

Fast Inference Method for *Roman* Microlensing Unveils a New Unifying Degeneracy

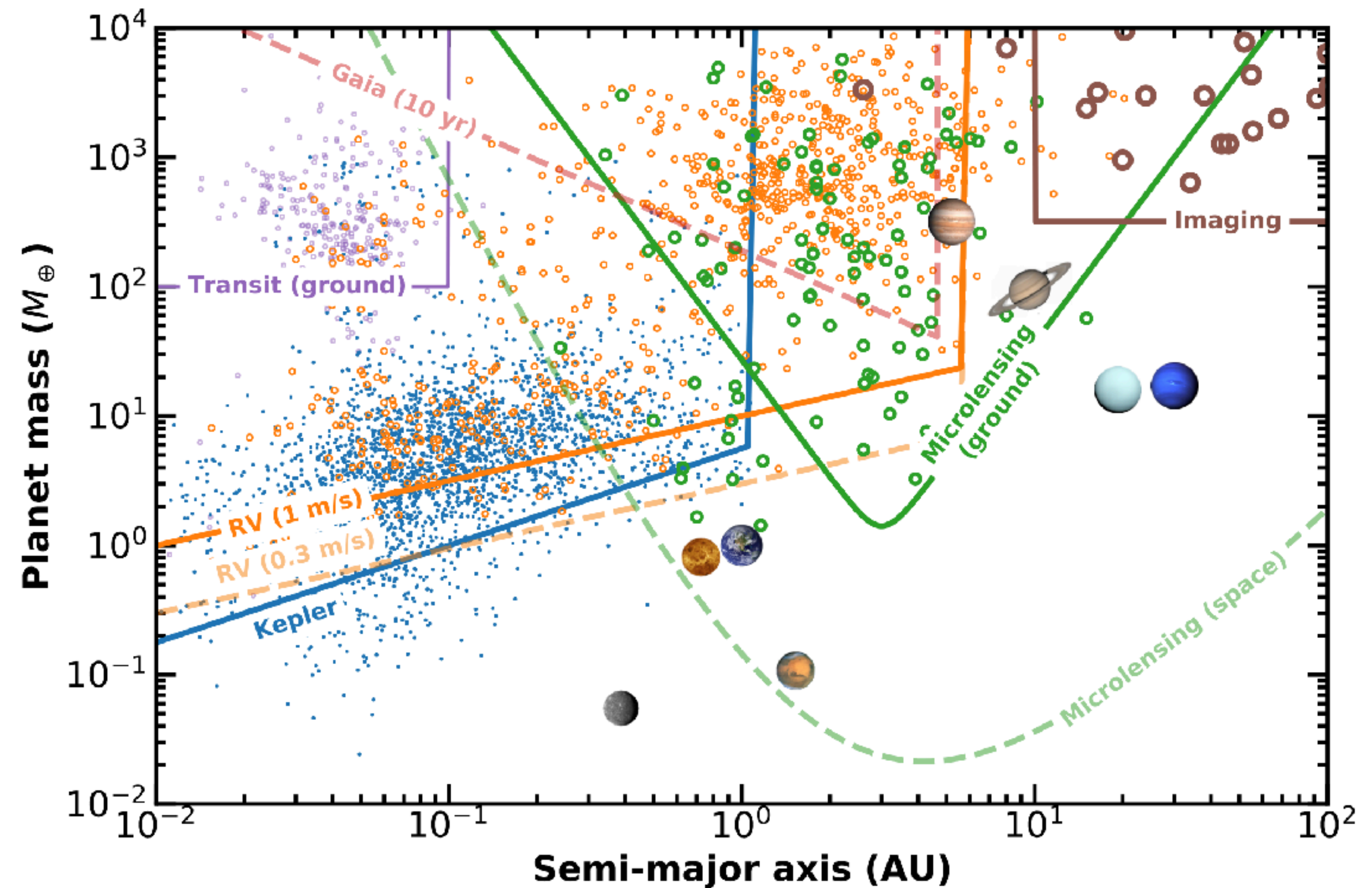
Exploring the Transient Universe with the the Nancy Grace Roman Space Telescope
February 9th, 2022

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LSSTC Data Science Fellow



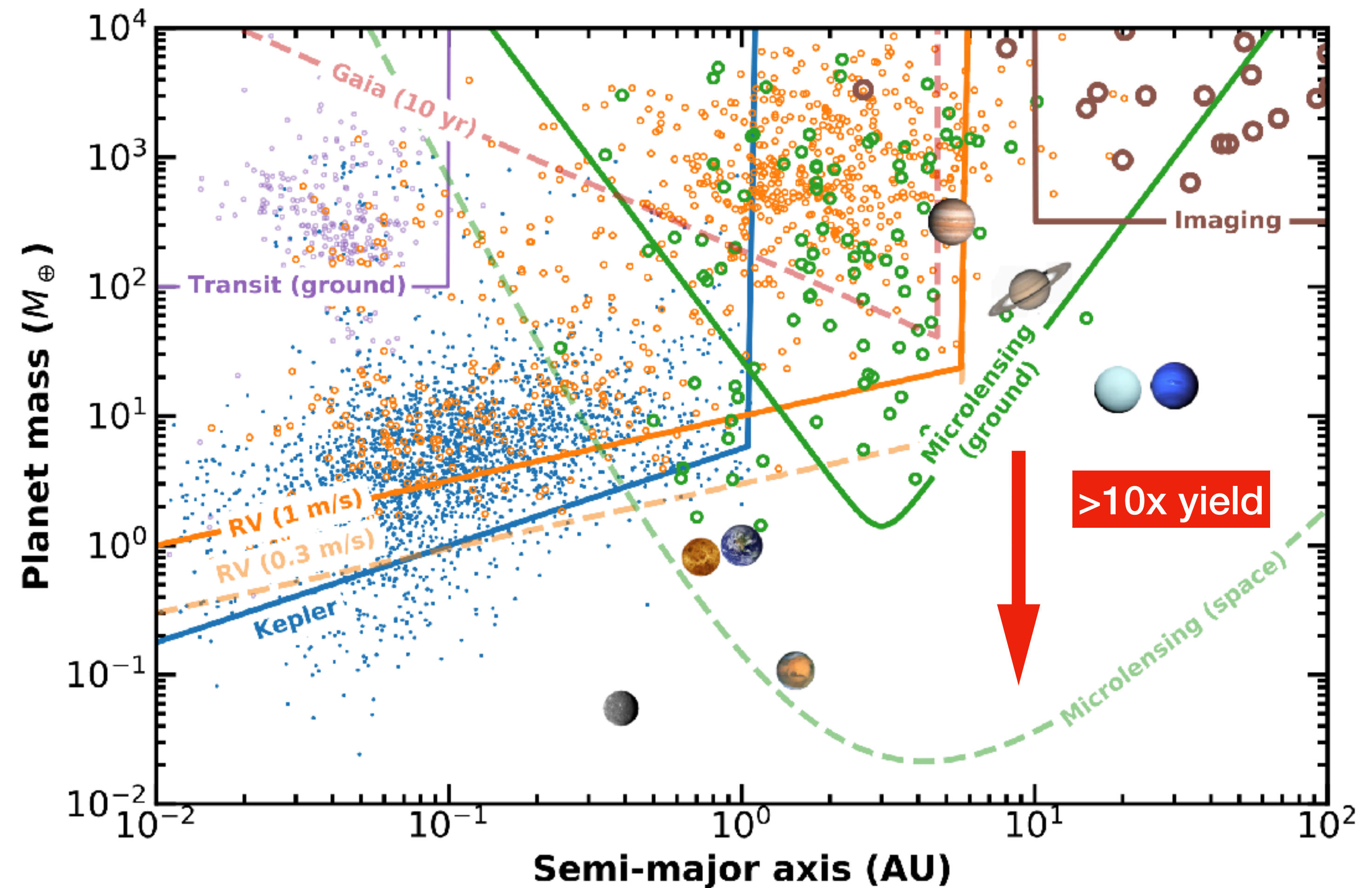
Microlensing for Planet Discovery and Characterization

- Unique sensitivity beyond the snow line
- Roman expects to discover ~ 1400 via microlensing. Currently: ~ 120
- Calls for automated and more efficient inference approaches

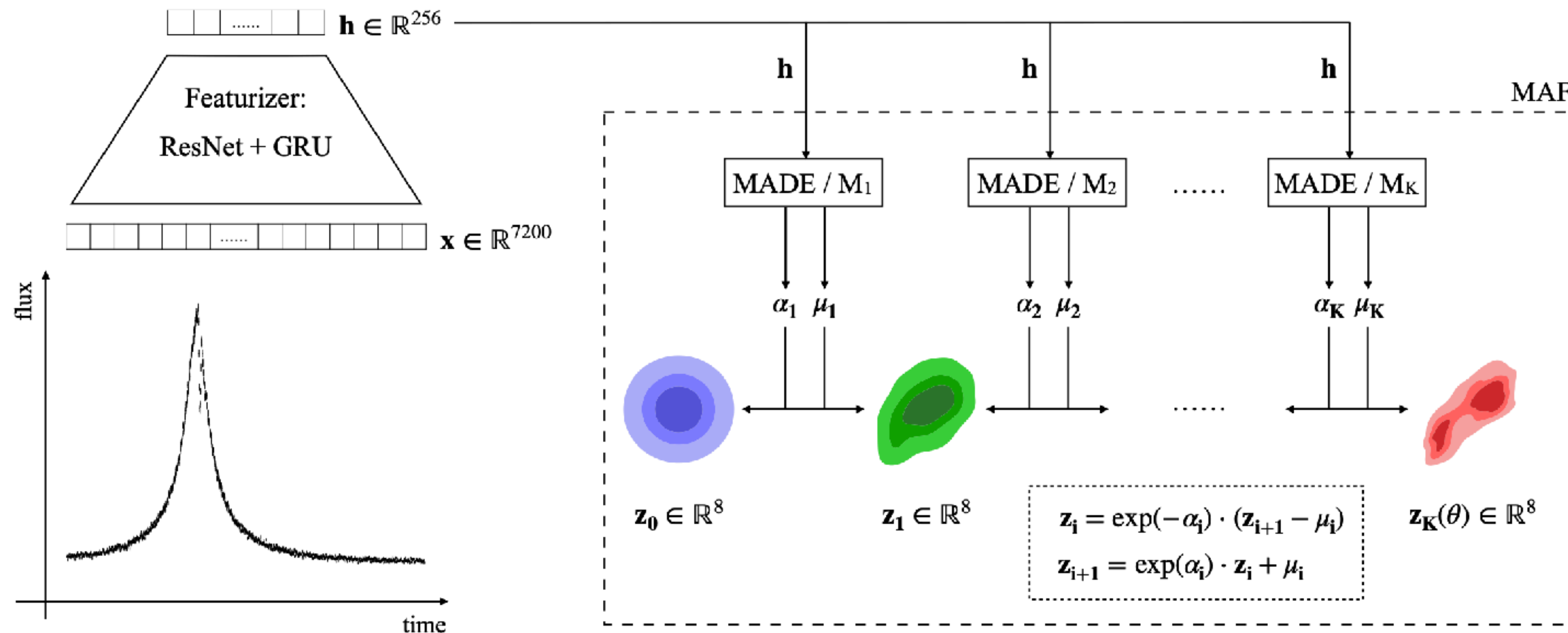


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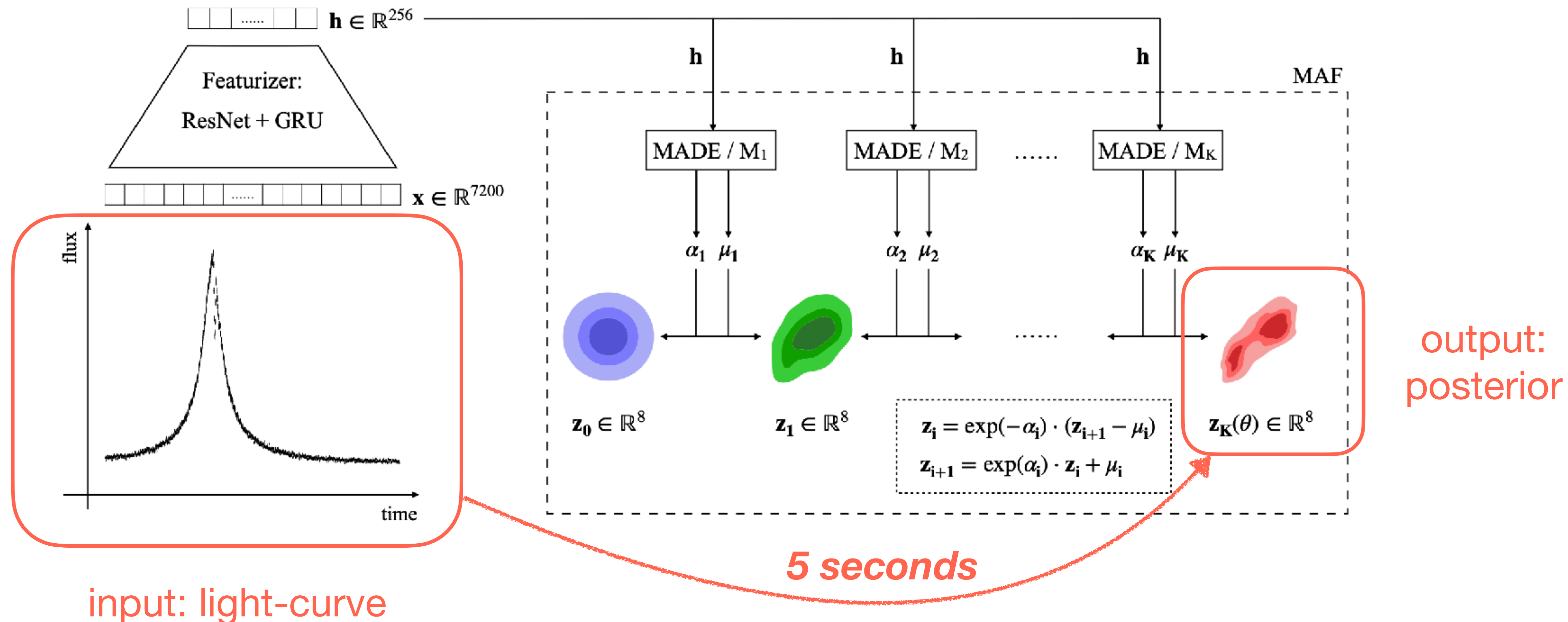
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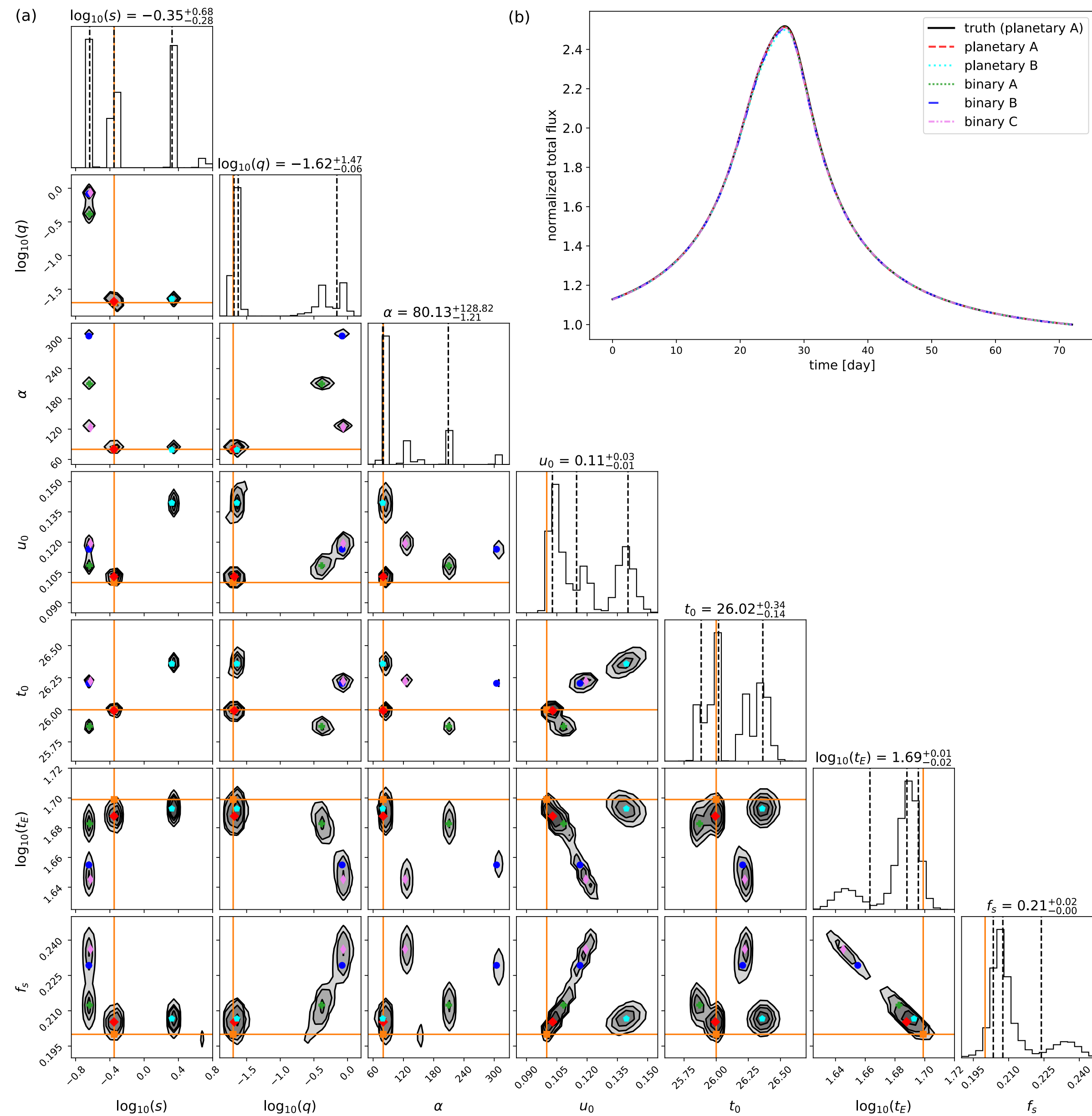
A Fast AI Inference Engine: NDE



