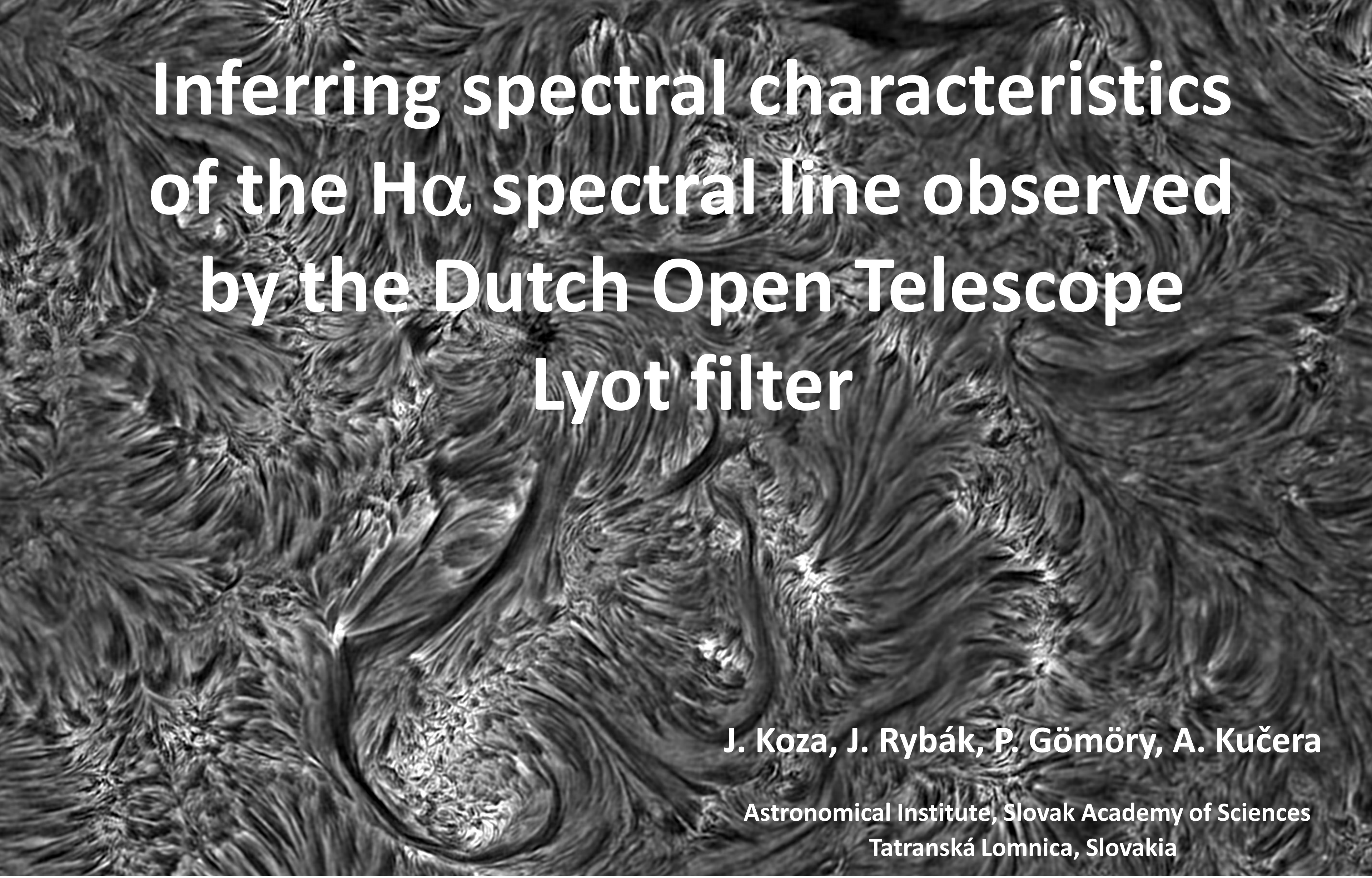

Inferring spectral characteristics of the Hα spectral line observed by the Dutch Open Telescope Lyot filter

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DUTCH OPEN TELESCOPE

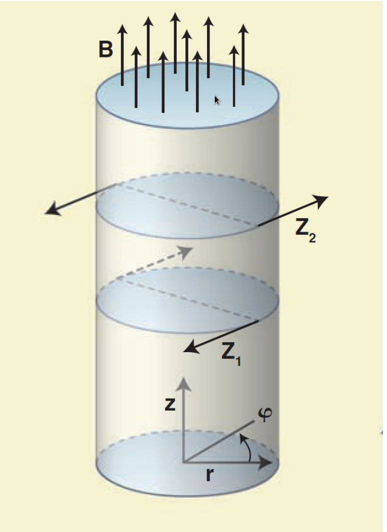
22. celoštátny slnečný seminár
Nižná nad Oravou, 26. - 30. jún 2014

