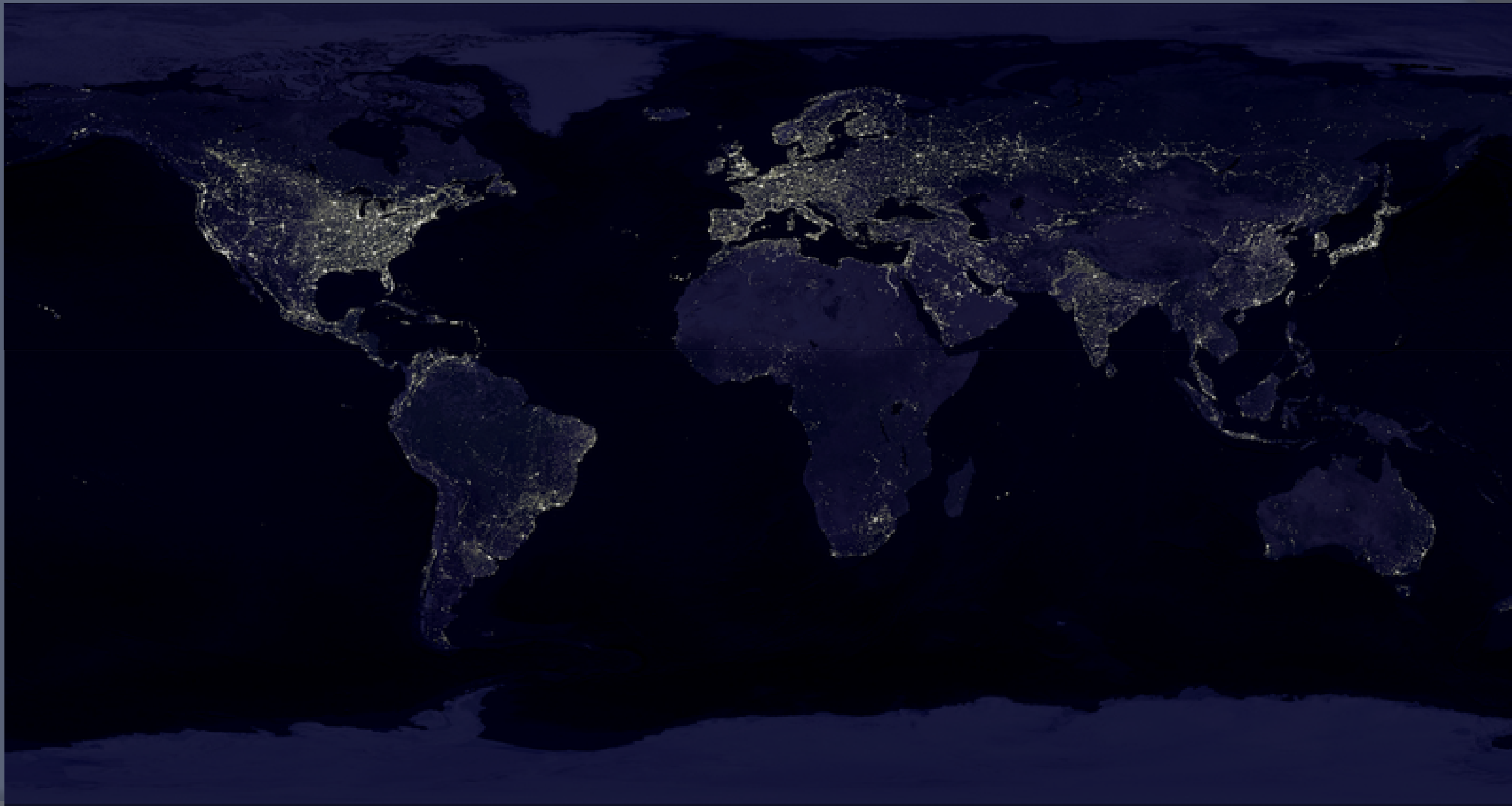
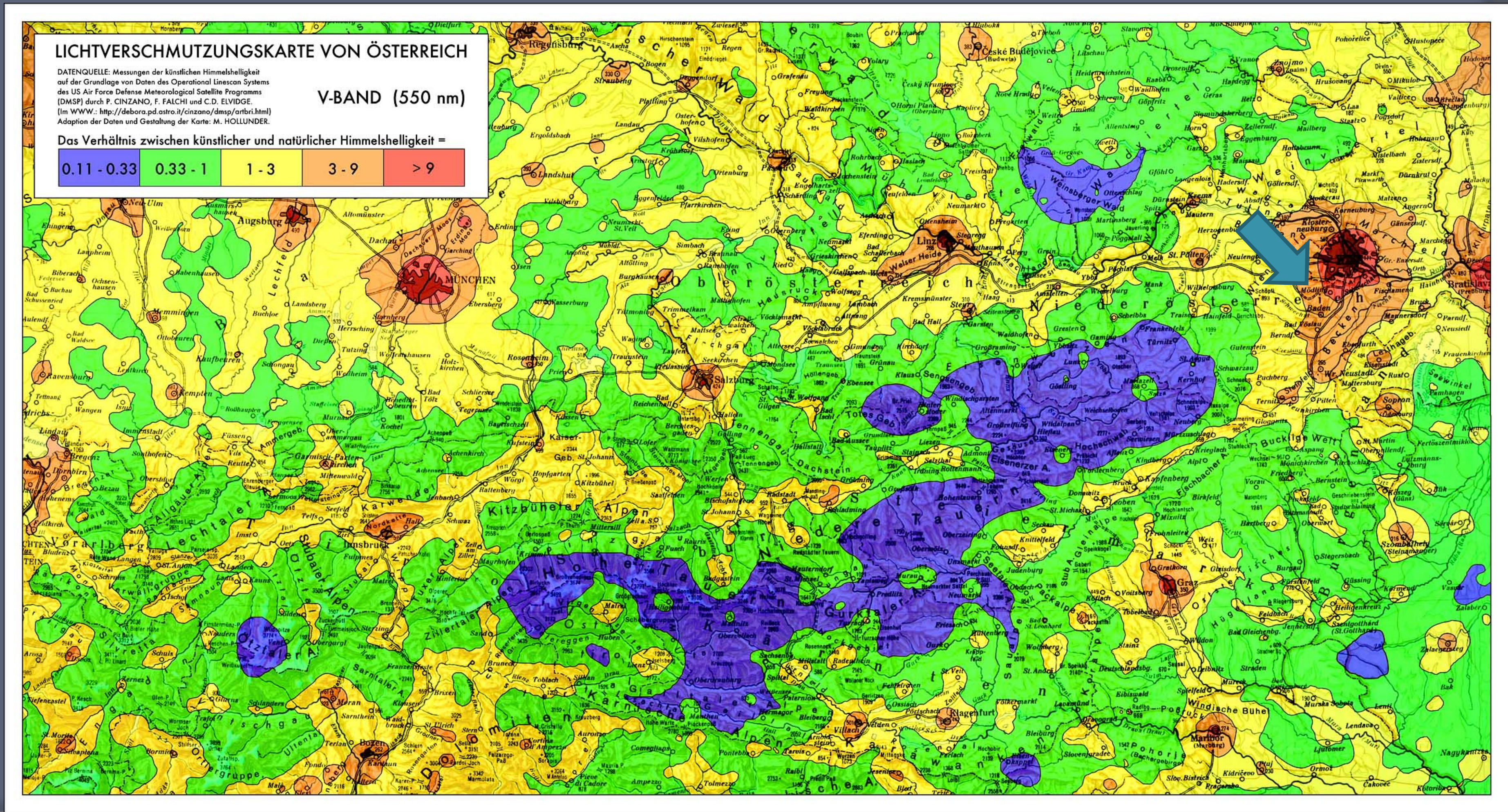
Astroimaging under a light-polluted sky (Narrow Band Imaging)