A Fast AI Inference Engine: NDE



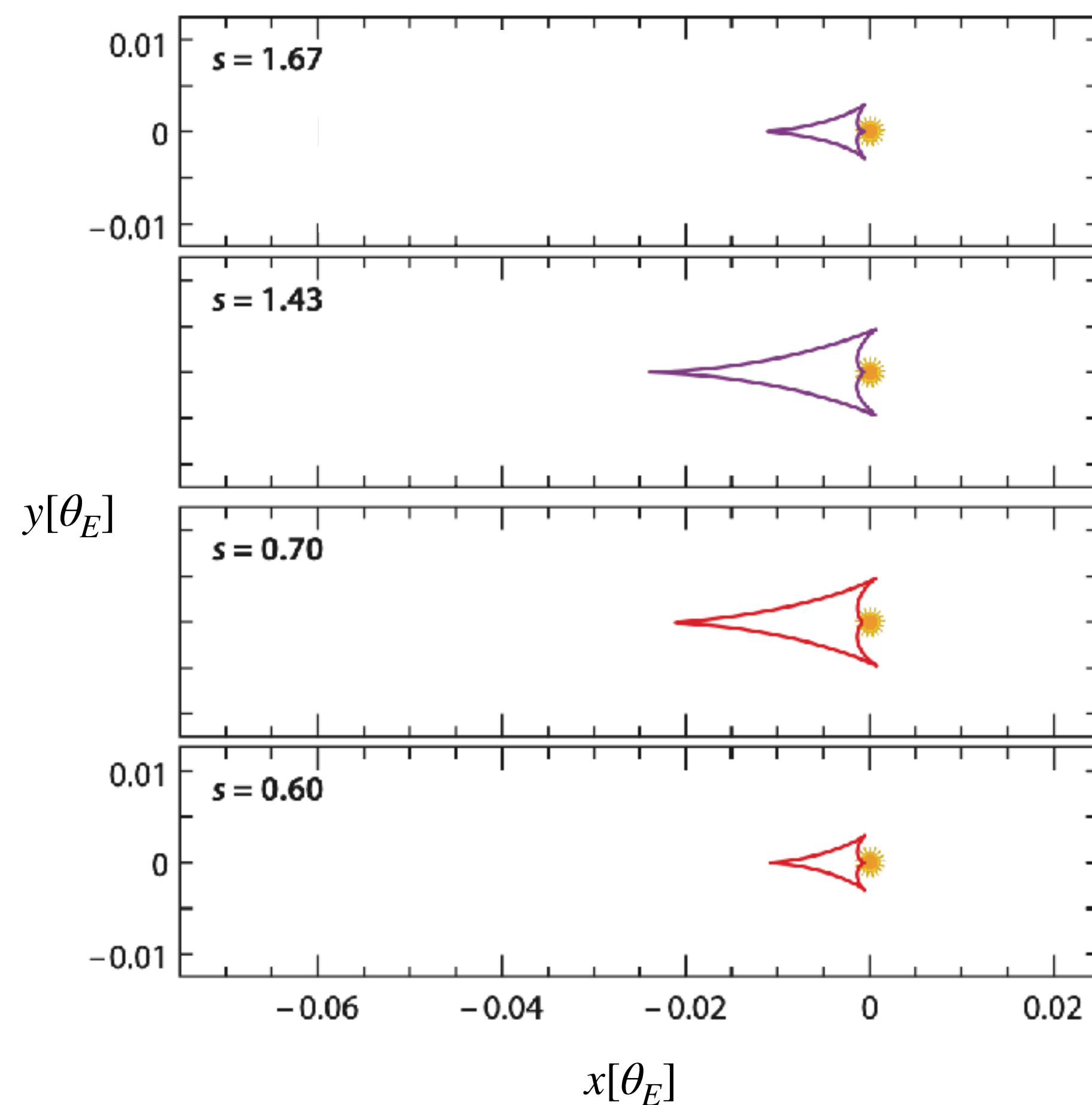
An Example NDE Posterior



- Training: $\sim 300,000$ events
- OGLE-2011-BLG-0526 *ish
- 5 distinct solutions: even more degenerate solutions found than reported in Choi+ 2012
- Posterior in 5 seconds. Light-curve realizations show accuracy of solutions

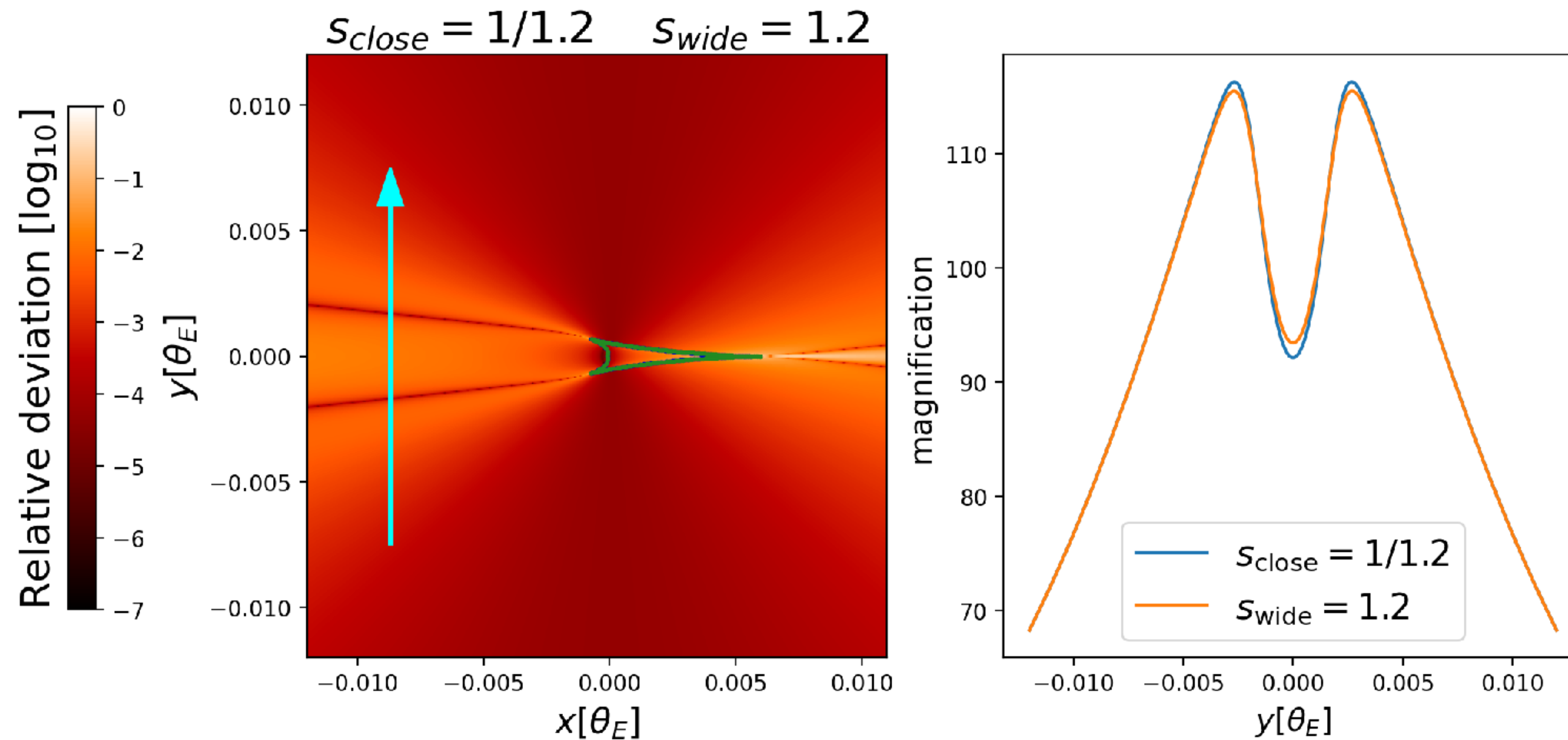
Microlensing caustics and degeneracies

Central Caustics

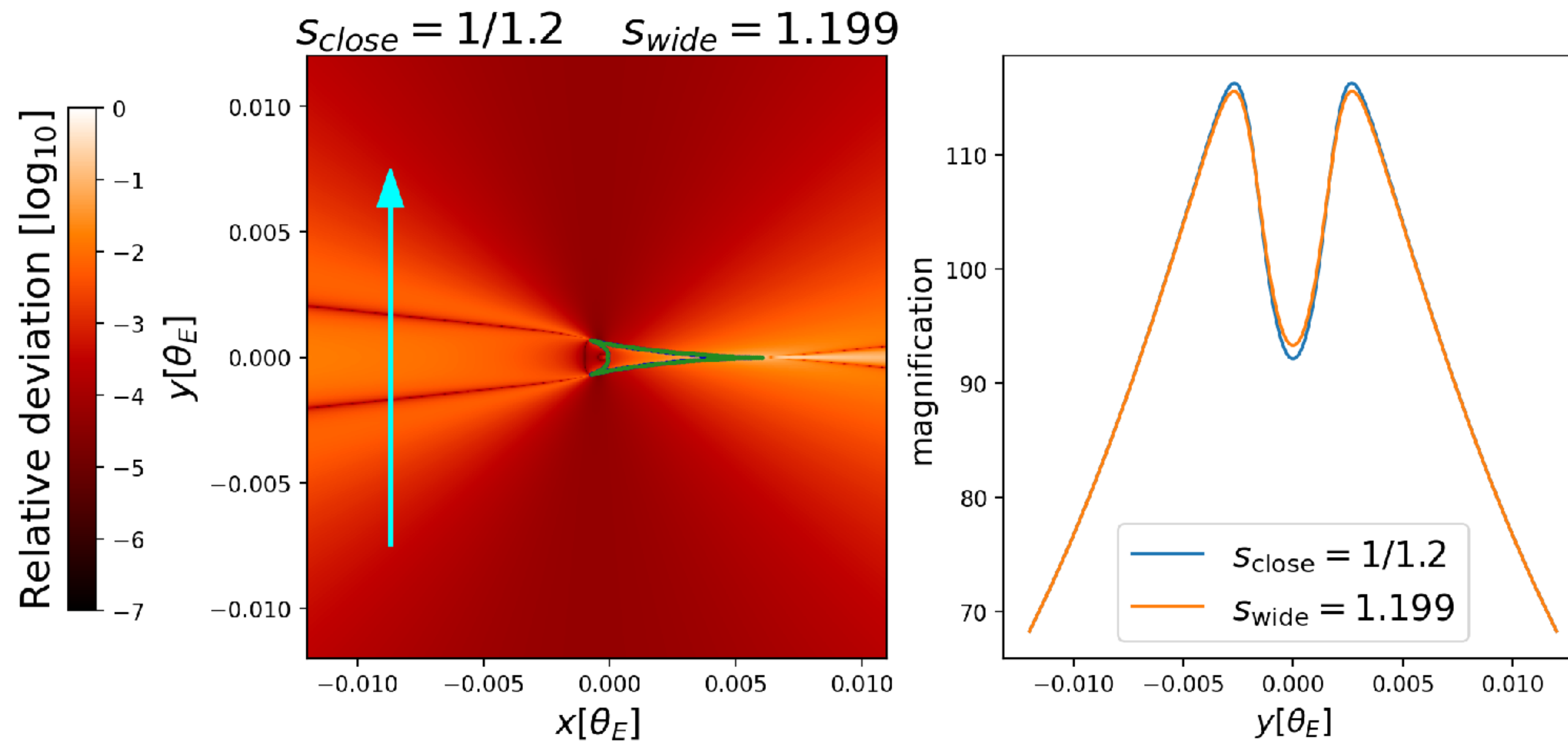


- $s \equiv D/\theta_E$ (star-planet separation)
- Close-wide degeneracy: central caustic invariant under $s \leftrightarrow s^{-1}$ deep in the *non-resonant* limit (Griest & Safizadeh 1998; Dominik 1999)

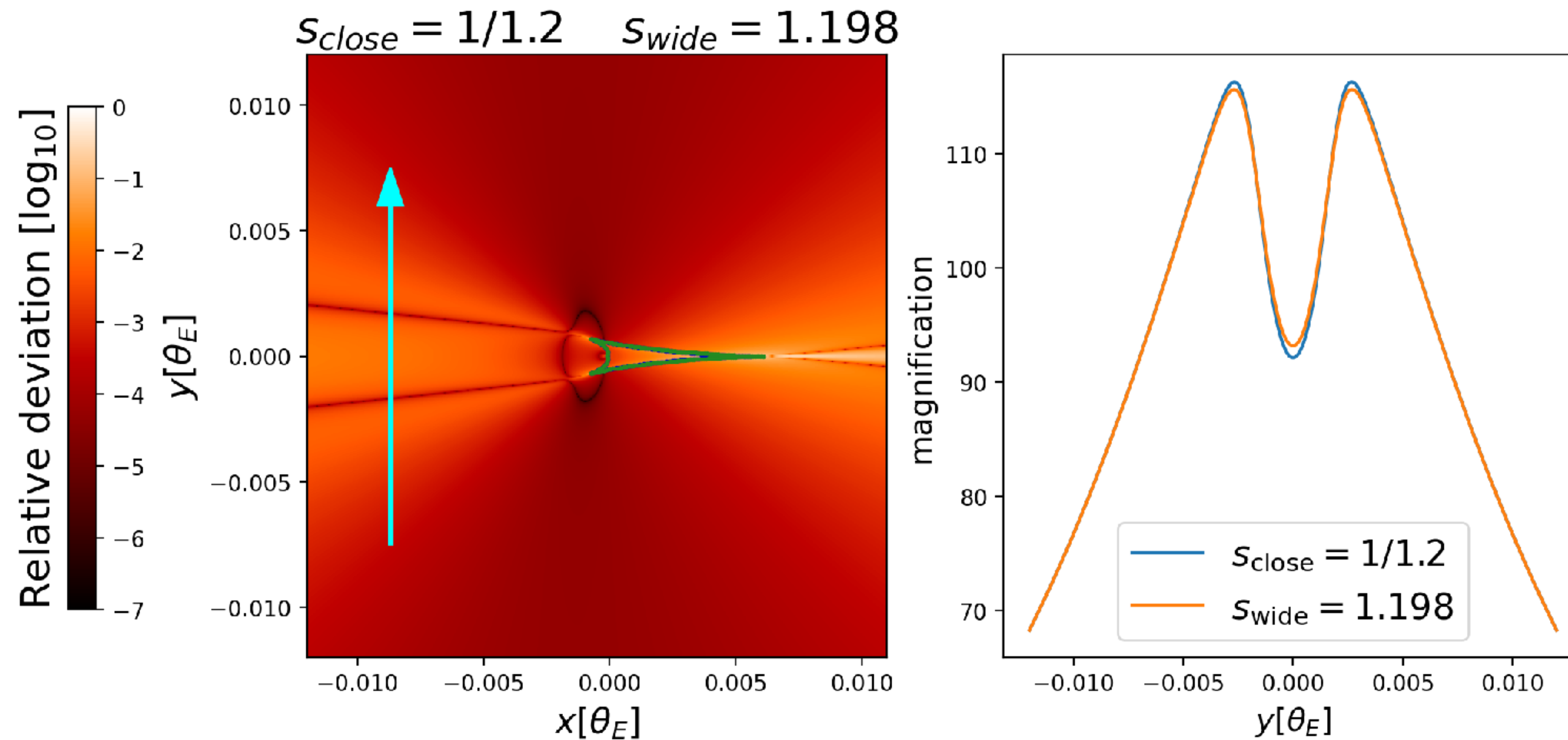
Can we do better than *close-wide*?



