Lightweight Space Coronagraph Simulator

https://github.com/leonidprinceton/LightweightSpaceCoronagraphSimulator

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Lightweight Simulator

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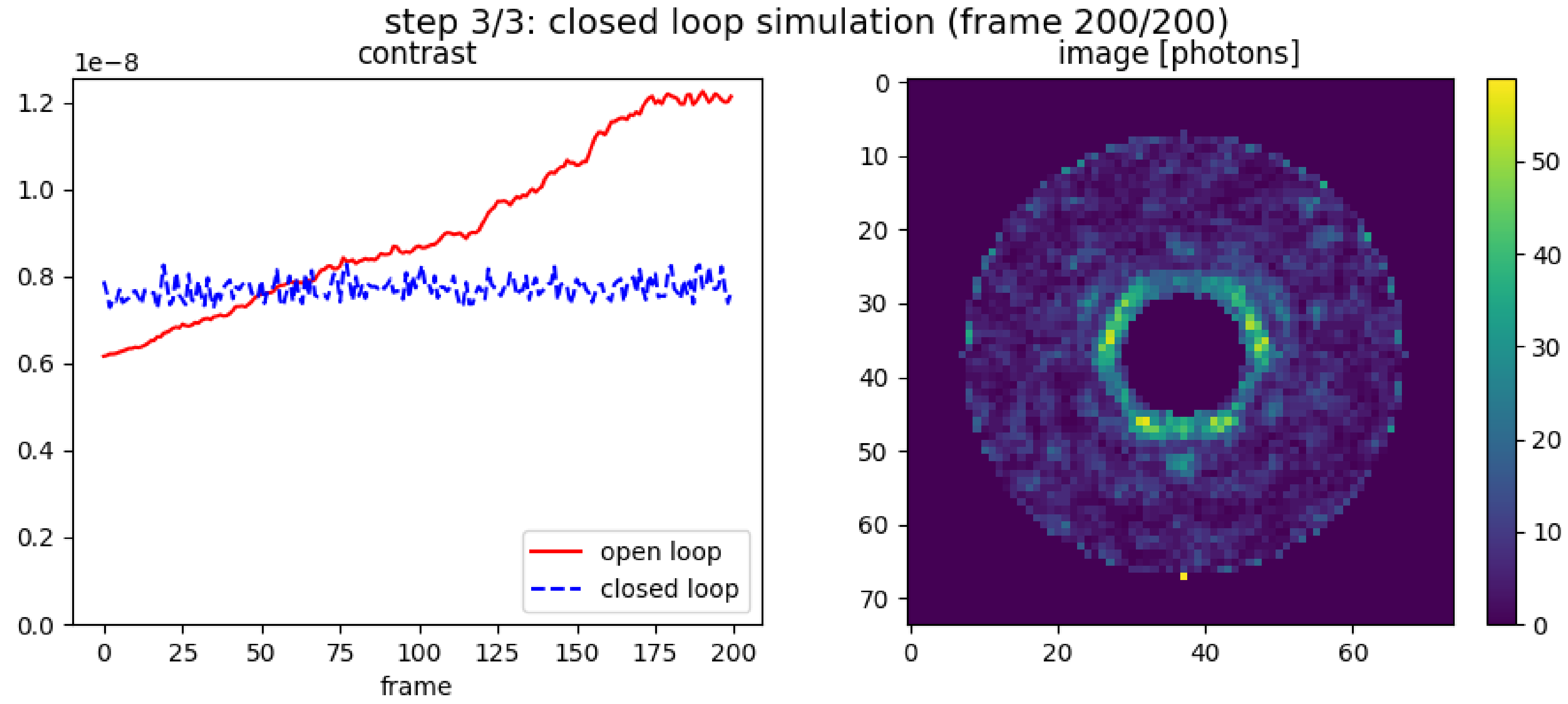
- Testing dark hole maintenance algorithms
  - in the linear regime after dark hole creation
  - with realistic effects (broadband, jitter, etc.)
- Testing post-processing algorithms
  (e.g. projections on instrumental modes, Xin *et al.*)
- Based on FALCO (https://github.com/ajeldorado/falco-matlab)
- Currently only Roman HLC is supported

Dark Hole Maintenance Example

- Zernike and DM drift
- LOWFS residuals, dark current and shot noise
- Broadband measurements



As a FALCO Derivative

	FALCO	Lightweight Simulator
Pros	• Full propagation (large perturbation) • Up to date Roman model • Dark hole creation	• Fast and simple to use • Rudimentary models for LOWFS residual jitter, wavefront drift, DM drift, measurement noise • Python
Cons	• Not readily extendable with wavefront maintenance • MATLAB	• Linear regime (only small perturbations) • Only HLC model for now

