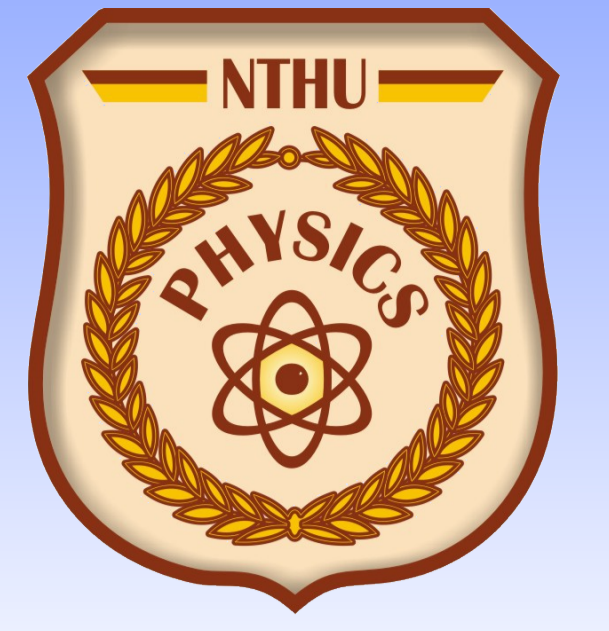




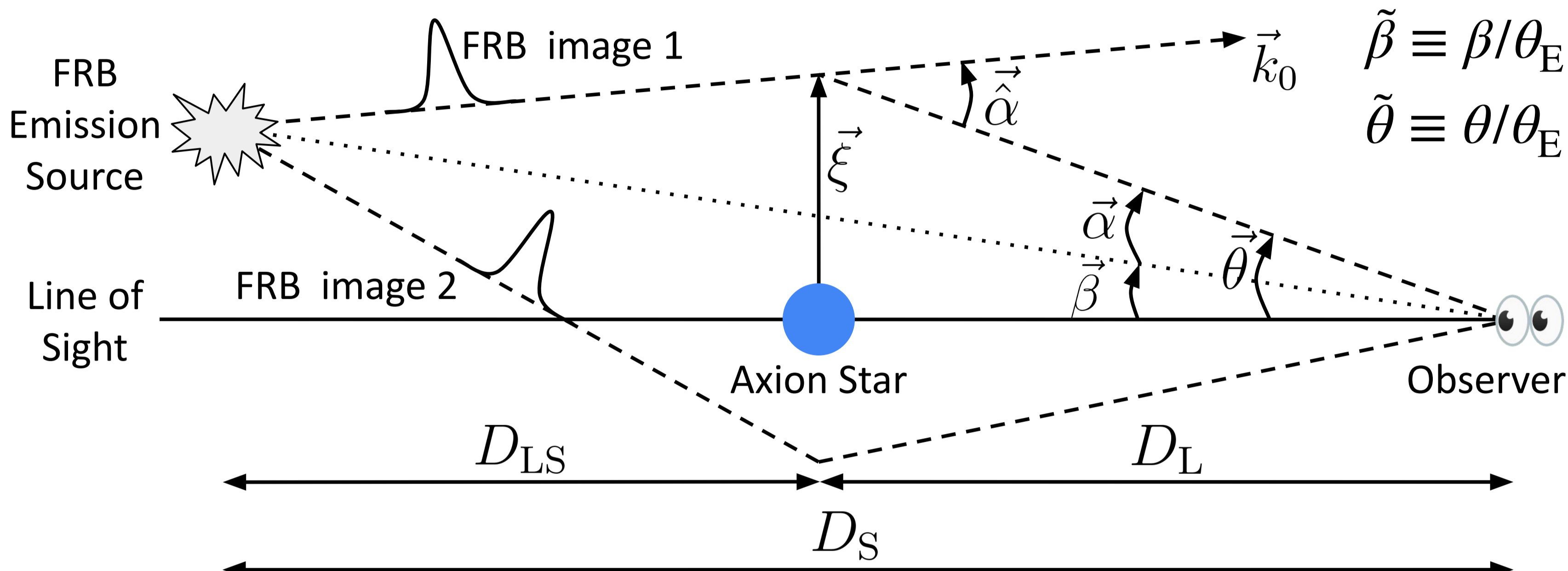
Constraints on Extended Axion Structures from Lensing Effects of Fast Radio Burst



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Sub-solar mass axion stars may be constrained by FRB lensing with non-negligible finite-size and axion-induced lensing effects.