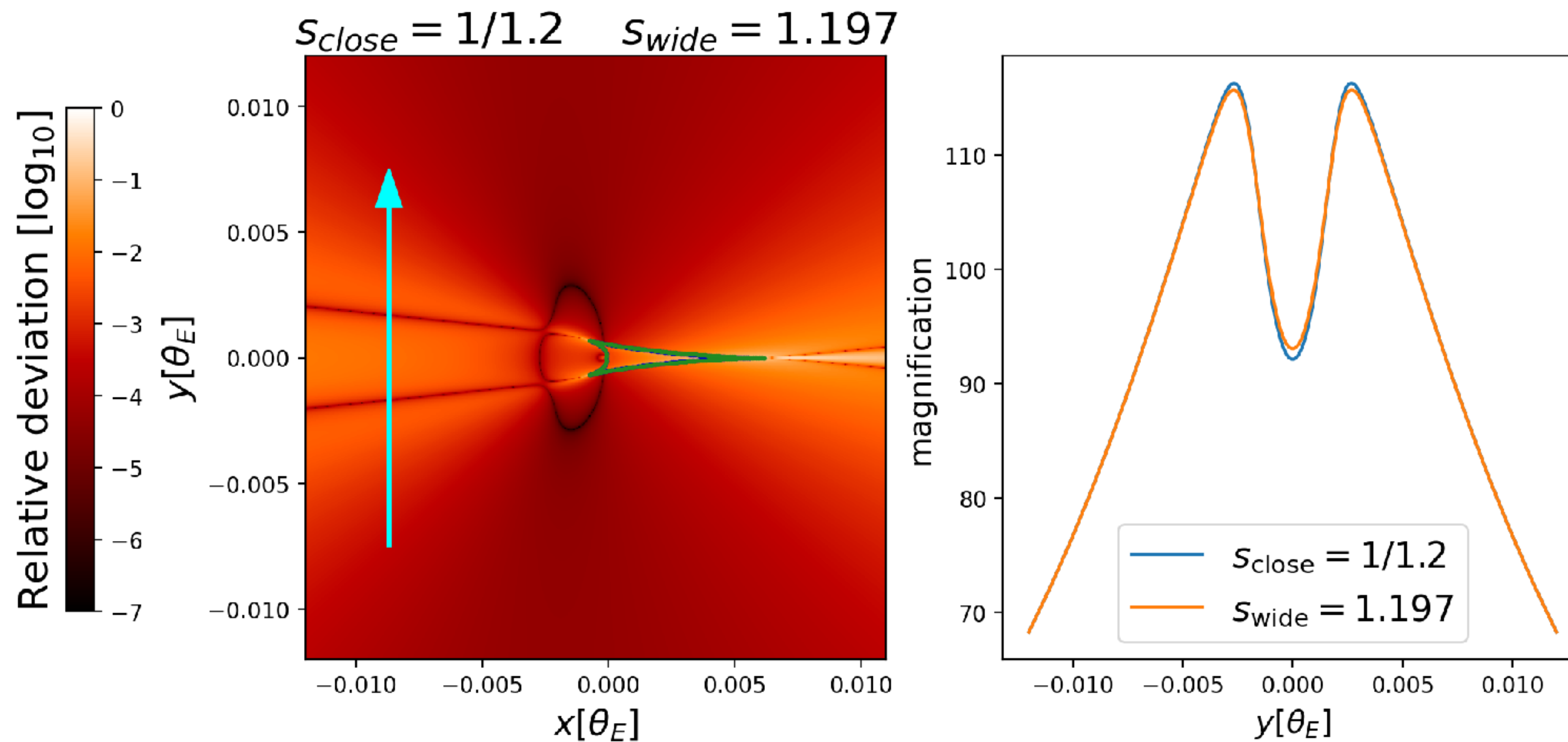
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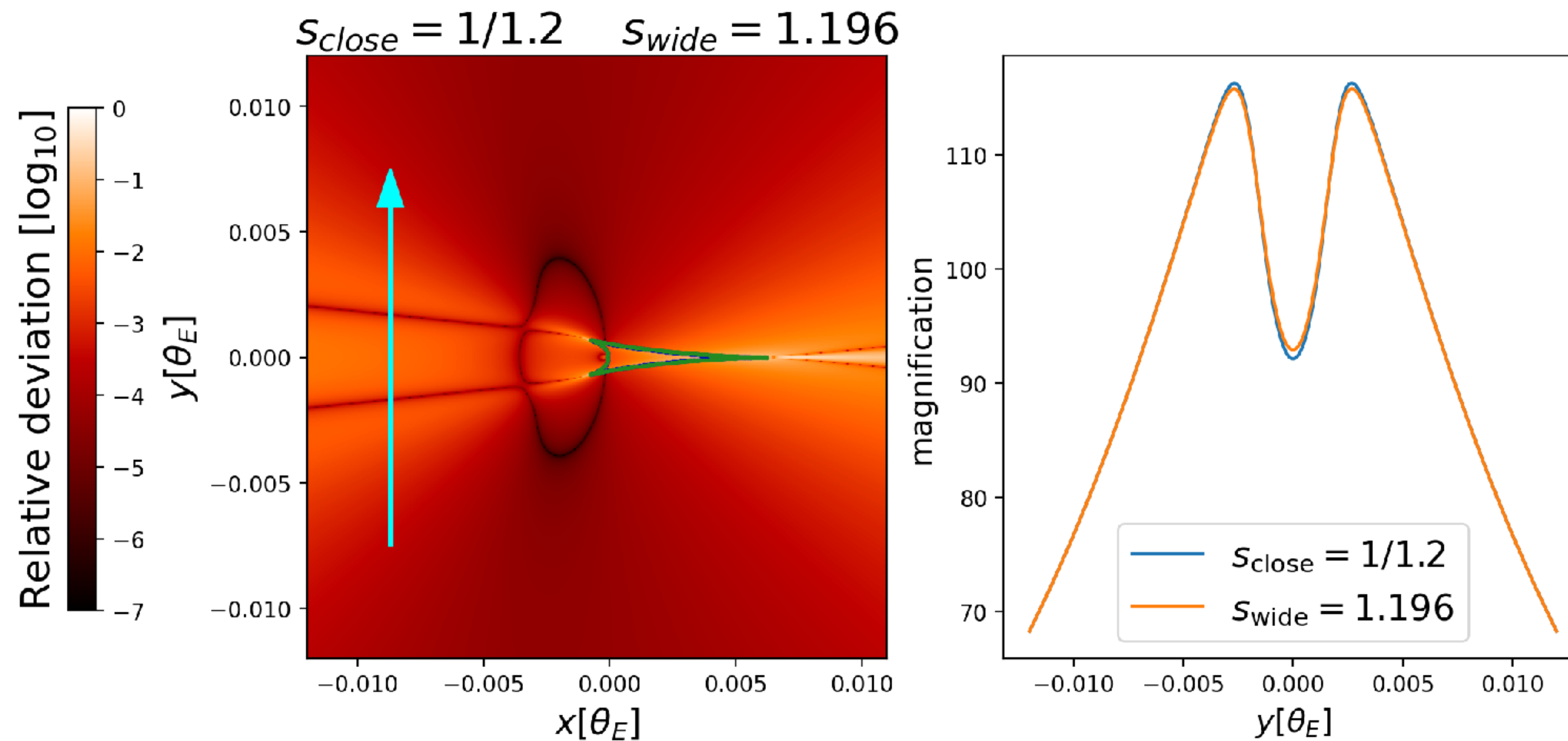
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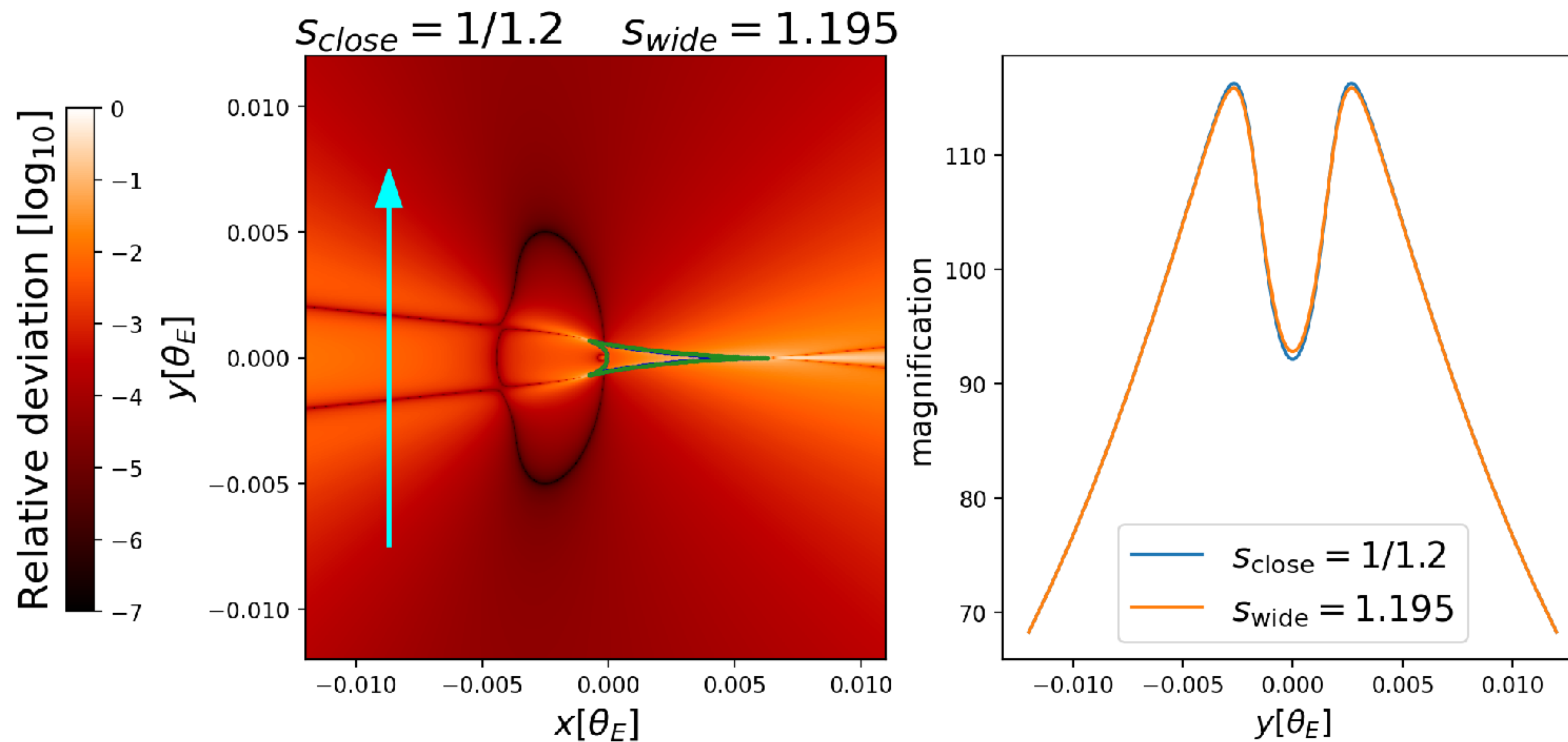
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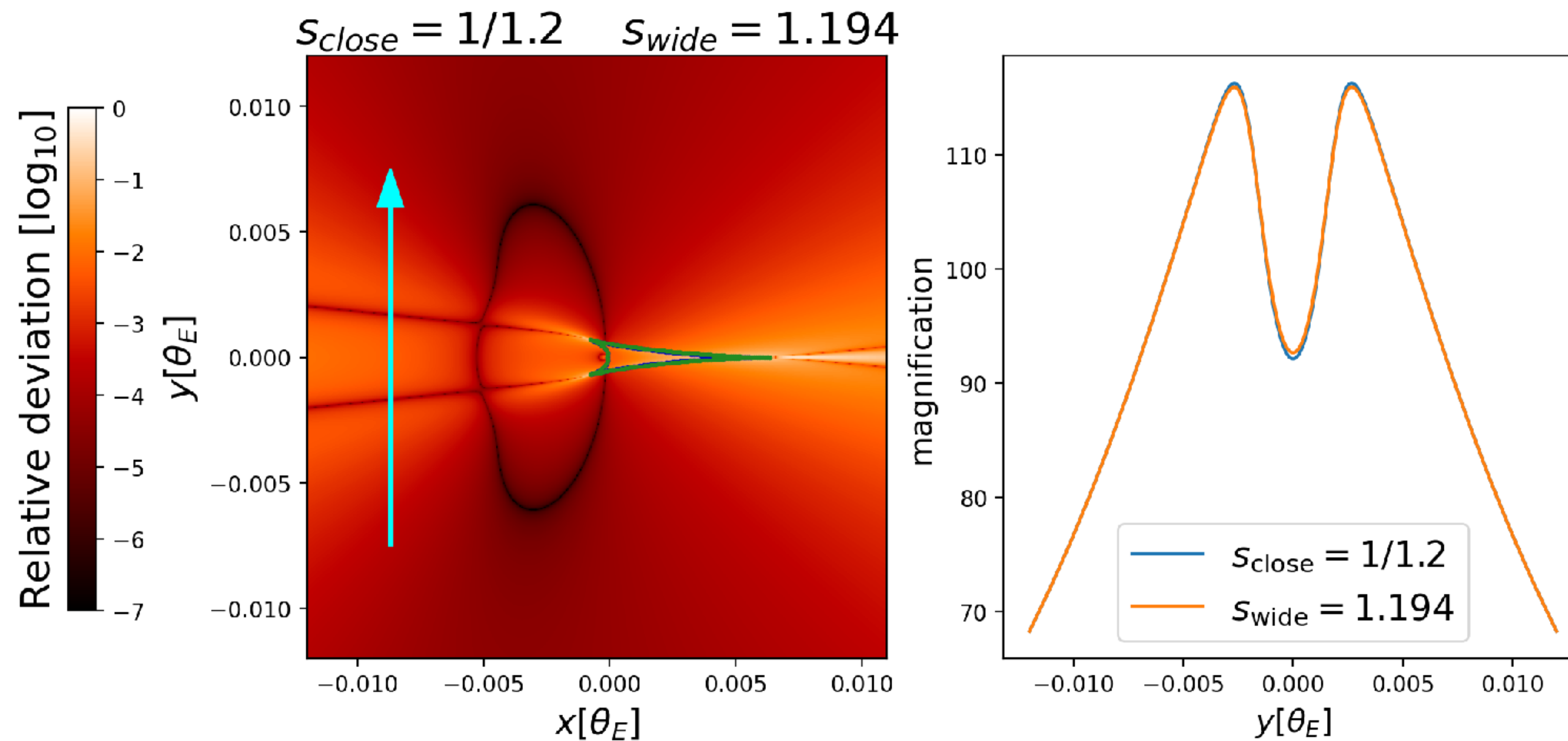
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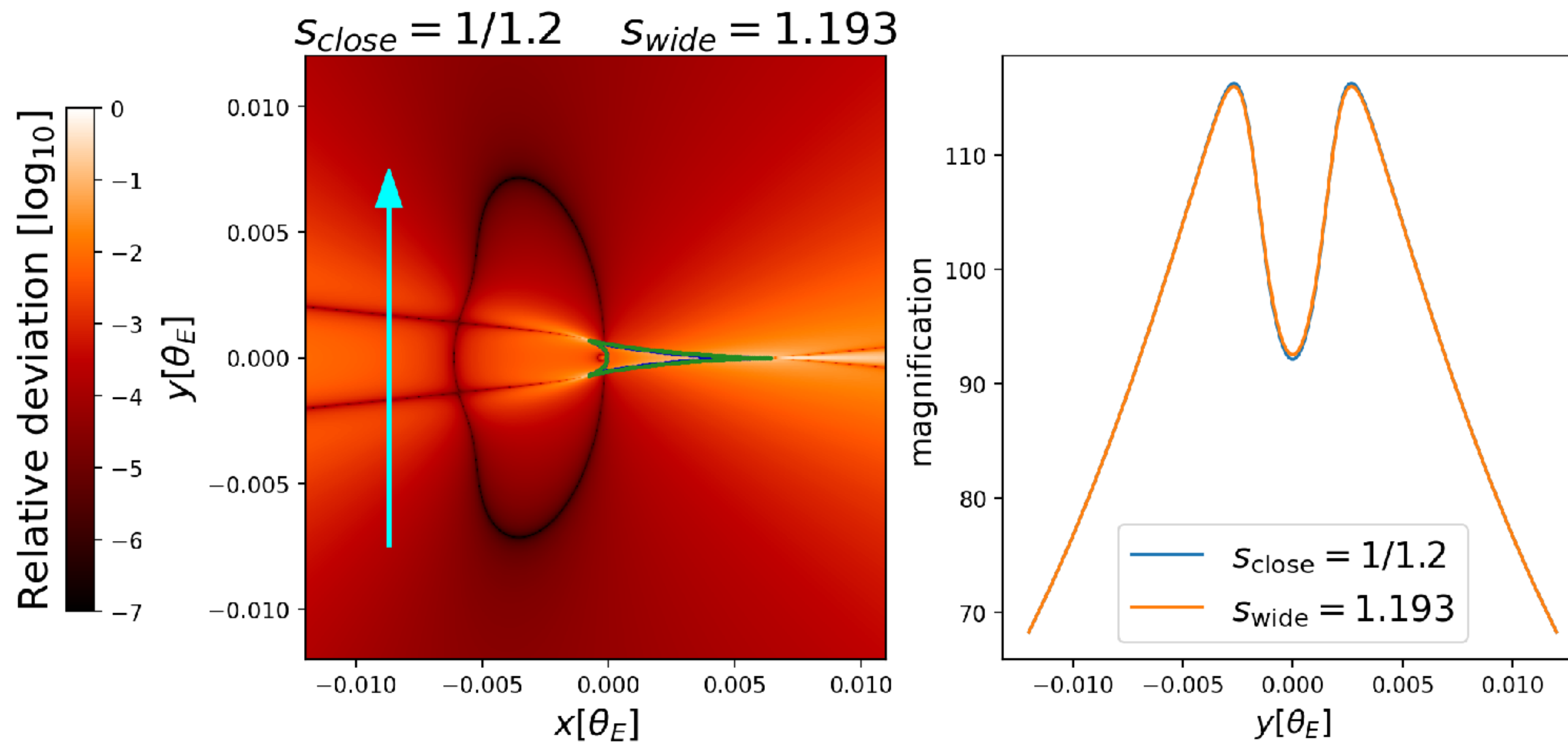
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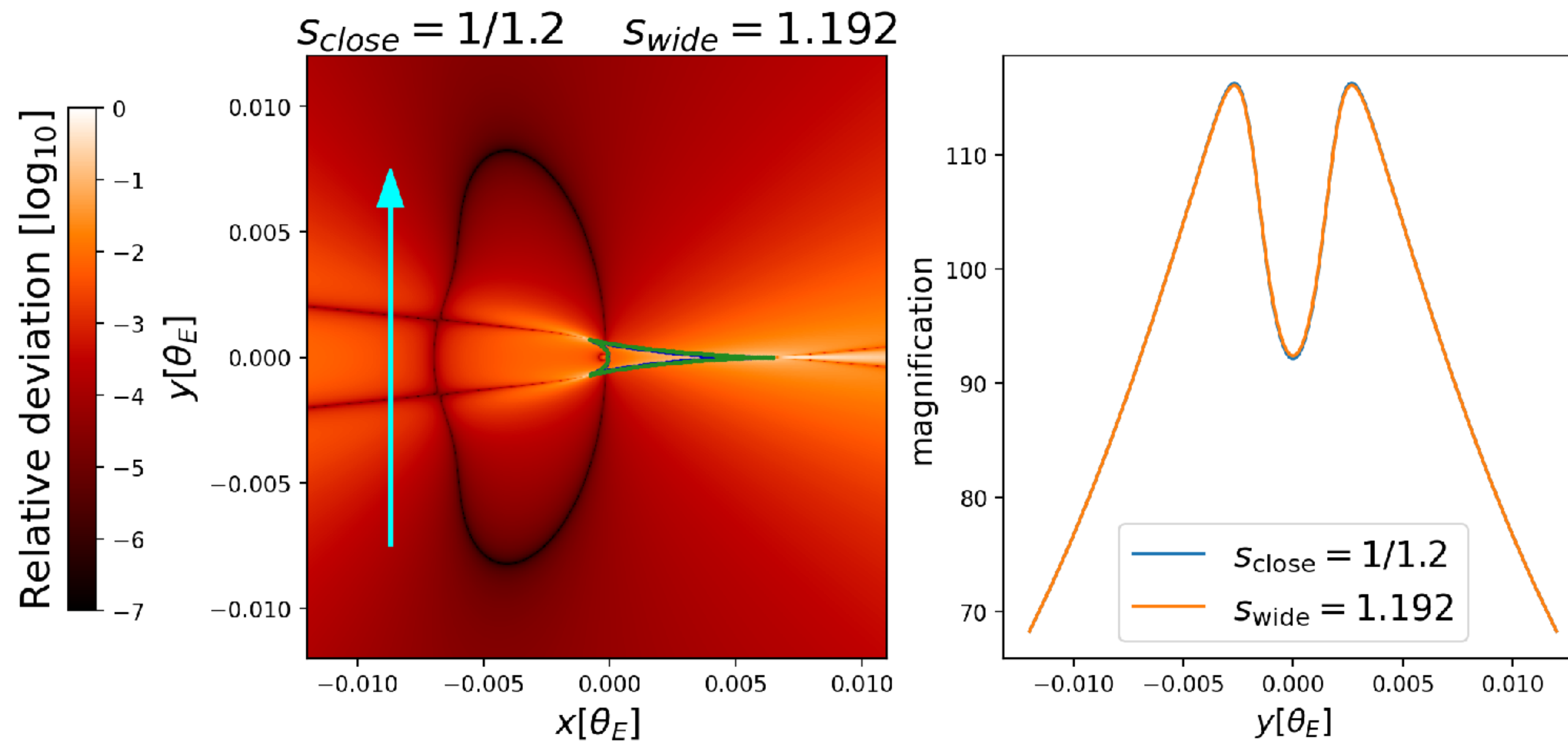
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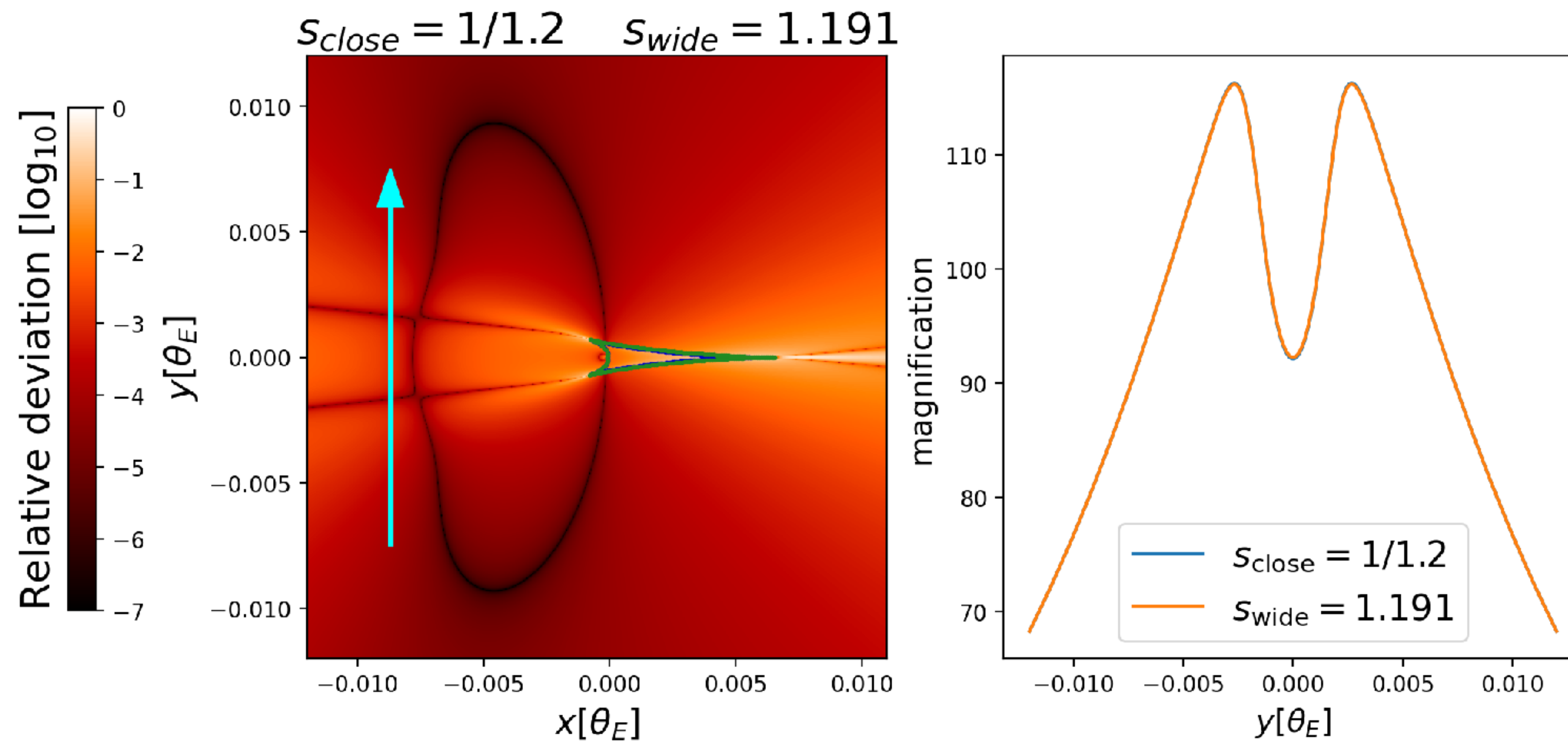
