

Reinforcement Learning for Sensorless Astronomical Imaging

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Problem

- Telescopes capture light from millions of light years away
- Light gets distorted by the atmosphere
- **Adaptive Optics (AO)**: System of deformable mirrors to compensate for distortions
- Telescopes use AO to improve image quality
- Traditional methods rely on using a wavefront sensor and guide stars

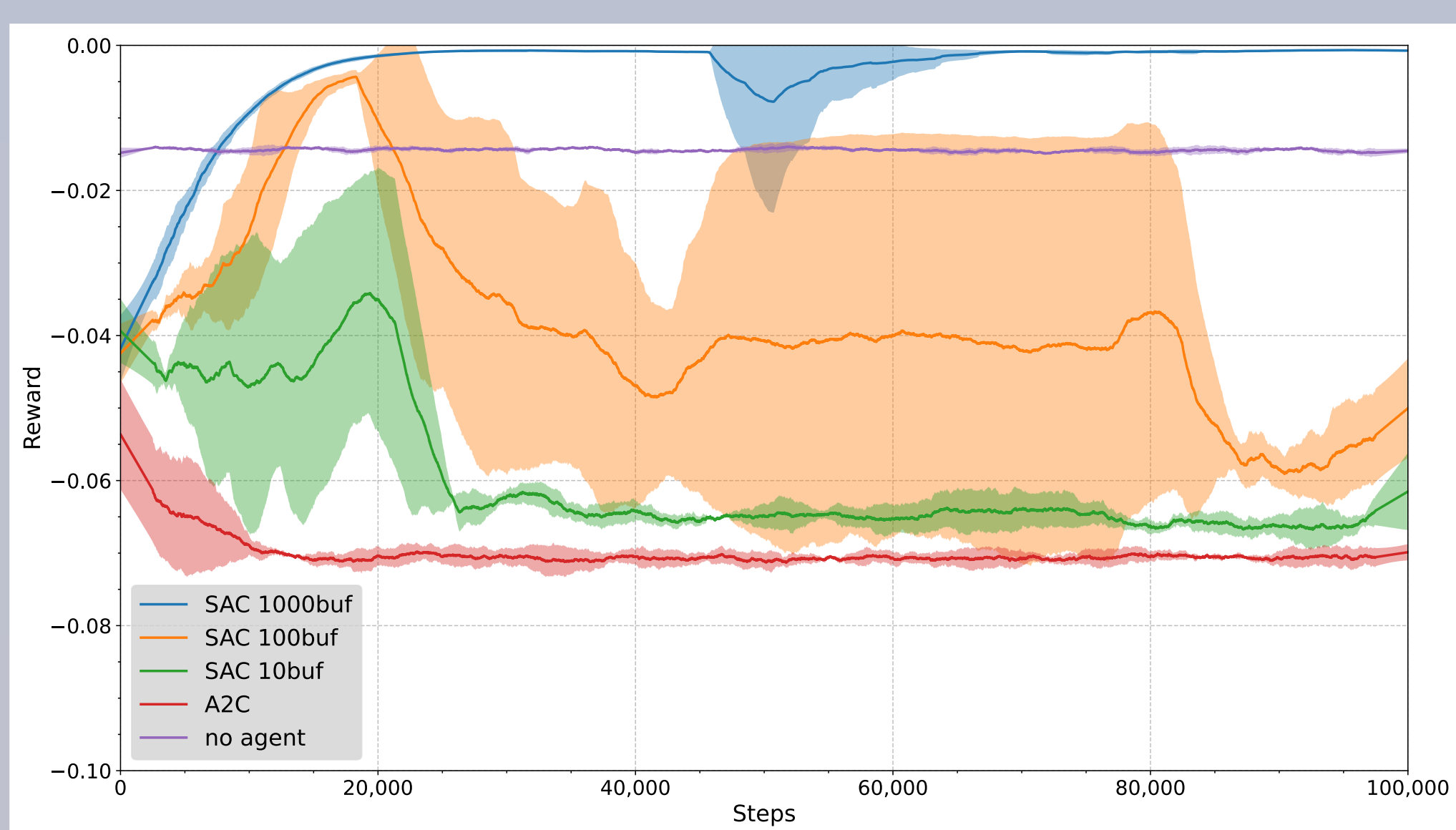
Can RL perform sensorless control of adaptive optics?