CEDIC '09

Global light pollution

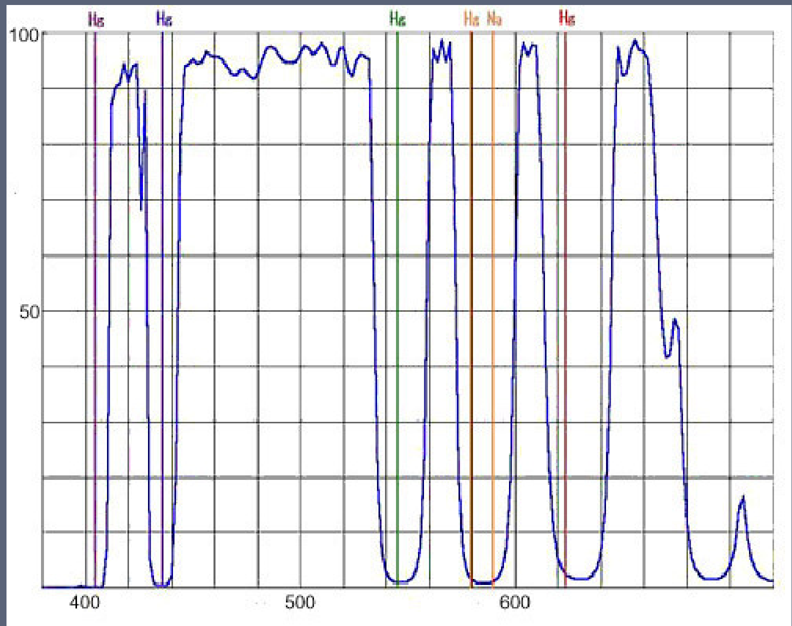


Light pollution in Austria



Reducing the effects of light pollution I

- Most cities use HPS lamps (with an amalgam of sodium and mercury) which emit pressure widened spectral lines
- These emission lines can be suppressed with appropriate filters



IDAS-LPS Filter

Reducing the effects of light pollution I

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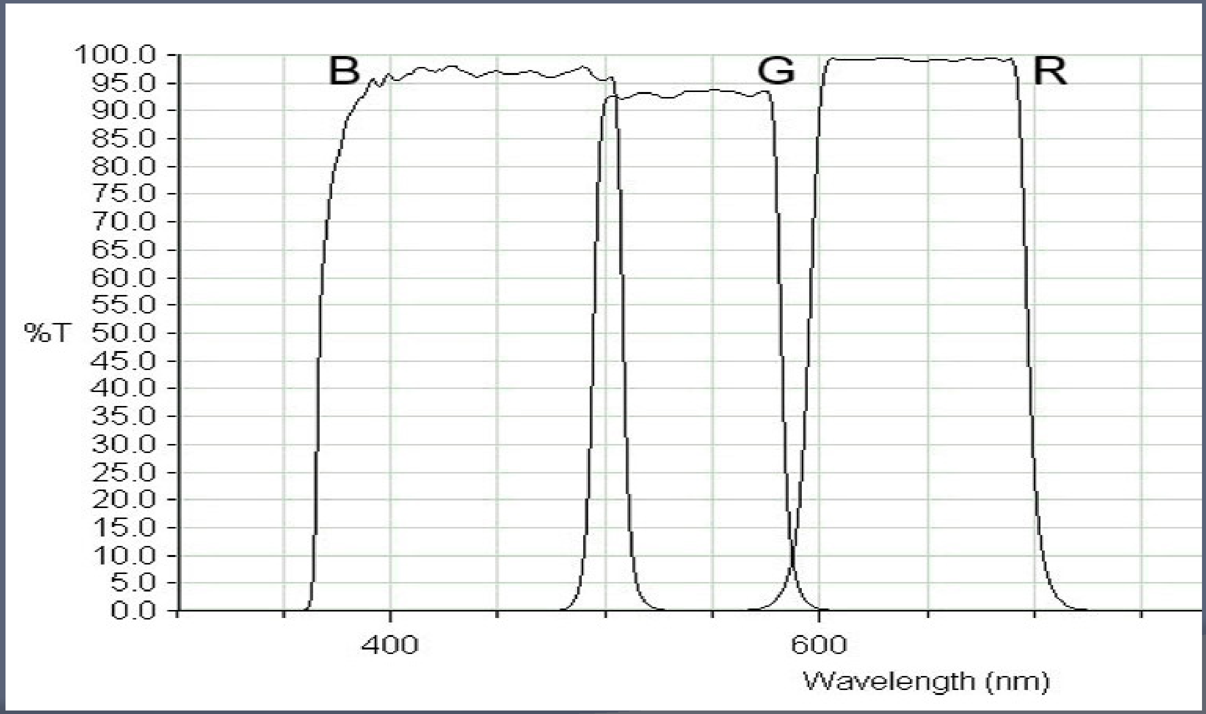