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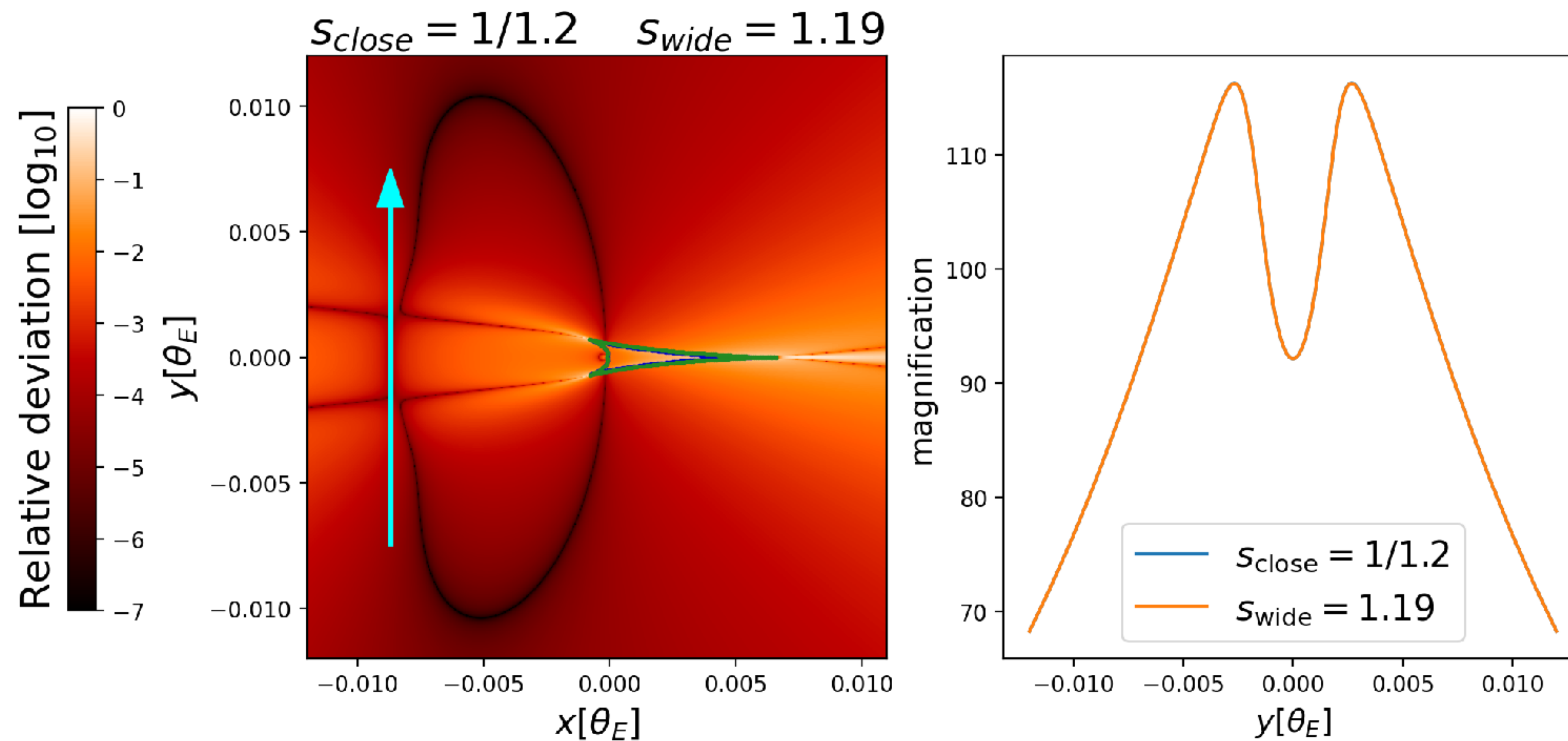
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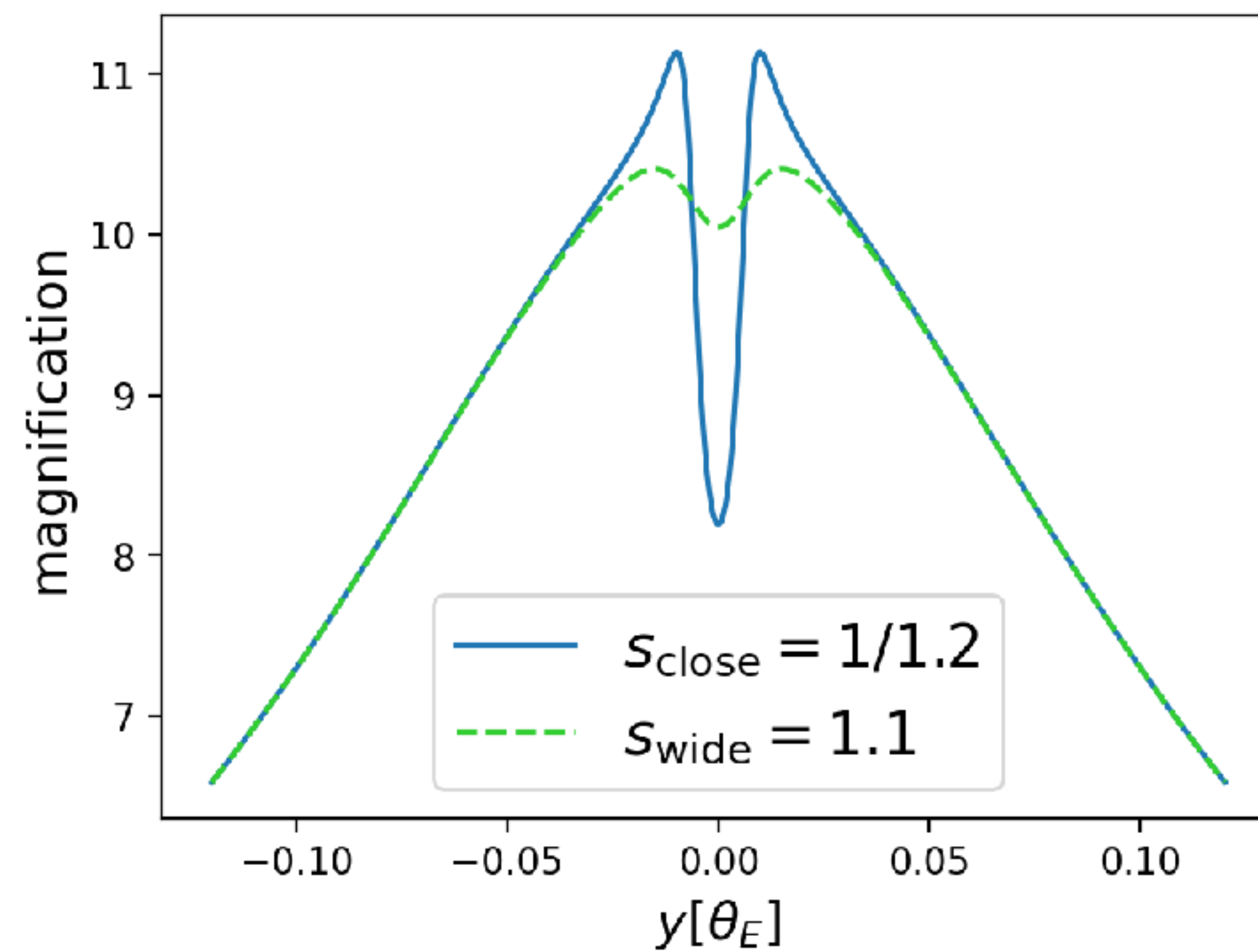
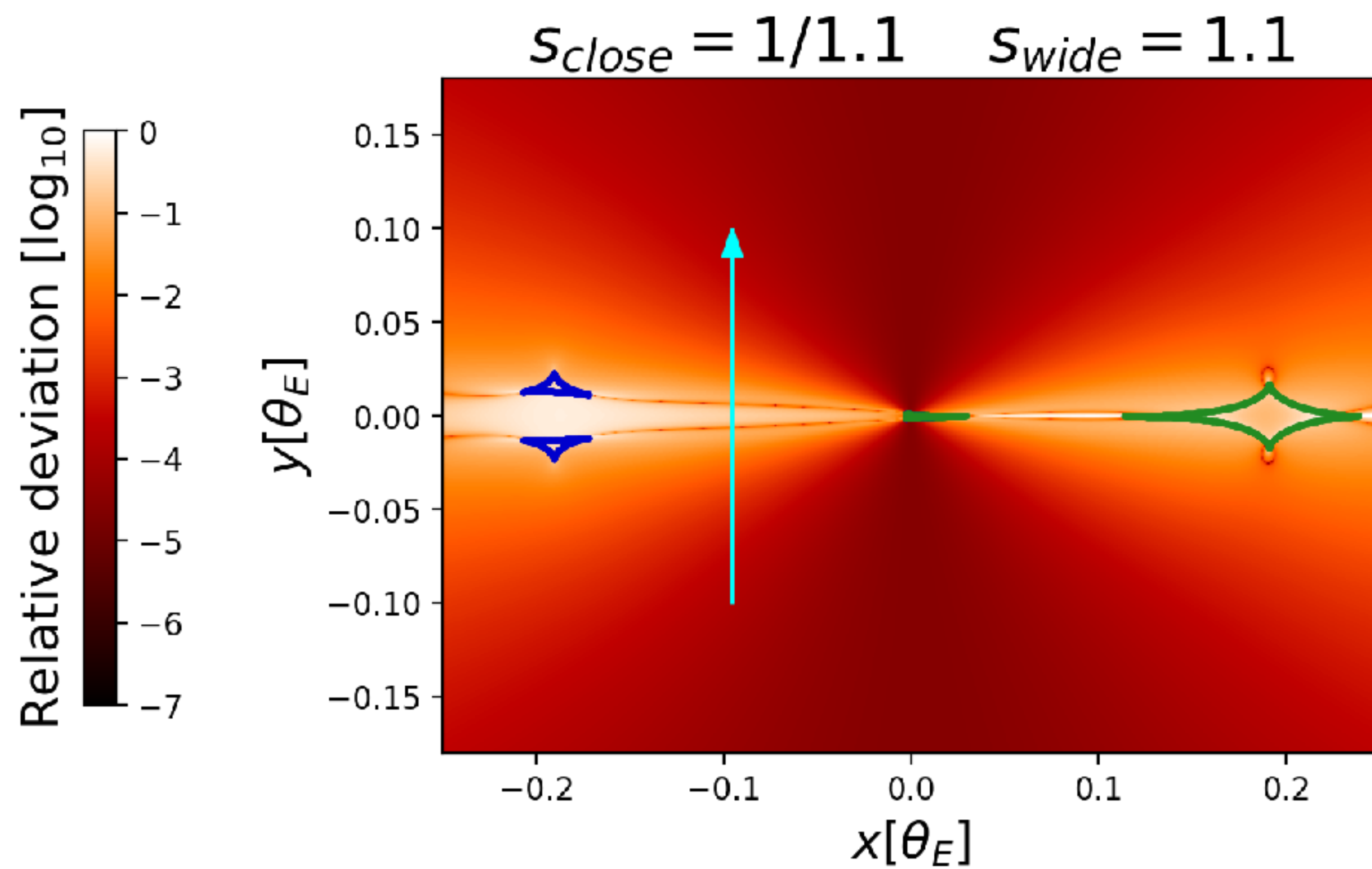
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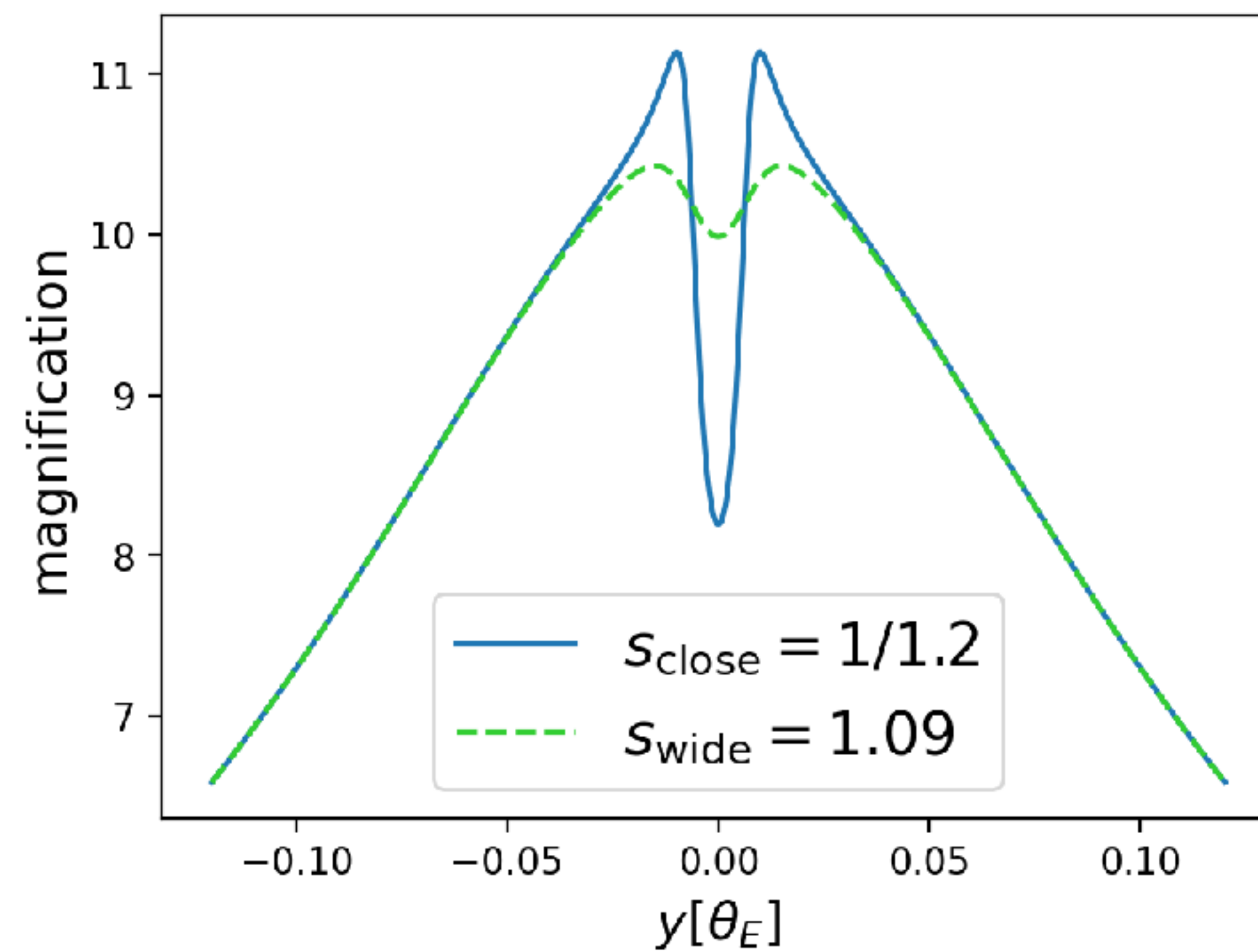
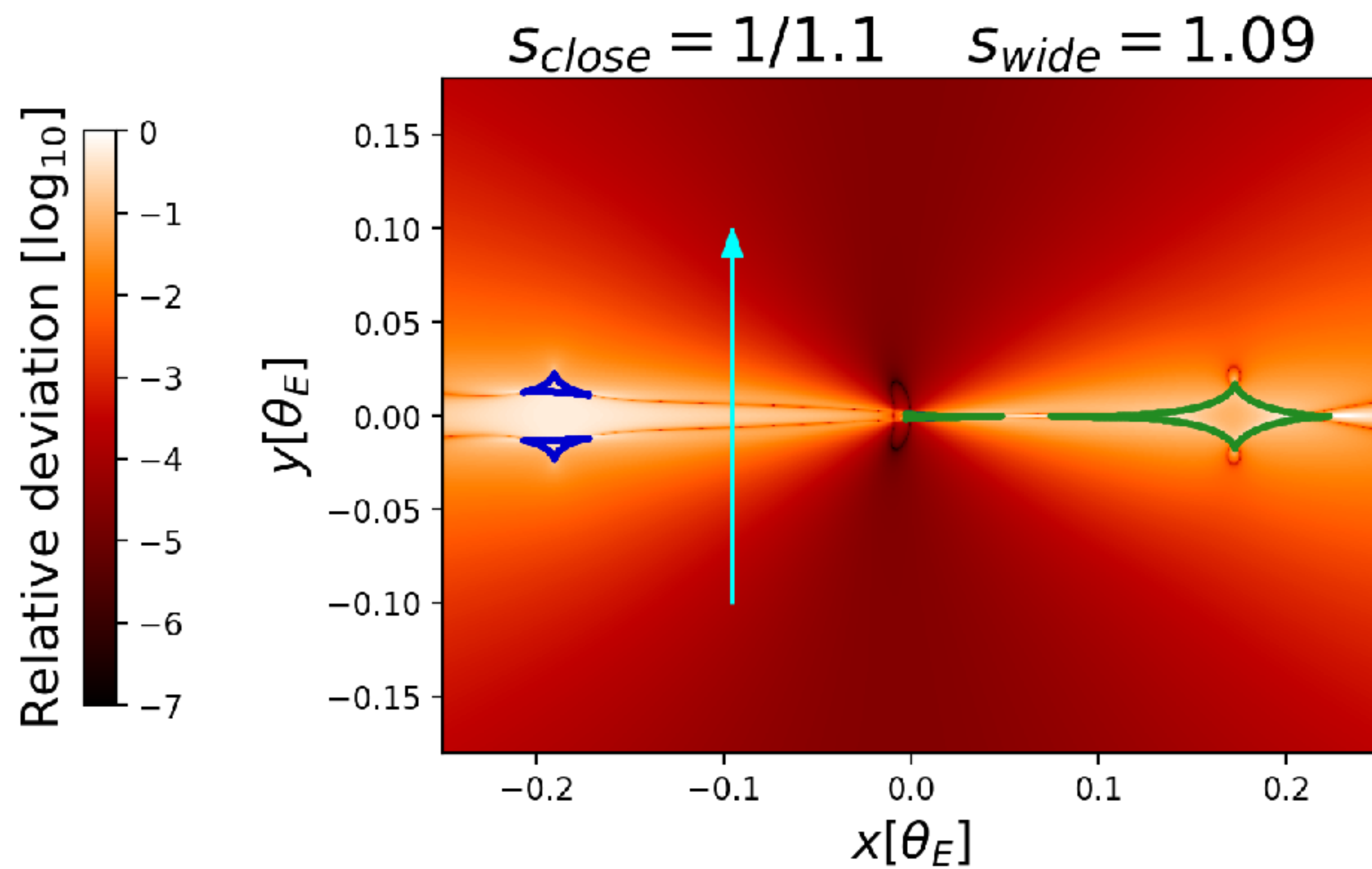
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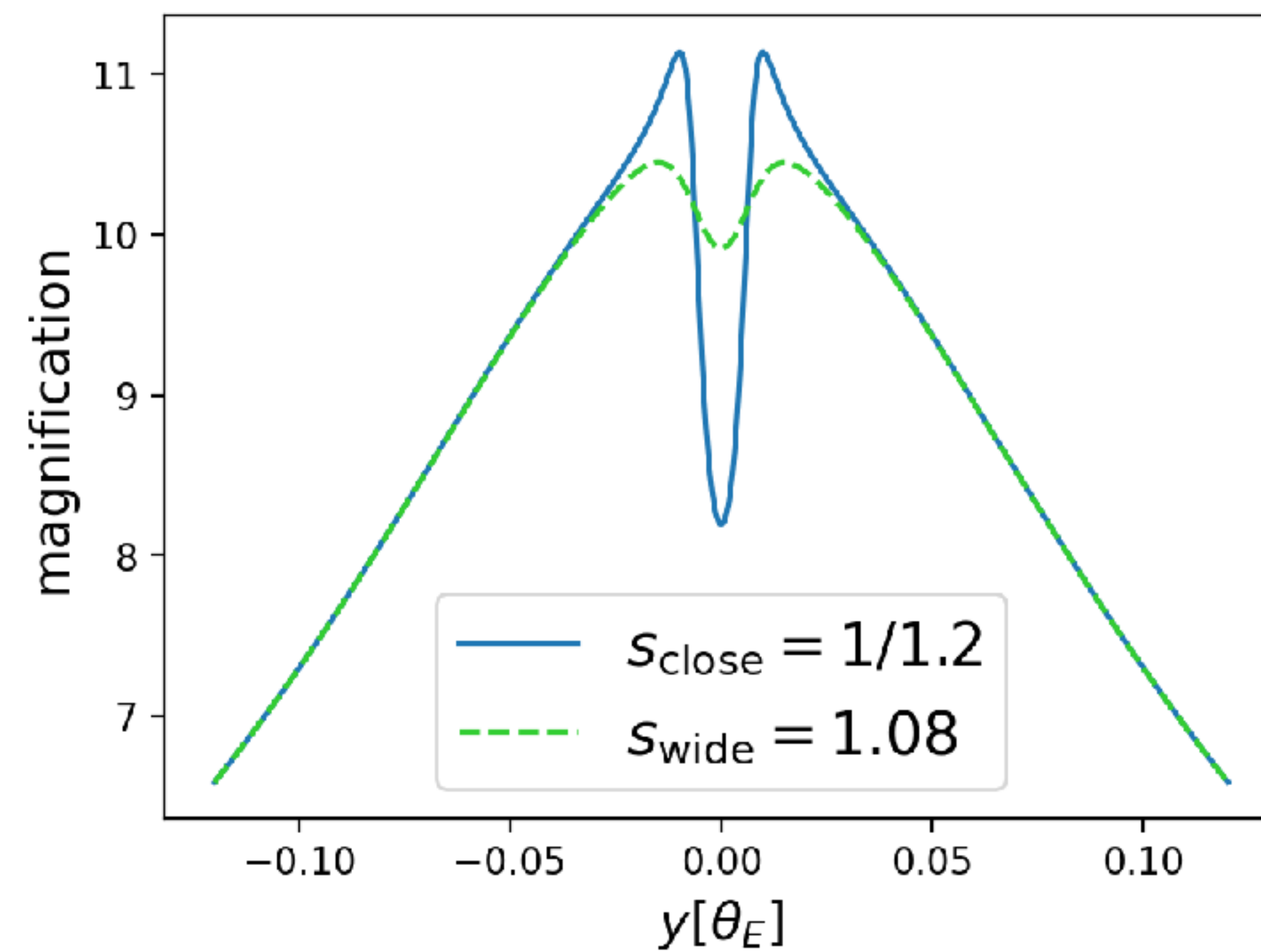
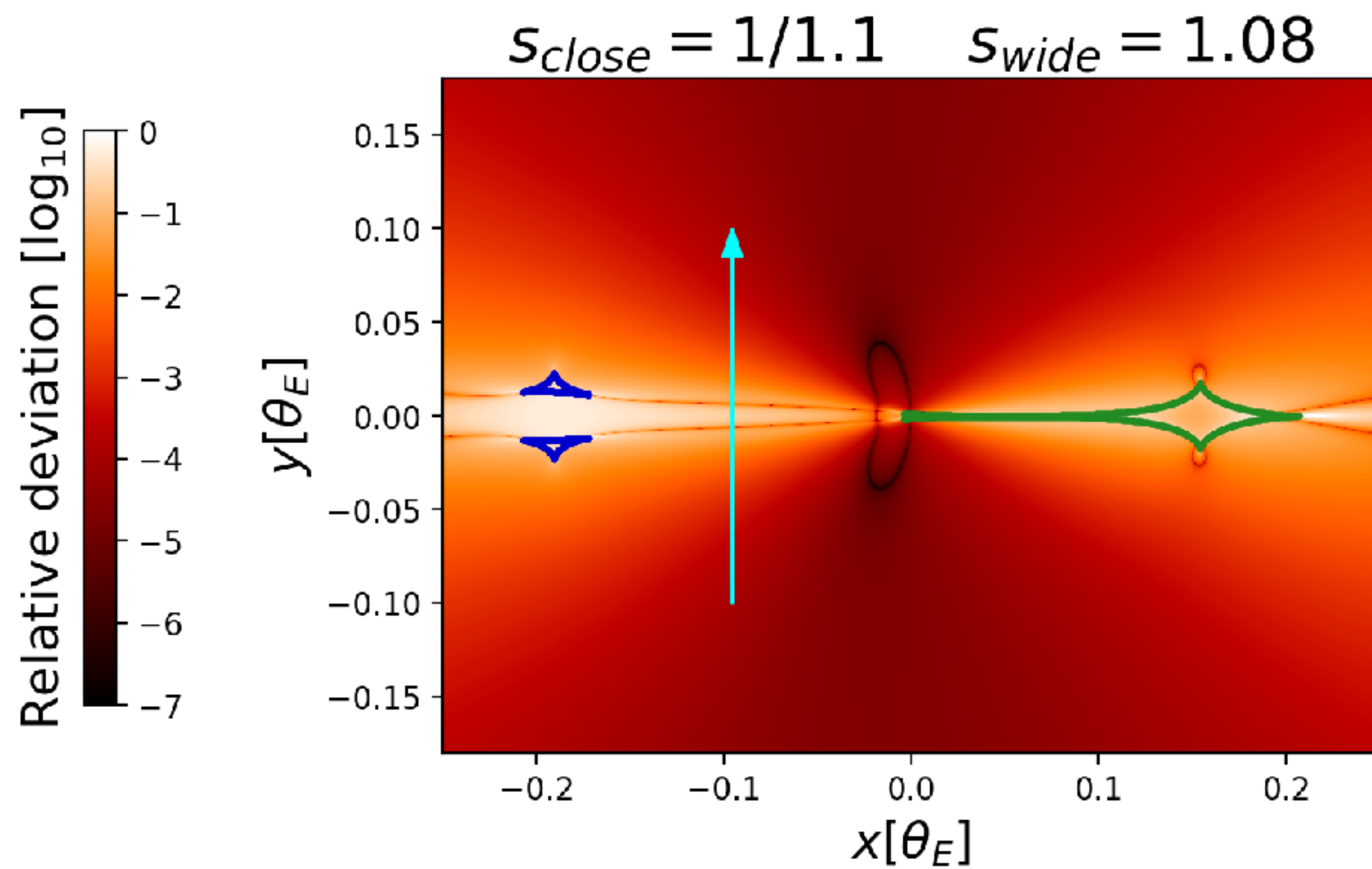
Beyond the central caustic ...



