A novel observable expected in lensed FRBs

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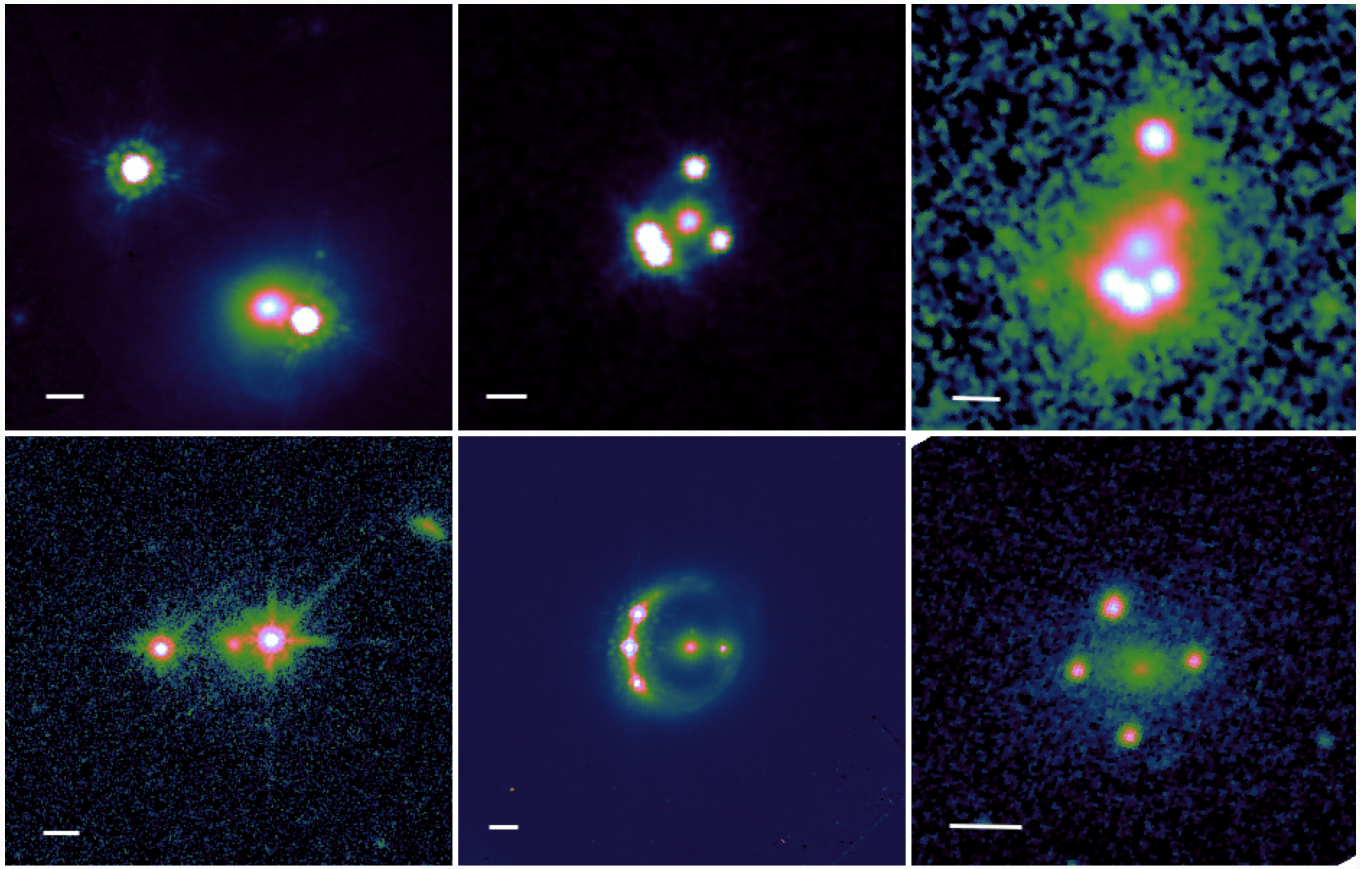
(Macro-)Lensing by Galaxies



Q0957+561 PG1115+080 RXJ0911+0551
HE1104-1805 RXJ1131-1231 Q2237+030
Figures from arxiv:2401.04165

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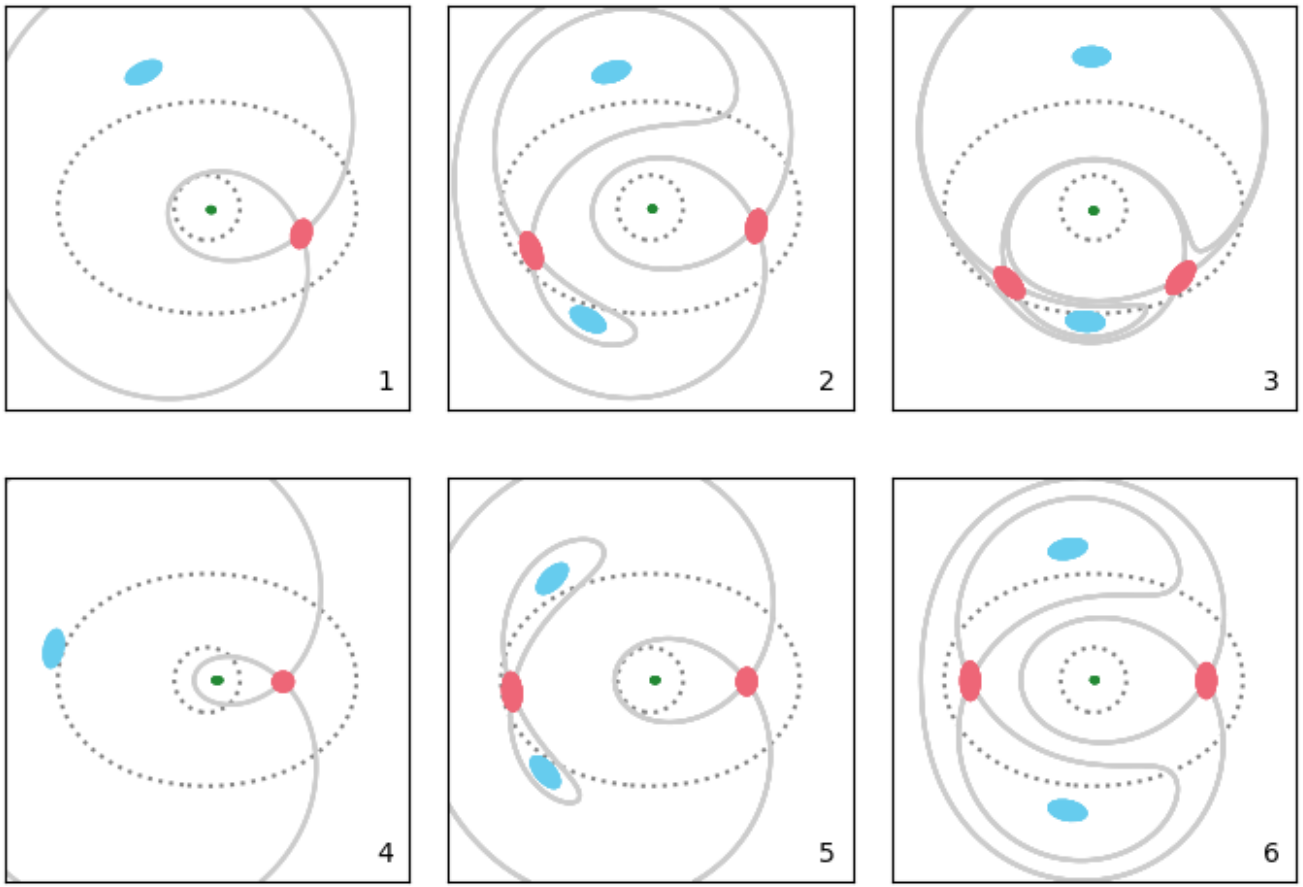

