Innovations Foresight

AI Based Wavefront Sensing

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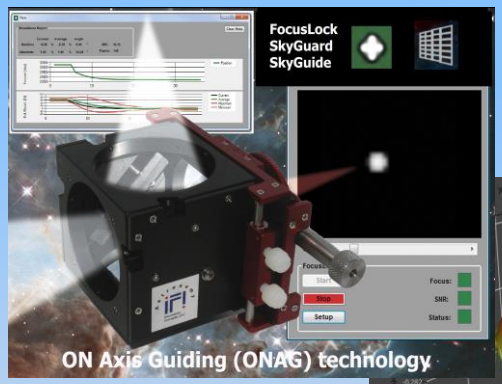
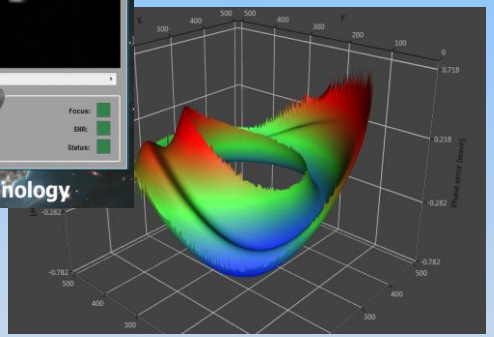
Our company (IF)

Innovations Foresight

- Innovations Foresight (IF) was founded 2007 initially active in eyecare.
- Today IF designs, makes and sells innovative astronomical products.





- Collaboration/licensing with third parties
- IF owns patents on ONAG, astigmatic focusing, full frame guiding.
- Filed US utility patent and PCT on AI based WFS (patent pending).

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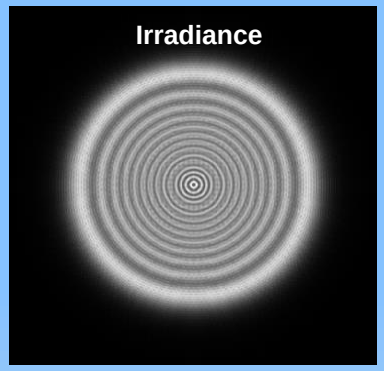
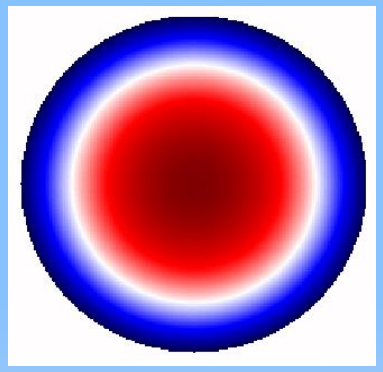
Non-ambiguous phase retrieval from defocused (engineered) images



Defocused image



Wavefront error

Direct model:

- Curvature Sensing (CS) Roddier & Roddier (1993), Hickson & Burley (1994), ... Use of the irradiance transfer equation.

$$\frac{\Delta I}{I_0}(\vec{r}) = \frac{\lambda F l}{(l-F)}\left[\nabla^2 w_p(\vec{r}) - \delta(r-R)\frac{\partial w_p(\vec{r})}{\partial r}\right]$$

- Iterative numerical optimization at run time.
- Local minima, convergence, processing time, model accuracy.