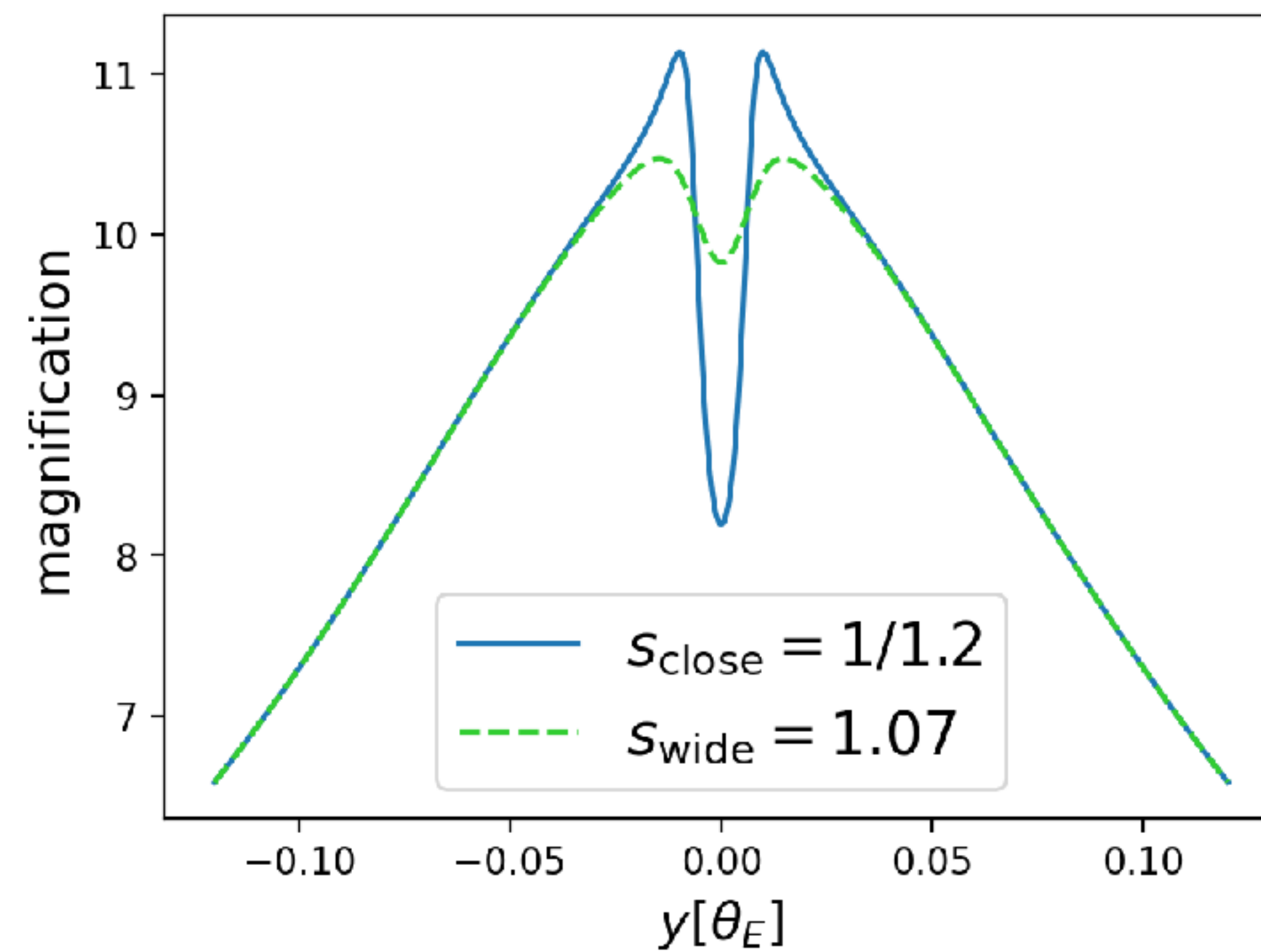
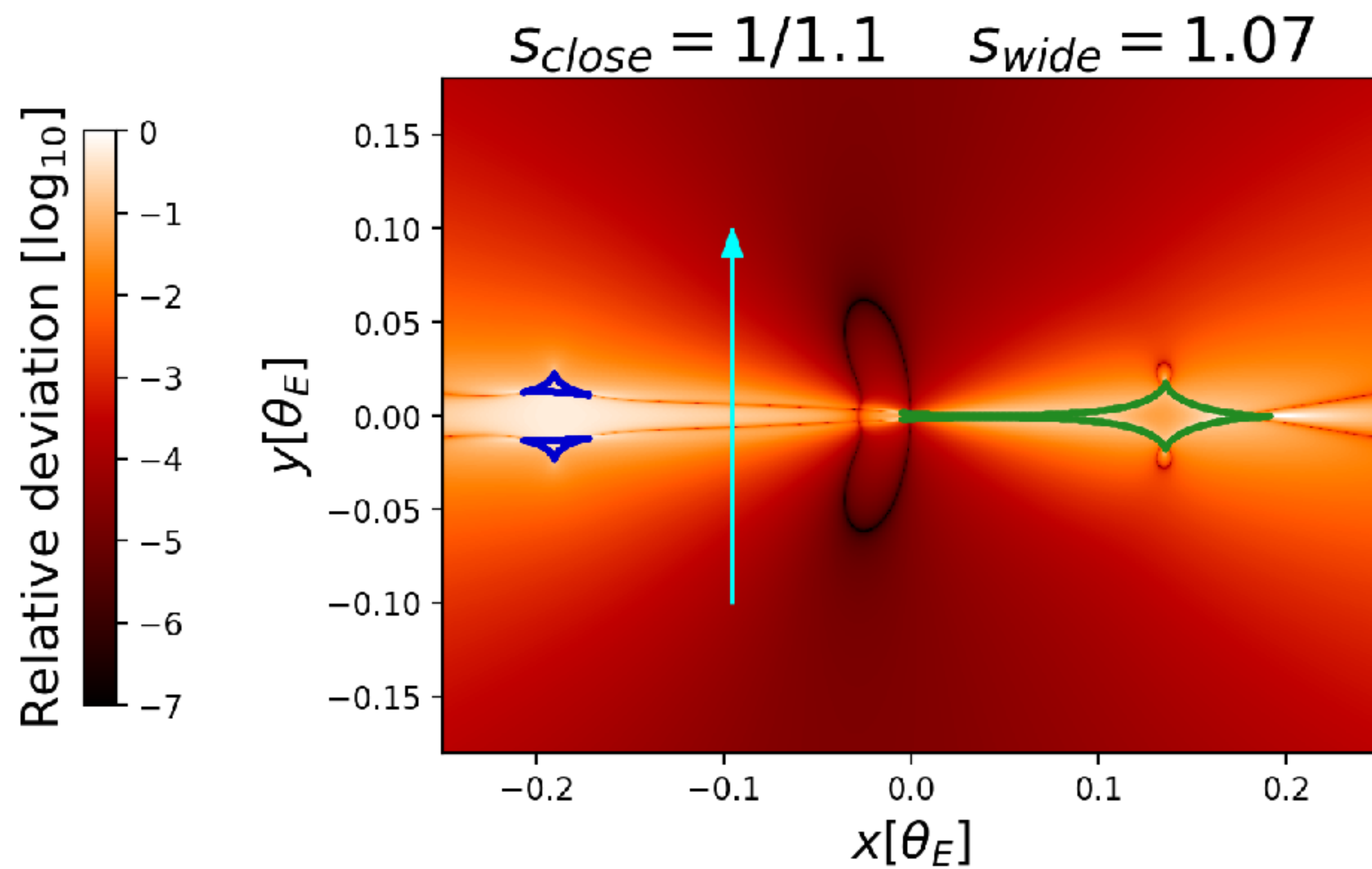
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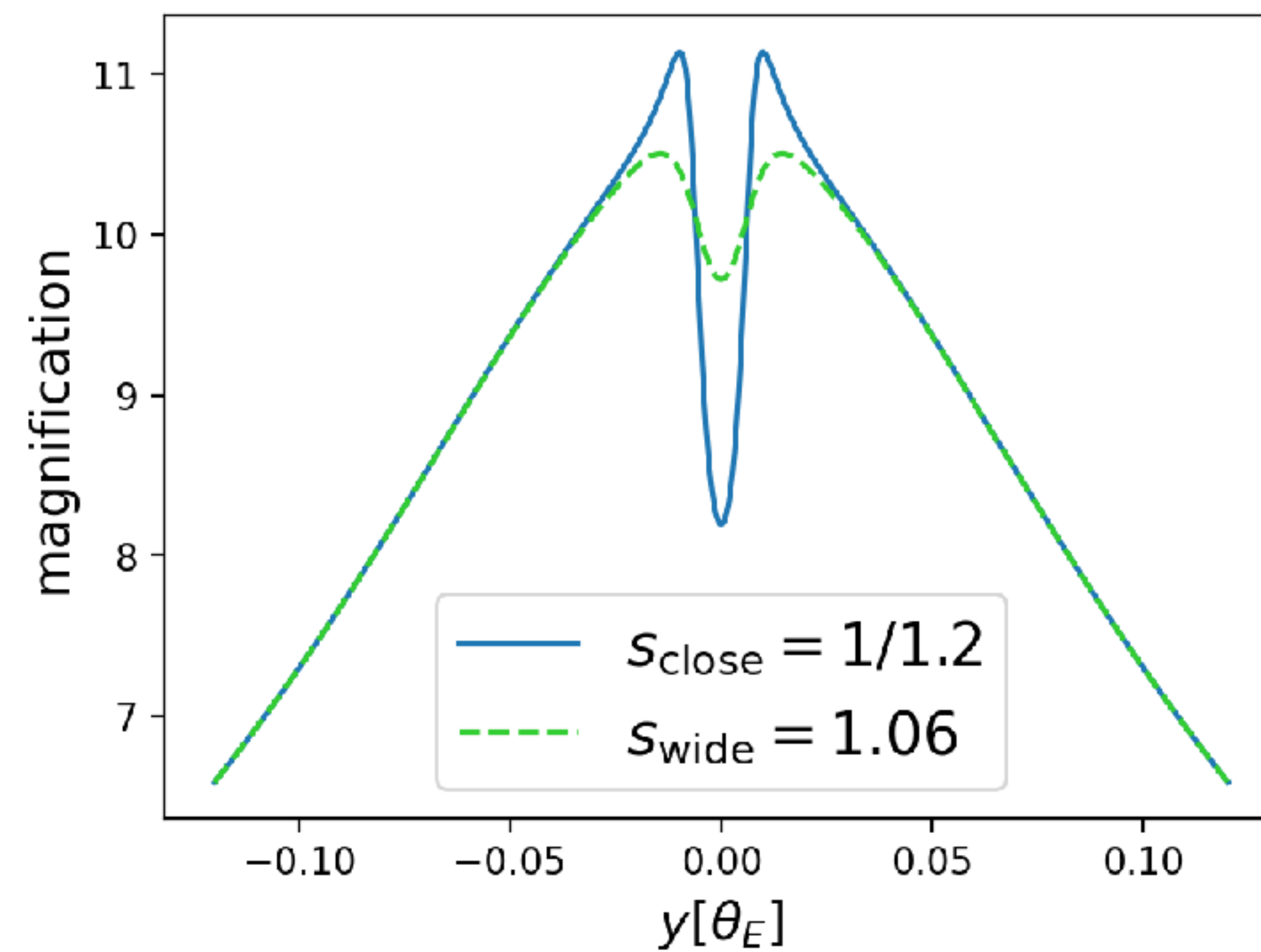
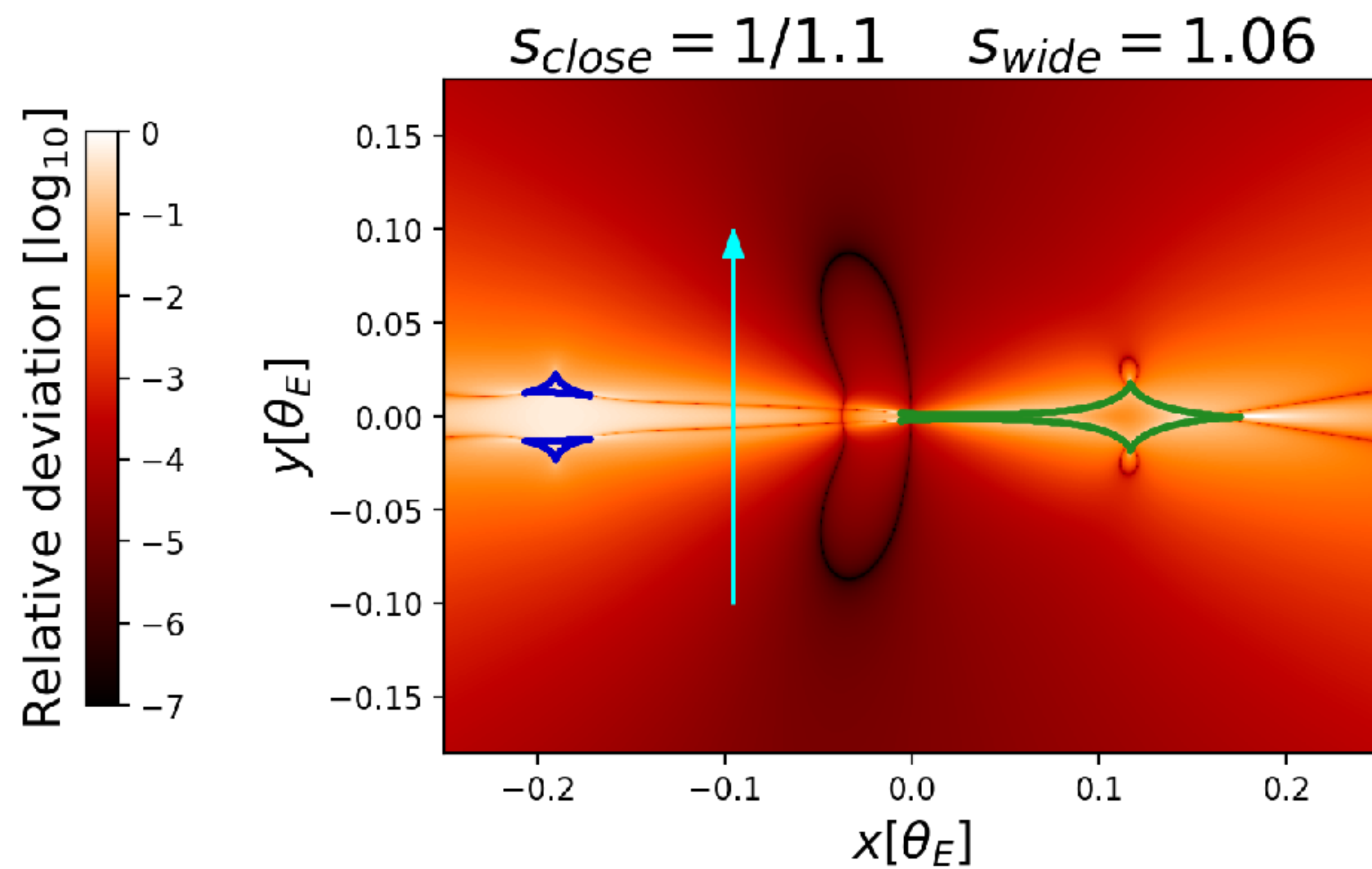
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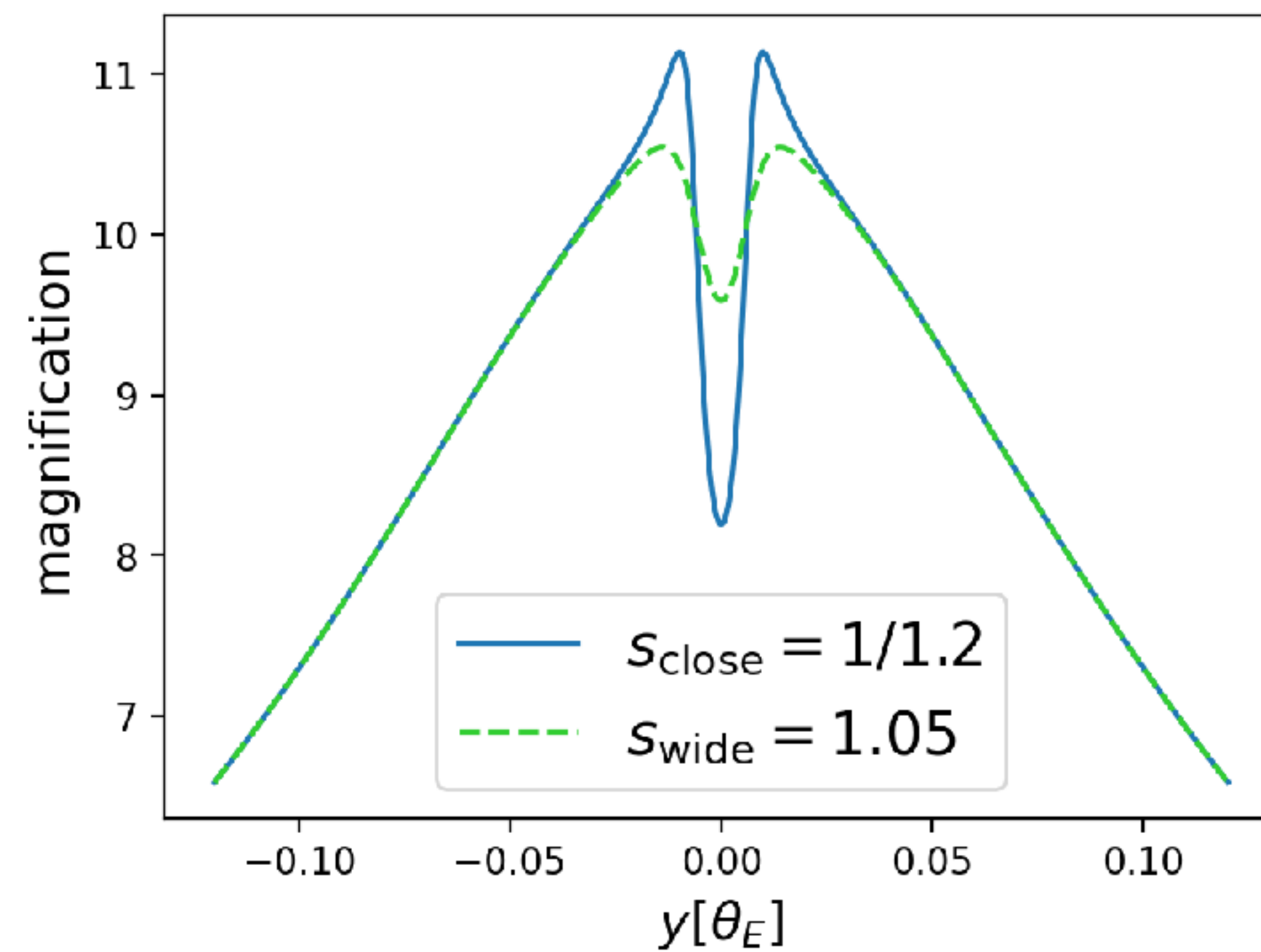
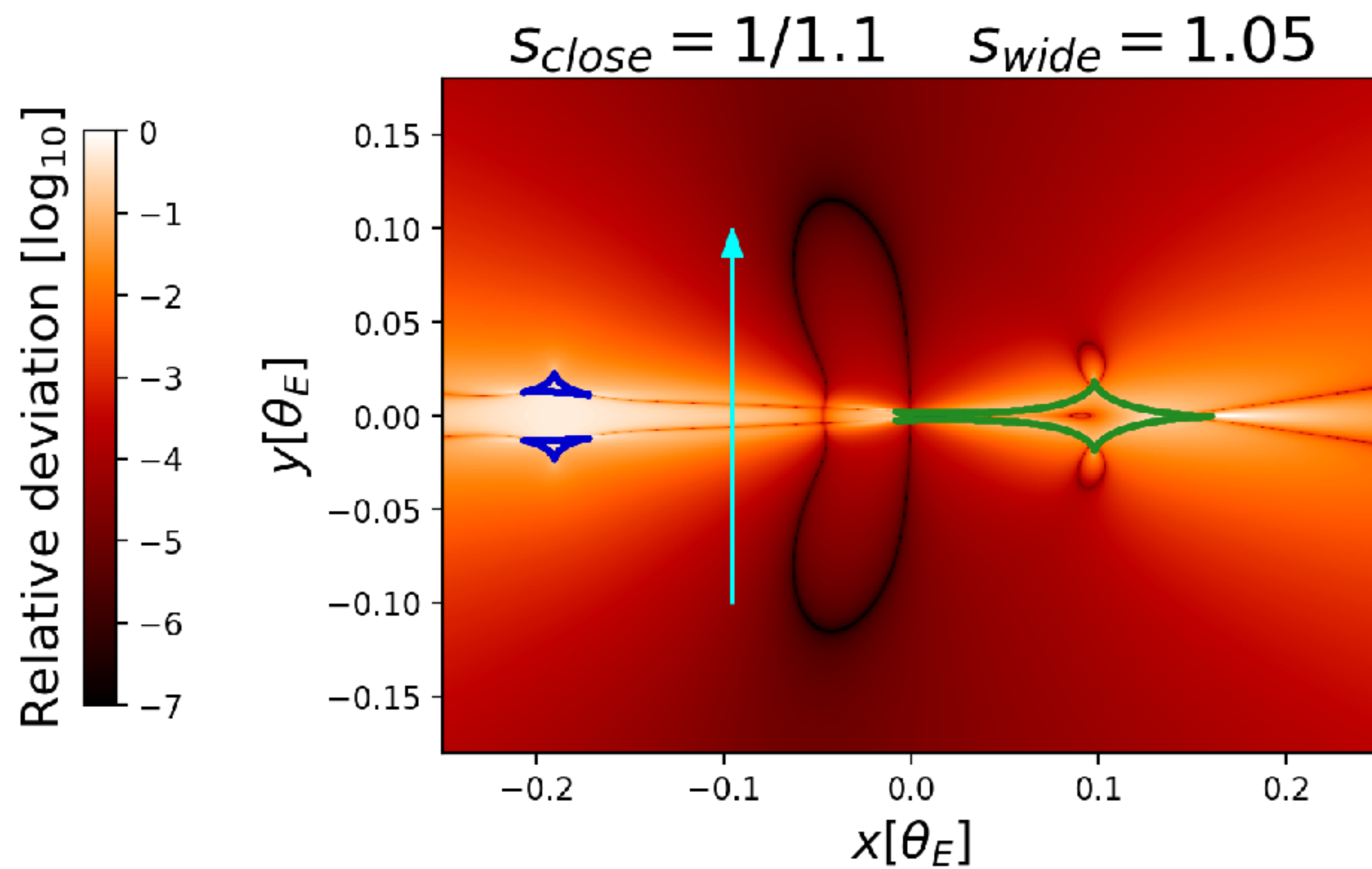