Approach

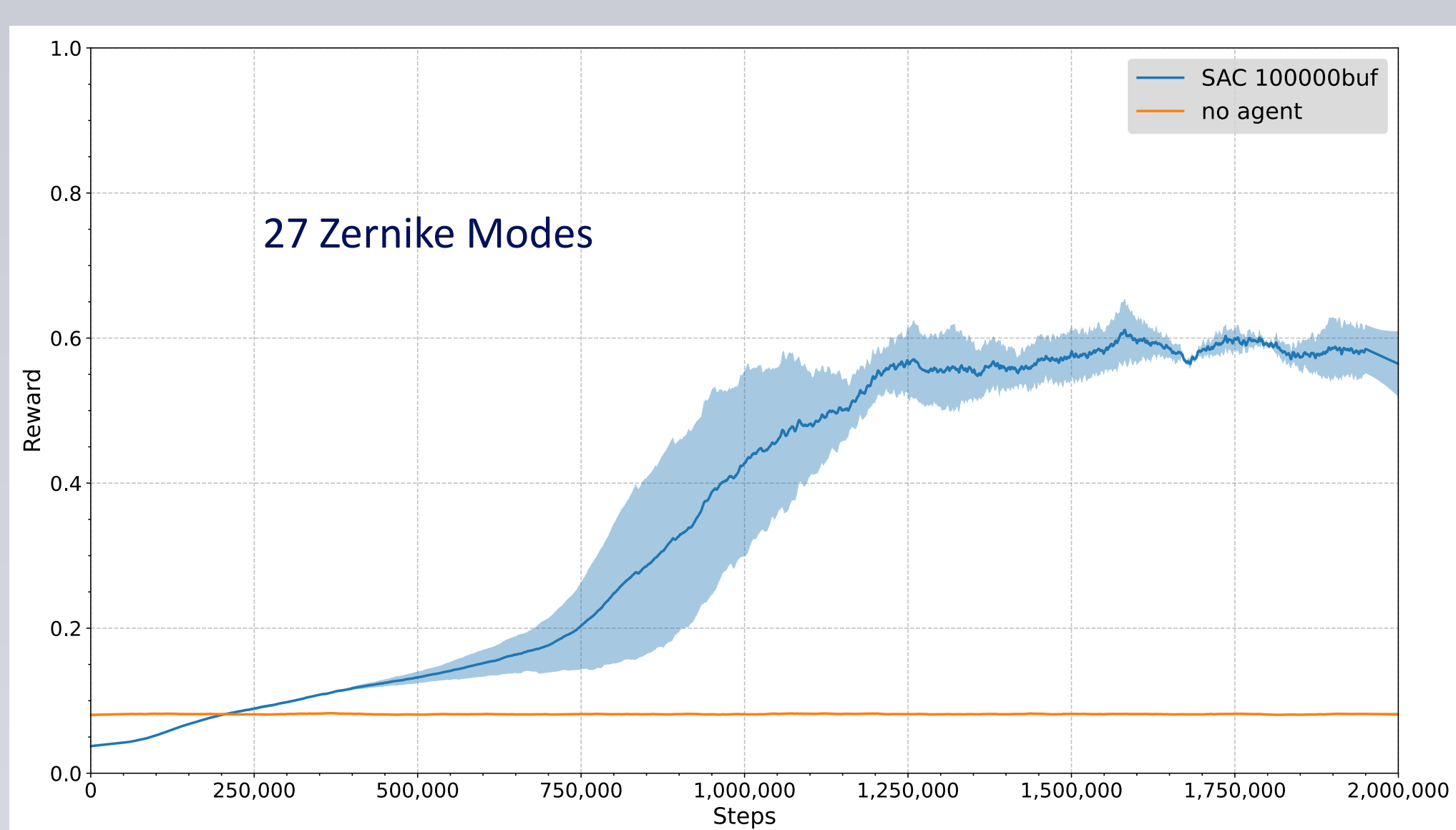
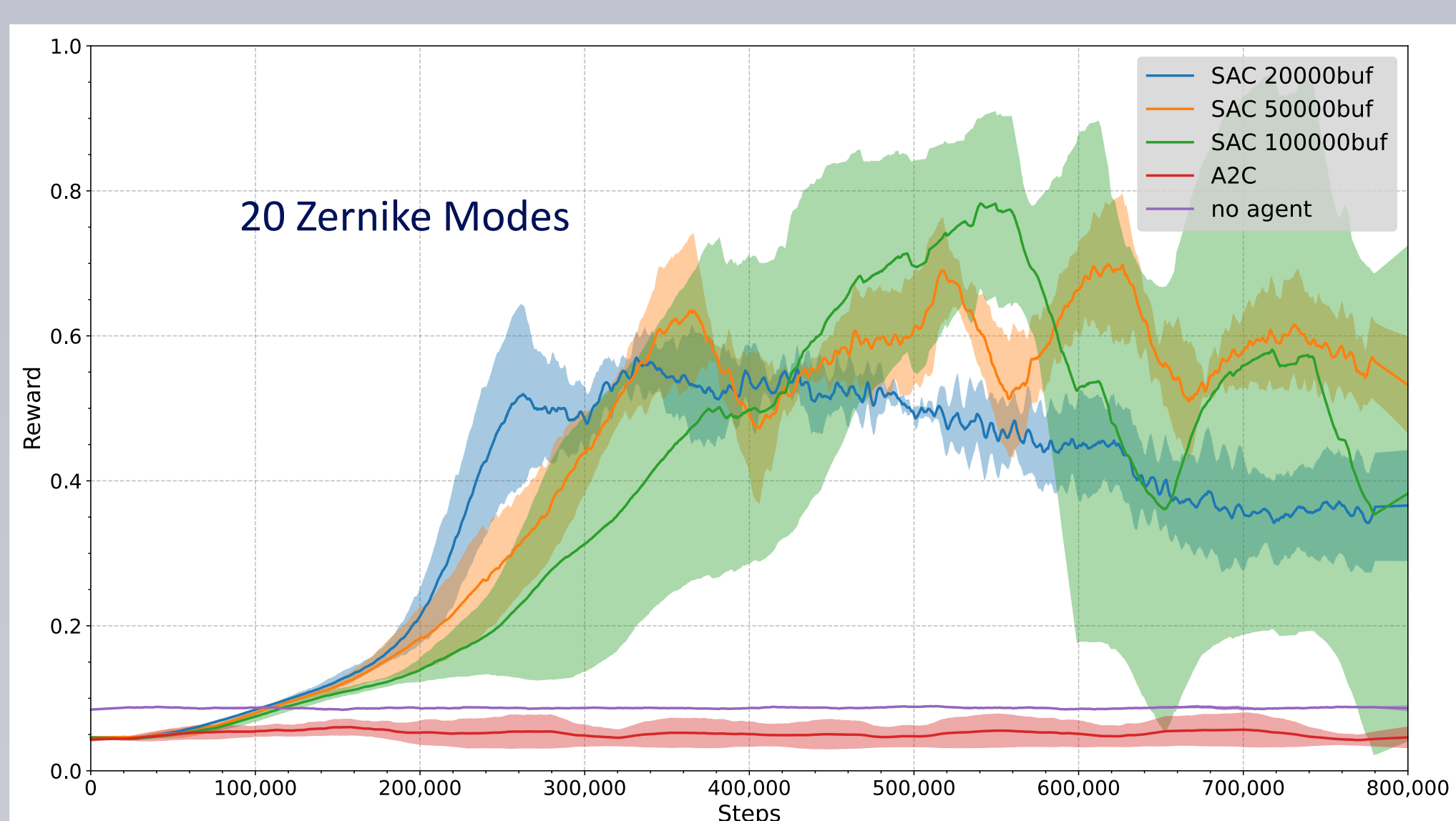
- Simulating noise in astronomical imaging & adaptive optics
- Train **Soft Actor-Critic (SAC)** agent to control adaptive optics
- Two tasks:
 - **Centering**, minimizing distance between star and center
 - **Sharpening**, maximizing Strehl ratio
- Start simple, gradually increase complexity
 - **Zernike modes** define distortion complexity and action dimensionality

