Transmission profile of the Dutch Open Telescope Hα Lyot filter

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Abstract: The poster summarizes facts about the transmission profile of the Dutch Open Telescope (DOT) Hα Lyot filter pointing to a discrepancy between Gaussian-like profile measured spectroscopically and signatures of possible leakage of parasitic continuum light in DOT Hα images. To reconcile it, a method for indirect testing of filter transmission profiles is suggested and applied. The method is based on wing-to-center intensity ratios resulting from convolution of a transmission profile with the Hα profile taken from the spectral atlas. The ratios are compared with ratios derived from observations of the quiet Sun chromosphere at disk center. We interpret discrepancies between the anticipated and observed ratios and the sharp limb visible in the DOT Hα image as an indication of possible leakage of parasitic continuum light. We suggest two theoretical transmission profiles of the DOT Hα Lyot filter which should be considered as the best available approximations allowing reliable comparing of DOT Hα images with simulated data.

Figure 1. DOT image taken at the limb on 2005 October 4 in the Hα line center. Note the sharp limb shining clearly through the mass of spicules.

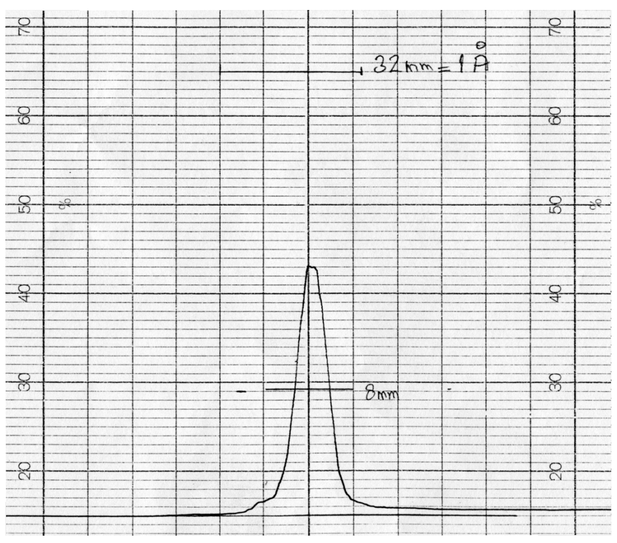

Figure 2. Scanned registration from ink recorder showing measured transmission profile of the DOT Hα Lyot filter. Filter FWHM of 250 mÅ is marked by the horizontal line. Measurement was performed in 1999 by the solar spectrograph in Sonnenborgh observatory in Utrecht.

Transmission profile of the DOT Hα Lyot filter was measured photometrically in 1999 (Fig. 2). The measurement confirmed symmetric and Gaussian-like transmission profile with FWHM = 250 mÅ without significant subsidiary maxima or far-center sidelobes ruling out a leakage of parasitic light. It also confirmed invariance of the profile in tuning. On the contrary, Rutten (2013) admits presence of parasitic continuum light in DOT Hα images pointing to the sharp limb in Fig. 1. We performed a quantitative indirect testing of the transmission of the DOT Hα filter represented by the Gaussian with FWHM = 250 mÅ (Fig. 2) and a square of normalized sinc function (from Latin *sinus cardinalis*) having the form

$$sin\,c^2(\Delta\lambda) = \left(\frac{sin\,\pi x}{\pi x}\right)^2 .$$

First, we perform a simple check whether these theoretical transmission profiles are compatible with observations. To this purpose, we have chosen the Hα observation of very quiet area at the disk center available in the DOT database taken on 2005 October 19 at the Hα line center and at ±0.35 and ±0.7 Å off the center (Fig. 3). We computed the spatio-temporal mean of each datacube at the employed wavelength positions of the filter and the ratios as defined in Column 1 of Table 1. Column 2 shows observed ratios and Columns 3 and 5 show anticipated ratios for the Hα profile extracted from the spectral atlas and convolved with the Gaussian and $sinc^2$ function. Apparently, these models of the transmission profile yield ratios significantly exceeding the observed ones. It suggests in contradiction with the result of measurement in 1999 that the real transmission profile of the DOT Hα filter might have larger throughput than these models and lets in some parasitic continuum light contaminating mainly the core and thus decreasing the observed ratios compared to the anticipated ones. Then the additional continuum light in limb images taken in the Hα center increases significantly the limb contrast with respect to offlimb emission structures (Fig. 1) shining on the background of scattered continuum light. To account for the missing parasitic light, we constructed two models combining the Gaussian and $sinc^2$ function with two ad hoc rectangle functions Λ and Π (Fig. 4) centered at Δλ = ±2 Å around the Hα line center. The areas of rectangles were found by a trial and error (Columns 4 and 6 of Table 1) to match the observed ratios. Parameters of a single rectangle are summarized in Table 2. These extensions of Gaussian and Eq. (1), referred as Gauss+Λ and $sinc^2$+Π, represent new theoretical transmission profiles of the DOT Hα Lyot filter accounting for the sharp limb in Fig. 1 and reconciling discrepancies between anticipated and observed intensity ratios in Table 1.

