

Multiresolution Analysis for Denoising and Pattern Detection: Radiation Symmetry and the Effects of Hydrodynamic Instabilities on X Ray Implosion Images

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We present the results of curvelet and wavelet based techniques for analyzing implosion images from three laboratories (SNL, LANL and LLNL) created by ICF lasers and Z pinches. Our aim is to denoise such images to determine the degree of symmetry of the radiation with which the implosions are driven as well as the hydrodynamic instabilities that may arise during such implosions. Decompositions in spherical harmonics and Legendre polynomials are crucial in some cases as well as the determination of the radius of maximum plasma density or minimum X ray transmission. In addition, experiments on the Z machine in Sandia have produced X ray images of plasmas which emulate astrophysical jets and mix which require denoising so as to extract the relevant scales of the turbulent mixing. We will compare various multiresolution approaches applied to these daunting tasks and determine their relative efficacy. Some of our recent work along these lines was presented at Wavelet X and published in its proceedings [1].

[1] "Wavelets, Curvelets and Multiresolution Analysis Techniques in Fast Z Pinch Research," Proc. SPIE 5207, 740 (2003).

Scale sensitive reconstruction of astronomical images

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Interferometric telescopes sample the Fourier plan at discrete points. Imaging with such telescopes require an image reconstruction process involving Fourier transform and deconvolution of the point spread function (PSF). The PSF of such telescopes have significant widely spread sidelobes, which couple widely separate pixels in the image. Treating deconvolution as a search algorithm for a model image, which when convolved with the PSF fits the data, this coupling implies a covariance matrix with significant off-diagonal elements. Traditionally, image reconstruction is done iteratively treating each pixel as a degree of freedom (scale-less reconstruction, with a diagonal or band-diagonal approximation for the covariance matrix). Such a representation ignores the finite range of scales of emission in the image due to extended emission, and is therefore non-optimal, resulting into errors which are significantly larger than the sensitivity of many current, and certainly of future radio telescopes. Modeling of the true emission in a scale-sensitive basis has been shown to be significantly reduce such errors, and will be required to exploit the full sensitivity of next generation radio telescopes. However, scale-sensitive reconstruction algorithms pose many computational as well as mathematical challenges. This paper briefly describes the

current advances and outstanding problems in the development of scale-sensitive image reconstruction algorithms for interferometric radio telescopes.

Spatial and temporary simulations of atmospheric phases distortions.

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A method of simulations of atmospherically corrupted wavefronts is proposed. It is described an extension of the method, which make possible to build both spatial and temporal models of the atmosphere. The method has been used for modeling Kolmogorov's turbulent atmosphere without Taylor's assumption about "frozen" atmospheric distortions .

Magnitude differences measurements for speckle interferometric binaries.

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A method of magnitude differences measurements for speckle interferometric binary stars is presented. The method is based on standard power spectrum analysis of speckle series without correction speckle interferometric transfer function . Both accuracy and sources of systematical errors are analyzed. Photometrical accuracy range within between 0.02 and 0.1 magnitude, depending on the seeing , the separation and brightnesses of the components of the system .

Problems of Fitting Gaussians to Interferometric Data, and Their Solutions

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Although fitting a set of elliptical Gaussians to visibility measurements is an obvious way of converting data from an interferometer into something easier to interpret, astrophysicists tend to approach the process with trepidation, if at all. Models made with elliptical Gaussians have earned a reputation for producing different results when fitted by different people, collapsing into points or knifeedges, or simply behaving in a bizarre way. This poster investigates the reasons for these failures, and at least partial solutions.

Smear Fitting - A New Deconvolution Method For Radio Interferometry

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Smear fitting models the source with a set of functions (usually elliptical Gaussians) and then convolves each component with its own elliptical Gaussian to account for the uncertainty in its shape and location. This produces much sharper resolution for high signal to noise components than CLEAN while at the same time using the optimum sensitivity of natural weighting for faint and/or diffuse features. It can be thought of as a form of the maximum entropy method, but by greatly reducing the number of variables (typically several dozen, as opposed to a million pixels) in the model it avoids the "ringing" artifacts of traditional maximum entropy. Another, often more important, benefit, is that the model parameters tend to be interesting in their own right.

Photometric and astrometric analysis of Gemini Galactic Center observations using “StarFinder” and blind deconvolution packages.

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Abstract

We present a study of photometric and astrometric measurements from adaptive optics (AO) observations of a very crowded field. We compare three different techniques to extract the point spread function (PSF) from the field. We primarily investigate the ability of the StarFinder package to generate both the photometric and astrometric measurements and PSFs. These results are compared with those obtained using blind deconvolution techniques.

Techniques which extract the PSF from AO observations of very crowded fields are important because there are no isolated stars which can be used for PSF calibration necessary for the photometric and astrometric analysis of the field. A reference star measurement will not always produce a satisfactory calibration PSF. Therefore alternative methods have to be used to extract the PSF from the data itself.

We measured the photometry and astrometry of four 4.8² isoplanatic sub-fields from the Gemini/Hokupa'a observations of the Galactic Center. Both StarFinder and blind deconvolution extract the numerical PSF directly from the data. The parametric blind deconvolution extracts an analytic PSF. The photometry and astrometry were obtained from StarFinder using both numerical PSFs and also measured from the blind deconvolution results. The results from these analyses are compared. The performance of these algorithms depends upon the quality of the AO compensation.

We also generated a synthetic field of this region to test the accuracy of each technique and to investigate the performance of each algorithm to recover the relative photometry. We find that StarFinder produces results to within 0.15 magnitudes over a dynamic range of » 6 magnitudes.