FLI – RGB Filters

Reducing the effects of light pollution I

- Most cities use HPS lamps (with an amalgam of sodium and mercury) which emit pressure widened spectral lines
- These emission lines can be suppressed with appropriate filters
- Many cities reduce lighting after midnight
- Wait for nights with highly transparent air – the lack of aerosols reduces scattering of light from nearby cities
- Focus on objects with a pure emission line spectrum and use narrowband filters to isolate the spectral lines of e.g. SII, Hα and OIII
- Light pollution decreases SNR (signal-to-noise ratio) – increase total exposure time for compensation

Reducing the effects of light pollution II

- Light pollution adds additional noise and gradients to a captured image – therefore the elimination of negative effects from other sources becomes mandatory
  - make darks to eliminate the 'dark fixed pattern noise' of the camera sensor
  - make flats as perfect as possible to compensate for the imperfections of the optical train
    - collect ~ 500.000e⁻ in total, with every sub-exposure well below sensor saturation
    - good light sources are:
      - sky at dusk and dawn near the zenith
      - specially designed 'light boxes'
      - EL (electro-luminescent) sheets

Reducing the effects of light pollution II

- Light pollution adds additional noise and gradients to a captured image – therefore the elimination of negative effects from other sources becomes mandatory
  - make darks to eliminate the ‘dark fixed pattern noise’ of the camera sensor
  - make flats as perfect as possible to compensate for the imperfections of the optical train
  - consider ‘super-flats’
    - take several images of a part of the sky next to the target, but not containing any extended objects
    - introduce an offset of several pixels between each image
    - remove stars during stacking and combination (no alignment!) with an ‘outlier-rejection’ algorithm and blur it a little bit for noise reduction
    - use this image as an additional flat to remove uneven gradients by subtraction

Reducing the effects of light pollution II

- Light pollution adds additional noise and gradients to a captured image – therefore the elimination of negative effects from other sources becomes mandatory
  - make darks to eliminate the 'dark fixed pattern noise' of the camera sensor
  - make flats as perfect as possible to compensate for the imperfections of the optical train
  - consider 'super-flats'
  - dither sub-exposures during imaging
    - an offset of a few pixel between images gives the possibility to remove cosmics and fixed patterns by using 'outlier rejection' algorithms

Reducing the effects of light pollution II

- Light pollution adds additional noise and gradients to a captured image – therefore the elimination of negative effects from other sources becomes mandatory
  - make darks to eliminate the ‘dark fixed pattern noise’ of the camera sensor
  - make flats as perfect as possible to compensate for the imperfections of the optical train
  - consider ‘super-flats’
  - dither sub-exposures during imaging
- Use SW-tools to eliminate gradients during post processing
  - GradientXTerminator – a PS-plug-in from Russell Croman
  - DBE (Dynamic Background Extractor) in PixInsight

Examples – HW + SW

- **Hardware**
  - Astrograph: ASA10N-OK3 f 3,6
  - Guiding: TMB 80/F6 + StarlighXPress Lodestar
  - Camera: FLI PL16803
  - Filter-wheel: FLI 5-7 (L,R,G,B,Ha,OIII,SII filters)
  - Mount: OTE 150 + Boxdörfer Powerflex MTS-3SDI
  - Acer Travelmate 270 (WindowsXP)

Examples – HW + SW

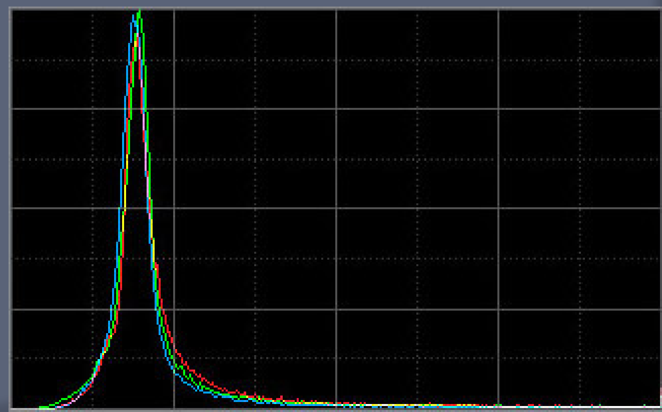
- **Software**
  - Maxim DL 5 for image acquisition
  - CCDStack 1.5 for calibration, stacking and combination
  - PixInsight 1.4 for post processing
  - PS CS2 when using GradientXTerminator

Examples – ‘True color’ narrowband imaging

- The presented method works best with objects emitting light in isolated spectral lines – e.g. emission nebulae and supernova remnants
- Use narrowband image for superior SNR
- Additional RGB image used only for ‘true’ star colors
- Choose sub-exposure times for matching star sizes (e.g. Hα, OIII – 15min, RGB – 2min)

