Measurements of optical wavefront by assembling an optical system

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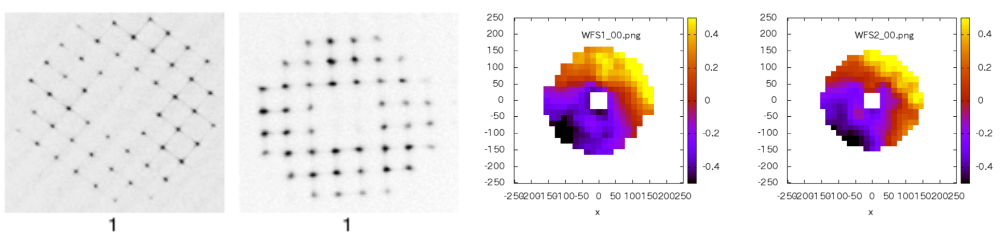
GPPU Experimental Point (GEP): 4

Goal of Study

(1) understand the image formation with an optical system and the relation between aberrations in an image and distortions in the optical wavefront through Fourier optics.
(2) understand the setup for optical experiment, and measure the distortions in the optical wavefront by applying an inverse problem solver to the measured dataset.
(3) master methods to handle 2D imaging data with your own C programs.

Contents

Optical systems for observations of the universe are always affected by aberrations caused by various origins in the systems. Moreover, ground-based observations are affected by aberrations caused by fluctuation and turbulence in the atmosphere. Due to the aberrations, object images on a detector will be distorted from the ideal diffraction-limited pattern. Because observations of the universe are moving toward higher spatial resolution with larger lens/mirror/dish, understanding of the aberrations becomes more critical in the observations not only in the optical/visible wavelength, but also in the UV, IR, and mm wavelengths. In this course, at first the relation between aberrations in an image and distortions in the optical wavefront is explained through Fourier optics as a lecture, then participants will conduct an optical experiment to measure the distorted optical wavefront. Obtained images are analyzed through your own C programs, and the distortion in the measured wavefront will be evaluated.



Examples of wavefront sensor images (left) and estimated optical wavefronts from the images (right). The sensor images are analyzed with your own code to estimate the distorted wavefront.

A1(GEP=4)

Textbook and References

[1] General background: "OPTICS", Hecht
[2] Fourier optics: "Introduction to Fourier Optics", Goodman
[3] Wavefront measurements: "Principles of Adaptive Optics", Tyson
[4] Adaptive optics application to the astronomy: "Extreme Adaptive Optics", Guyon, O, 2018, 56, 315, "Adaptive Optics for Astronomy", Davies, R., and Kasper, M. 2012, ARA&A, 50, 305

Progress Schedule

- Day 1
  Fourier optics (Lecture)
  Relation between aberration and distortion in the optical wavefront (Lecture)
  Method to measure the distorted optical wavefront (Lecture)
  Image data handling with C programs (Lecture)
- Day 2
  Optical experiment setup (Experiment)
  Measuring the optical wavefront (Experiment)
  Image data acquisition (Experiment)
- Days 3—4
  Image data analysis with C programs (Experiment)
  Final wrap up (Presentation)

Other Details

Course Period	2023 Winter
Place	Optics Lab, Astronomical Institute (Science Complex C, N505)
Number of Students	1—3
Evaluation method	The evaluation will be made based on the participation to the experiment (30%) and quality of the final report made by each participant (70%)

In Addition

Each participant is requested to make his/her own analysis codes and a report based on the 4 day experiments.

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