security) usually need IR cut

Some other effects of filters

- Adding a filter will change your camera's white balance (WB)
  - Deepsky filters normally give magenta cast, Halpha gives monochromatic red, IR adds orange cast
  - Some filters provide better WB than others (eg. IDAS LPS-P2)
  - In some cases you may not be able to completely correct for the filter with camera or software controls

- Filter glass is another surface in your optical train
  - can result in new reflections in your FOV, better quality filters have anti-reflective coatings
  - another surface upon which dirt, dust, or dew can settle – most evident when Solar observing

Some other effects of filters

- Adding a filter will change your focus
  - Small amount of refraction occurs through filter glass, changing focus position slightly
  - Focus is different for different filters

- Changing filters while observing raises risk of dew on CCD
  - Best to observe with same filter all evening so CCD window is not exposed to outside air
  - A focal reducer between camera and filter greatly reduces the risk of dew formation when changing filters

Pretty pictures #1

Light polluted sky (Ottawa)

No Filters (8sec INT, 0 BRT)

Orion Deepsky Wideband (8sec INT, >0 BRT)

IDAS LPS-P2 (8sec INT, >0 BRT)

Astronomik UHC(8sec INT, >0 BRT)

Pretty pictures #2

Semi-dark sky (Petawawa)

IDAS LPS-P2 (60sec INT, 0 BRT)

Meade O-III + BDRB (60sec INT, ~40 BRT)

IDAS LPS-P2 (60sec INT, 0 BRT)

Meade O-III + BDRB (60sec INT, ~70 BRT)

Pretty pictures #3

Dark sky (Foymount)

No Filters (60sec INT, 54 BRT)

Astronomik UHC + IR cut (60sec INT, 82 BRT)

Meade O-III + BDRB (60sec INT, 93 BRT)

Meade O-III + BDRB (120sec INT, 82 BRT)

Pretty pictures #4

Dark sky (Foymount)

No Filters (20sec INT, 0 BRT)

Baader UV/IR Cut (45sec INT, 0 BRT)

- Images captured with Canon TV camera lens (17-102mm zoom)
- Affect of unfocused IR very evident – not simply bloated stars, fuzzy stars

Last words

- Feel free to experiment. Recommendations here are based on MY experience; yours may be different.
- Do not feel obligated to buy one of everything. Start with an affordable general purpose filter and build from there.
- For goodness sake HAVE FUN!