SKALNATÉ PLESO

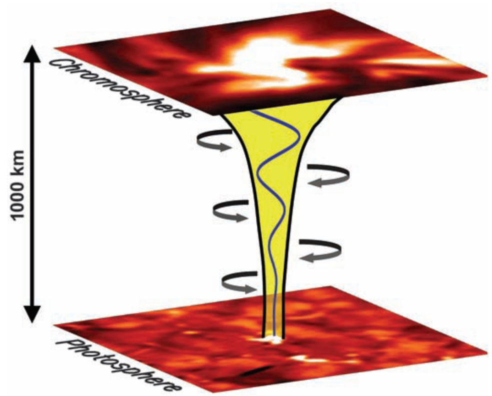
Alfvén waves

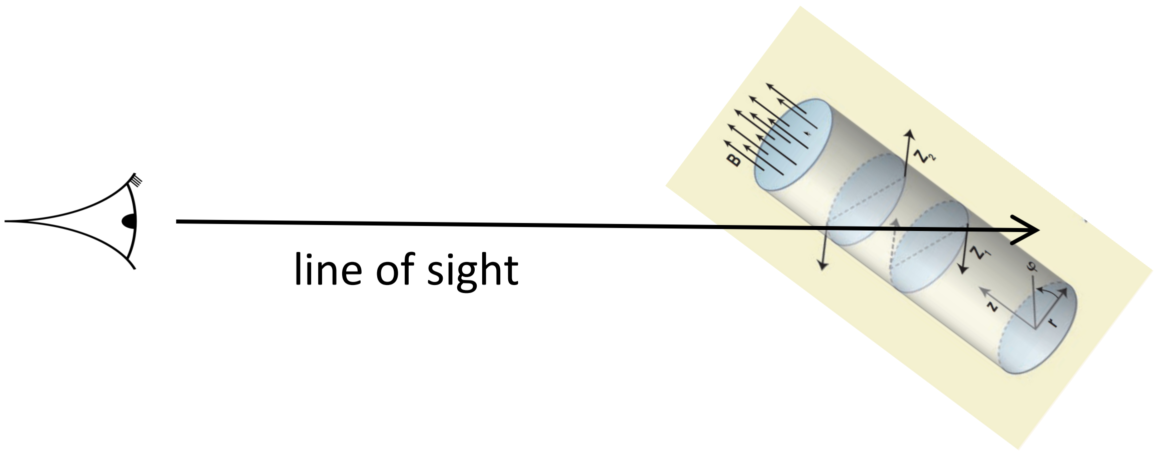
- possible transporters of magneto-convective energy for coronal heating

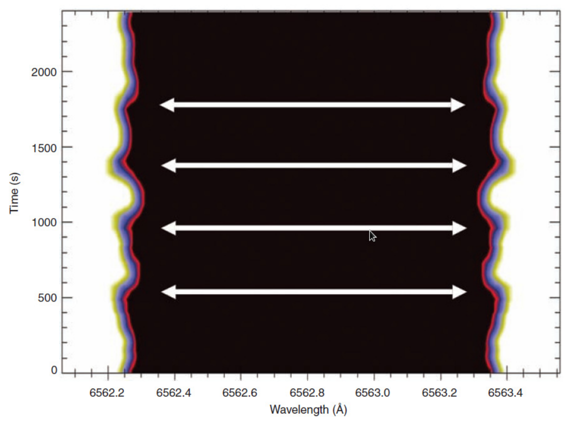
  [Tomczyk et al. 2007: Science 317, 1192](#)
  [De Pontieu et al. 2007: Science 318, 1574](#)
  [Jess et al. 2009: Science 323, 1582](#)
  [Antolin & Shibata 2010: ApJ 712, 494](#)
  [McIntosh et al. 2011: Nature 475, 477](#)



- pure magnetic waves
- magnetic tension as the restoring force
- incompressible transverse oscillations of magnetized plasma propagating along field lines
- detectable as periodic variations of non-thermal broadening (line width) of a spectral line



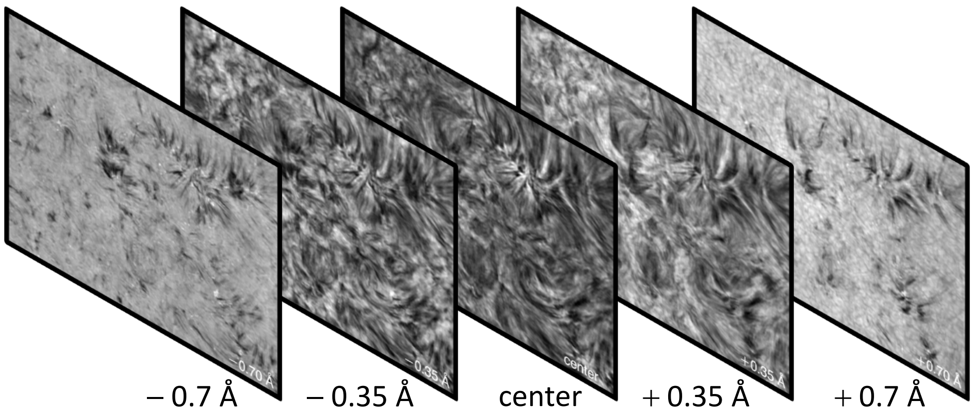




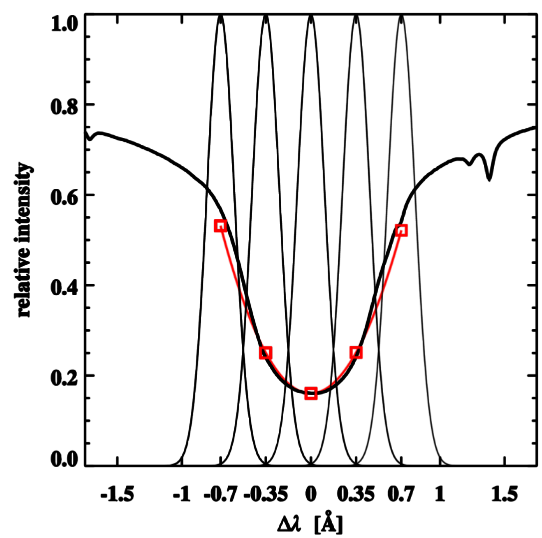
Search for Alfvén waves by Hα imagery of the Dutch Open Telescope (DOT)