Geometrical Schematic of FRB Lensing



$$\hat{\alpha}_{a\gamma\gamma} = -\frac{g_{a\gamma\gamma}^2}{8|\mathbf{k}_0|^2} \int \nabla_{\perp} (\partial a)^2 dt \quad t_{a\gamma\gamma} = -\frac{g_{a\gamma\gamma}^2}{8|\mathbf{k}_0|^2} \int (\partial a)^2 dt$$

- Lens equation: Assume AS spatial profile is Gaussian
- $$\tilde{\beta} = \tilde{\theta} - \frac{1}{\tilde{\theta}} \left[1 - \exp(-w_E^2 \tilde{\theta}^2) \right] - \frac{A w_E^2 \tilde{\theta} \exp(-w_E^2 \tilde{\theta}^2)}{w_E \equiv D_L \theta_E / R_{AS} \quad A \propto g_{a\gamma\gamma}^2 f_0^{-2}}$$

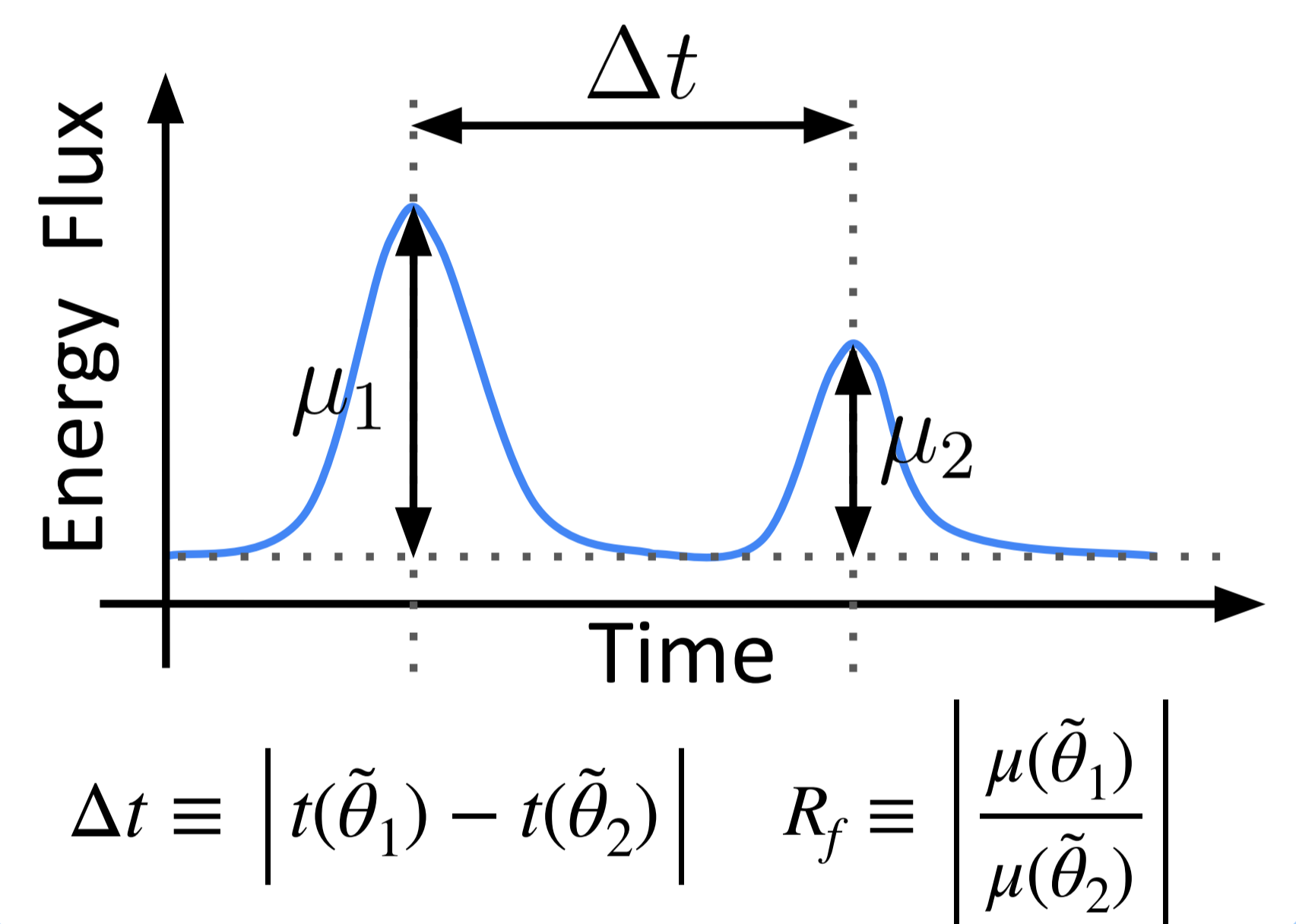
- Lensing probability: Assume ASs at extragalaxy and the Milky Way.

