Narrow bandpass steep edge optical filters for the JAST/T80 telescope instrumentation

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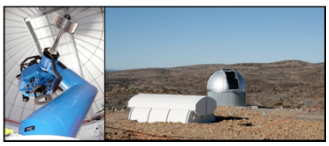
Abstract

The Observatorio Astrofisico de Javalambre (OAJ) in Spain observes with its JAST/T80 telescope galaxies in the Local Universe in a systematic study. This is accomplished with a multi-band photometric all sky survey called Javalambre Photometric Local Universe Survey (J-PLUS). A wide field camera receives the signals from universe via optical filters. In this presentation the development and design of a narrow bandpass steep edge filter with wide suppression will be shown. The filter has a full width half maximum in the range of 13-15 nm (with <1 nm tolerance) with central wavelengths in the range 350-860nm and an average transmission larger than 90% in the passband. Signals beyond the passband (blocking range) have to be suppressed down to 250nm and up to 1050nm (spectral regime), where a blocking of OD 5 (transmission < 10-5) is required. The edges have to be steep for a small transition width from 5% to 80%. The spectral requirements result in a large number of layers which are deposited with magnetron sputtering. The transmitted wavefront error of the optical filter must be less than lambda/2 over the 100mm aperture and the central wavelength uniformity must be better than +/- 0.4% over the clear aperture. The filter consists of optical filter glass and a coated substrate in order to reach the spectral requirements. The substrate is coated with more than 120 layers. The total filter thickness was specified to be 8.0mm. The steep edge narrow bandpass filter Hα fulfills all these demanding requirements.

OAJ Project and JAST/T80 Telescope

- OAJ = Observatorio Astrofisico de Javalambre (OAJ) in Spain observes with its JAST/T80 telescope galaxies in the Local Universe in a systematic study
- JAST/T80 will be equipped with a wide field imager designed to exploit the telescope survey capabilities, the T80Cam. The JAST/T80 and T80Cam primary goal is to perform the photometric calibration of the JST/T250 surveys , by means of the Javalambre-Photometric Local Universe Survey (J-PLUS)

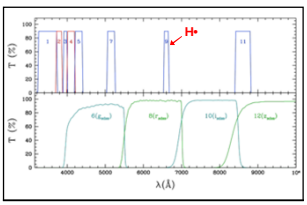
OAJ Project Development as for June 2013, Javalambre mountains (Teruel, Spain)



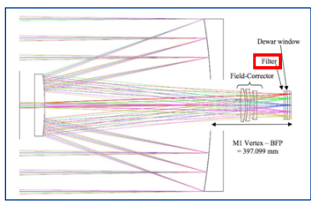
JAST/T80 Telescope: 83cm diameter, 2deg Field of View (left)
Enclosure building of the JAST/T80 telescope (right)

T80Cam wide field imager and its optical filters

- The whole system including the filters and the instrument dewar window, has been optimized to provide a polychromatic image quality better than 4.0 microns (EE50 radius) inside the 13 cm diameter focal plane



J-PLUS filters definition



JAST/T80 optical layout

Specification of the bandpass optical filters

For all filters: CWL = center wavelength, FWHM = full width at half maximum width

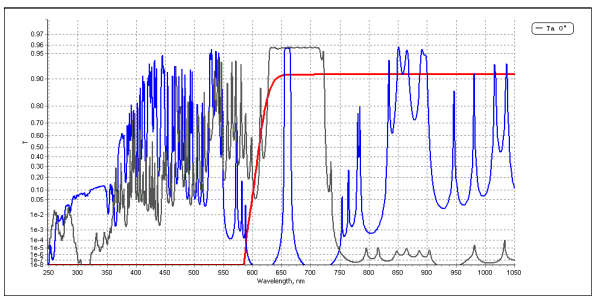
- Dimensions 106.8 x 106.8 x 8.0 +/- 0,1mm
- Tmax >90% (if CWL >400nm) and >80% (if CWL <400nm)
- Tmax – uniformity over clear aperture <+/- 4%
- Passband ripple (T- variation in transmission wavelength region) <7%
- Blocking: T(250-1050nm) < 10-5 average
- Transmitted Wavefront Error: <λ/2 @ 633nm over clear aperture (locally 25x25mm <λ/8 @ 633nm
- Roughnesss < 2nm rms, parallelity < 30 arcsec

Narrow bandpass filter types specification, i.e (CWL-FWHM) 348.5-50.8nm / 378.5-16.8nm / 395-10nm / 410-20nm / 430-20nm / 515-20nm / 660-14.5nm / 861-40nm

- CWL-tolerance +/- 0,2% and CWL-Uniformity +/- 0,4%
- FWHM- tolerance +/- 1nm
- Steepness (CWL/FWHM) = 1,1-1,3 (i.e. >6 cavities of Fabry-Perot filter design)

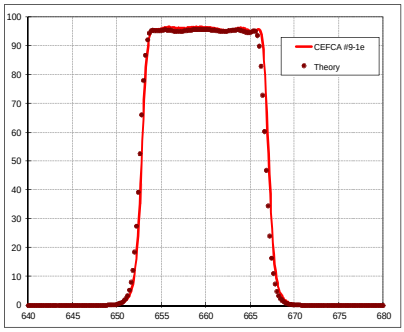
Optical Filter Design for Ha filter example

- Combination of a1. bsorbing filter glass and 2. interference filter on clear glass:
- 1st component: AR-coated longpass colorglass component (e.g. RG610/3mm)
- 2nd component: B270 coated with Fabry-Perot-Bandpass and Blockfilter-stack

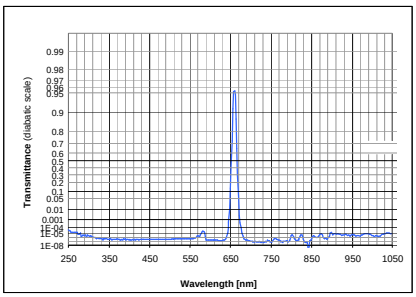


Measurements and achievments of manufactured Ha filter

- Center wavelength (measured): 659.97nm - theory: 659.66nm
- FWHM (measured: 14.36nm - theory: 14.50nm
- Tmax (measured): 96.6% - theory: Tmax > 90%
- Max. deviation from CWL in center of piece is +0,32%
- Blocking with average T < 10^{-5} (measured)



Theory (design) and measurement results of the manufactured Hα steep edge narrow bandpass filter



Measurement results of the blocking region (Hα-filter) measured with a Cary 500

Summary and next steps

- Hα -Filter: narrow bandpass steep edge filter was designed and manufactured
- Center wavelength = 659.97nm, FWHM = 14.38mm , T_{max} = 96.6%
- Center wavelength uniformity (100mm x 100mm) • than 0.16%
- Average blocking (250nm to 1050nm): OD5
- Transmitted wavefront rms error = 0.07 λ @ 660nm
- à The manufactured Hα -Filter exceeds the specification

NEXT STEPS:

- Integrate the Hα-Filter and the additional 11 filters into instrumentation
- Test the filters during operation at **Observatorio Astrofisico de Javalambre** with its telescope in a multi-band photometric all sky survey (Javalambre Photometric Local Universe Survey, **J-PLUS)**

References

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More information about SCHOTT optical filters could be find here:

SCHOTT glass made of ideas