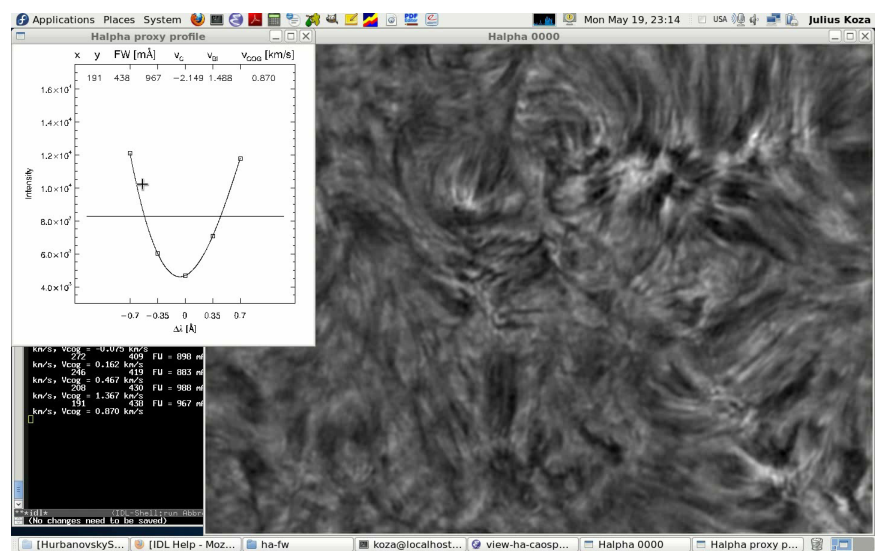
Koza et al. 2012: „Search for Alfvén waves and shocks in the chromospheric network, I. Temporal evolution of spectral characteristics" 21. celoštátny slnečný seminár, Stará Turá, 2012

Koza et al. 2013: „Search for Alfvén waves in a bright network element observed in Hα", CAOSP 43/1, 5



- 4^{th}-order polynomial fit of five Hα profile samples
- inferred spectral characteristics:
  - Doppler velocity of fit minimum v_C
  - Intensity of fit minimum I_C
  - fit width FW
  - fit asymmetry:
    - bisector velocity v_{BI}
    - center-of-gravity velocity v_{COG}





Examples of inferred spectral characteristics

source data: a sequence of 71 speckle-reconstructed Hα images taken by DOT in the quiet Sun at the disk center on October 19, 2005 at $\pm$ 0.7, $\pm$ 0.35, and 0 Å

time resolution: 1 min

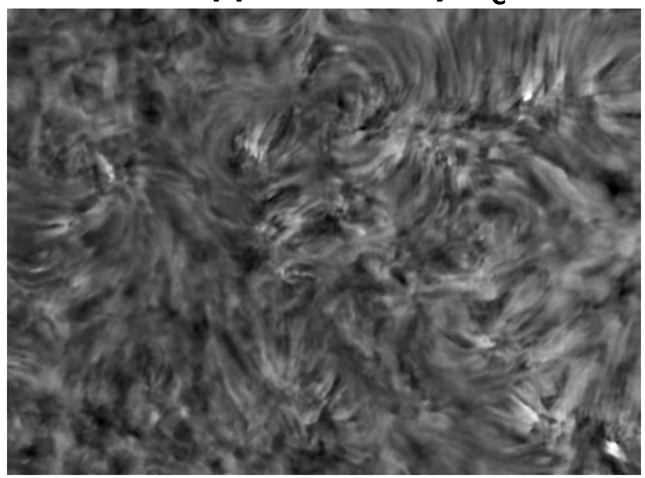
field of view: 79 arcsec $\times$ 58 arcsec

convention:

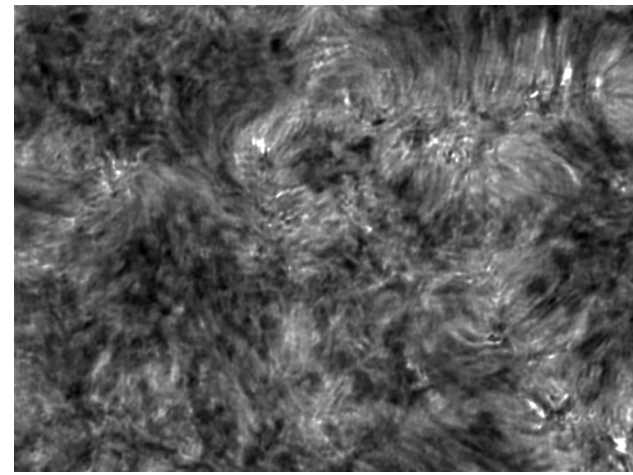
dark = blueshift = negative v_C

bright = redshift = positive v_C

Doppler velocity v_C



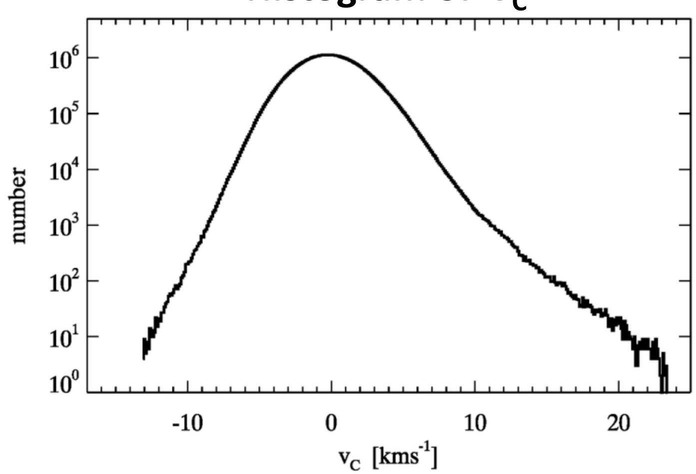
Fit width *FW*



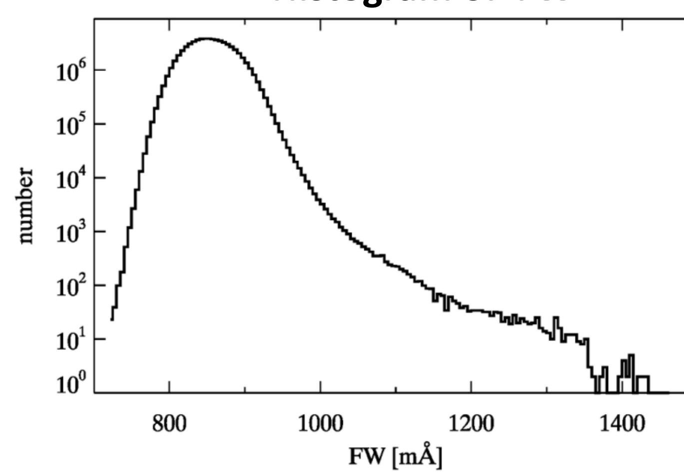
some results:

- an occurence of highly redshifted profiles with v_C > 15 kms^{-1}
- a long tail of broad profiles with *FW* > 1000 mÅ

Histogram of v_C



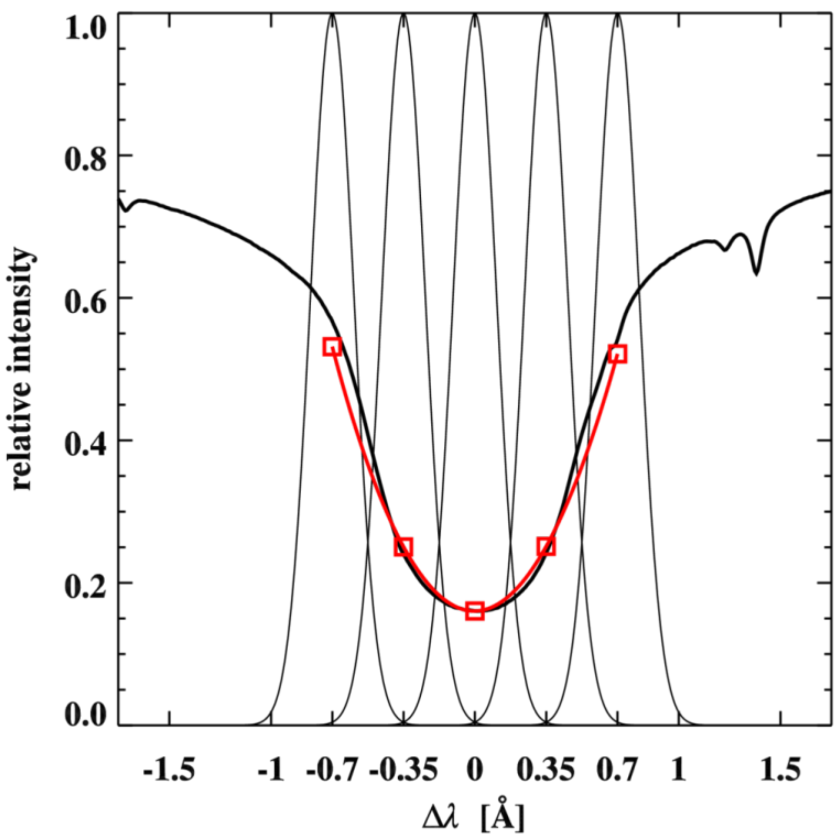
Histogram of *FW*



Motivation

low spectral resolution + curve fitting $\Rightarrow$ alternation of “true” spectral characteristics

A question of an accuracy of inferred spectral characteristics v_C I_C FW ... .



Aims

to estimate deviations of:

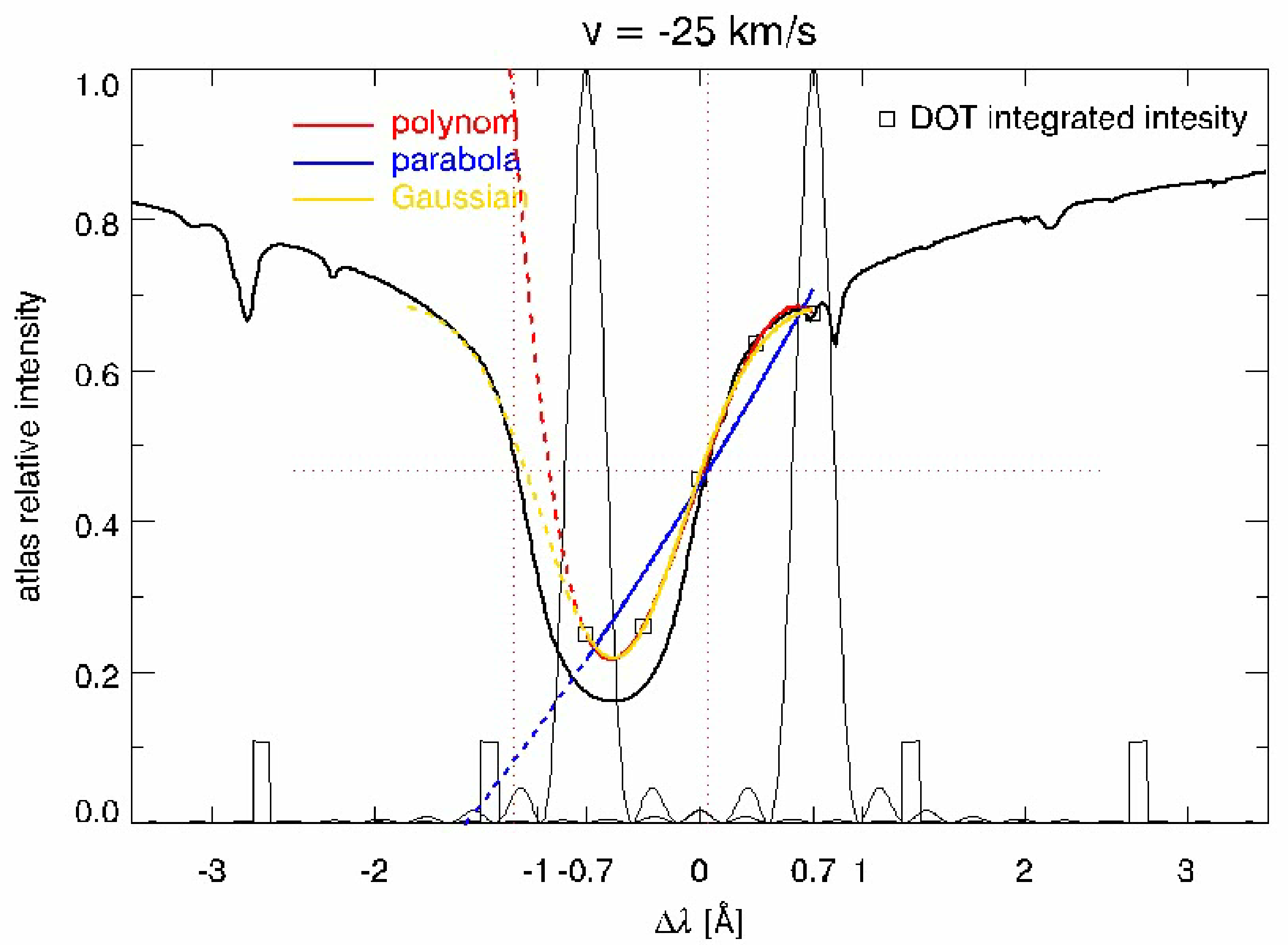
- Doppler velocity v_C
- core intensity I_C
- core width FW
- core asymmetry v_{BI} v_{COG}

of the Hα spectral line observed by the DOT Hα Lyot filter derived using:

- 4th-order-polynomial fit
- Gaussian fit
- parabolic fit

Procedure

- the reference Hα profile
  - taken from the disk-center spectral atlas
  - the source of the reference values of v_C I_C FW ...
  - shifted using Doppler velocities in the interval ±25 kms^{-1} with a step of 1 kms^{-1}
- the "alternated" spectral characteristics derived from the shifted Hα profile
- deviations: differences of the reference and alternated spectral characteristics



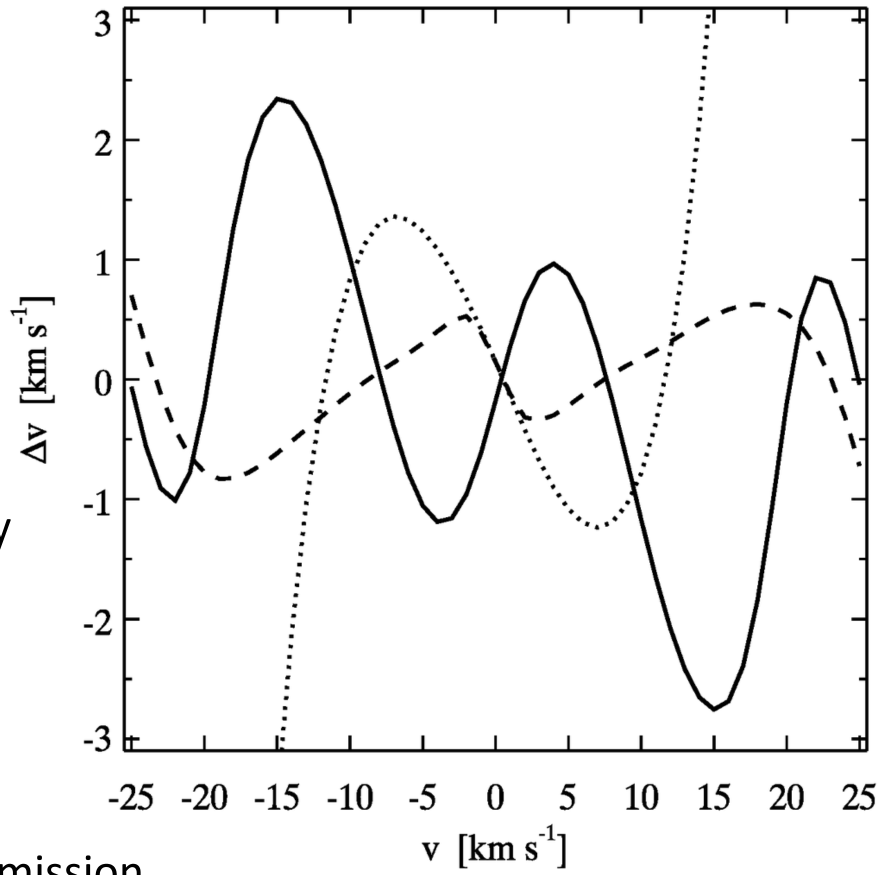
Results - deviations of Doppler velocity Δv

Fitting curve

4th-order polynomial ————

Gaussian - - - - - -

parabola ....



Δv absolute deviation of Doppler velocity

Δv = measured - reference

Deviations in general:

– **insensitive** to the shape of the filter transmission

– depend **non-linearly** on the Doppler shift, therefore they do not cancel out if the spectral characteristics are represented by their relative variations

Gaussian fit: the most preferable choice, deviations less than 1 kms^{-1}

4th-order polynomial fit: considerably variable deviations in the range ±2.5 kms^{-1}

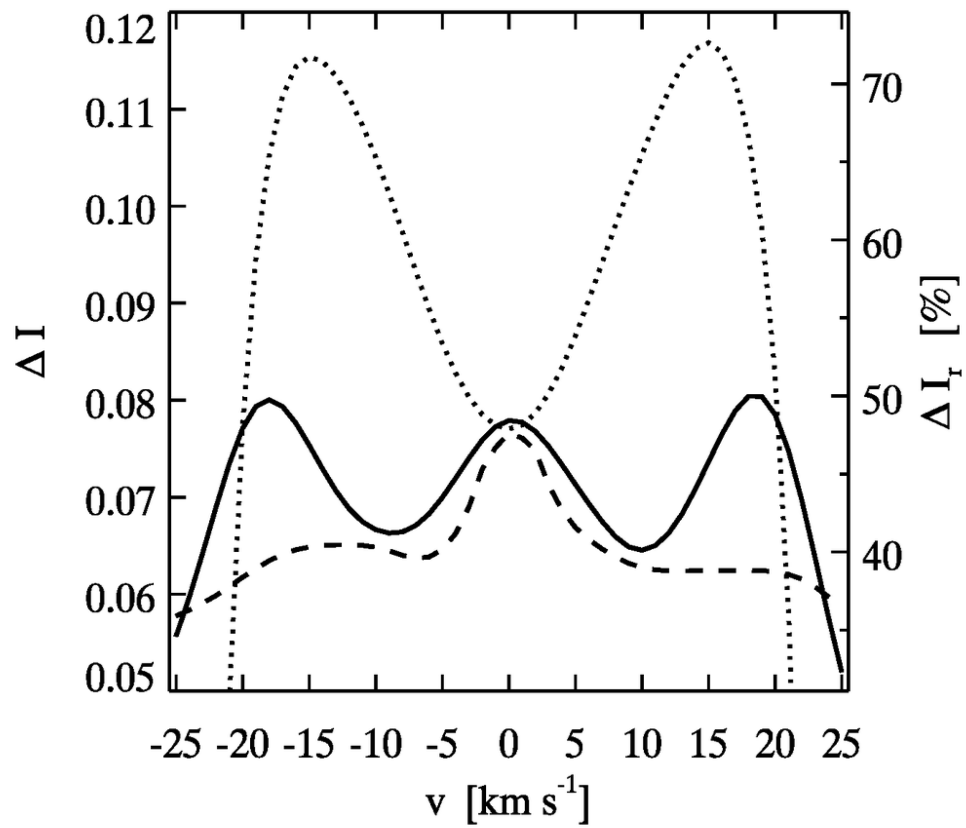
Results - deviations of core intensity ΔI

