2SWLFDO DQG ,QIUDUHG ,QWHUIHURPHWU\ DQG ,PDJLQJ 9, HGLWHG E\ 0LFKH
3HWHU * 7XWKLOO $QWRLQH 0pUDQG 3URF RI 63,(9RO . ‹
&&& FRGH ; GRL

3URF RI 63,(9RO .

Downloaded From: https://www.spiedigitallibrary.org/conference-proceedings-of-spie on
Terms of Use: https://www.spiedigitallibrary.org/terms-of-use

3URF RI 63,(9RO .
Downloaded From: https://www.spiedigitallibrary.org/conference-proceedings-of-spie on
Terms of Use: https://www.spiedigitallibrary.org/terms-of-use

Figure 6. Left: Simulated integrated intensity of a WIIT measurement at the camera plane. The red box indicates the science region. The sources outside the red box are the reference sources. Right: interferograms at science regions a, b, c and d for a 46mm baseline (top) and a 226mm baseline (bottom) at 0 degrees rotation.

3. RECONSTRUCTION OF THE INPUT SCENE

Once the interferograms have been acquired the next step is to extract the spatial and spectral information for each pixel of the datacube. Because each pixel on the detector plane acts as a single double Fourier interferometer, the single pixel data processing can be applied to the full array as a set of individual pixels.

The reconstruction of the WIIT scene from the recorded interferograms is a two-step process: a spectral inverse Fourier transform, and a spatial inverse Fourier transform. For a given camera pixel (v,h), the 'dirty' spectra $S_{v,h}(\nu, b_j)$ are extracted from the set of interferograms $I_{v,h}(\delta, b_j)$ for each baseline using Eq. 2:

$$S_{v,h}(\nu, b_j) = \sum_i I_{v,h}(\delta_i, b_j) \exp(-i2\pi\nu\delta_i) d\delta \tag{2}$$

The next step is the extraction of the spatial features of $S_{v,h}$; this is the dirty datacube, $Sky_{v,h}$. This step converts a single pixel from each baseline into a datacube covering the angle subtended by the FWHM of the telescope beam (or entrance pupil Airy pattern). To extract the spatial features, one has to perform the two-dimensional Fourier transform of the uv-map. Combining each baseline position b_j and each wavenumber ν_k , the dirty datacube is calculated as

$$Sky_{v,h}(\theta_x\theta_y; \nu_k) = \sum_{j=1}^{N_b} |Im\{S_{v,h}(\nu_k, b_j)\} \cos(2\pi(u_{j,k}\theta_x + v_{j,k}\theta_y)) - Re\{S_{v,h}(\nu_k, b_j)\} \sin(2\pi(u_{j,k}\theta_x + v_{j,k}\theta_y))\} | \tag{3}$$

where $u_{j,k} = b_{x,j}\nu_k$ and $v_{j,k} = b_{y,j}\nu_k$ are the spatial frequencies. In this operation, prior knowledge of the sky grid (θ_x, θ_y) has to be used to mosaic the individual $Sky_{v,h}$ datacubes and reconstruct the wide-field scene.

Fig. 7 (left) shows the spatial distribution of the reconstructed scene or dirty image of the science region. Spatially, all the sources are resolved, but one can observe the distortions induced by the dirty beam, with sidelobe power comparable to that of the dimmer sources. By applying post-processing algorithms such as CLEAN[18] and MEM,[19] these artifacts will be minimized.

Downloaded From: https://www.spiedigitallibrary.org/conference-proceedings-of-spie on Terms of Use: https://www.spiedigitallibrary.org/terms-of-use

Figure 6. Left: Simulated integrated intensity of a WIIT measurement at the camera plane. The red box indicates the science region. The sources outside the red box are the reference sources. Right: interferograms at science regions a, b, c and d for a 46mm baseline (top) and a 226mm baseline (bottom) at 0 degrees rotation.

3. RECONSTRUCTION OF THE INPUT SCENE

Once the interferograms have been acquired the next step is to extract the spatial and spectral information for each pixel of the datacube. Because each pixel on the detector plane acts as a single double Fourier interferometer, the single pixel data processing can be applied to the full array as a set of individual pixels.

The reconstruction of the WIIT scene from the recorded interferograms is a two-step process: a spectral inverse Fourier transform, and a spatial inverse Fourier transform. For a given camera pixel (v,h), the 'dirty' spectra $S_{v,h}(\nu, b_j)$ are extracted from the set of interferograms $I_{v,h}(\delta, b_j)$ for each baseline using Eq. 2:

$$S_{v,h}(\nu, b_j) = \sum_i I_{v,h}(\delta_i, b_j) \exp(-i2\pi\nu\delta_i) d\delta \tag{2}$$