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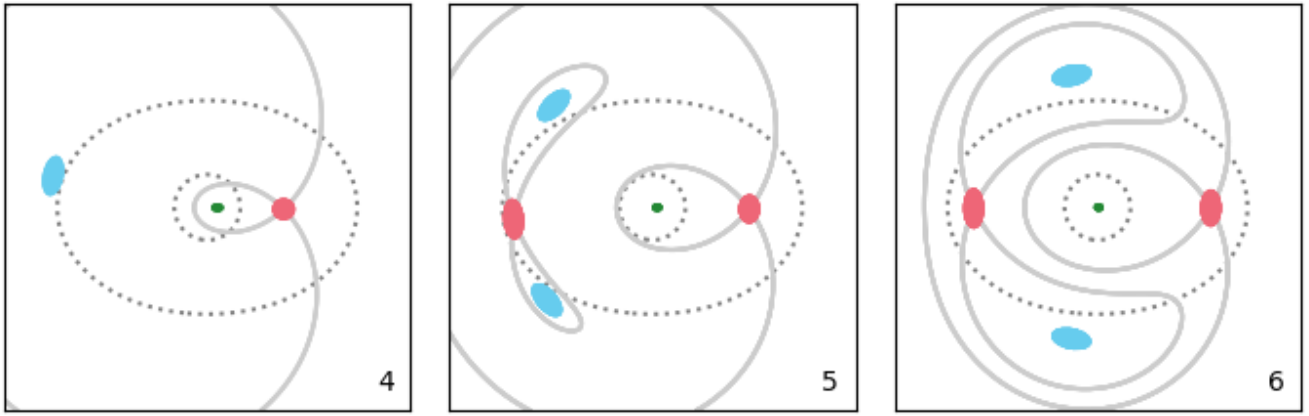

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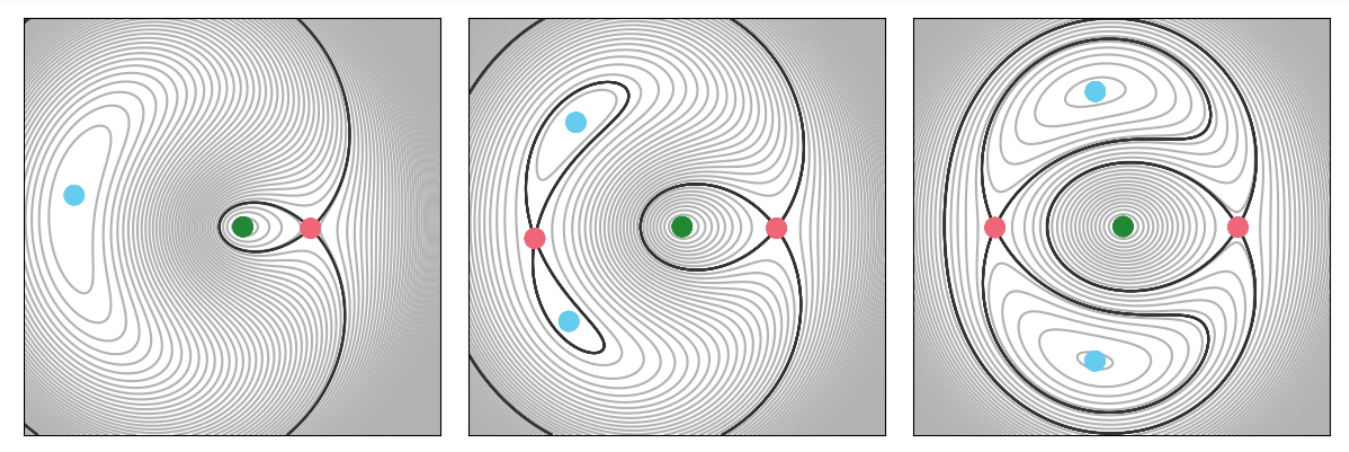
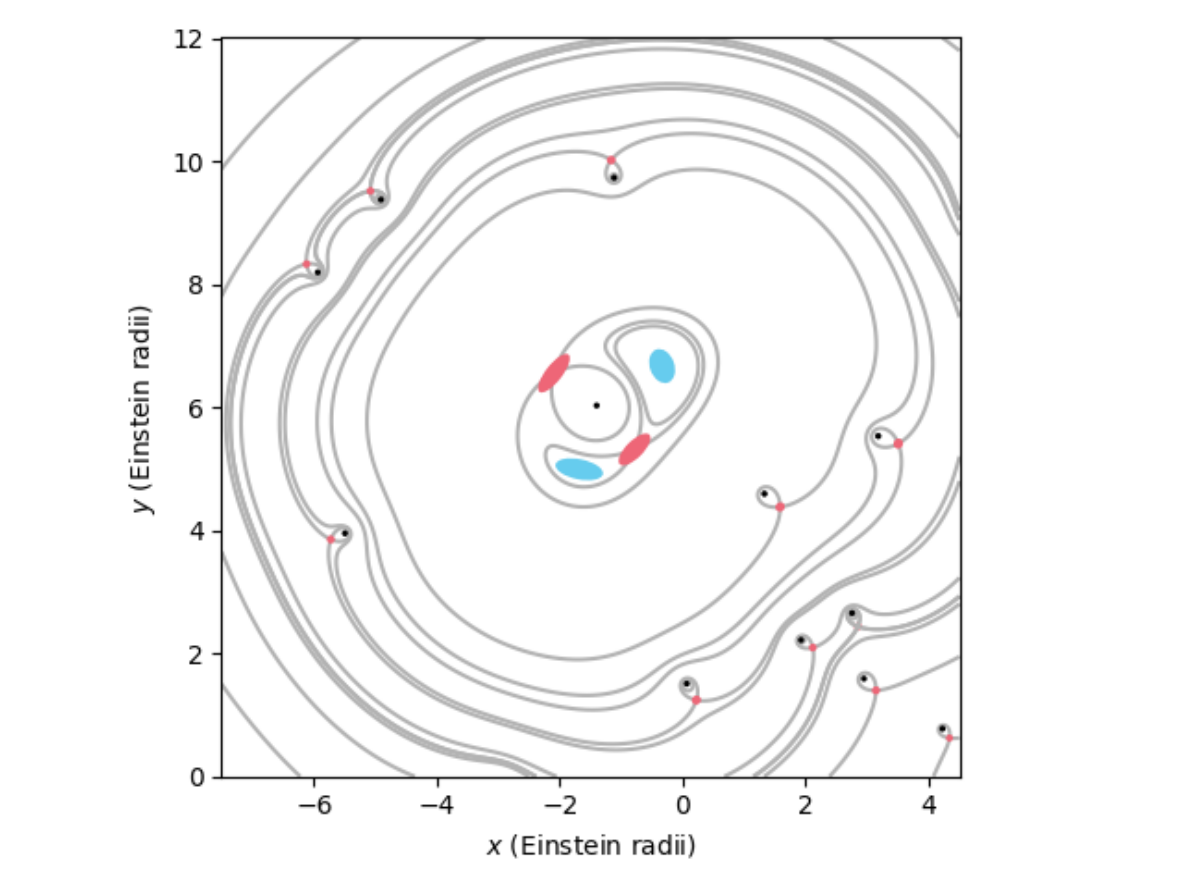


Micro-Lensing by Stars within (macro-)Lensing by Galaxies



Lensing of compact sources (FRBs!)

$$\sum_{\nu} S(\nu) \exp(2\pi\nu i t) \quad \overset{\text{lensing}}{\longrightarrow} \quad \sum_{\nu} A(\nu)\, S(\nu) \exp(2\pi\nu i t)$$

$$A(\nu) = \sum_{k} \exp(2\pi\nu i\, \tau_k)\ |\mathrm{H}(\tau_k)|^{-1/2} \times \begin{cases} 1 \text{ for minima} \\ i \text{ for saddle points} \\ -1 \text{ for maxima} \end{cases}$$

τ_k is the time delay of the k-th micro-image
$\mathrm{H}(\tau_k)$ is the Hessian (curvature) of the τ surface.