Examples – ‘True color’ narrowband imaging

RGB



Examples – ‘True color’ narrowband imaging

Hα

Examples – 'True color' narrowband imaging

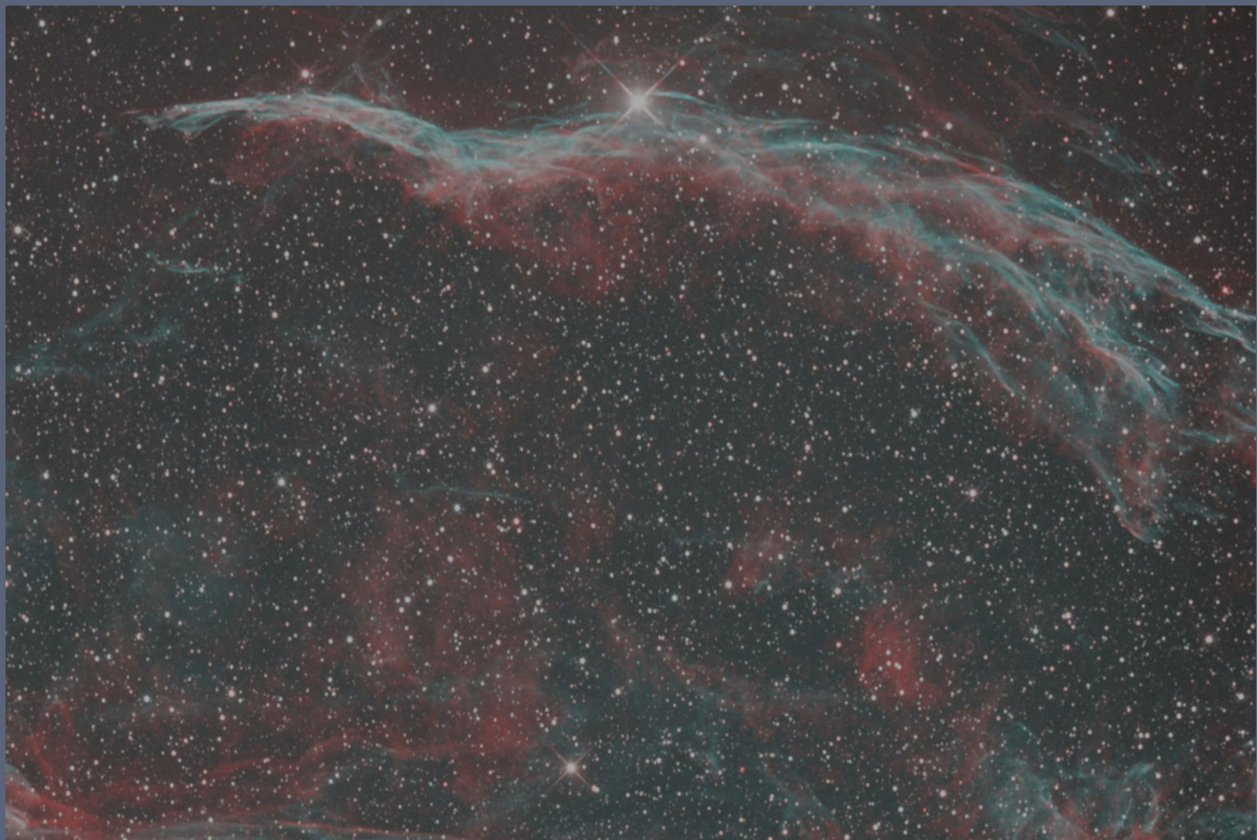
OIII

Examples – ‘True color’ narrowband imaging

$L = H\alpha + w{*}OIII$

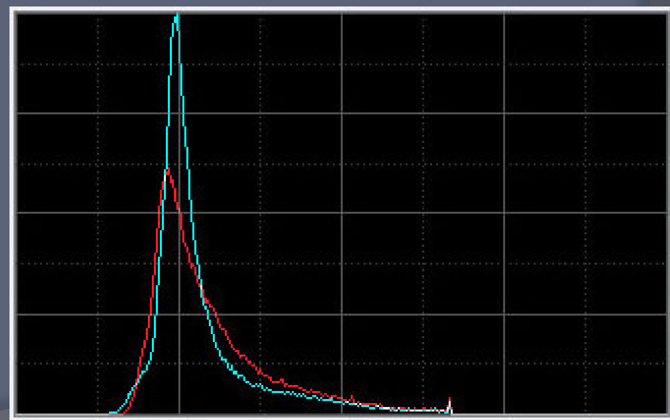
Choose w to compensate for difference in sensitivity