Fitting curve

4th-order polynomial ————

Gaussian – – – – – –

parabola ……………



ΔI absolute deviation of core intensity

ΔI = measured - reference

$$E(\lambda) = \int_{0}^{\infty} I(x)\,T(x-\lambda)\,dx$$

- all fitting curves overestimate the core intensity I_C due to the integration over the area-normalised filter transmission profile T
- the 4th-order-polynomial fit overestimates I_C with the sinus-like relative deviation varying from 40 to 50%

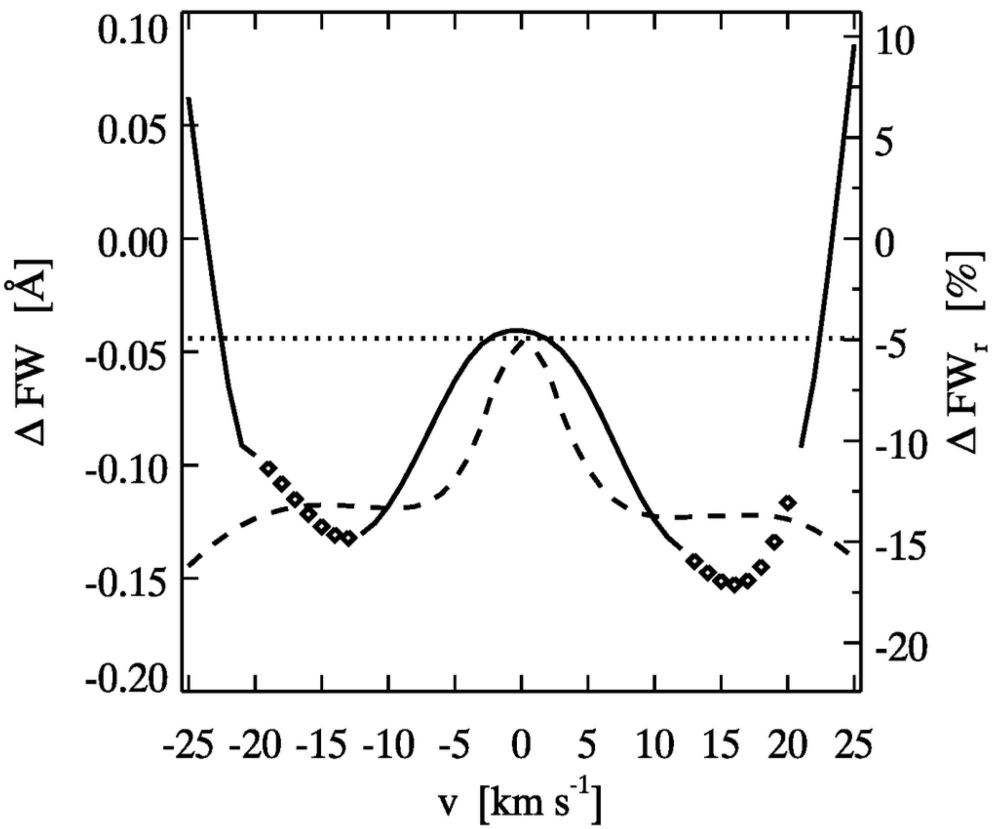
Results - deviations of fit width ΔFW

Fitting curve

4th-order polynomial ———

Gaussian – – – – –

parabola ··········



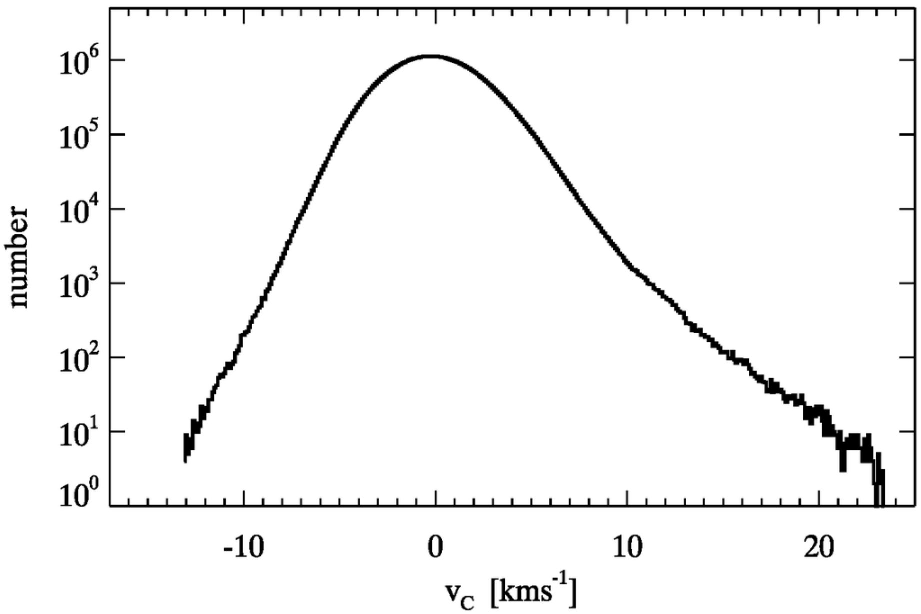
ΔFW absolute deviation of fit width
ΔFW = measured - reference