The next step is the extraction of the spatial features of $S_{v,h}$; this is the dirty datacube, $Sky_{v,h}$. This step converts a single pixel from each baseline into a datacube covering the angle subtended by the FWHM of the telescope beam (or entrance pupil Airy pattern). To extract the spatial features, one has to perform the two-dimensional Fourier transform of the uv-map. Combining each baseline position b_j and each wavenumber ν_k , the dirty datacube is calculated as

$$Sky_{v,h}(\theta_x\theta_y; \nu_k) = \sum_{j=1}^{N_b} |Im\{S_{v,h}(\nu_k, b_j)\} \cos(2\pi(u_{j,k}\theta_x + v_{j,k}\theta_y)) - Re\{S_{v,h}(\nu_k, b_j)\} \sin(2\pi(u_{j,k}\theta_x + v_{j,k}\theta_y))\} | \tag{3}$$

where $u_{j,k} = b_{x,j}\nu_k$ and $v_{j,k} = b_{y,j}\nu_k$ are the spatial frequencies. In this operation, prior knowledge of the sky grid (θ_x, θ_y) has to be used to mosaic the individual $Sky_{v,h}$ datacubes and reconstruct the wide-field scene.

Fig. 7 (left) shows the spatial distribution of the reconstructed scene or dirty image of the science region. Spatially, all the sources are resolved, but one can observe the distortions induced by the dirty beam, with sidelobe power comparable to that of the dimmer sources. By applying post-processing algorithms such as CLEAN[18] and MEM,[19] these artifacts will be minimized.

Downloaded From: https://www.spiedigitallibrary.org/conference-proceedings-of-spie on Terms of Use: https://www.spiedigitallibrary.org/terms-of-use

Downloaded From: https://www.spiedigitallibrary.org/conference-proceedings-of-spie on
Terms of Use: https://www.spiedigitallibrary.org/terms-of-use

Downloaded From: https://www.spiedigitallibrary.org/conference-proceedings-of-spie on
Terms of Use: https://www.spiedigitallibrary.org/terms-of-use

Downloaded From: https://www.spiedigitallibrary.org/conference-proceedings-of-spie on
Terms of Use: https://www.spiedigitallibrary.org/terms-of-use

Downloaded From: https://www.spiedigitallibrary.org/conference-proceedings-of-spie on
Terms of Use: https://www.spiedigitallibrary.org/terms-of-use

Downloaded From: https://www.spiedigitallibrary.org/conference-proceedings-of-spie on
Terms of Use: https://www.spiedigitallibrary.org/terms-of-use

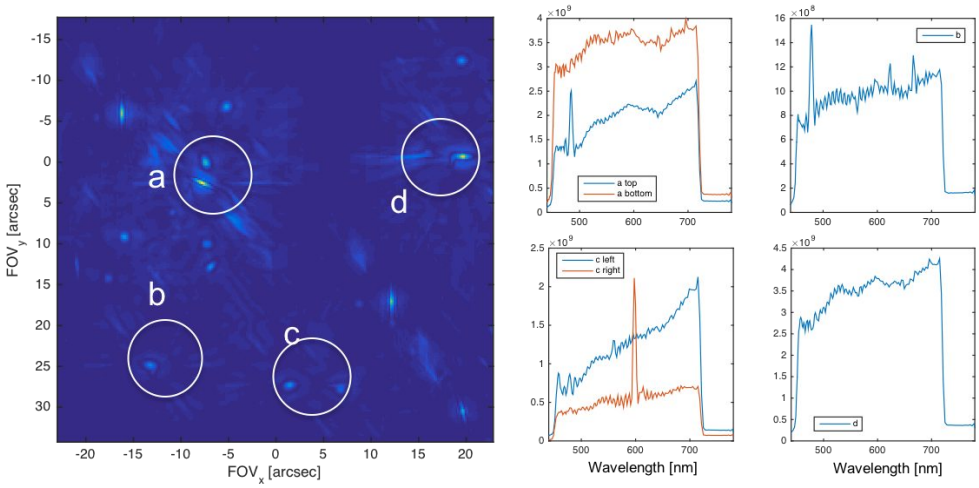

Figure 7. Spatial structure of the reconstructed scene or dirty image. Left: spectrally integrated intensity of the full science scene. Right: derived spectra of each source in the science regions a, b, c and d.

The derived spectra are in good but not perfect agreement with the known input spectra, as shown in Fig. 7 (right). In the cases where one of the extended sources is substantially more intense than its companion, there is a transfer of power from the brighter to the fainter source at longer wavelengths. This is due to the fact that the width of the interferometric dirty beam is bigger at longer wavelengths.

4. PROCESSING OF WIIT DATA

Although WIIT resides in the well-controlled environment of the AIM Lab, there are aspects of the interferometer that require the data to be preprocessed prior to employing image synthesis techniques. For example, there is heat generated by WIIT's imaging camera and CHIP that cause mild motion between image measurements for a single baseline length and orientation. Also, the lamp that provides the illumination for CHIP fluctuates in its overall intensity during each delay line scan, causing features in the collected data that appear as low-order signatures for the fringes at each pixel. Due to the micromirror devices that control how the hyperspectral projector operates, CHIP also imparts a spatially variant background on the scenes being measured. WIIT's CCD also has hot pixels, typically comprising the bottom few rows of pixels in the image frame, that must be removed in processing. Finally, because baseline orientations are varied by digitally rotating the scene being projected by CHIP, all baseline measurements must be registered and resampled to the same orientation prior to image synthesis. To aid in the preprocessing of the data, a collection of image measurements are taken to identify the background imparted by CHIP and the imaging camera before starting each delay line scan.