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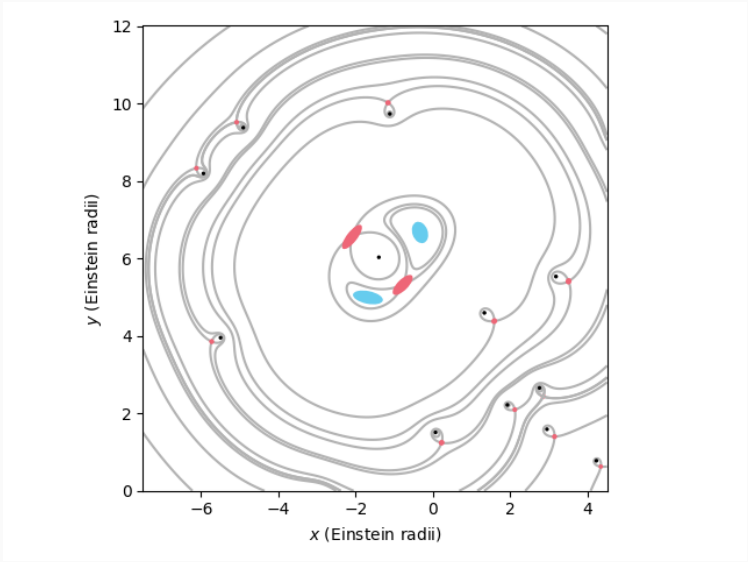
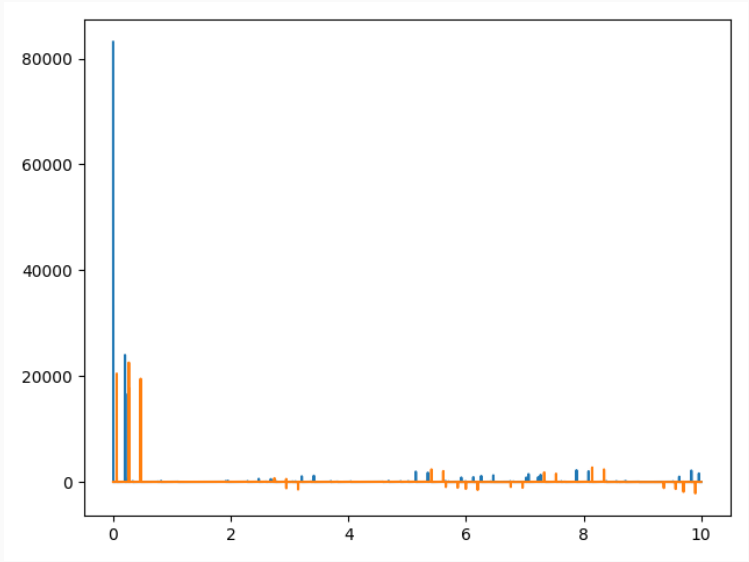
Microlensing is imprinted in auto-correlation of the lensed electric field.

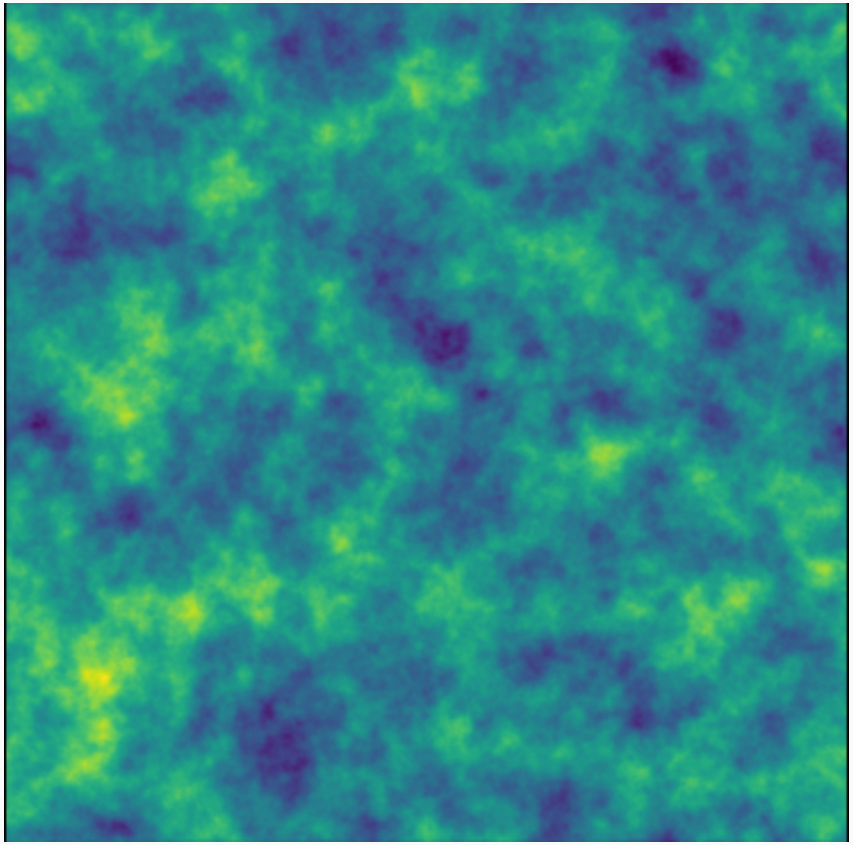
The observable





Complication: the Interstellar Medium

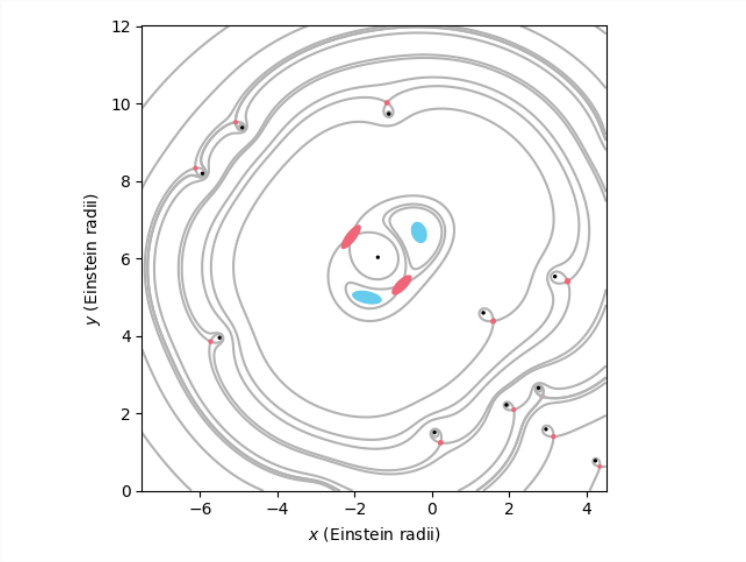
Electron density (turbulent spatial spectrum $R^{-11/3}$)

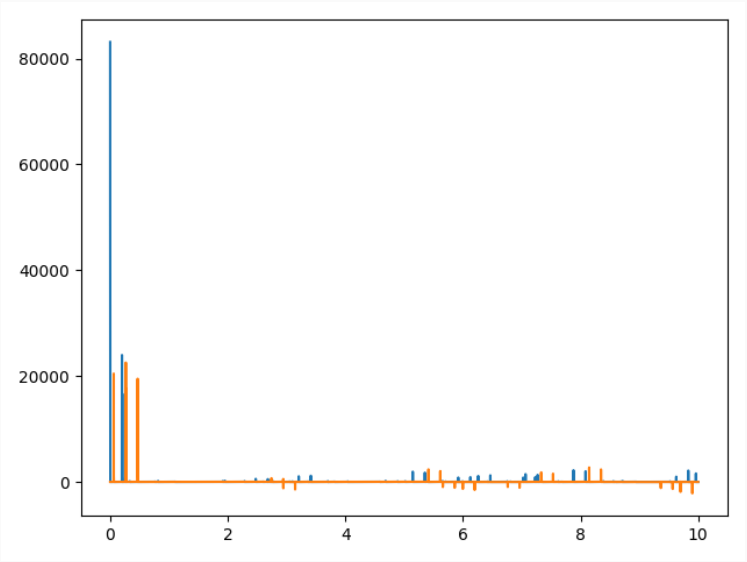


contributes to τ as ν^{-2}

Follows Armstrong et al. 1995ApJ...443..209A

Frequency dependence (high to low ν)





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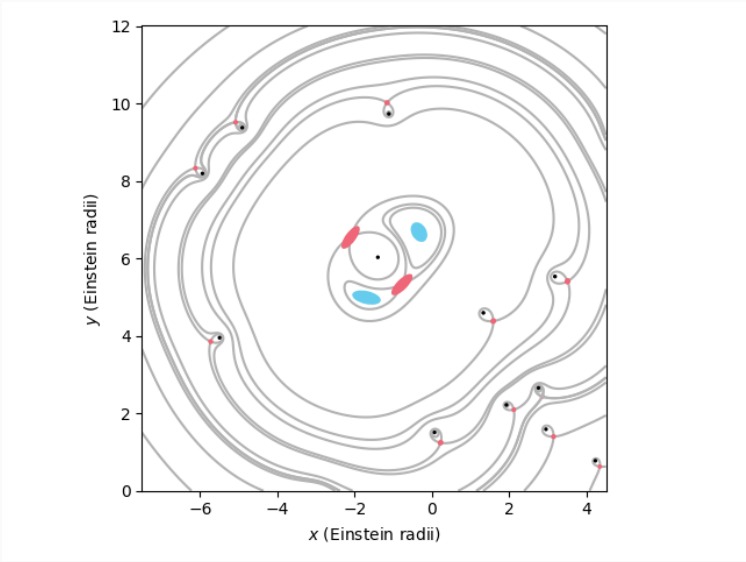