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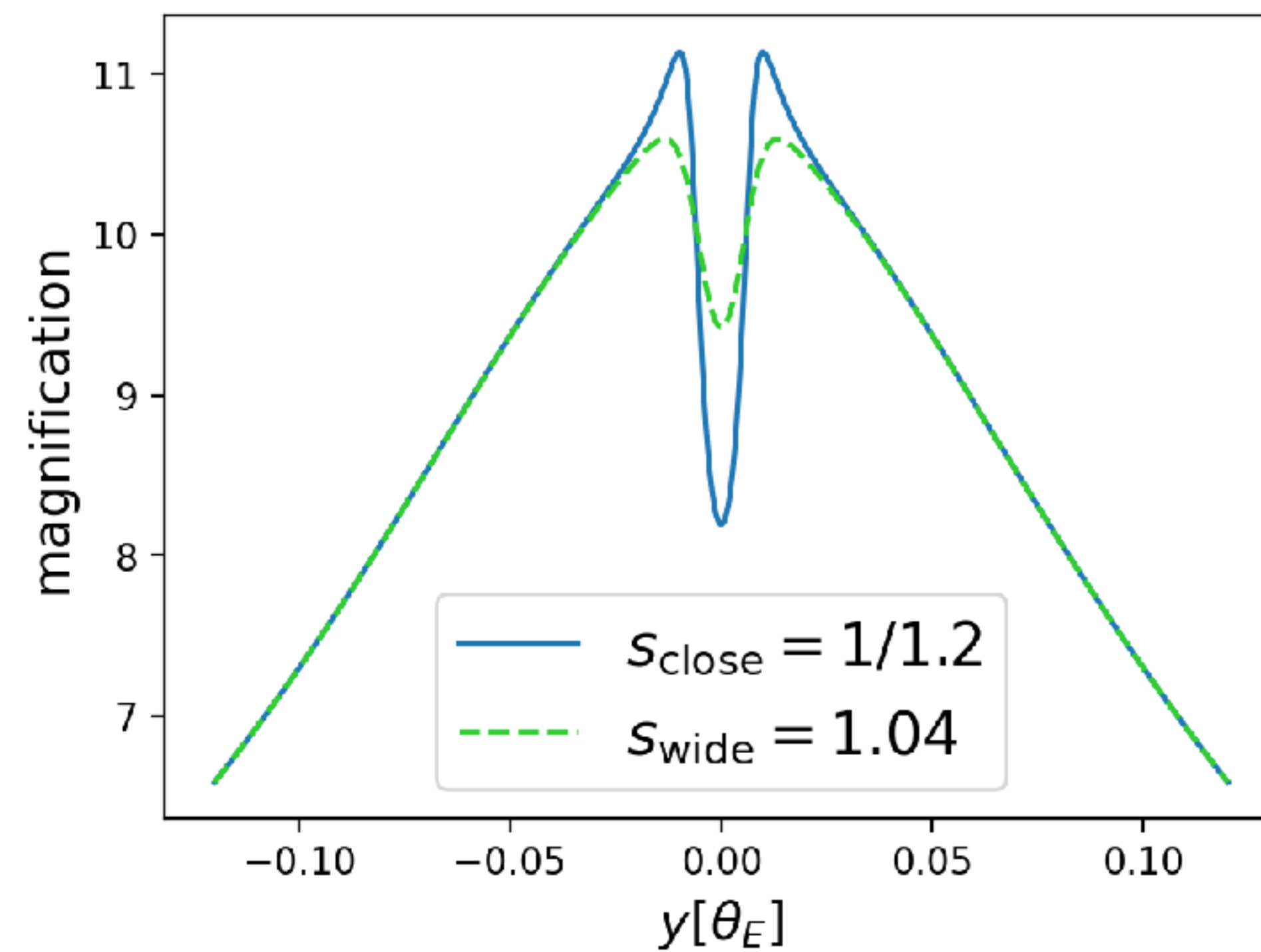
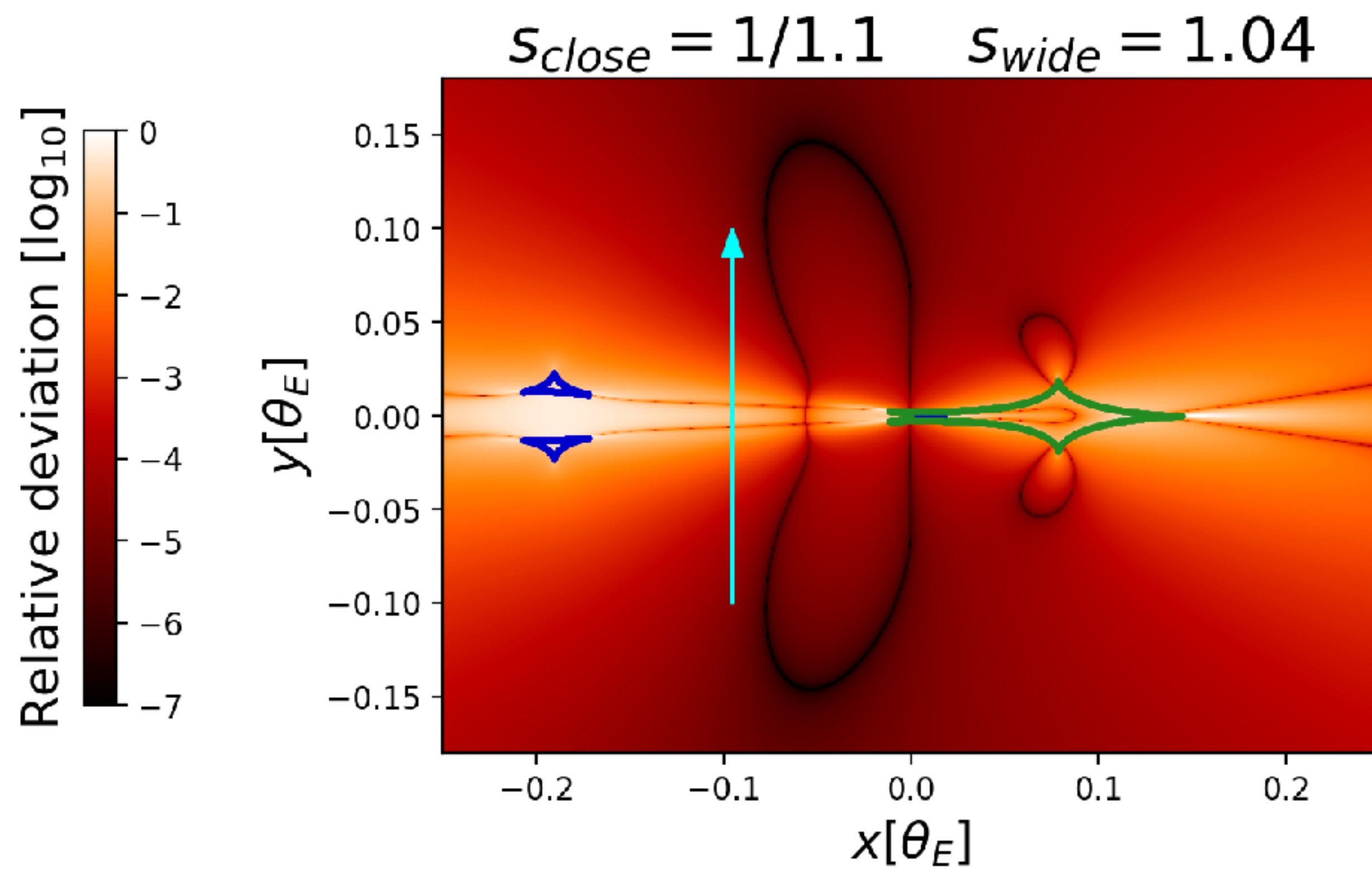
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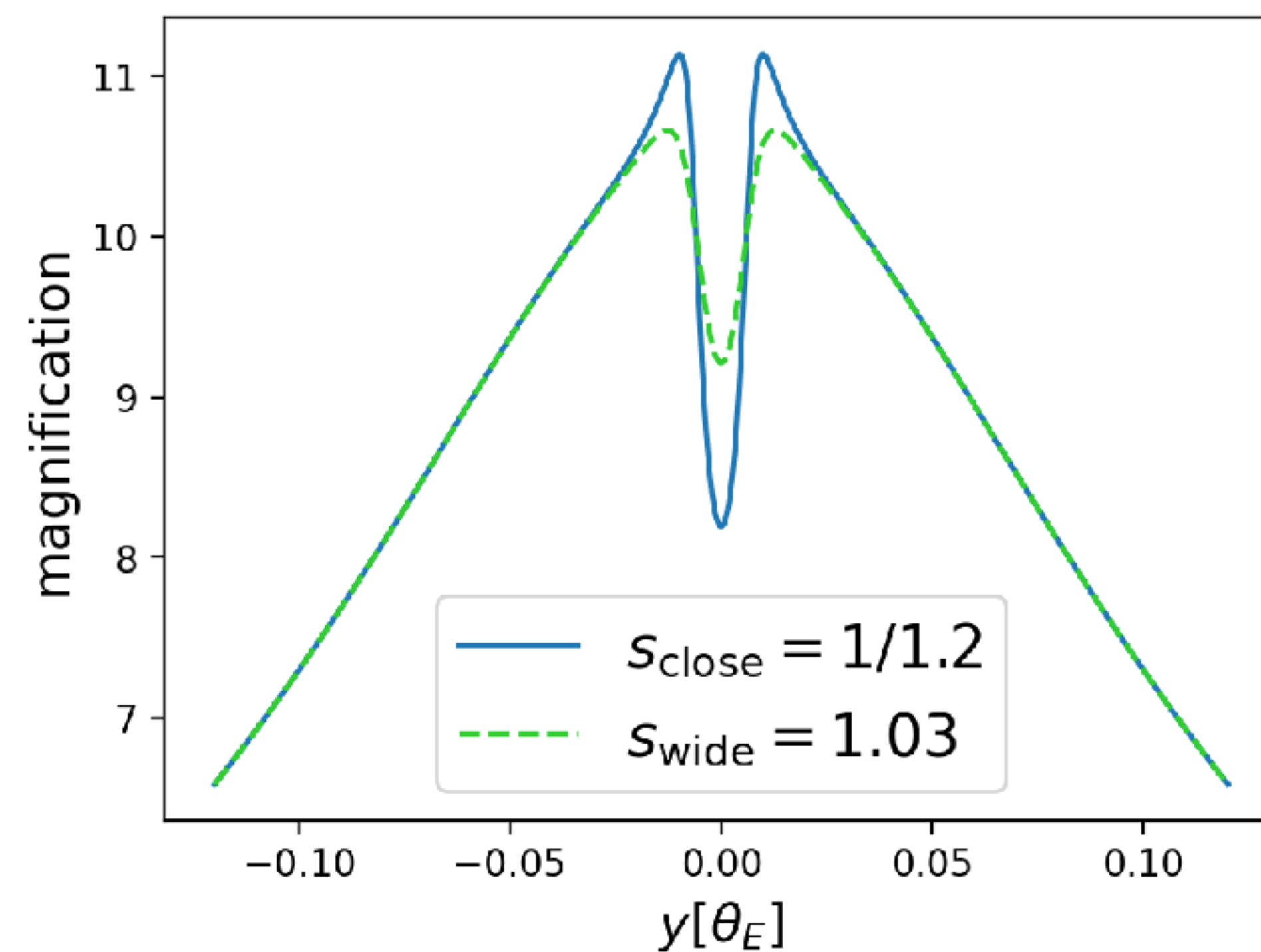
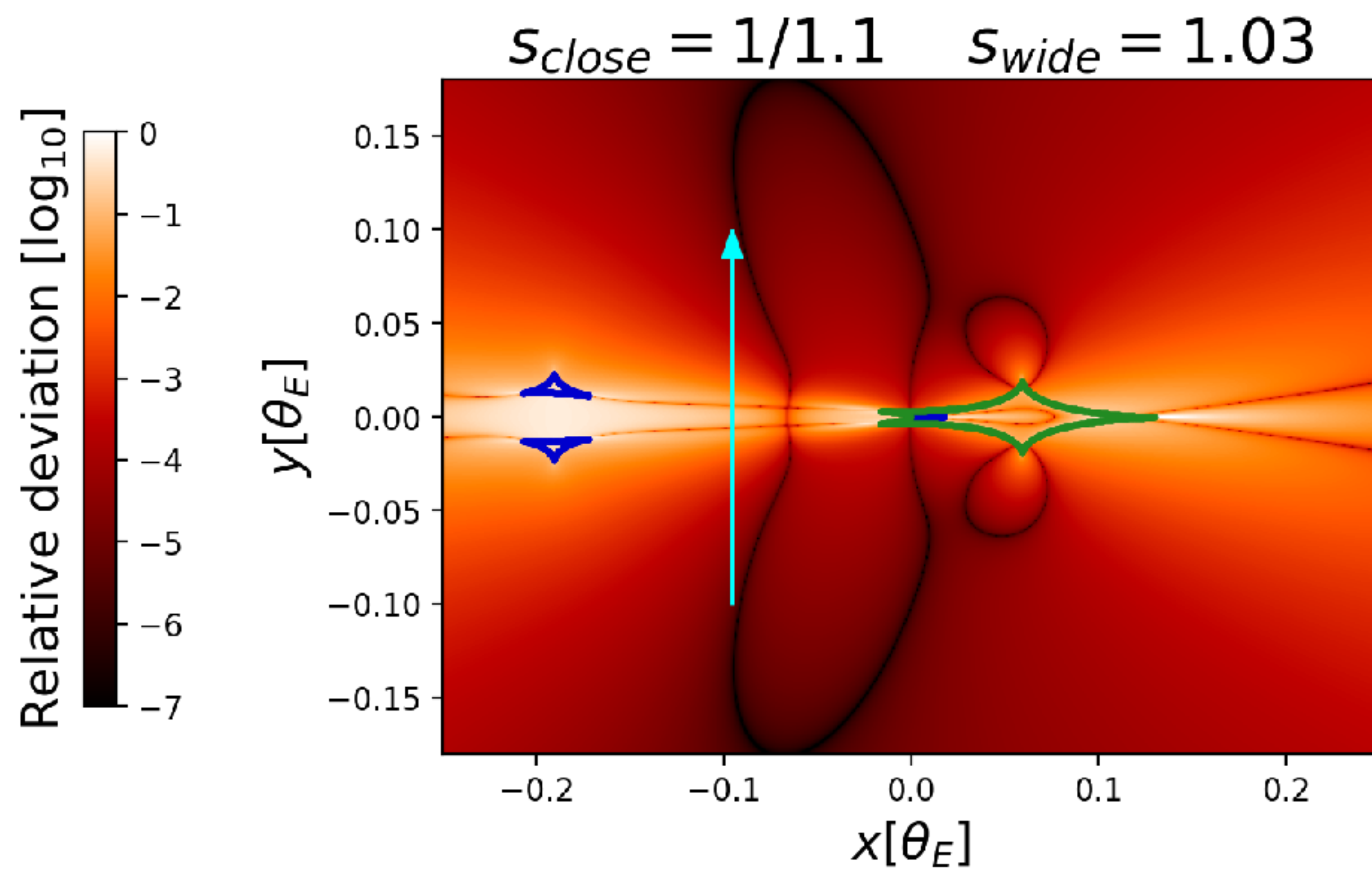
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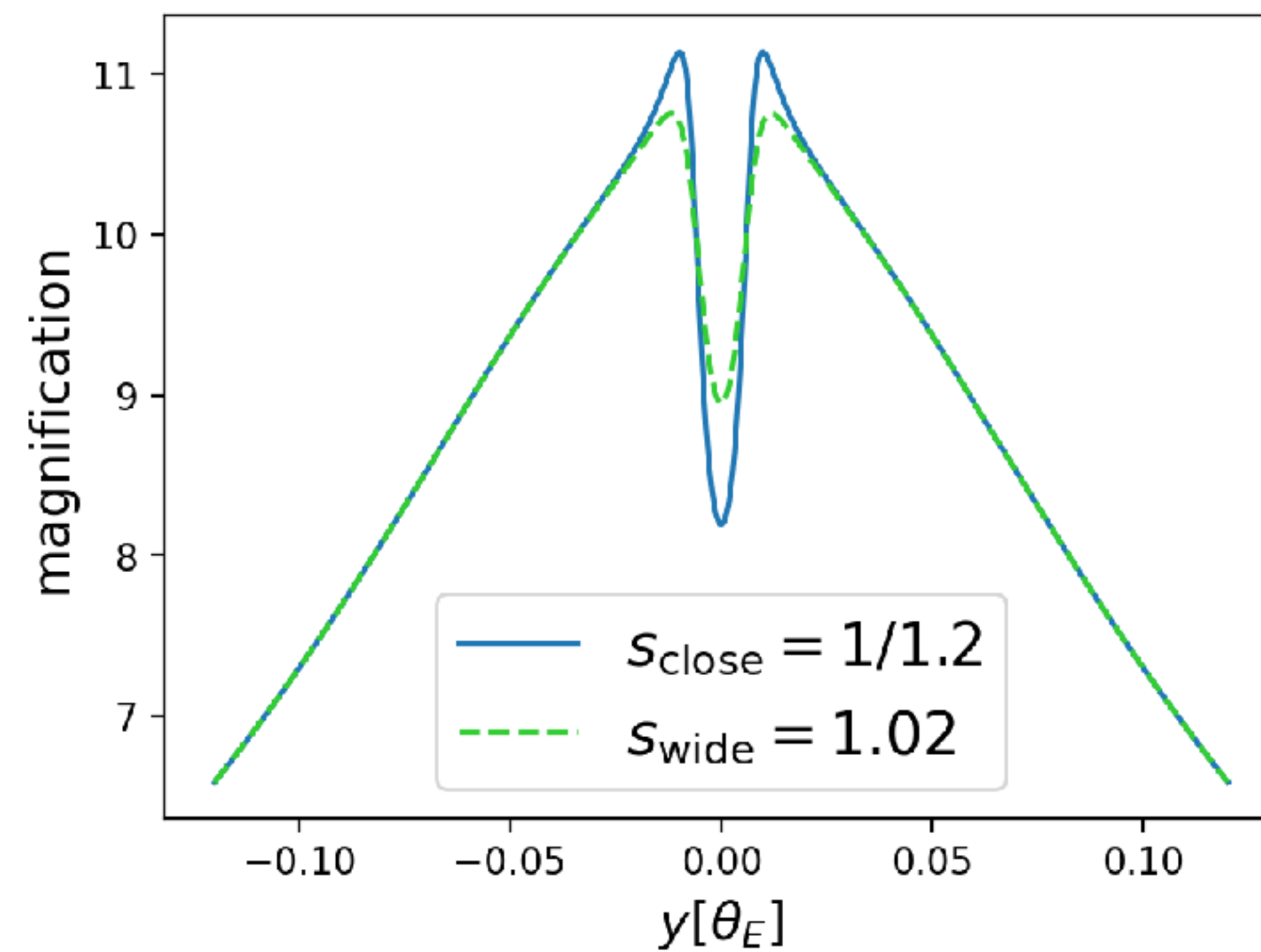
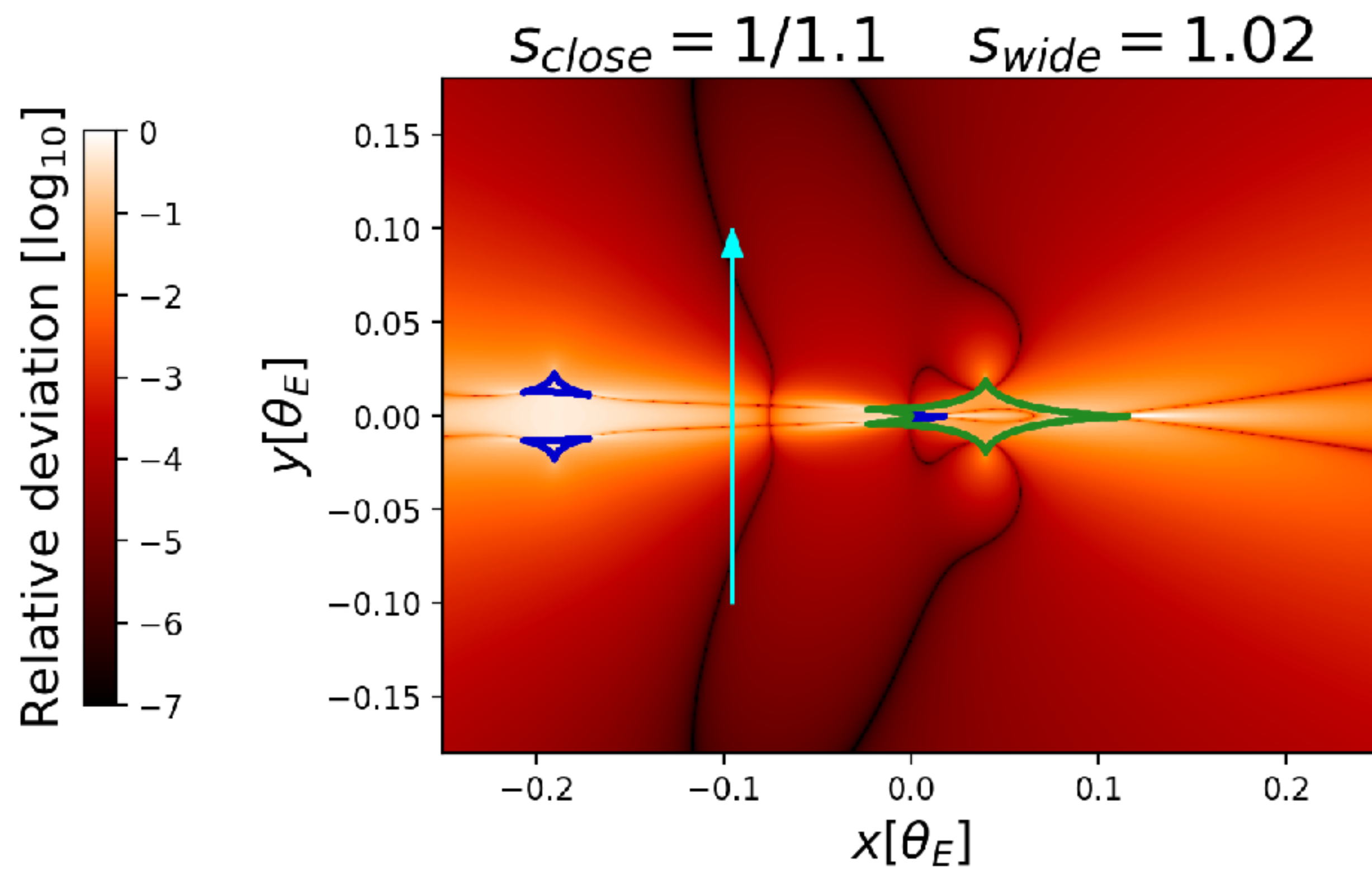
