From HSC to HST?
How deconvolution improves lens modeling

Eric Paic, Kenneth Wong

The University of Tokyo

ericpaic@g.ecc.u-tokyo.ac.jp, kcwong19@gmail.com

Background

The Hyper Suprime-Cam Subaru Strategic Survey (HSC-SSP) has discovered **1000+ strong lens candidates**. Accurate mass modeling of lensing systems is critical for extracting insights into cosmology, galaxy environments, and the nature of dark matter. While high-resolution imaging is essential for lens modeling, **the current ∼ 0.6″resolution of HSC imaging poses challenges for detailed analyses of these systems.**

In this work, we aim to improve the lens modeling of ground-based HSC data using the **STARRED deconvolution algorithm** ([1]). This software leverages Starlet regularization to enhance the resolution of HSC imaging from ∼ **0.6″to ∼ 0.17″**.

As a proof of concept to validate this approach, **we compare lens modeling of single system using 3 types of data: HSC, HSC deconvolved, and Hubble Space Telescope (HST).**

Choice of lens system

We focus on the **galaxy-galaxy lens system** HSCJ021247−055552 discovered by [3] in the HSC Wide Public Data Release 2. The availability of HST data in the F475X filter (PI: T. Treu, 17130), together with the presence of an **almost-complete Einstein ring** blended with the lens light makes this system ideal for assessing the quality of the deconvolution.

Conclusion

In this work, we show that **deconvolution significantly improves the precision of lens modeling** by comparing analyses of STARRED-deconvolved HSC imaging data with high-resolution space-based imaging data. We will build on this to **incorporate the multiple bands of HSC imaging into the lens modeling, which will further constrain the lensing observables from ground-based data**. Eventually, this methodology will be applied to a large number of lens systems.

This resolution boost paves the way for **two key advances for strong lensing science with HSC**: (1) **improved mass modeling accuracy** for ground-based images, comparable to results from space-based telescopes (e.g., HST), and (2) the **discovery of new lens systems** by resolving faint, compact features undetectable in the original HSC data.

References

[1] M. Millon et al. : *Image Deconvolution and Point-spread Function Reconstruction with STARRED: A Wavelet-based Two-channel Method Optimized for Light-curve Extraction*, ApJ, (2024)

[2] A. Galan et al. *Herculens: Differentiable gravitational lensing*, ASCL (2024)