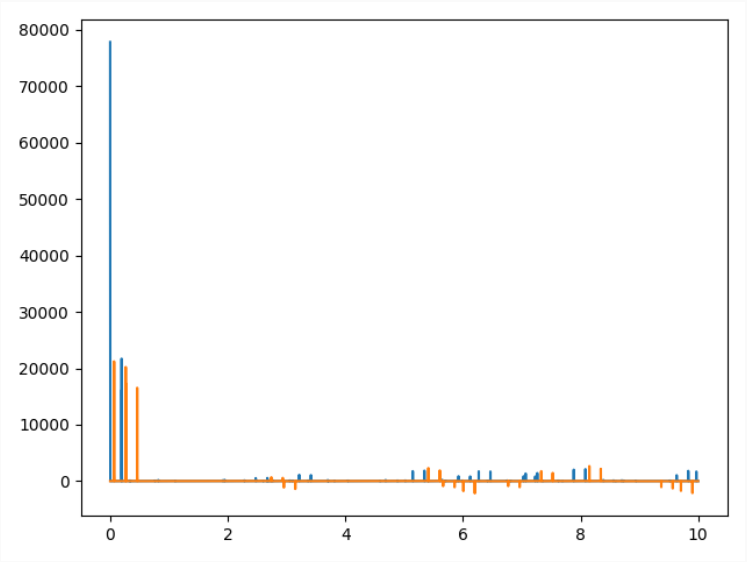

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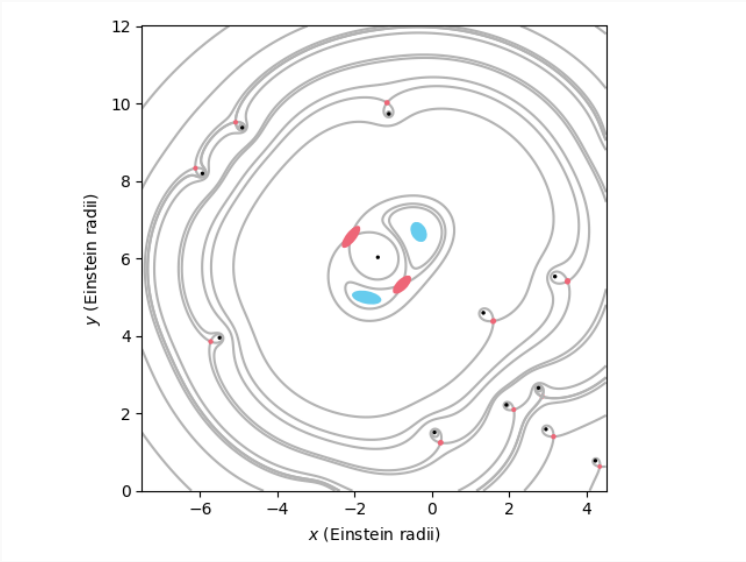

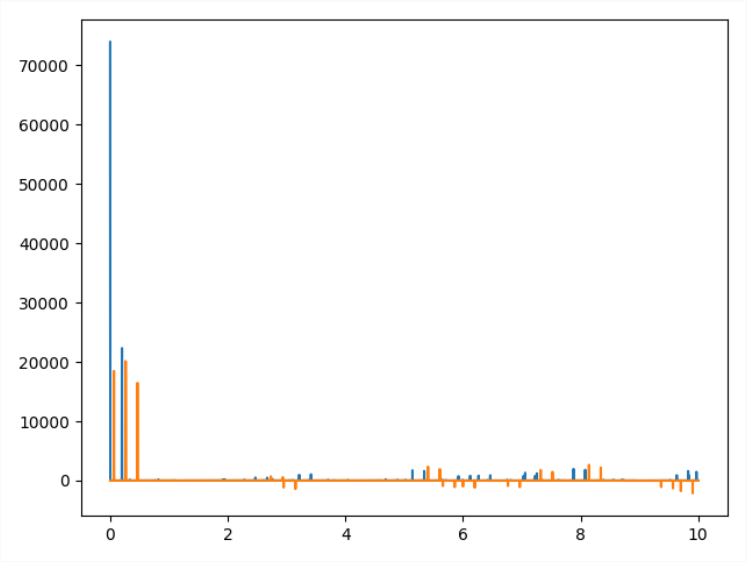

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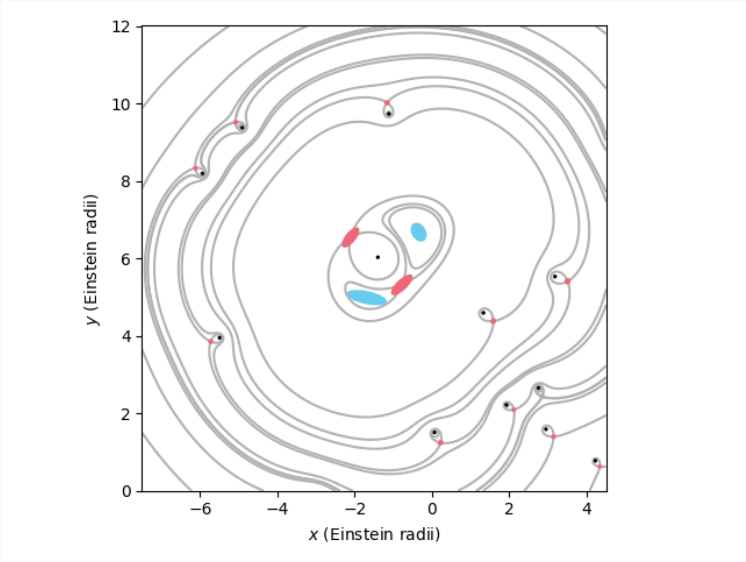

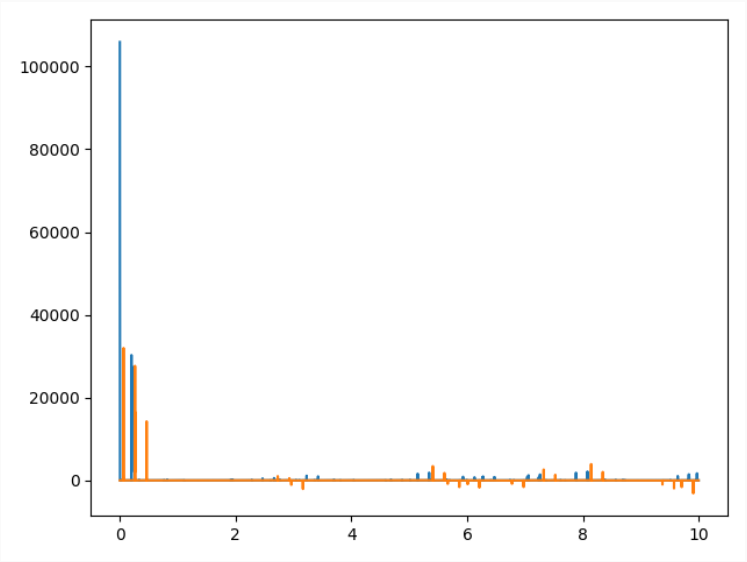

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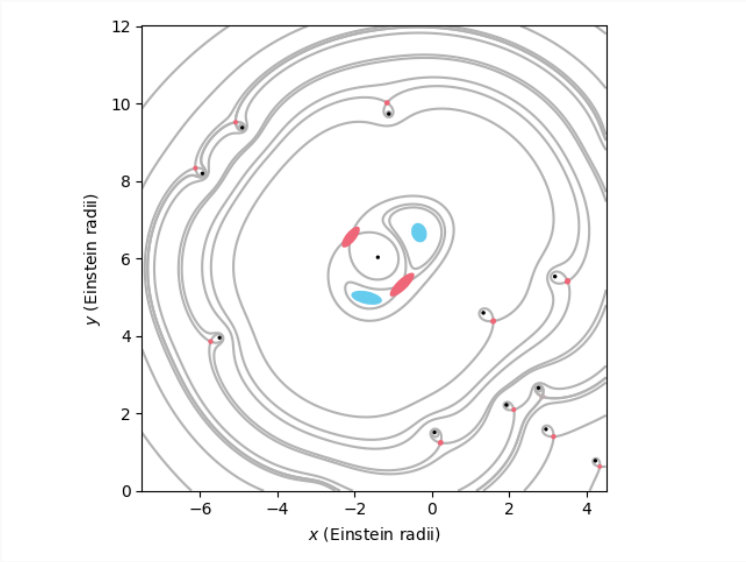