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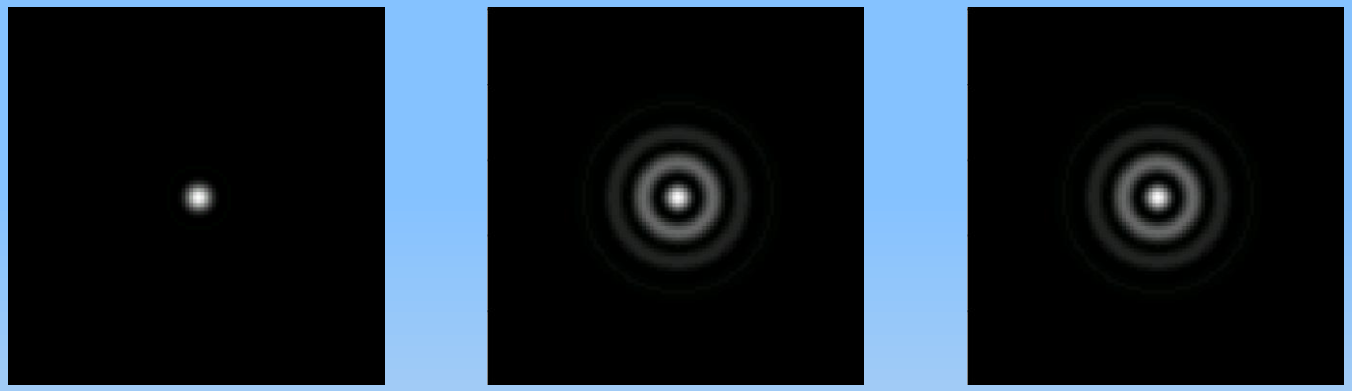
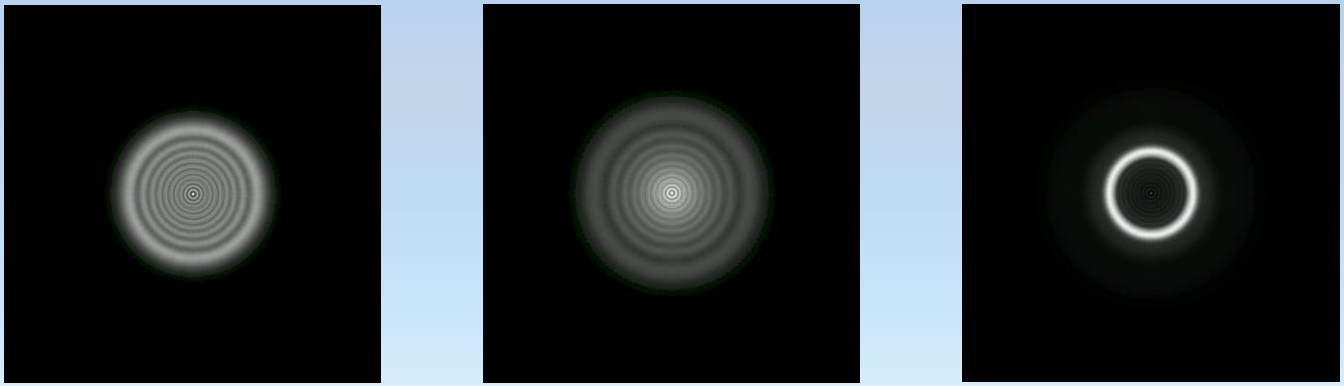
Defocus bias for unambiguous phase retrieval

No bias: DL +3w SA3 -3w SA3



+10w bias: DL +3w SA3 -3w SA3



AI based wavefront sensing (AIWFS)
patent pending

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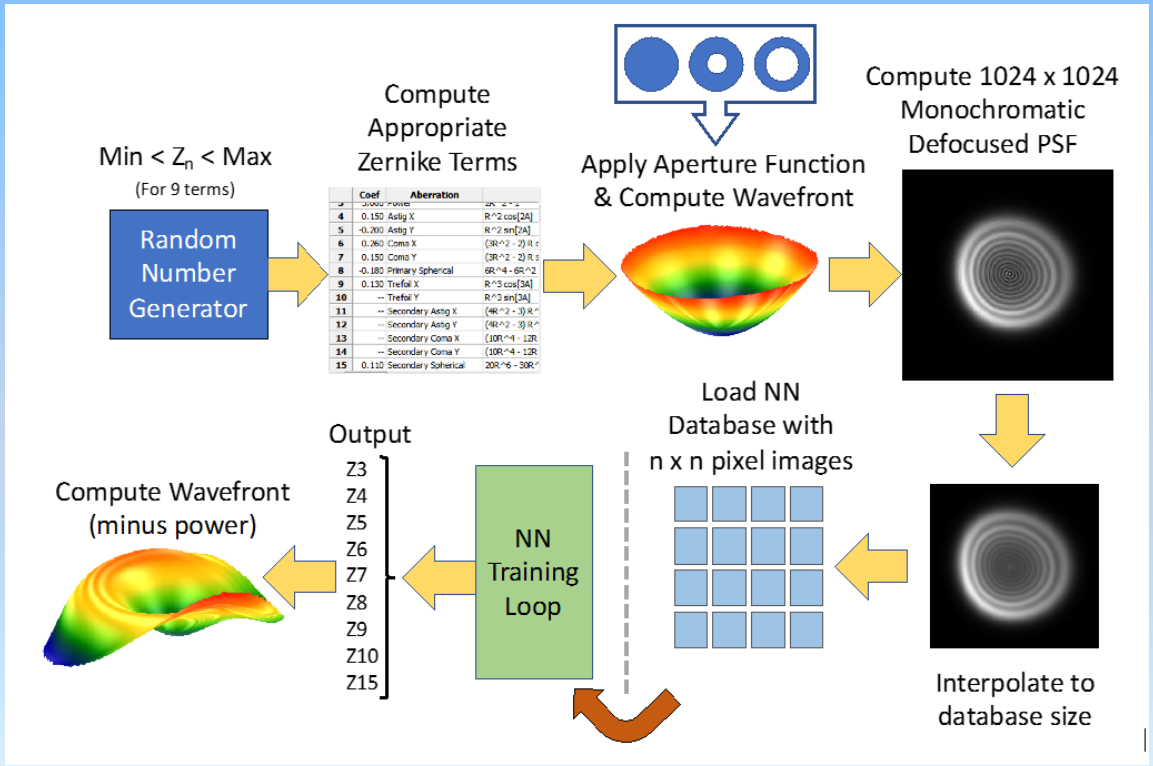
Inverse model:

- Learning is done beforehand, arbitrary figures of merit.
- Fast run time, no optimization of a model nor iteration.



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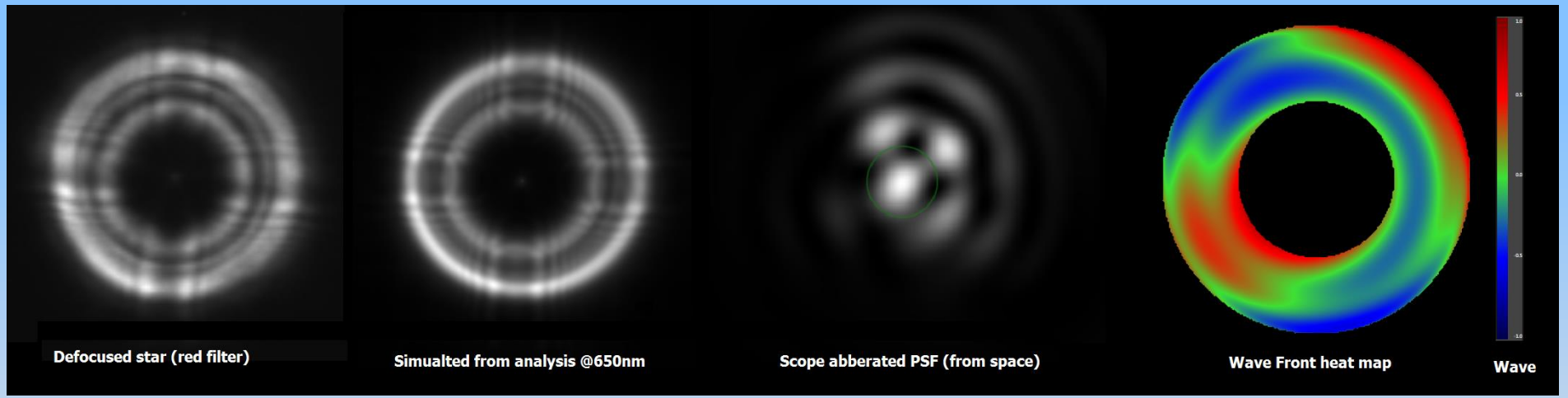
AIWFS: A generic approach

- Training and synthetic (simulated) data are a fully generic.
- A normalized optic is used for the training database construction then a denormalization operation takes place when processing an actual optical system & camera data.
- Defocused (engineered) images are generated using scalar diffraction theory. Relevant noises, if any, are added.
- Synthetic data is computed for a given optical system class.
- NN directly outputs desired figures of merit:
  Such as: Sampled wavefront, Zernike radial annular polynomials, Seidel's aberrations, ophthalmic data, optical surface figures, direct actuator control (CNC),…

AI Wavefront Sensing on the Sky

- Scope: CDK 17” from PWI @ f/6.8, CO 49%, red filter.



- Wavefront error @650nm in wave:
  Astigmatism=0.65, Coma=1.37, Trefoil=-0.46, 3rd SP=0.09
  5th SP=21.06, 7th SP=-35.10, 9th SP=18.87
  Total=0.2 wave rms, 1.1 wave PV, Strehl Ratio=20%.

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Key features

- Generic approach using only synthetic data.
- Various engineered images (mutli & extended sources, …).
- Field dependent WFS at once (on/off axis), no extra sensor.
- Versatile, can learn and output many figures of merits.
- Disruptive compact, light & low-cost technology.
- Minimum integration for existing optical systems (software).
- Demonstrated rms accuracy in the order of 5mw to 10mw.
- Can output WF & related figures of merit at very high speeds.

Astronomy

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Thank you!