$$\bar{\tau}(M_{AS}) = \int dz_S \mathcal{N}_{FRB}(z_S) \int_0^{z_S} d\chi(z_L) (1+z_L)^2 n_{AS}(M_{AS}) \sigma(M_{AS}, z_L)$$

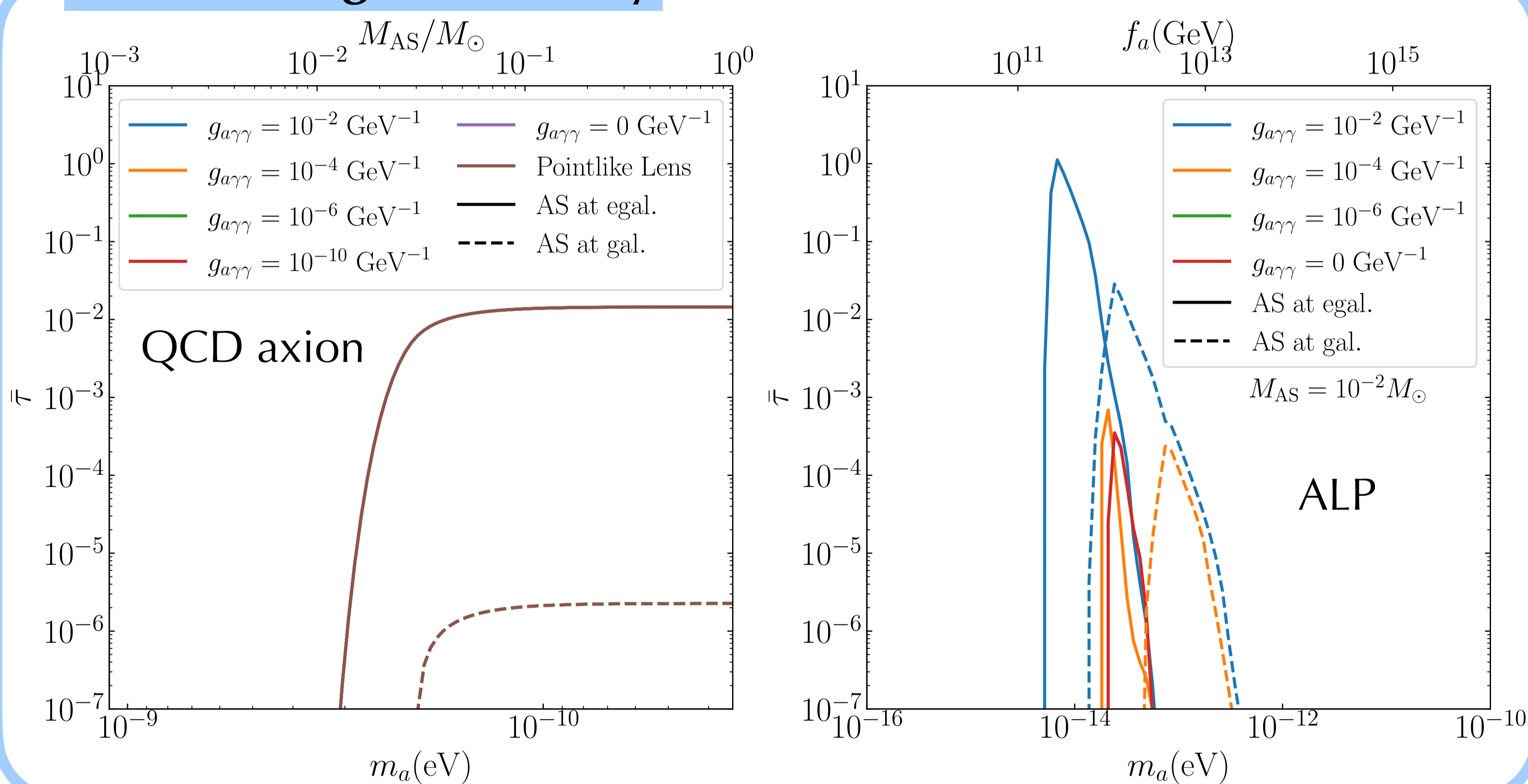
$$\sigma(M_{AS}, z_L) \propto (\tilde{\beta}_{max}^2 - \tilde{\beta}_{min}^2) \quad \Delta t_{thres} \leq \Delta t(\tilde{\beta}_{min} \leq \tilde{\beta}) \quad R_f(\tilde{\beta} \leq \tilde{\beta}_{max}) \leq R_{f,max}$$