The procedure for preprocessing WIIT datasets starts by processing each datacube, which consists of all measurements for a delay line scan for each baseline length and angle, independently. First, the fixed background created by the hot pixels of WIIT's imaging camera are removed from all background and data measurements. The remaining background frames registered such that all background frames no longer suffer from image shifts caused by the mild turbulence in the system before averaging the background frames together. The data frames for each datacube are also registered to the first measured frame of the delay line scan. Before removing the background caused by CHIP from all of the data frames, we first remove the intensity fluctuations caused by CHIP's illumination source. This is accomplished by using a high-pass filter designed with the spectral bandpass

Downloaded From: https://www.spiedigitallibrary.org/conference-proceedings-of-spie on Terms of Use: https://www.spiedigitallibrary.org/terms-of-use

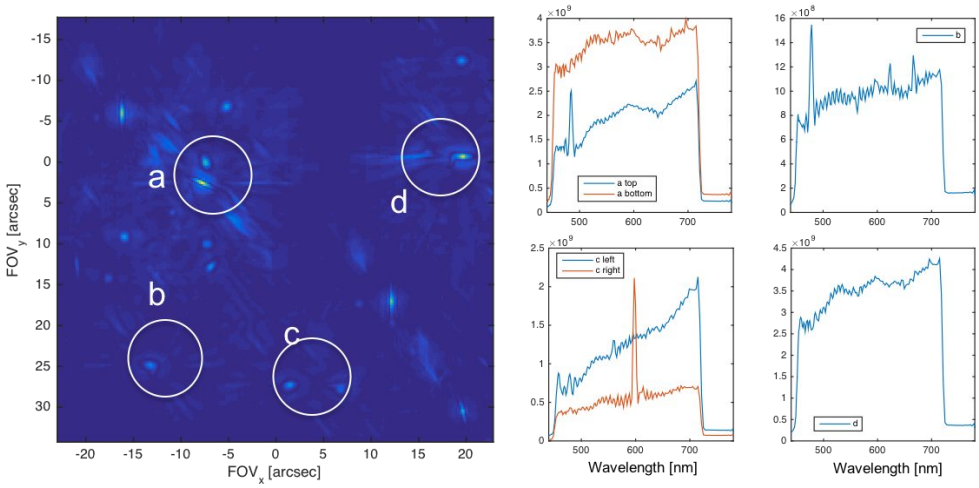

Figure 7. Spatial structure of the reconstructed scene or dirty image. Left: spectrally integrated intensity of the full science scene. Right: derived spectra of each source in the science regions a, b, c and d.

The derived spectra are in good but not perfect agreement with the known input spectra, as shown in Fig. 7 (right). In the cases where one of the extended sources is substantially more intense than its companion, there is a transfer of power from the brighter to the fainter source at longer wavelengths. This is due to the fact that the width of the interferometric dirty beam is bigger at longer wavelengths.

4. PROCESSING OF WIIT DATA

Although WIIT resides in the well-controlled environment of the AIM Lab, there are aspects of the interferometer that require the data to be preprocessed prior to employing image synthesis techniques. For example, there is heat generated by WIIT's imaging camera and CHIP that cause mild motion between image measurements for a single baseline length and orientation. Also, the lamp that provides the illumination for CHIP fluctuates in its overall intensity during each delay line scan, causing features in the collected data that appear as low-order signatures for the fringes at each pixel. Due to the micromirror devices that control how the hyperspectral projector operates, CHIP also imparts a spatially variant background on the scenes being measured. WIIT's CCD also has hot pixels, typically comprising the bottom few rows of pixels in the image frame, that must be removed in processing. Finally, because baseline orientations are varied by digitally rotating the scene being projected by CHIP, all baseline measurements must be registered and resampled to the same orientation prior to image synthesis. To aid in the preprocessing of the data, a collection of image measurements are taken to identify the background imparted by CHIP and the imaging camera before starting each delay line scan.

The procedure for preprocessing WIIT datasets starts by processing each datacube, which consists of all measurements for a delay line scan for each baseline length and angle, independently. First, the fixed background created by the hot pixels of WIIT's imaging camera are removed from all background and data measurements. The remaining background frames registered such that all background frames no longer suffer from image shifts caused by the mild turbulence in the system before averaging the background frames together. The data frames for each datacube are also registered to the first measured frame of the delay line scan. Before removing the background caused by CHIP from all of the data frames, we first remove the intensity fluctuations caused by CHIP's illumination source. This is accomplished by using a high-pass filter designed with the spectral bandpass

Downloaded From: https://www.spiedigitallibrary.org/conference-proceedings-of-spie on Terms of Use: https://www.spiedigitallibrary.org/terms-of-use