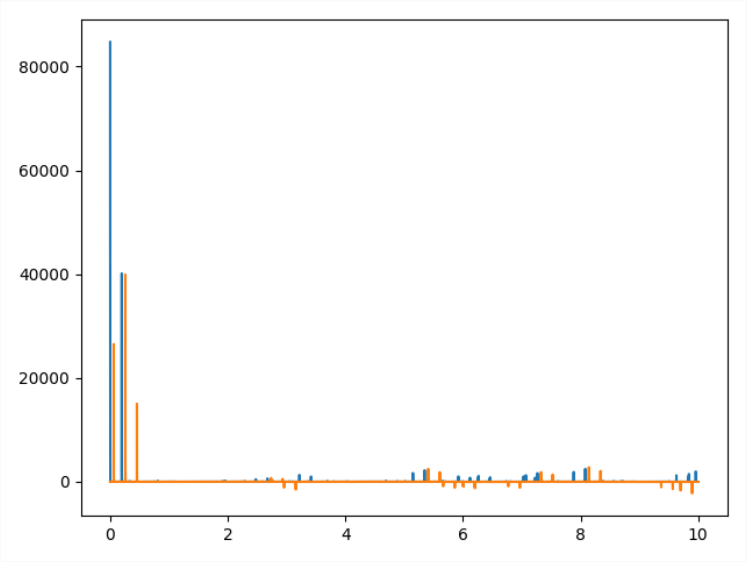

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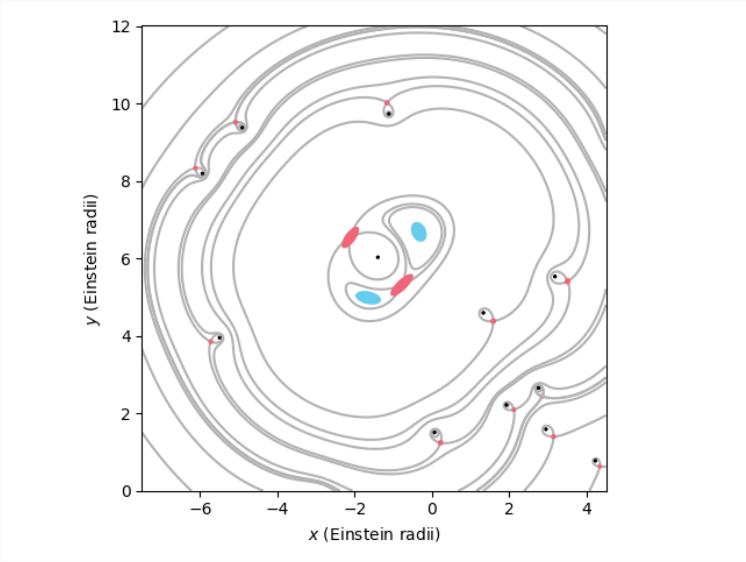

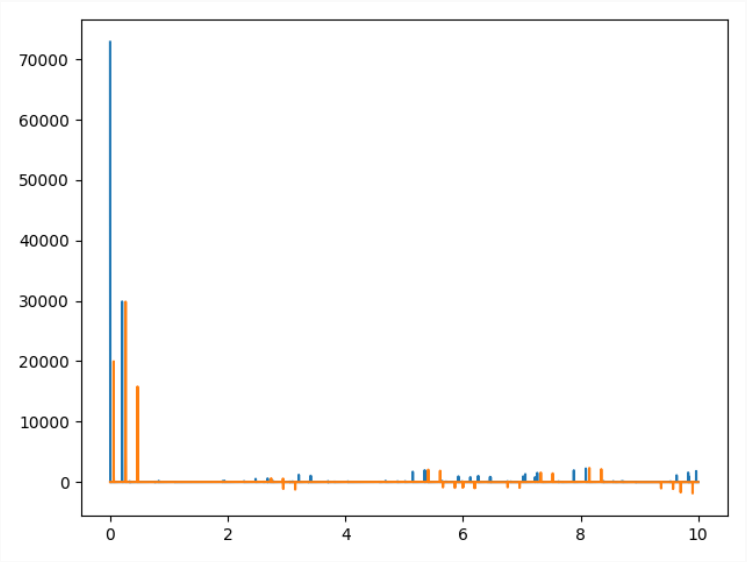

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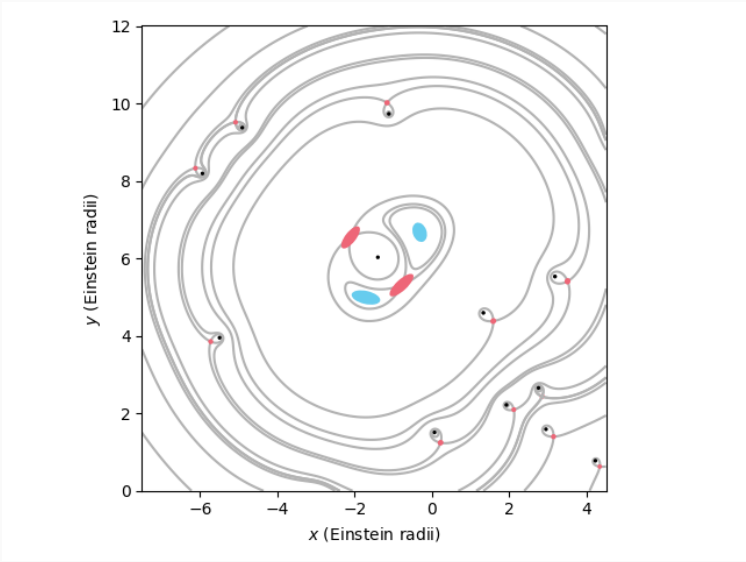

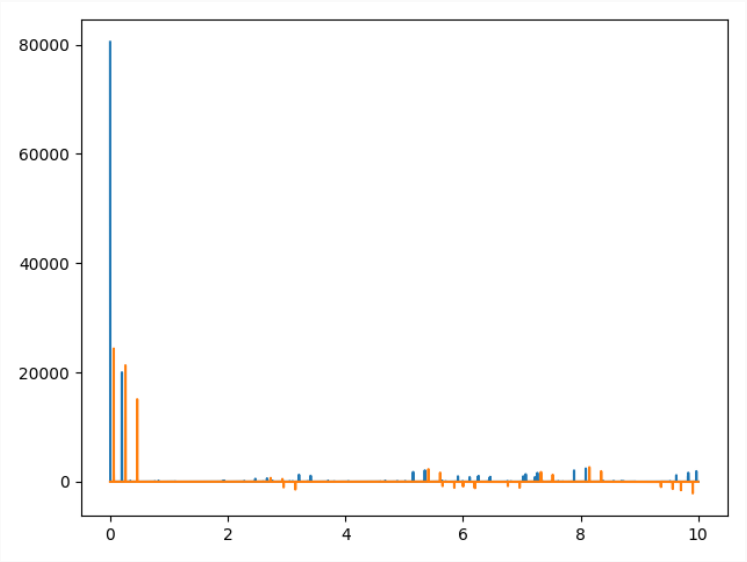

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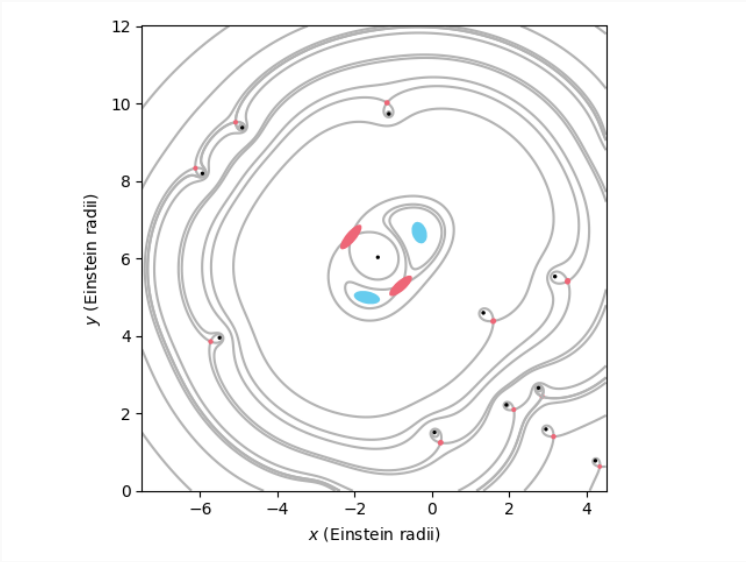