– all fitting curves underestimate *FW*

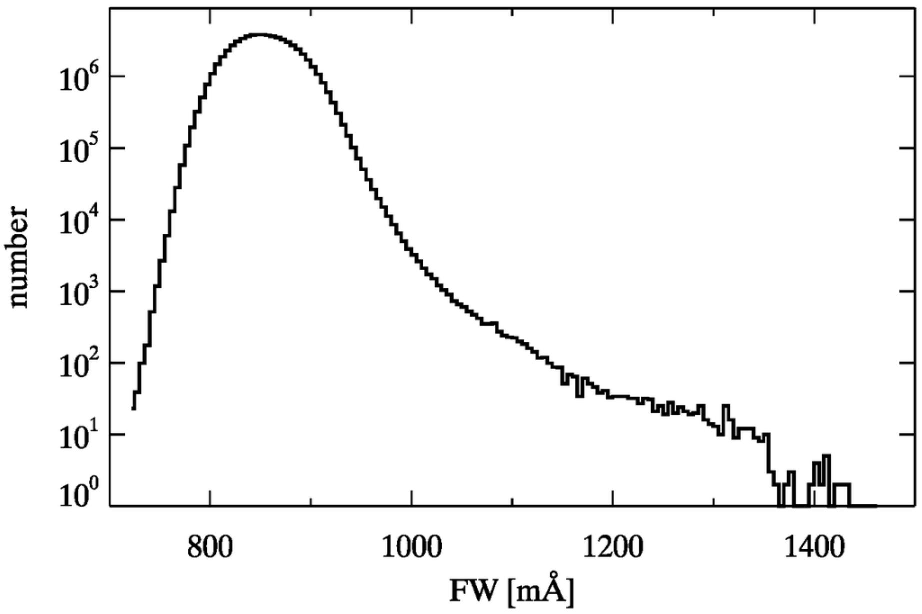
– the 4th-order-polynomial fit underestimates *FW* with relative deviations varying from 5 to 15%

Application of corrections

Histogram of v_C in log scale



Histogram of *FW* in log scale



Application of corrections

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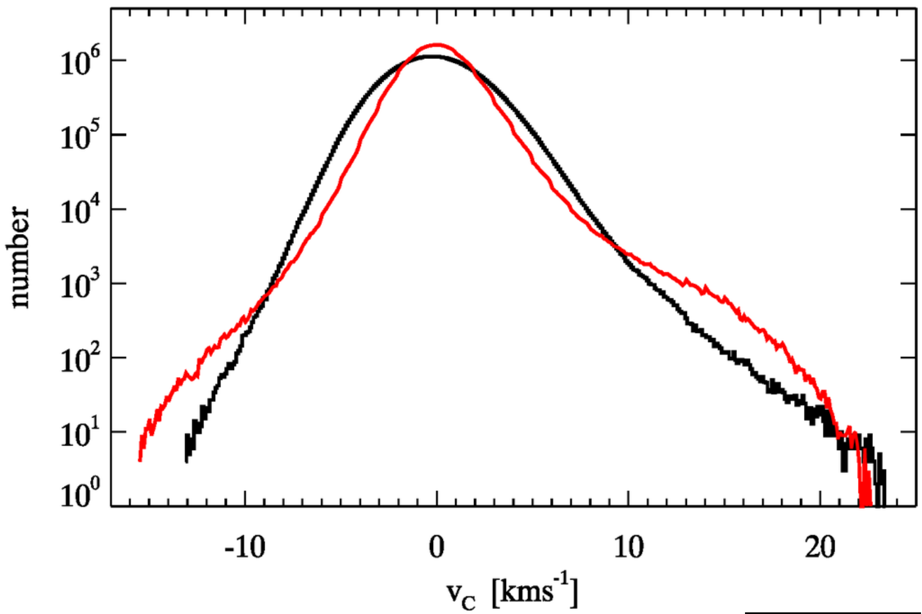
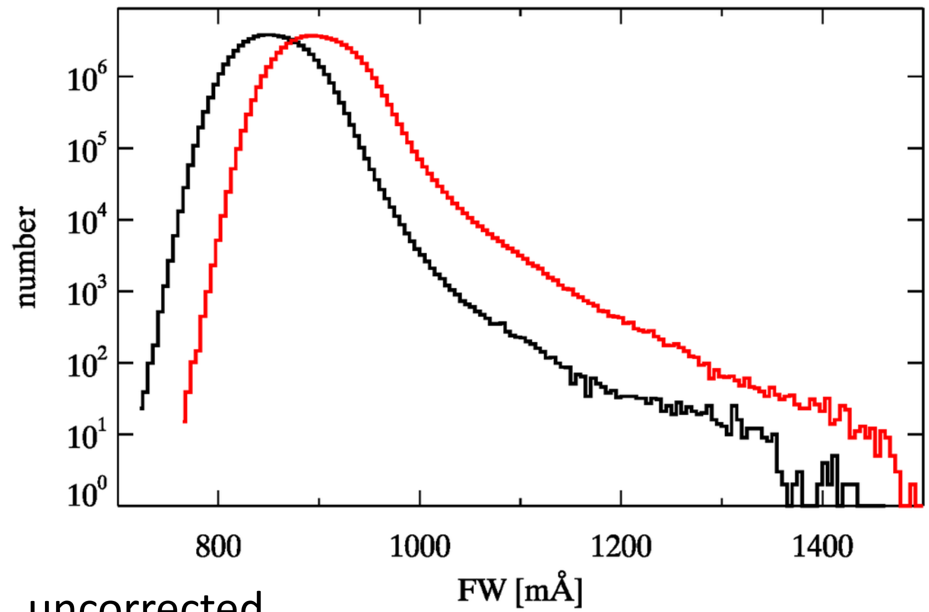