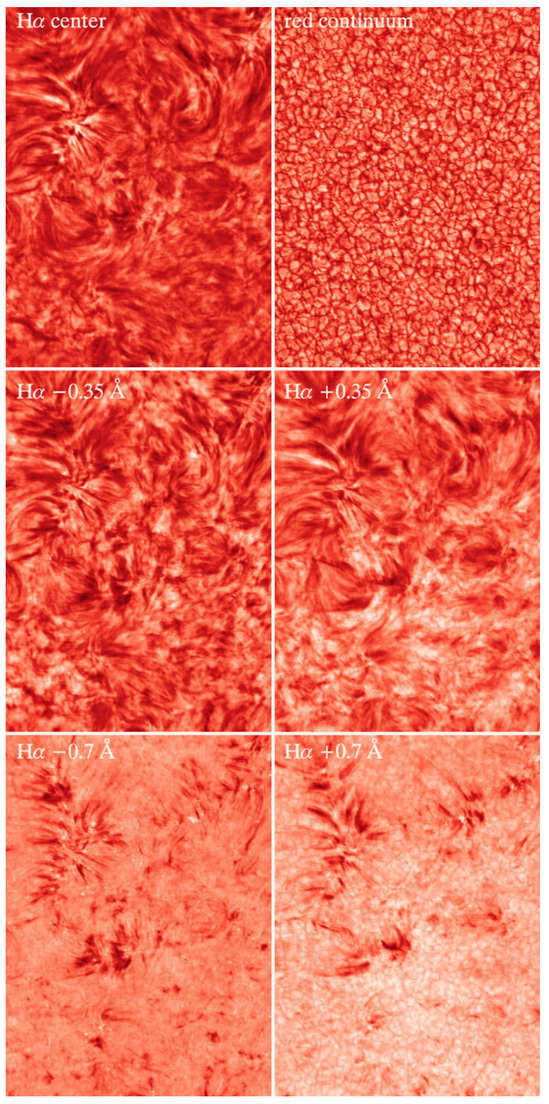

Figure 3. Hα and continuum images of the quiet Sun at the disk center taken by DOT on 2005 October 19.

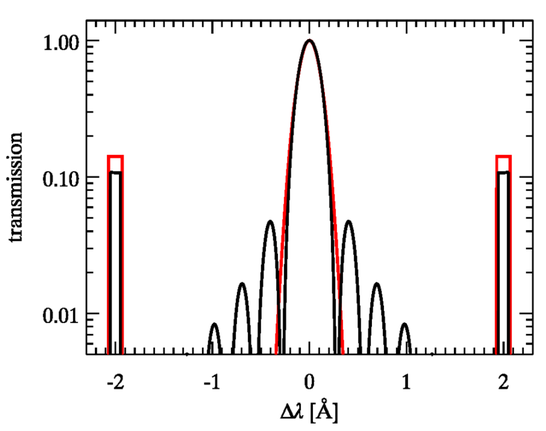

Figure 4. The theoretical transmission profiles of the DOT Hα Lyot filter in the logarithmic scale: Gaussian+Λ (**red**) and $sinc^2$+Π (**black**), both with FWHM = 250 mÅ.

Table 2. Rectangle parameters in Fig. 4.

Rectangle	Area (mÅ)	Width (mÅ)	Height
Λ	20.0	141	0.141
Π	11.5	107	0.107

Table 1. Column 1: ratios of convolved intensities E(Δλ). Column 2: observed ratios of spatio-temporal means of DOT Hα datacubes obtained in the quiet Sun (Fig. 3). Columns 3–6: anticipated ratios computed by the atlas Hα profile and the particular transmission profile with FWHM = 250 mÅ centered at Δλ = 0, ±0.35, and ±0.7 Å from the center of the atlas profile. The symbols Λ and Π represent two rectangle add-ons of the Gaussian and $sinc^2$ function, respectively.

Ratio	DOT Hα Observation	Atlas Hα Profile + Transmission Profile:			
	2005 Oct 19	Gauss	Gauss + Λ	$sinc^2$	$sinc^2$ + Π
⟨E(±0.7)⟩ / E(0)	2.32	3.28	2.35	2.78	2.35
⟨E(±0.7)⟩ / ⟨E(±0.35)⟩	1.75	2.10	1.77	1.94	1.76
⟨E(±0.35)⟩ / E(0)	1.33	1.56	1.33	1.43	1.34

References

Rutten, R. J. 2013: Astronomical Society of the Pacific Conference Series, Vol. 470, p. 49

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