FRB Lensing Signatures

- Flux Magnification + Time delay

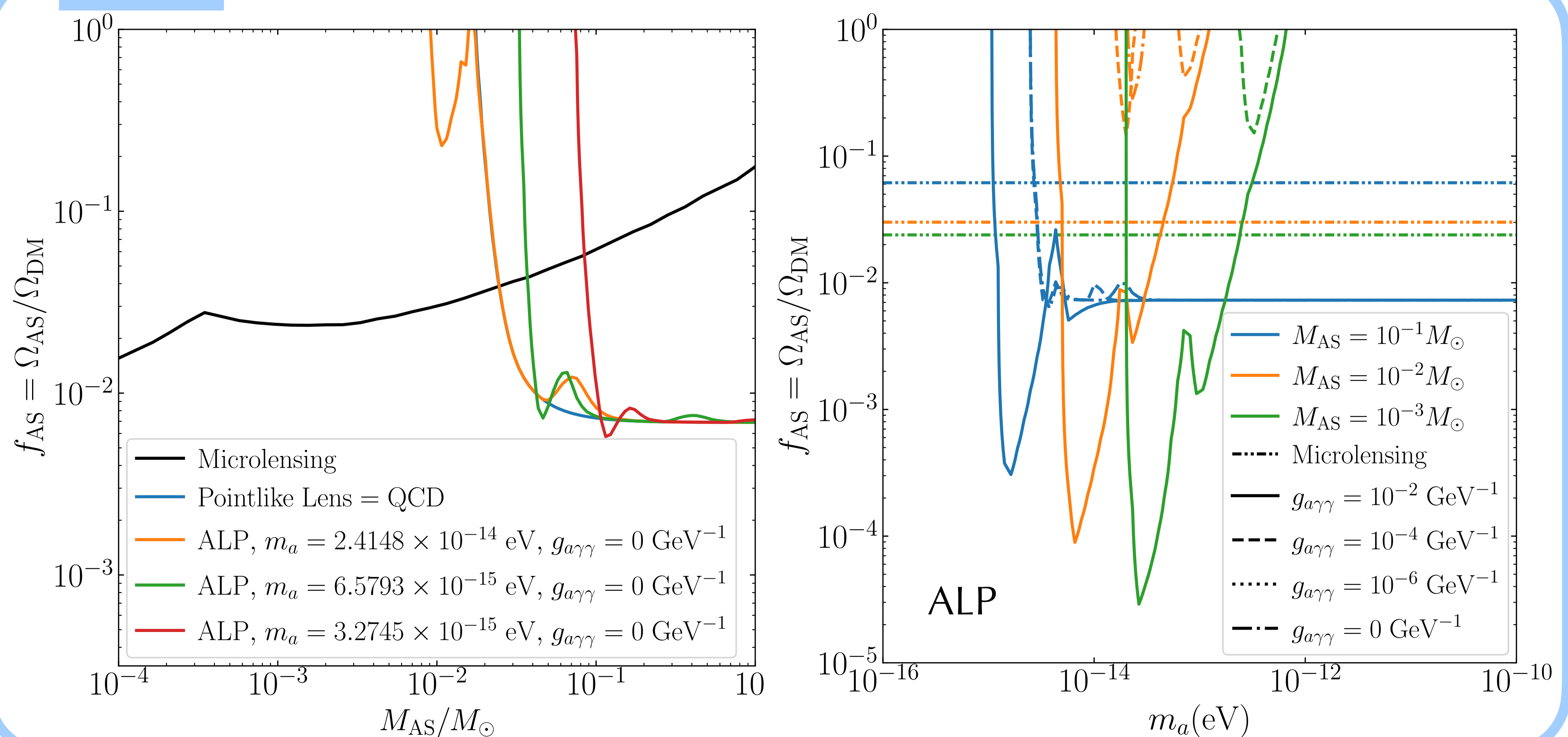


FRB Lensing Probability



- Estimated # of lensed FRB: $N_{lensed} = (1 - e^{-\bar{\tau}}) N_{obs}$
- Parameters with $N_{lensed} > 1$ are excluded by CHIME.

Results



References

1. Jamie I. McDonald and Luís B. Ventura. *Phys. Rev. D* 101 (2020), no. 12, 123503, arXiv: 1911.10221.
2. K. Fujikura et al.. *Phys. Rev. D* 104 (2021), no. 12, 123012, arXiv: 2109.04283.
3. Julian B. Muñoz et al.. *Phys. Rev. Lett.*, 117(9):091301, 2016, arXiv: 1605.00008.