Histogram of *FW* in log scale



uncorrected

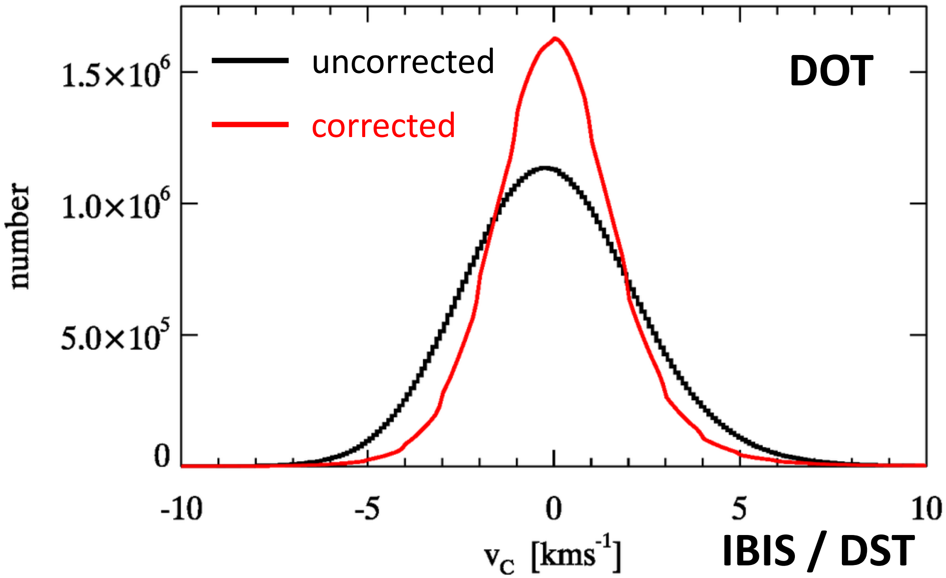
corrected

- corrections **narrow** the distribution in the range ±8 kms^{-1} **decreasing** the original v_C
- out of it, corrections **broaden** the distribution **increasing** the original v_C

- corrections shift the distribution towards larger fit widths *FW*
- peak of original distr. at 850 mÅ
- peak of corrected distr. at 900 mÅ

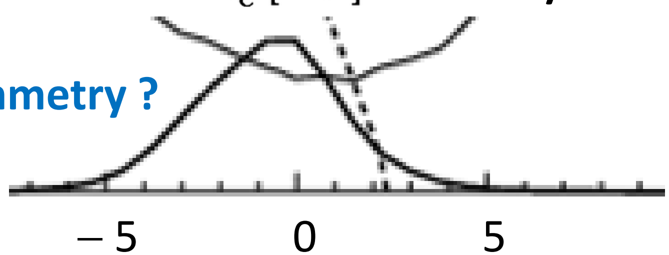
Comparison

Histogram of v_C in linear scale



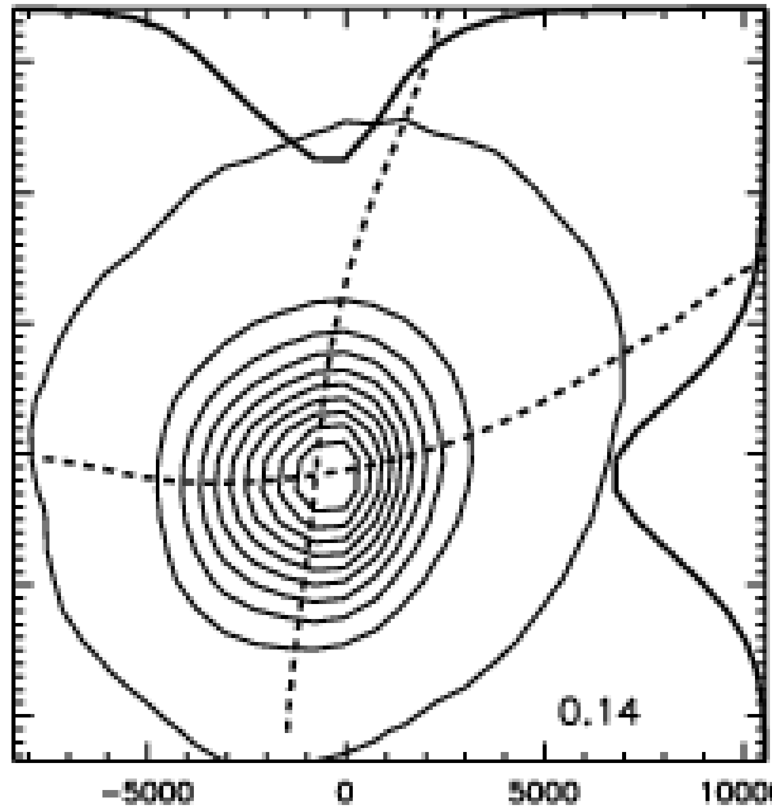
IBIS / DST

Blue asymmetry ?



Hα Dopplershift [km/s]

Hα Dopplershift from IBIS / DST



Hα Dopplershift [m/s]

[Cauzzi et al. 2009: A&A 503, 577]

DOT: 45-cm mirror
No Adaptive Optics
5 profile samples of Hα

DST: 76-cm entrance window of telescope
Adaptive Optics
22 profile samples of Hα

Brief summary

- method of inferring and correcting of spectral characteristics of the Hα line observed by the DOT Lyot filter was developed

- deviations of characteristics:
  - are insensitive to the shape of the filter transmission
  - depend mostly non-linearly on the Doppler shift, therefore

they do not cancel out if the characteristics are represented by their relative variations.

- the 4th-order polynomial is an acceptable fitting curve in terms of deviations. It allows estimating an asymmetry of profiles.

Koza et al. 2014: CAOSP 44, 43

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Outlooks

- repeating of the study but with reference Hα profiles taken by THEMIS or IBIS/DST, or VTT with high spatial and spectral resolution

- creating an extensive database of corrections for spectral characteristics derived from DOT Hα observations