Method of Operation

- Electric field representation

nominal E-field Zernike sensitivity matrix control Jacobian

c = # channels
N = #pixels

$$\mathbf{E} = \mathbf{E}_0 + G^V \mathbf{v} + G^U \mathbf{u} \in \mathbb{C}^{cN}$$

channel summation

- Coherent intensity $\mathbf{I}^S = B \cdot |E|^{\circ 2} \in \mathbb{R}^N$

jitter modes covariance

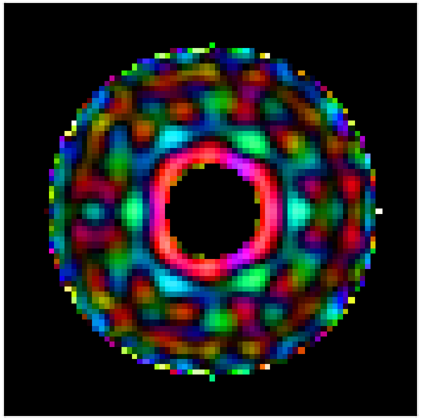
- Jitter intensity $\mathbf{I}^J = B \cdot \mathrm{diag}\left\{G^V V (G^V)^*\right\}$
- Total intensity $\mathbf{I} = \mathbf{I}^S + \mathbf{I}^J + \mathbf{I}^D$ dark current
- Measurements $y_i \sim poisson\left(I_i \cdot \alpha\right),\ 1 \leq i \leq N$

intensity-to-photons conversion

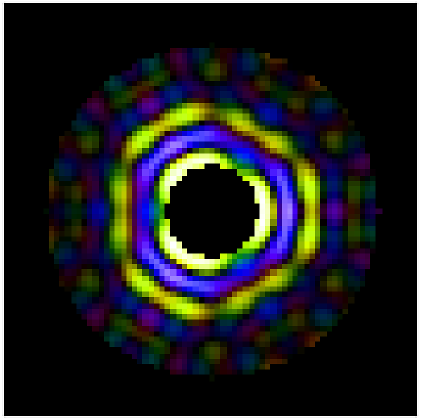
Functionality

- 6 wavelengths
- DM Jacobian
- Sensitivity to 136 Zernikes
- LOWFS residual jitter
- Off-axis PSFs

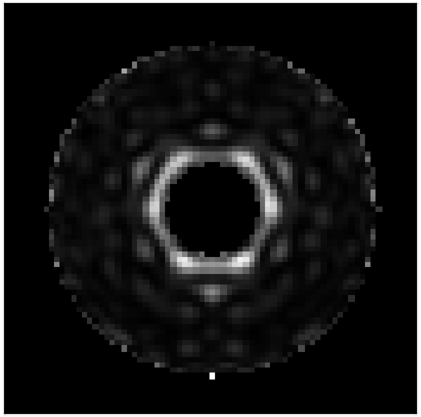
initial E-field



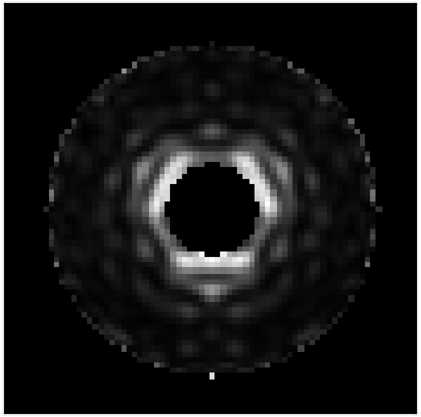
sensitivity to Z12



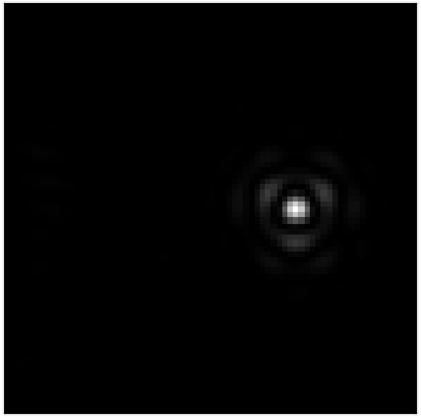
initial intensity



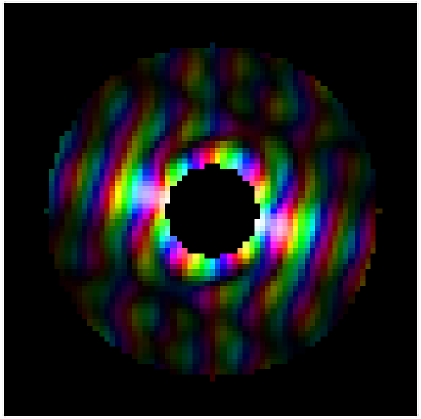
intensity with jitter



off-axis PSF



actuator poke



Summary

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- Linear regime approximation
- Requires only basic Python libraries
- Includes some realistic effects
- Will be updated with OS9-compatible Jacobians (that include polarization) in the near future