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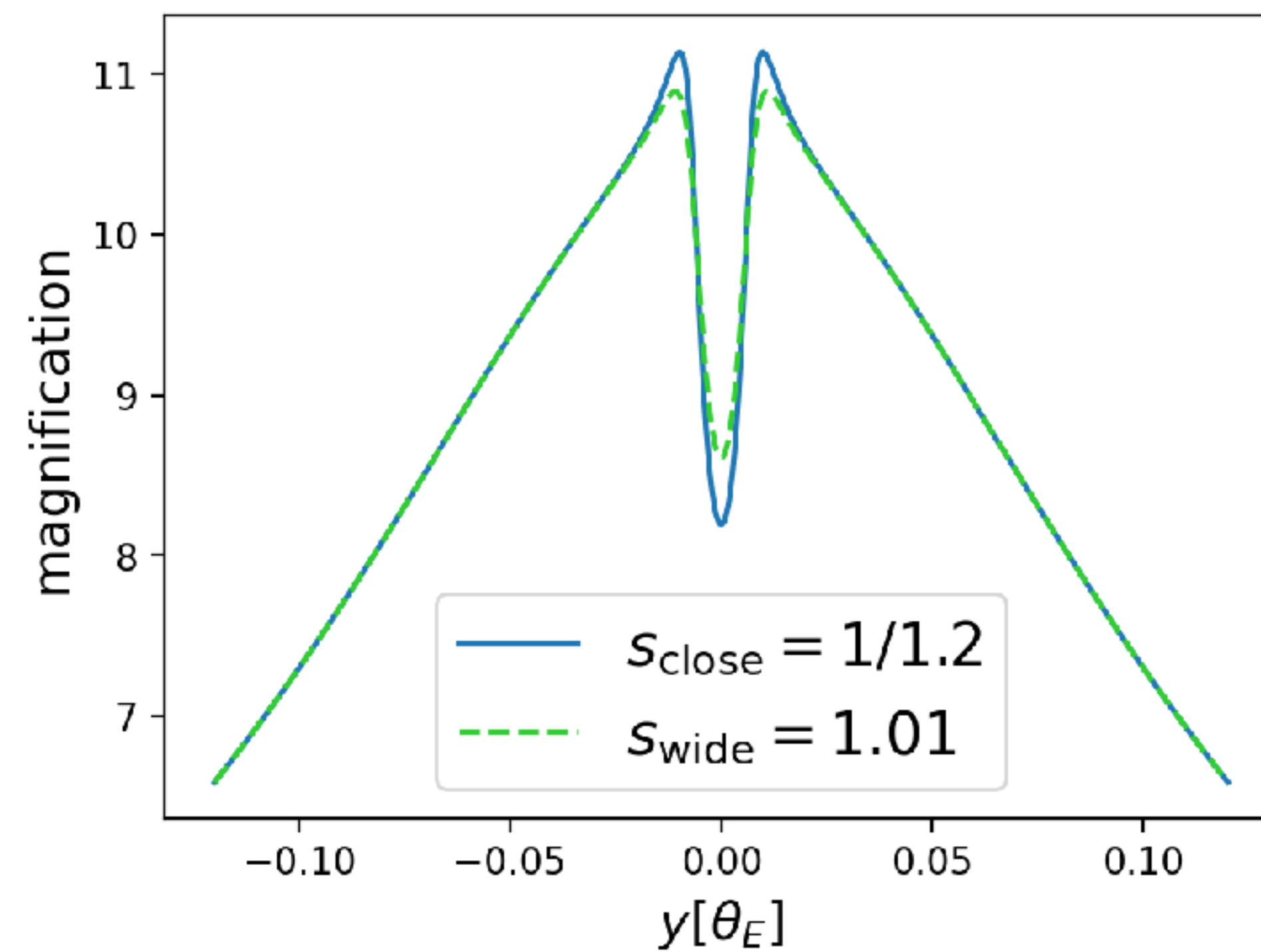
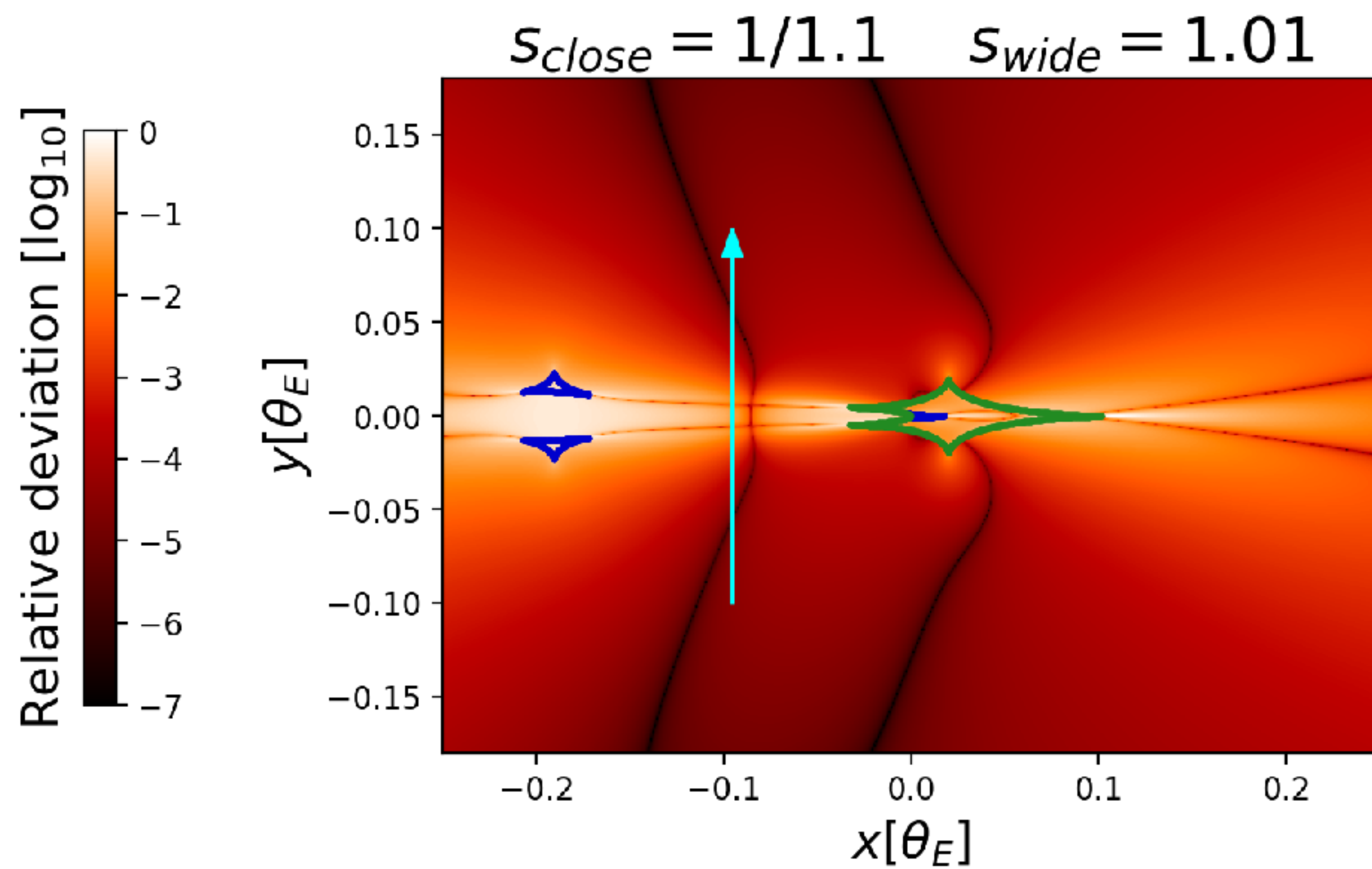
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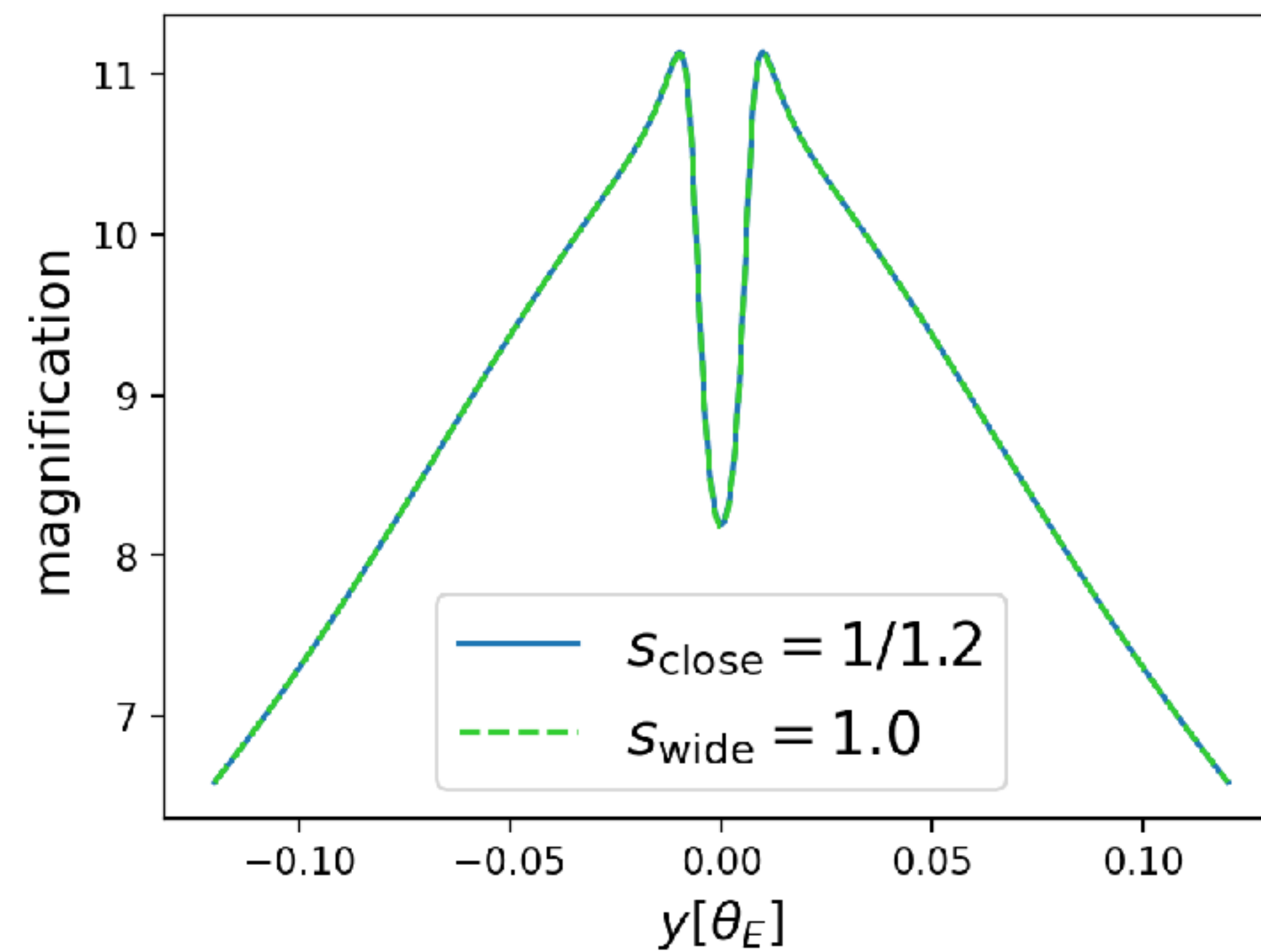
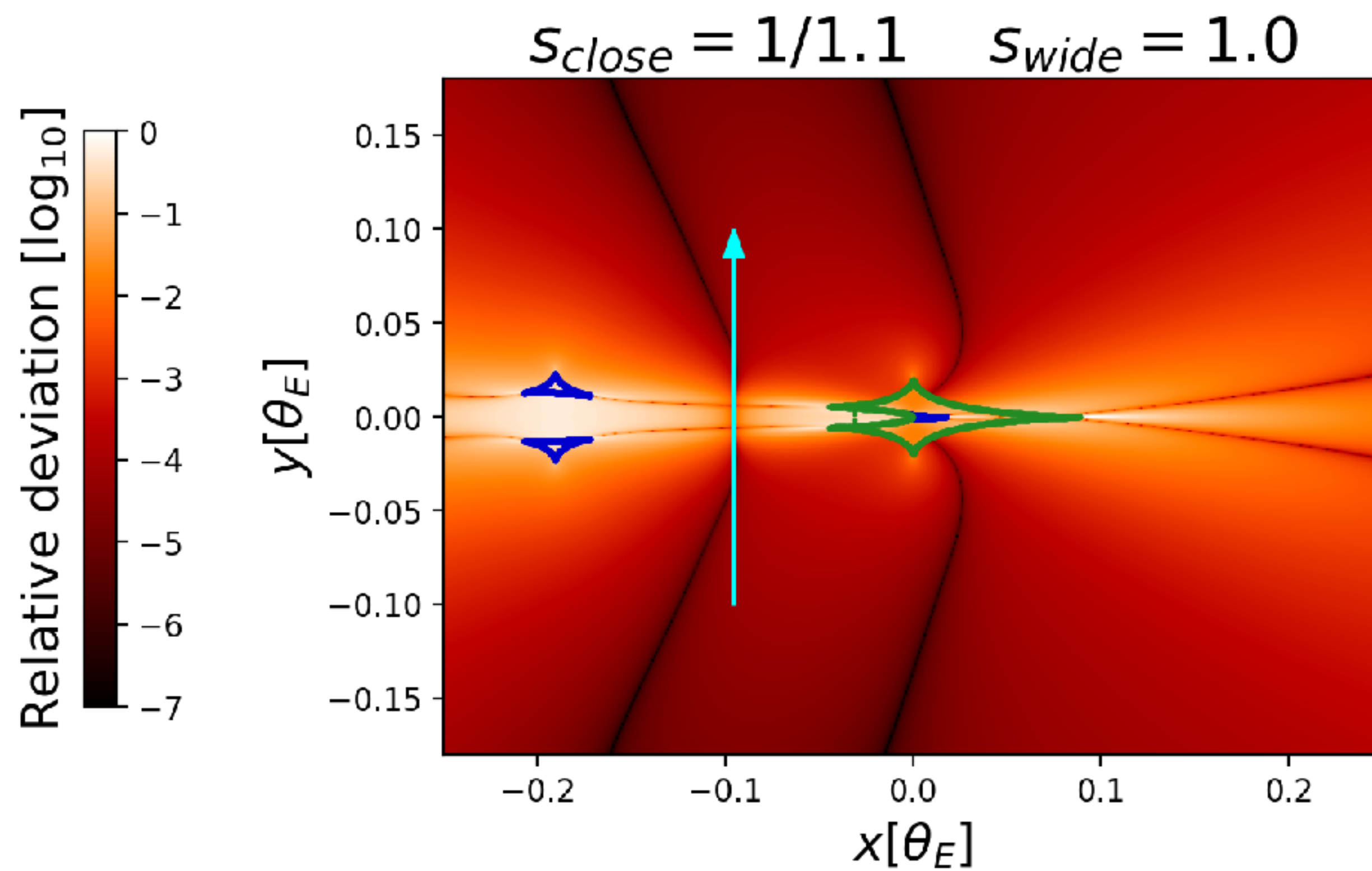
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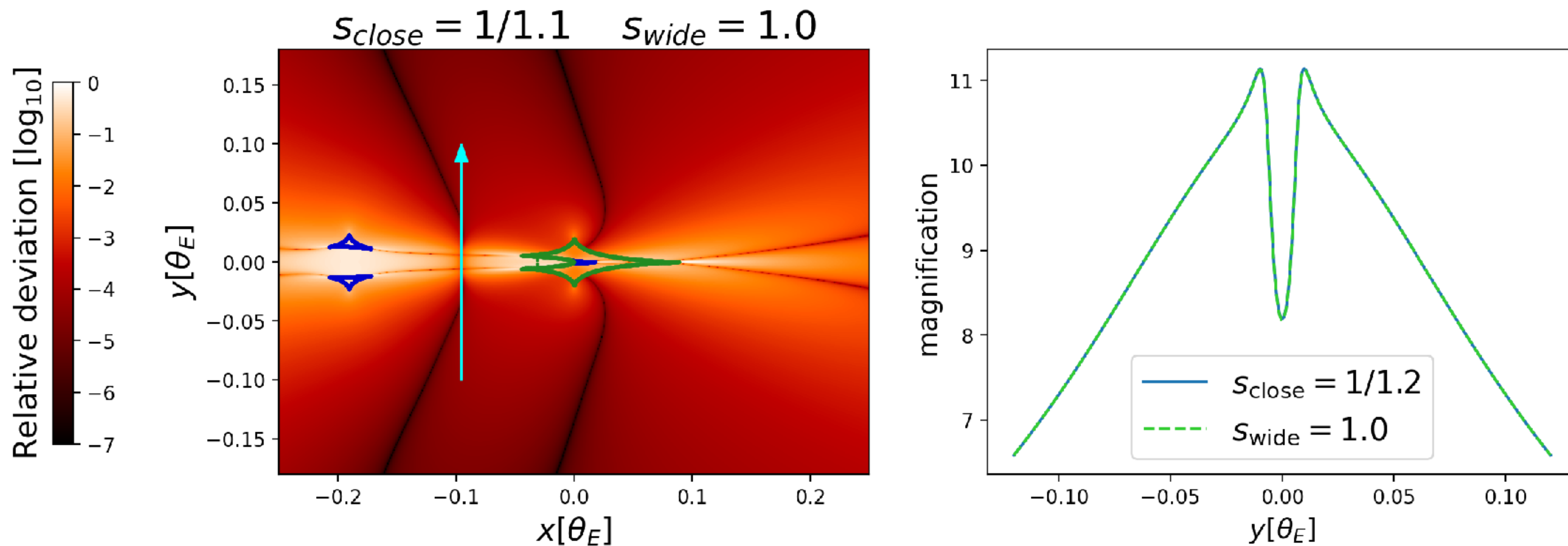
Beyond the central caustic ...