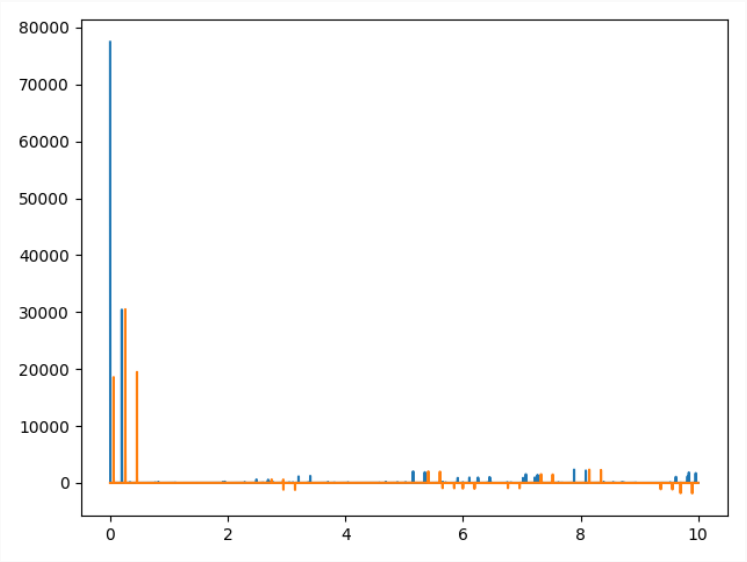

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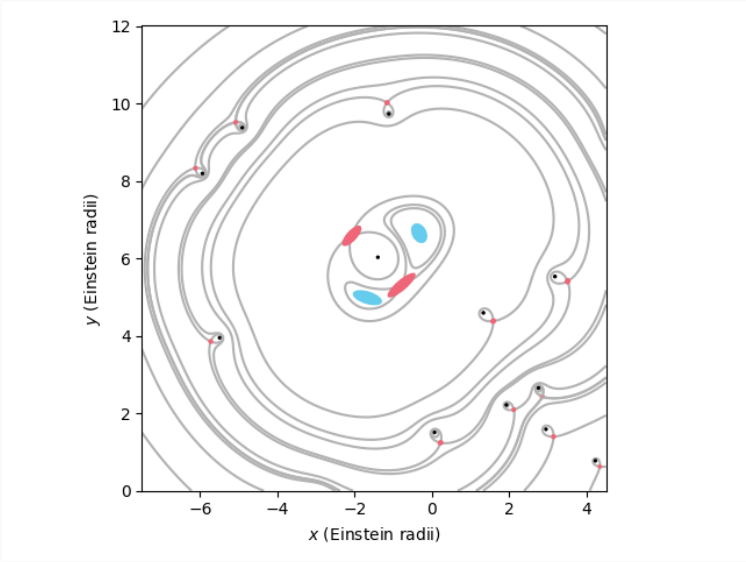

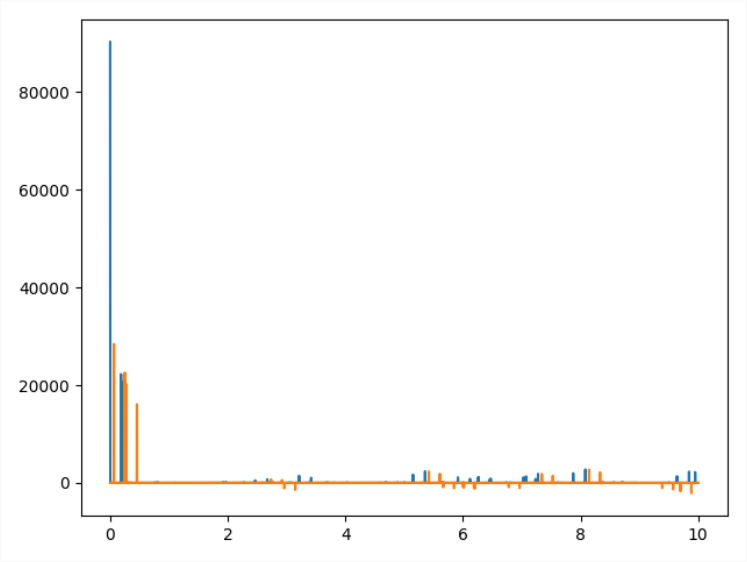

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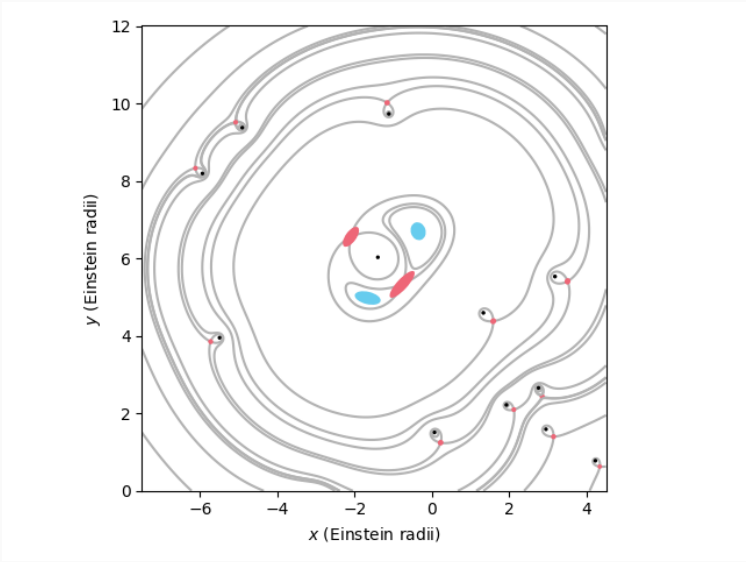

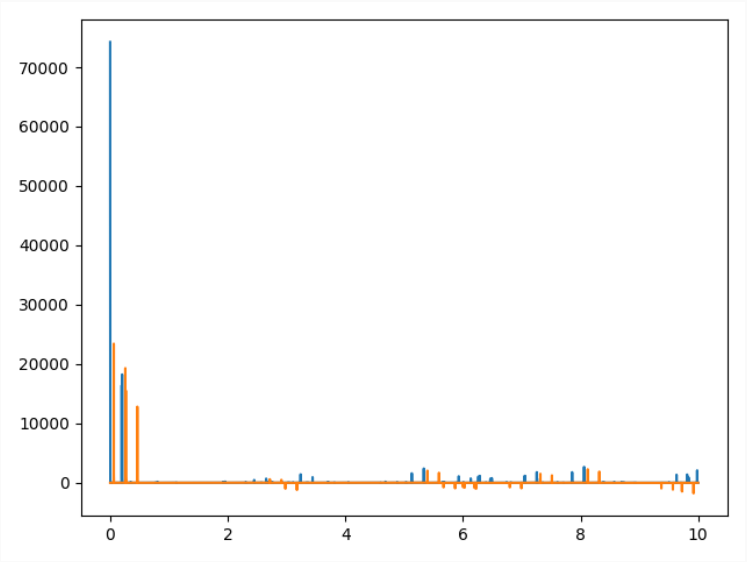

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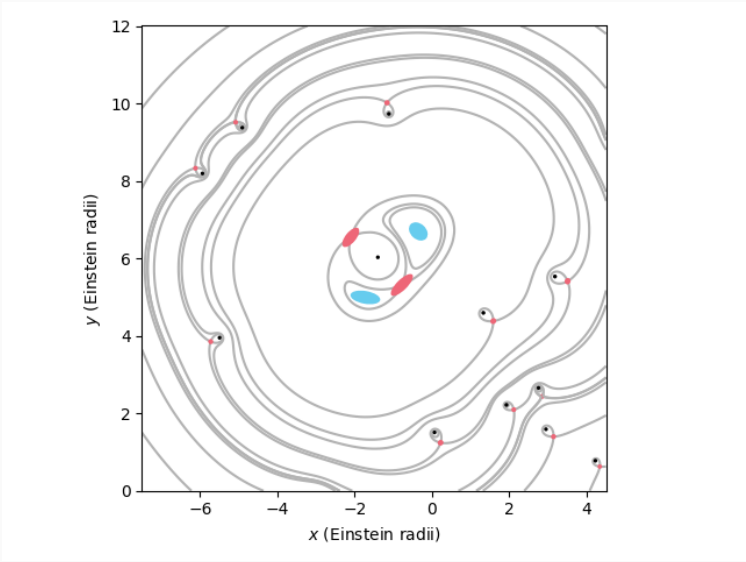