Results

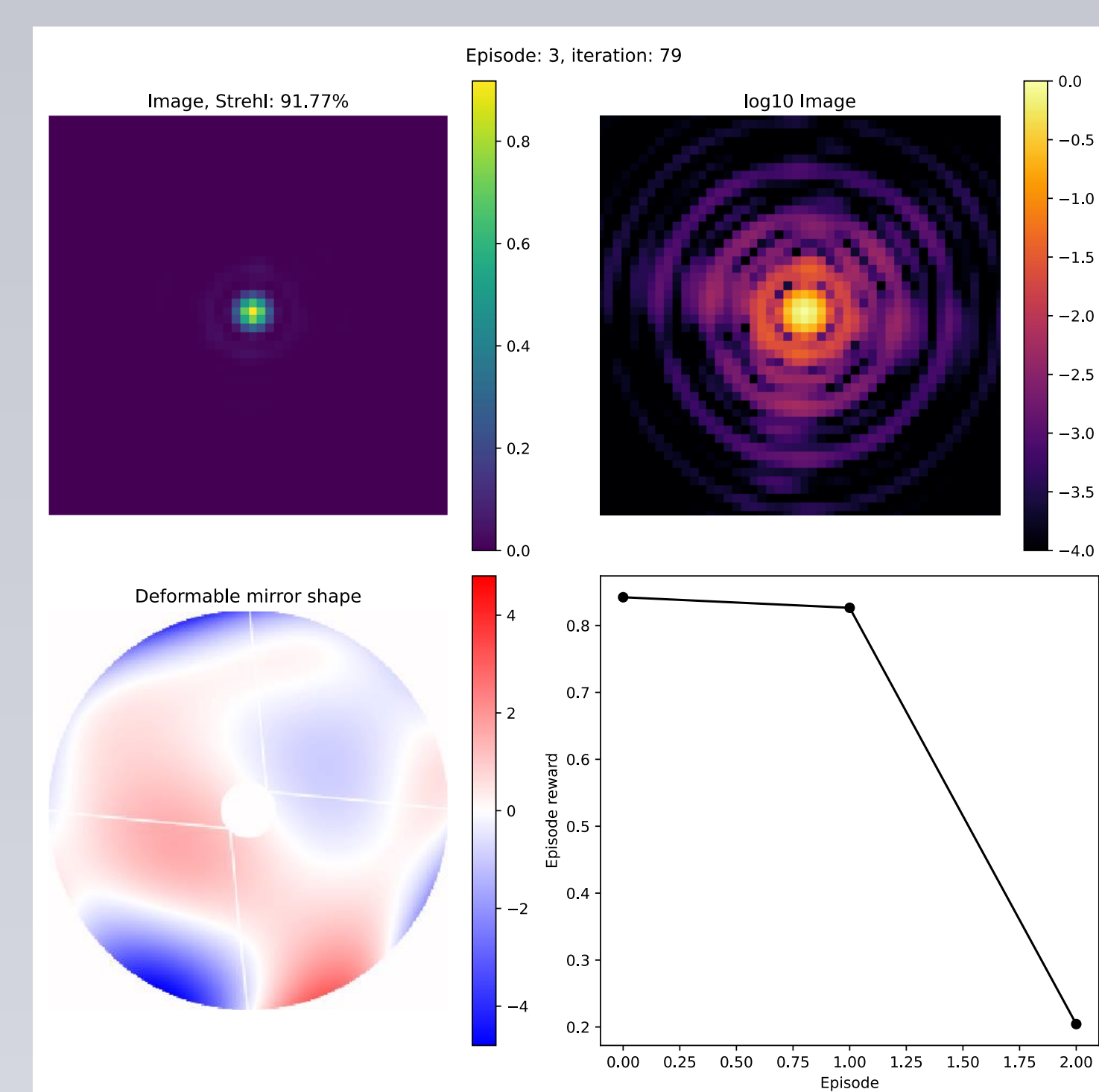
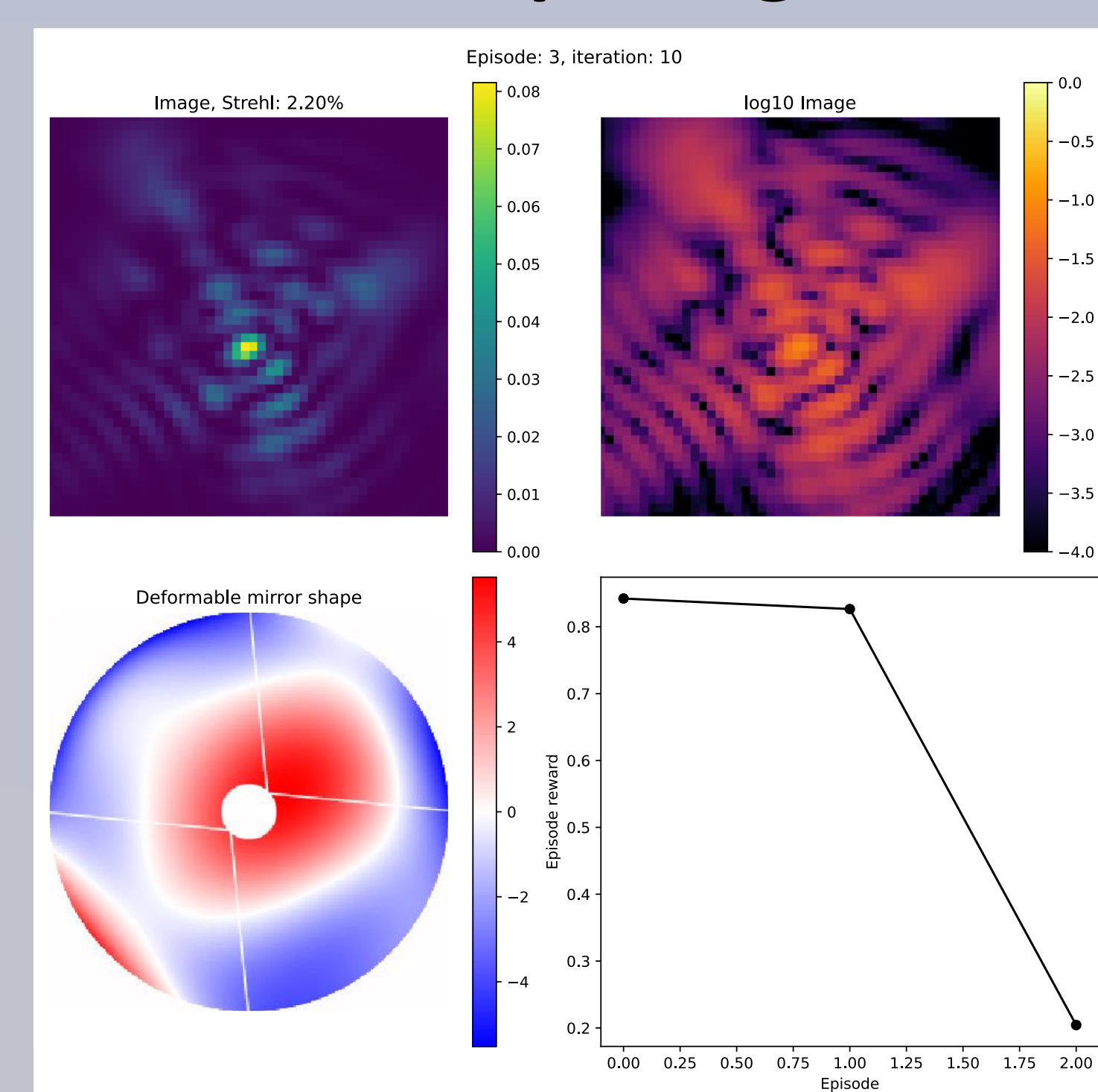
Centering



Sharpening



Sharpening



Conclusion

- **Centering** solved!
- **Sharpening** is more challenging, especially for high distortions
- Agent gets unstable with increased environment complexity
- Bigger buffer sizes are effective for more complex environment
- For higher Zernike modes, no learning was possible
- Main challenge: High action dimensionality

Next Steps

- Improve SAC agent (e.g. hyperparameter tuning)
- Explore curriculum learning
- Real-World testing

References

Landman et al. (2021) Self-optimizing adaptive optics control with Reinforcement Learning for high-contrast imaging
doi.org/10.1103/PhysRevD.110.063008

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