Beyond the central caustic ...



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$$x_{null} = \frac{(s_A - 1/s_A) - (s_B - 1/s_B)}{2} = x_{source}$$

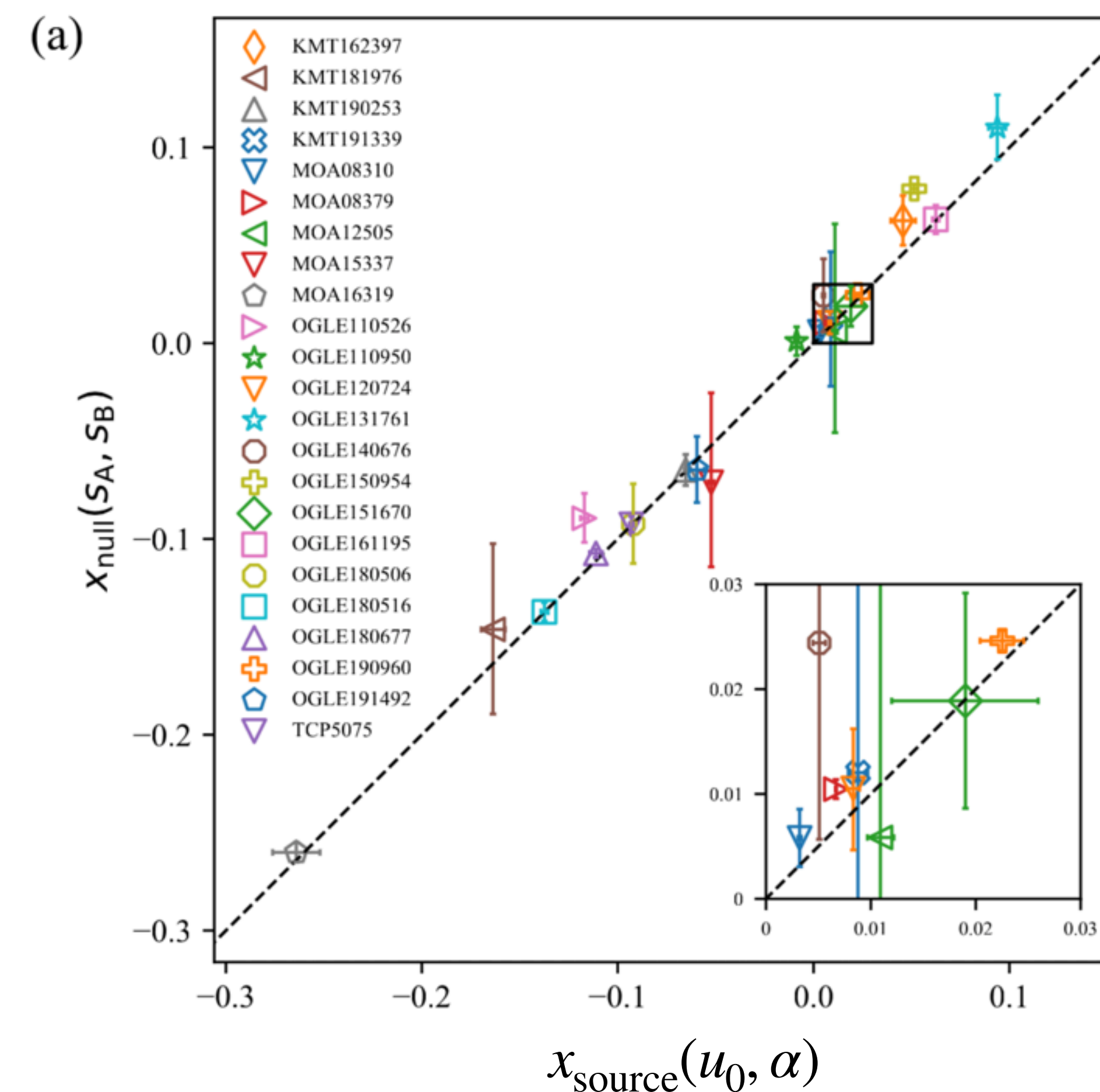
The *source-null* matching principle

The *Offset* Degeneracy:

“The source shall pass through the *null* created by an *offset* of the planet location”

$$x_{null} = \frac{(s_A - 1/s_A) - (s_B - 1/s_B)}{2} = x_{source}$$

Reanalysis of past events





Summary

- New machine-learning based inference method allows for automated, real-time batch inference of Roman planetary microlensing events
- Mock inference on a large number of simulated *Roman* events lead to the discovery of a new type of microlensing degeneracy ...
- ... which unifies previously known *close-wide* and *inner-outer* degeneracies, extends to resonant topologies, and is ubiquitous in past events