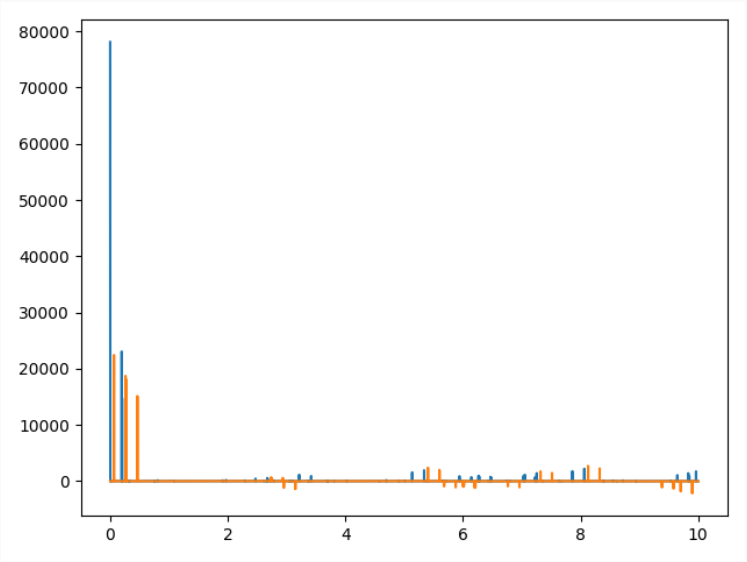

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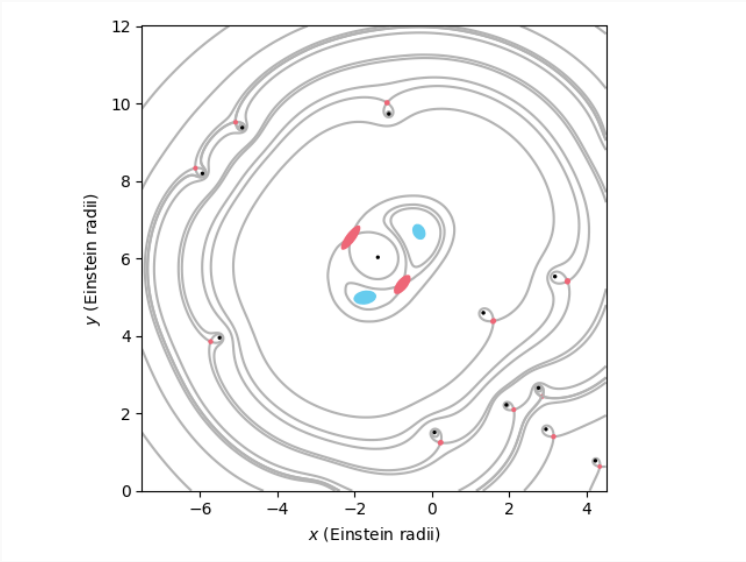

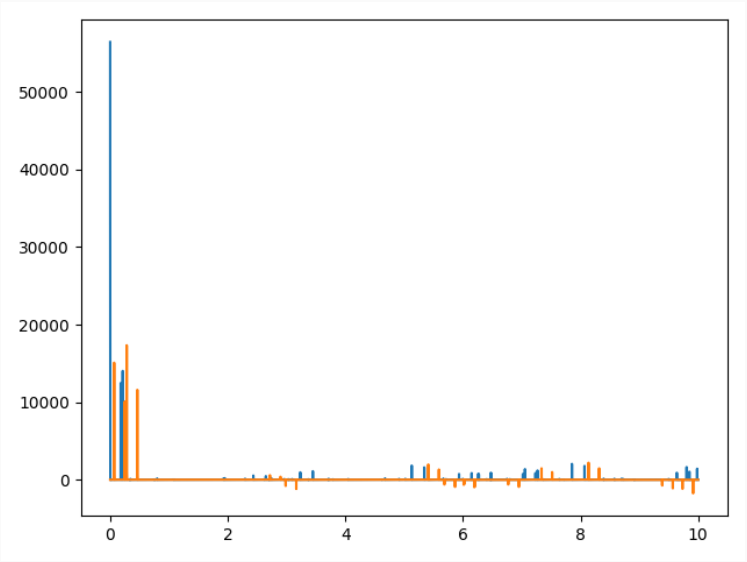

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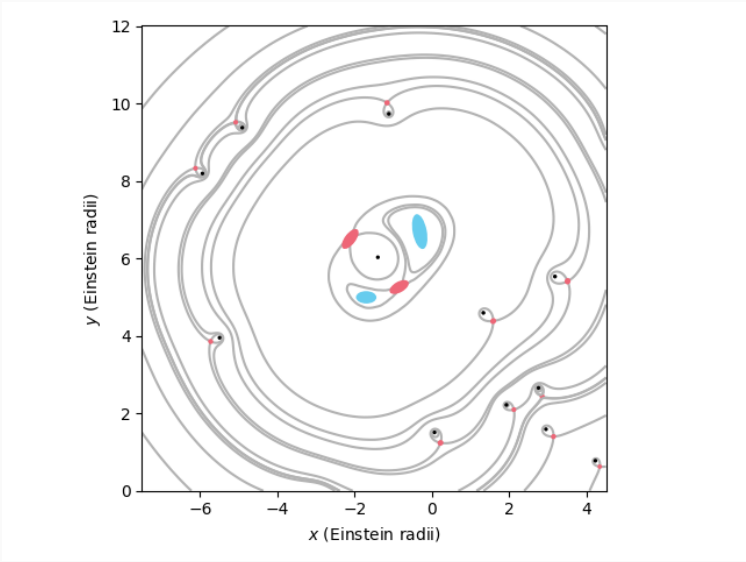

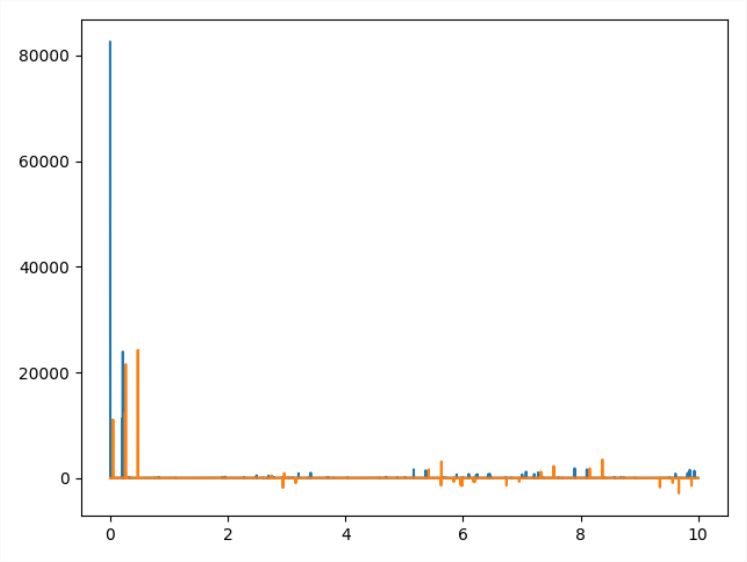

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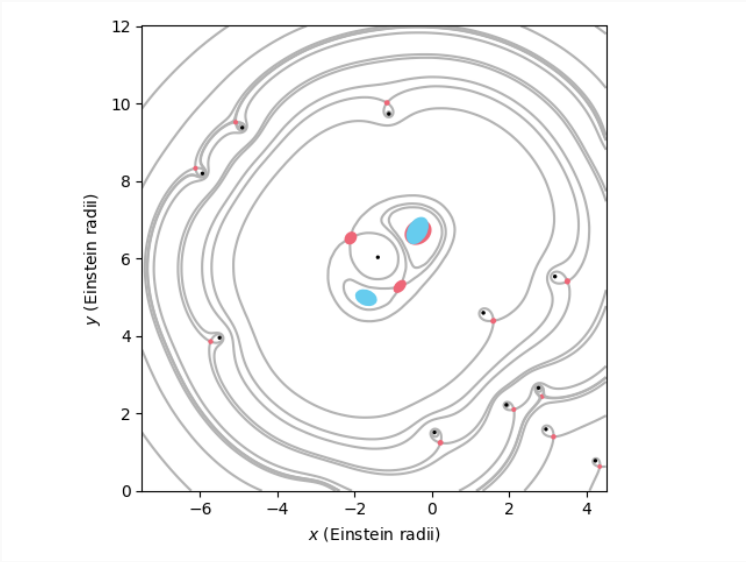