Examples – ‘True color’ narrowband imaging

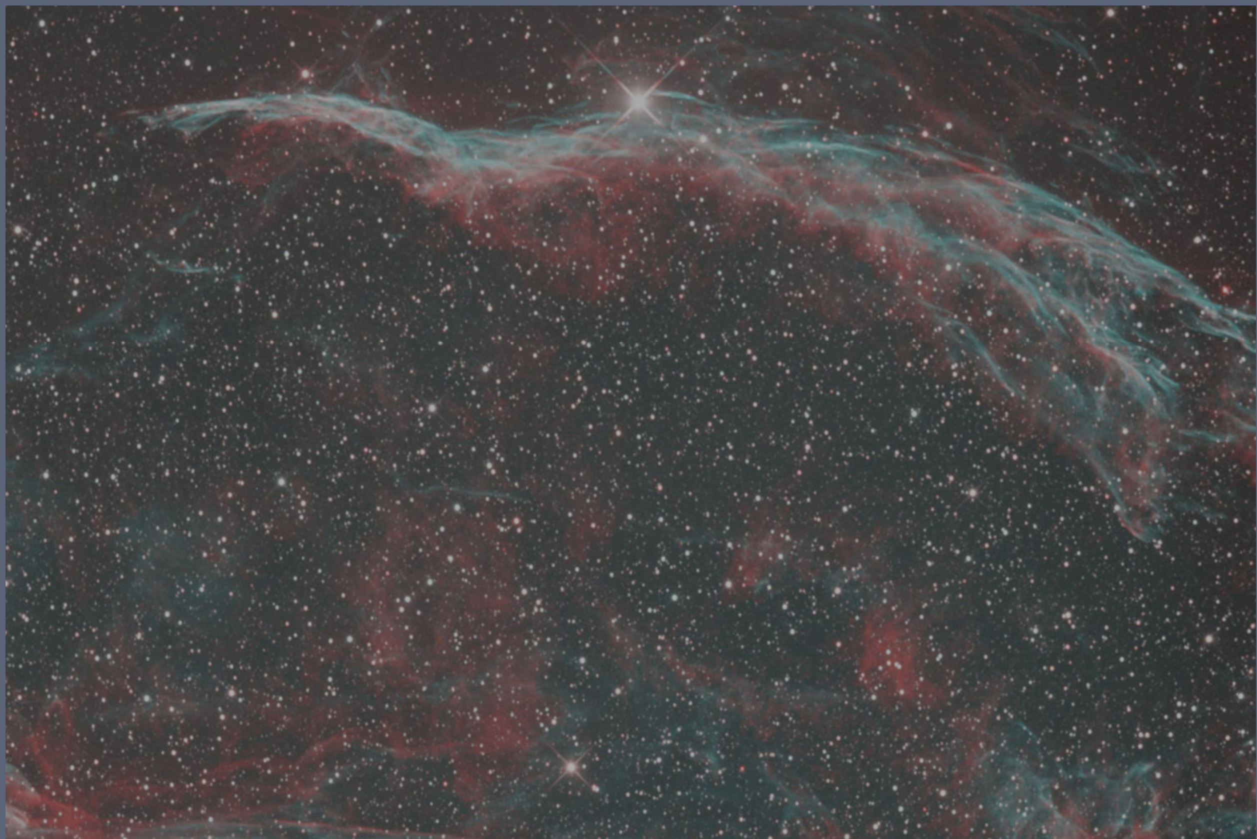


HαOIII

(R = Hα, G = B = w*OIII)



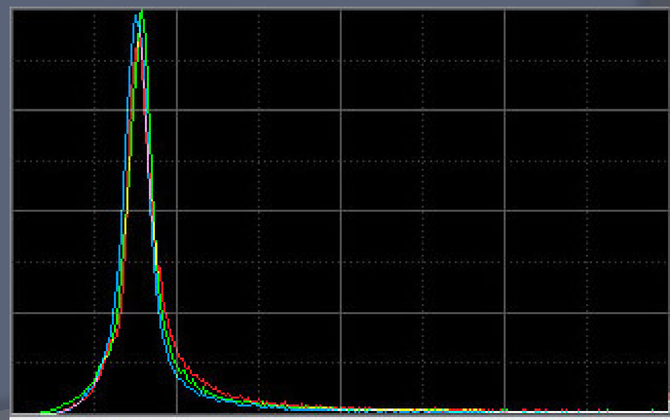
Examples – ‘True color’ narrowband imaging



HαOIII

(R = Hα, G = B = w*OIII)

RGB



Examples – ‘True color’ narrowband imaging

Max(RGB, v*HαOIII)

Choose v<1.0 so background is defined by NB-image, but stars are defined by RGB image

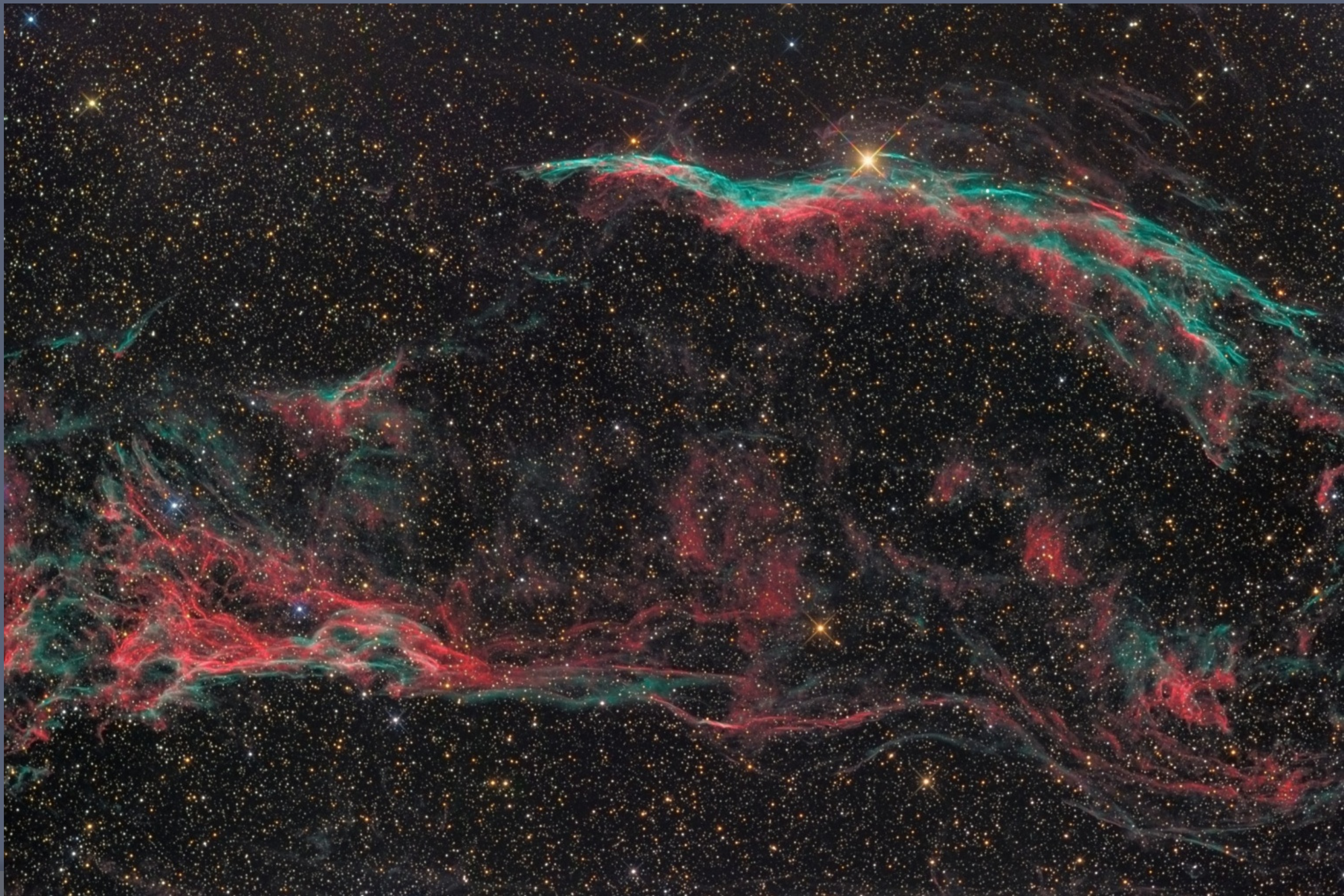
Examples – 'True color' narrowband imaging

