**INTRODUCTION**

For a variety of purposes such as the design and development of adaptive optics systems, speckle imaging techniques, atmospheric propagation studies etc., it is essential to simulate a good atmospheric phase screen model. Methods based on Zernike polynomial expansions\(^2\), FFT-based methods\(^3-9\). Optimization method\(^11\) etc.. have been in use for this purpose. FFT-based methods are computing memory size friendly and widely accepted. Because of undersampling at low and high frequency region in the power spectrum, it provides a limitation in resolution of phase power spectrum.

Explanation\(^1\) shown in Fig. 1

The simulation band \(\left(\frac{1}{G} - \frac{1}{\Delta}\right)\) is actually smaller than full band \(\left(\frac{1}{L_0} - \frac{1}{l_0}\right)\).

For simulations of imaging with small apertures relative to the outer scale, we need a screen of small size, but cutting out small screens from a larger screen is not the right solution to this problem.

In this work, we present a method to deal with small \(G/L_0\) phase screen simulation using the FFT-based method, inspired by Jingsong Xiang’s\(^9\) work on phase screen simulation.

**PROPOSED METHOD**

**Step:1**

Obtaining Phase Autocorrelation Matrix using Phase Power Spectrum

\[ D_0(m, n) = 2(B_0(0,0) - B_0(m, n)) \ldots (1) \]

\[ B_\phi(m, n) = \frac{\sum_{m=-N/2}^{N/2-1} \sum_{n=-N/2}^{N/2-1} f_{FFT}^2(m', n') e^{i2\pi \frac{m m'}{N} + i\frac{n n'}{N}}}{\sum_{m=-N/2}^{N/2-1} \sum_{n=-N/2}^{N/2-1} B_{FFT}^2(m, n)} \ldots (2) \]

\[ B_{\phi\text{SUB}}(m, n) = \sum_{m} \sum_{n} e^{i2\pi \frac{m m'}{N} + i\frac{n n'}{N}} \ldots (3) \]

\[ B_\phi(m, n) = B_{FFT}(m, n) + B_{\phi\text{SUB}}(m, n) \ldots (4) \]

**Step:2**

Compensation for residual error

Using eq (1) \(D_{error}(m, n) = D_{theory}(m, n) - D_\phi(m, n) \ldots (5)\)

Error matrix cannot be just added to the \(D_\phi\) matrix to compensate for remaining error.

**REASON:**

If we take the Fourier transform of this polynomial equation, the resultant curve will be completely different with a different order of moments, just like Gibbs phenomena. This introduces unwanted error in the final result.

Using MATLAB, we find the best fit of \(D_{error}(m, n)\) using cftool to obtain coefficients of the required Gaussian function (with 95% confidence bounds)

\[ B_{tot}(m, n) = B_0(m, n) + B_{gauss}(m, n) \ldots (6) \]

**Step:3**

Phase Screen Simulation using \(B_{tot}\) matrix

**CONCLUSIONS**

In this paper, we put forward a new method to compensate for the residual error in the low and/or high-frequency region of FFT simulated phase screens after compensating with the modified subharmonic method.

This method provides very accurate phase screen structure for even \(G/L_0\) ratios as small as 1/1000. No Patch Normalization factor is needed, no need to calculate subharmonic weight coefficient and weights to compensate for high-frequency components, as done by Sedmak. Finally, the accuracy of this method from low-frequency to high-frequency range is better than 1.8% for \(G/L_0\) as low as 1/1000.

**REFERENCES**

1. Sedmak, G., Private Comm., 2019