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Enhancing the spatial resolution of IBIS spectrograms via Multi-Frame Blind Deconvolution

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Abstract. We compare the spatial resolution between observed and restored spectrographs of the solar photosphere, acquired with IBIS (Interferometric BIdimensional Spectrometer) currently feeded by the HOAO (High-Order Adaptive Optics) channel of the DST (Dunn Solar Telescope). The observations consist of 3×120 sequences, containing a 25 images scan of the NiI 676.8 nm line, a 15 images scan of the FeI 709.0 nm line and a 13 images scan of the CaI 854.2 nm line. For each spectral image a broadband (661± 5 nm) and a G-band (430.5 ± 1 nm) counterpart were acquired simultaneously. The images were successively restored via the MFBD (Multi-Frame Blind Deconvolution) procedure to achieve near diffraction limit resolution in the whole FOV for the whole dataset duration.

Key words. Sun: photosphere – Instrumentation: interferometers, spectrographs – Techniques: image processing

1. Introduction

The data have been acquired with the IBIS (Interferometric BIdimensional Spectrometer) 2-D spectrometer (Cavallini 2006) on November 17th, 2007, imaging the active region NOAA 10974 at [11.0N, 16.1W], [12.5N, 18.9W] and [11.5N, 18.4W]. The dataset consists of 3x120 sequences, containing a 25 point scan of the NiI 676.9 nm line, a 15 point scan of the FeI 709.0 nm line, a 13 point scan of the CaII 854.2 line. The wavelength distance in-between the spectral points for NiI line is 25.0 mÅ, for FeI line is 30.0 mÅ, for CaII line is 50.0 mÅ, except for the two outermost spectral points (which were at 400 mÅ from the line core position). The exposure time for each narrow-band (NB) image was set to 80 ms and each spectral scan took 30 seconds to complete, thus setting the time resolution. The pixel scale of these 1024×1024 pixel images was set at 0.085 arcsec/pixel. For each spectral image a White Light (WL) and a G-Band counterpart, approximately imaging the same FOV, have been acquired. The pixel scale of the 1024×1024 pixel WL (CCD2) image (661± 5 nm) was set at 0.085 arcsec/pixel and the acquisition time was 80 ms (shared shutter with IBIS spectral images). The pixel scale of the 1024×1024 pixel G-band (CCD3) image

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(430.5 ± 0.5 nm) was set at 0.041 arcsec/pixel and the integration time was 80 ms. We also employed a dummy camera (CCD4) to record the telescope parameters in the image header every 15 seconds.

Fig. 1. Spectrographs from the dataset, acquired in the cores of 676.9 nm, 709.0 nm, 854.2 nm (from left to right) lines.

2. Data reduction

The calibration procedure consists in the main following steps: 1) Create mean dark and flat for WL channel. 2) Determine alignment parameters between NB and WL channel. 3) Create mean dark, mean flat field, blueshift map for NB observations. 4) Select WL images selection and apply MFBD restoring (van Noort et al. 2006). 5) Apply destretching procedure on WL images. 6) Reconstruct NB images by re-scaling, rotating, shifting and destretching

3. Data analysis

MFBD restoration improves spatial resolution and reduces inhomogeneities of dataset due to seeing variations. Figure 2 (top) shows for instance spatial resolution for the whole sample of WL images before and after application of MFBD.

LOS velocity fields have been computed from Doppler shifts in the three lines.

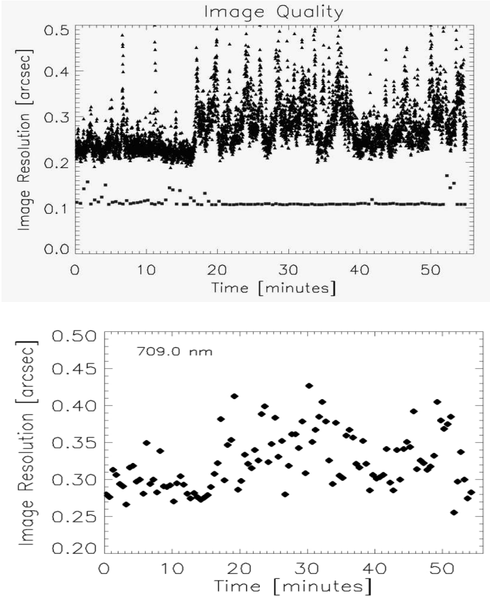

Fig. 2. Top: spatial resolution for WL images before (triangles) and after (squares) application of MFBD. Bottom: spatial resolution of 709.0 nm LOS velocity fields.

These were evaluated by a gaussian fit to the intensity values of the spectral points which sample the lines. The NB images destretching allows obtaining spatial resolutions of LOS velocity fields (see fig.2) comparable to the WL images ones. On the contrary, reduction without NB destretching produced in the best cases spatial resolutions of about twice larger values.

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