Max(RGB, v*HαOIII)

Choose v so background is defined by NB-image, but stars are defined by RGB image

Add L and boost saturation

Examples – 'True color' narrowband imaging



NGC6960

Examples – ‘Classic’ narrowband imaging

- Capturing of the three emission lines of SII, Hα and OIII
- Especially SII and OIII can be very weak and need very long total exposure times to achieve a good SNR
- Mapping of the three emission lines to RGB
  - Hubble palette: R = SII, G = Hα, B = OIII
  - CFHT palette: R = Hα, G = OIII, B = SII
- Adjust colors for a ‘pleasant’ color rendition

Examples – 'Classic' narrowband imaging

Hα

Examples – 'Classic' narrowband imaging

OIII

Examples – 'Classic' narrowband imaging

OIII

Reduce star size

Examples – ‘Classic’ narrowband imaging

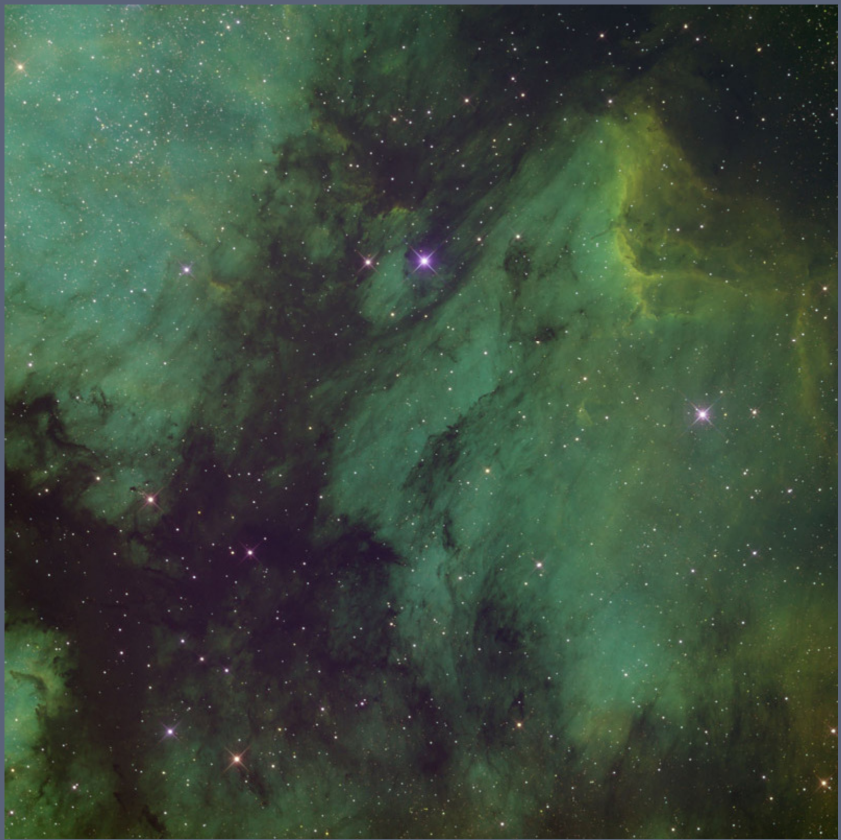
SII

Examples – ‘Classic’ narrowband imaging

SII

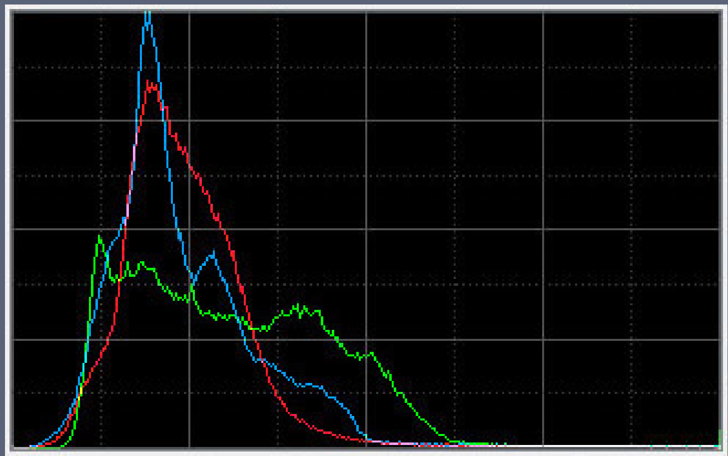
Reduce star size

Examples – ‘Classic’ narrowband imaging

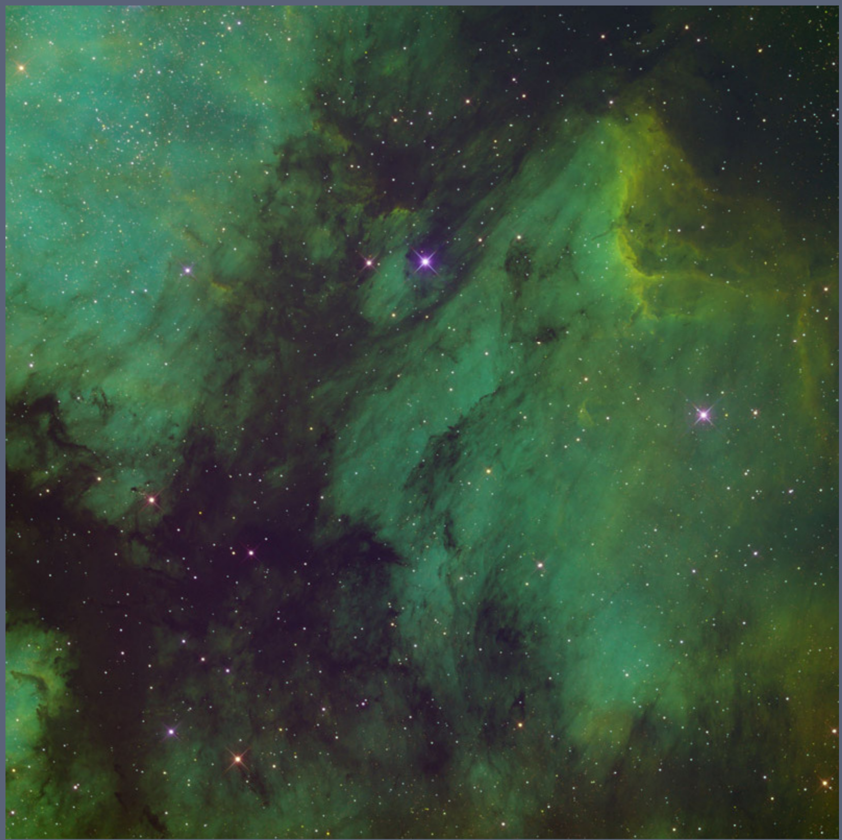


RGB

(R = SII, G = Hα, B = OIII)



Examples – 'Classic' narrowband imaging

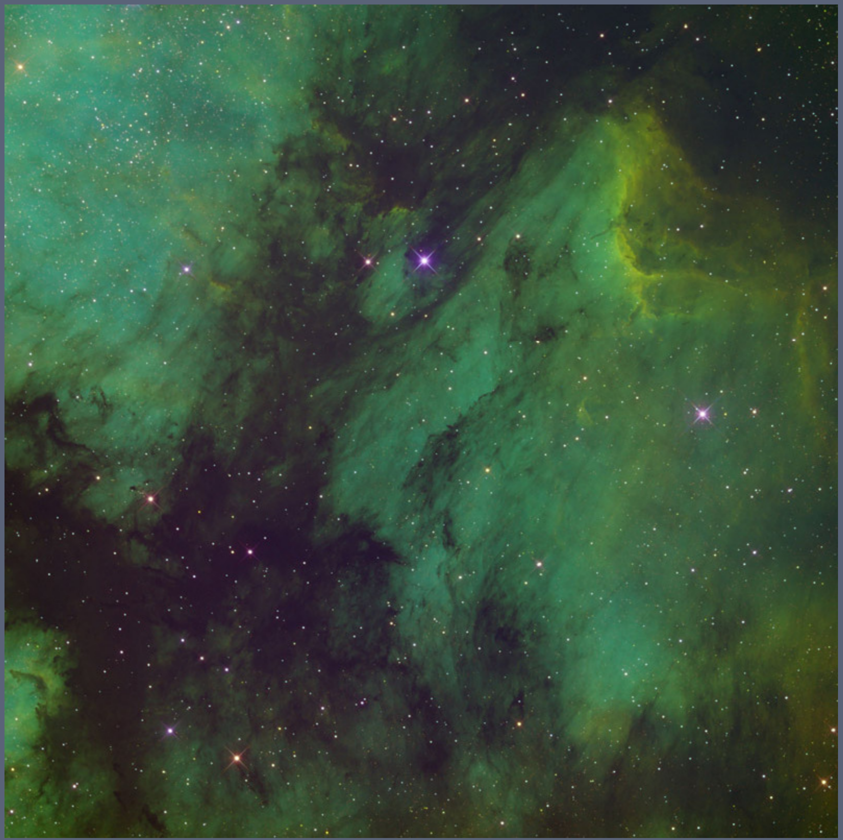


LRGB

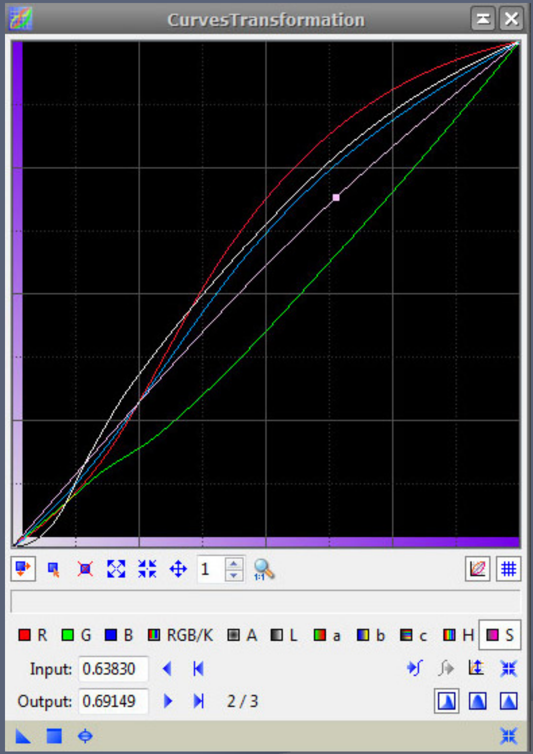
(L = Hα, R = SII, G = Hα, B = OIII)

Warning: using Hα as L is O.K. for this object, but this might not be always the case!