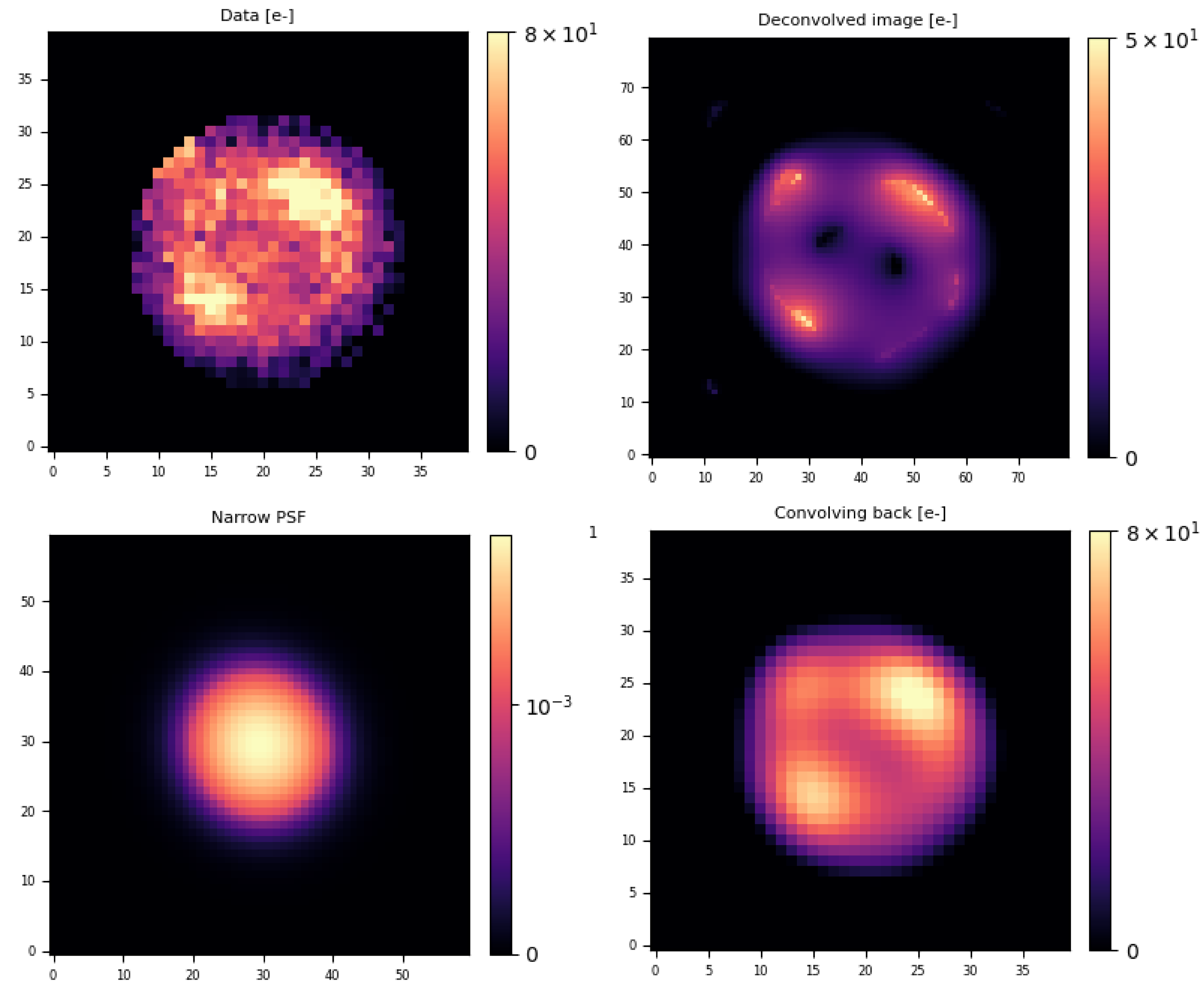
[3] R. Cañameras et al.: *HOLISMOKES VI. New galaxy-scale strong lens candidates from the HSC-SSP imaging survey.* A&A (2013)

Acknowledgements

The authors warmly thank Martin Millon and Aymeric Galan for their useful advice. This work is supported by JSPS KAKENHI Grant Number JP24H00221.

Deconvolution of HSC data

The Point Spread Function (PSF), given by the HSC PSF picker tool, is decomposed into the convolution of two terms: the so-called "Narrow PSF" and a Gaussian with a Full Width Half Maximum of 2 pixels, the latter setting the resolution of the deconvolved result. The following figure illustrates a deconvolution of **g-band HSC-SSP DR4 data** by the narrow PSF. By subsampling the data by a factor two, **the resolution of the deconvolved image reaches ∼ 0.17″**. Comparing this with the data of the HST panel in the second figure reveals shared features, including two bright regions and two faint regions but with sharp structures. As expected from the HST imaging, the deconvolved lens light is faint in this band giving a **visually accurate result**.



Lens modeling of HST, HSC and deconvolved HSC data

We model the lens with three data types using HERCULENS ([2]), adopting a Singular Isothermal Elliptical mass profile and Sersic profiles for the lens and source light. The first three panels of the figure confirm the accurate reproduction of the observed features, while the last panel shows that **deconvolution improves the recovered Einstein radius precision nearly twofold compared to original HSC data**. Additionally, the accuracy is also improved with a better agreement with the HST inferred value, likely thanks to the lens-source light deblending.