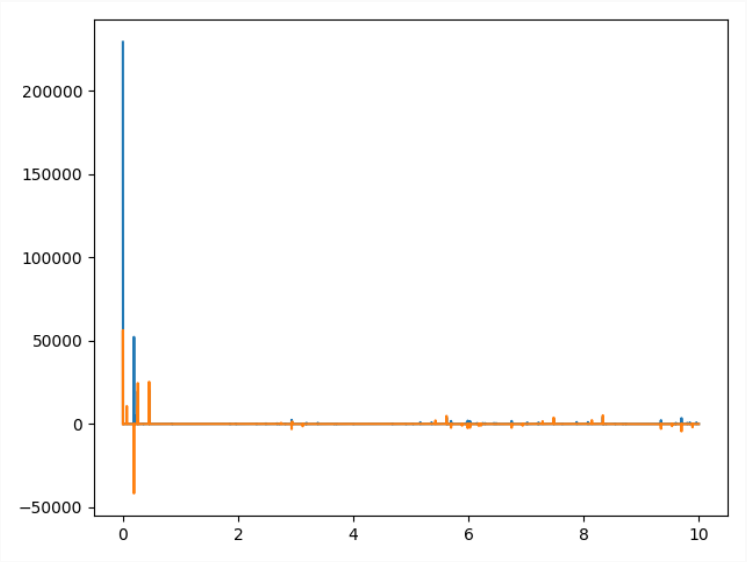

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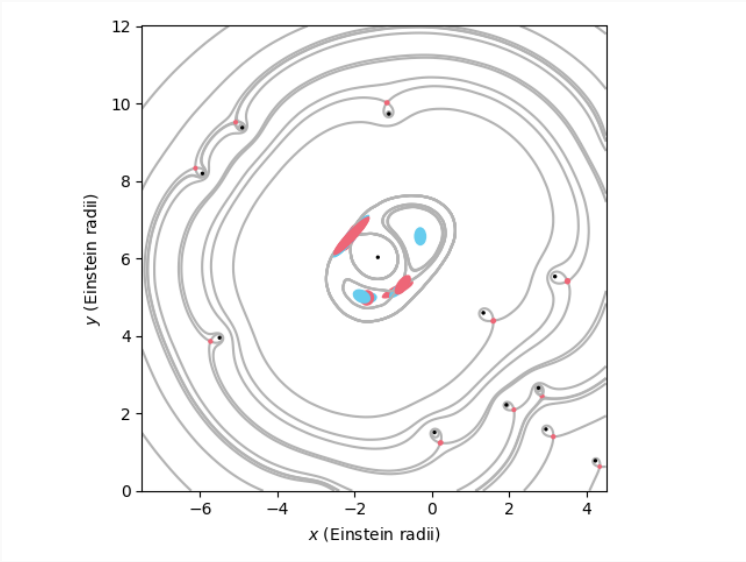

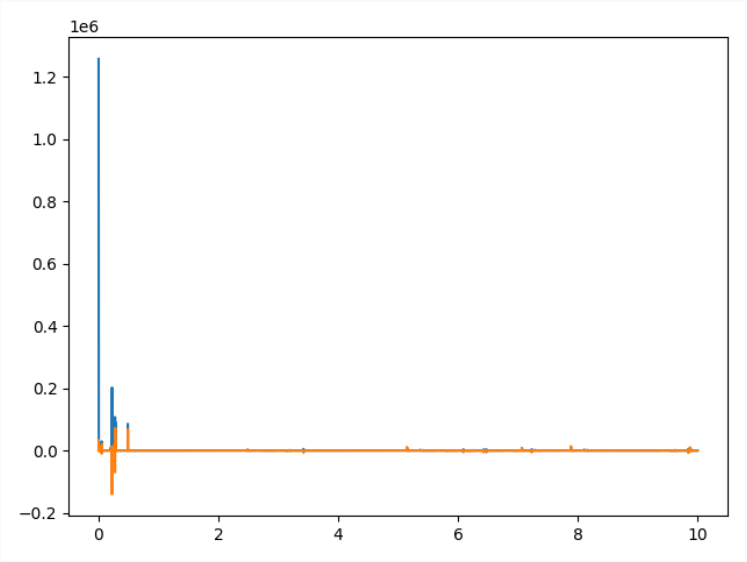

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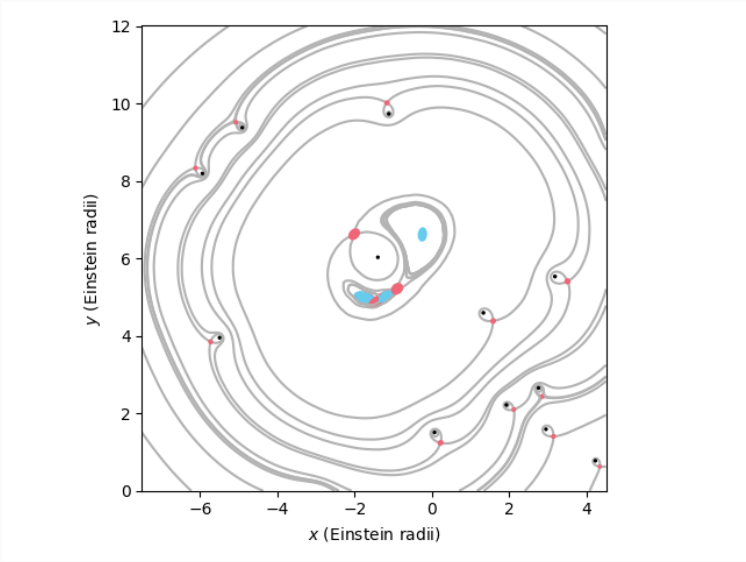

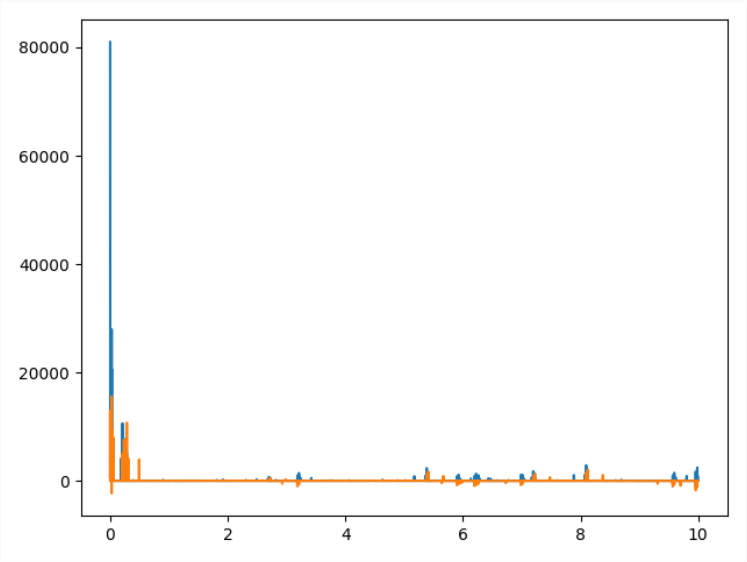

Summary

The well-known:

- One in $\sim 10^{-3}$ FRBs will be lensed by galaxies (clusters) to multiple images on the arcsec (arcmin) scales, with delays of weeks (years).
- Each image will be further microlensed collectively by stars into micro-images on micro-arcsecond scales, with delays on the microsecond scale.
- If they could be detected, potential applications range from stellar mass function to cosmological parameters.

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The new:

- Micro-images of will produce a distinctive signature in the auto-correlation of the FRB signal.
- Plasma scattering by the ISM is the likely limitation.