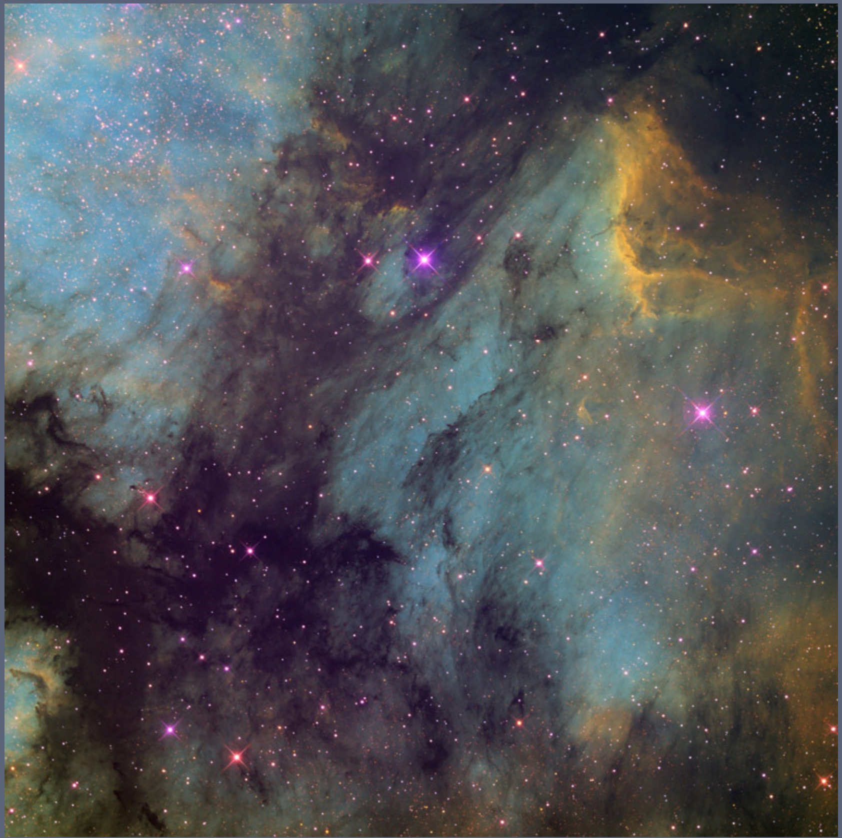
Examples – ‘Classic’ narrowband imaging



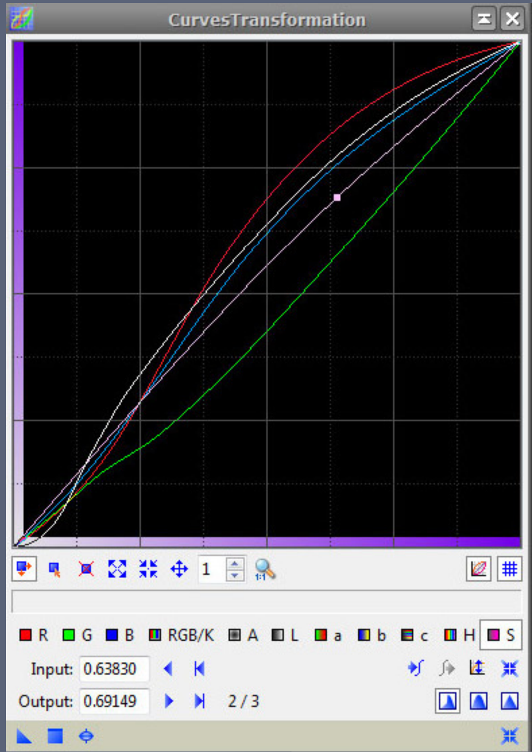
Modify color balance



Examples – 'Classic' narrowband imaging



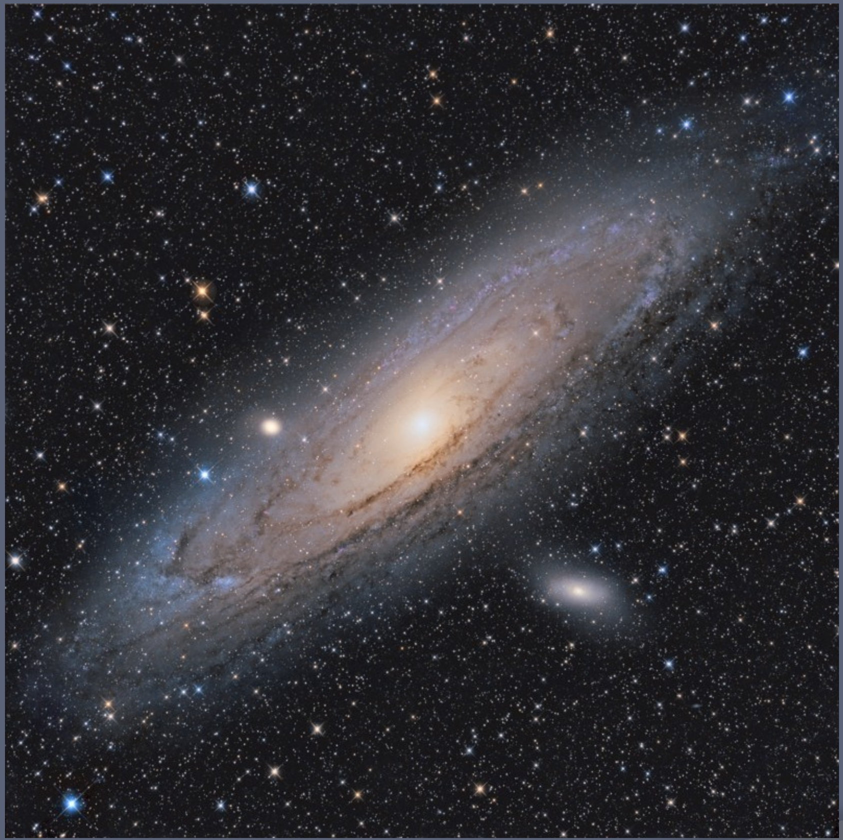
Modify color balance



Examples – 'Classic' narrowband imaging

NGC7000
+ IC5070

Examples – RGB imaging



M31

Thank you!