Prospects for Identifying Galactic IMBH through Microlensing Signatures

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Objective

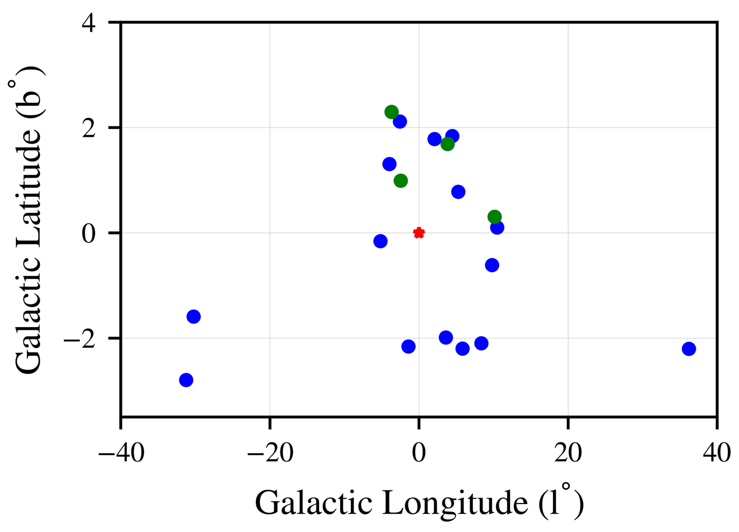
Microlensing can temporarily amplify continuous gravitational waves from Galactic sources, enhancing detectability and providing constraints on both the lens and the source.

Microlensing

The point-mass lens (PML) approximation applies to compact lenses, such as IMBHs, in microlensing. The amplification factor $\mathcal{A}$ varies with the source's position relative to the lens, while CW signals have a nearly constant frequency.

$$\mathcal{A}(W, y) = \frac{h_{\rm L}}{h}; \qquad T_{\rm E} = \frac{1}{V_{\rm rel}}\sqrt{\frac{4GM_{\rm L}}{c^2} D_{\rm L}\left(1 - \frac{D_{\rm L}}{D_{\rm S}}\right)}; \qquad W = \frac{8\pi G M_{\rm L} f}{c^3}$$

Where, $T_{\rm E}$: Einstein crossing time, W: Dimensionless frequency, $h_{\rm L}$: lensed signal, h: unlensed signal, $M_{\rm L}$: lens mass, f: source frequency, $V_{\rm rel}$: source's relative velocity to the lens, $D_{\rm L}$: lens-observer distance, $D_{\rm S}$: the source-observer distance.



- Green circles: Potential IMBH candidates closer to the Galactic bulge, Blue circles: $b \pm 3°$, Red star: Galactic centre
- Structural concentration with core-to-half-mass radius ≤ 0.2 is consistent with clusters hosting IMBHs.

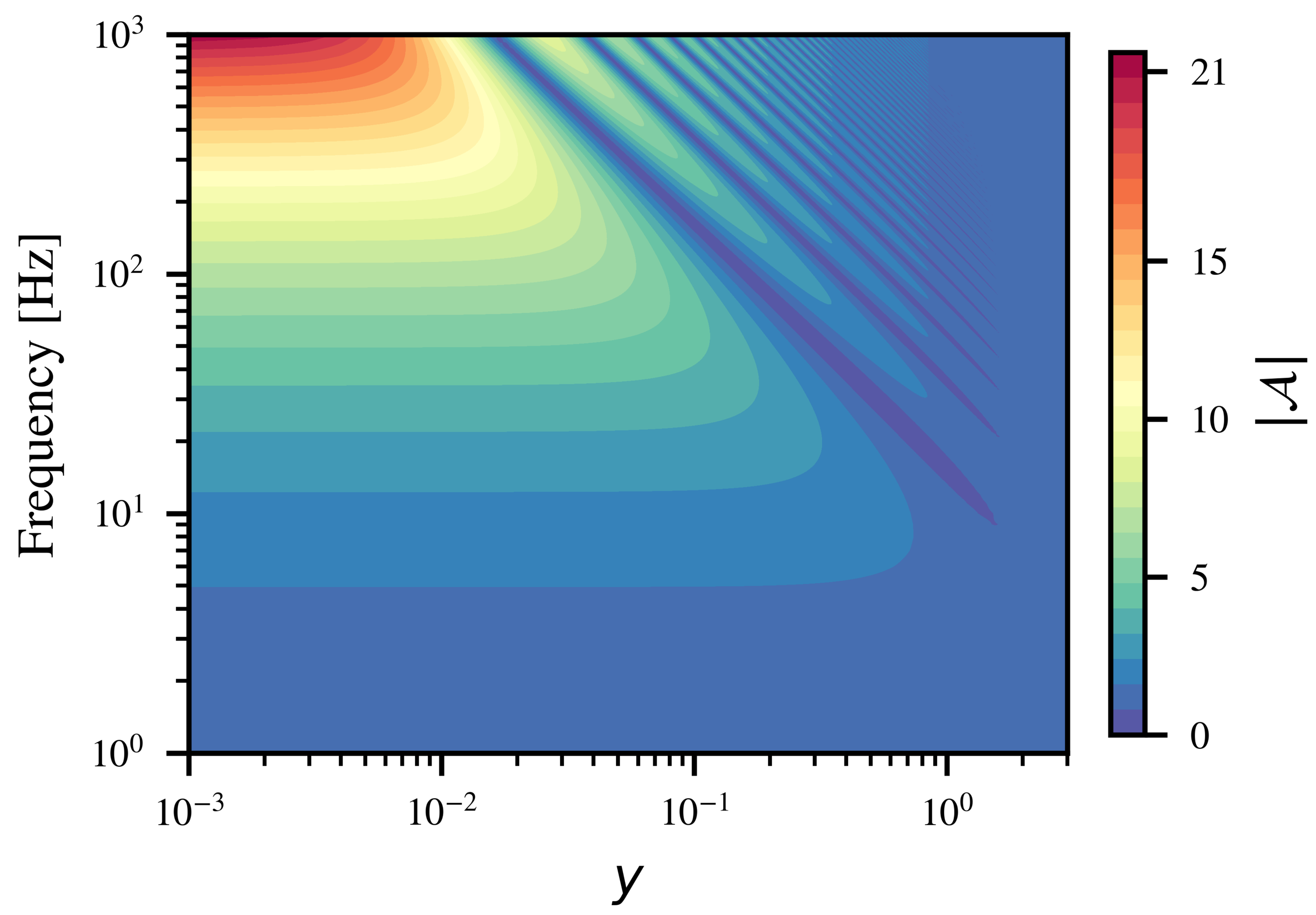


Figure 1: Terzan 1: Amplification factor versus frequency for different impact parameters.

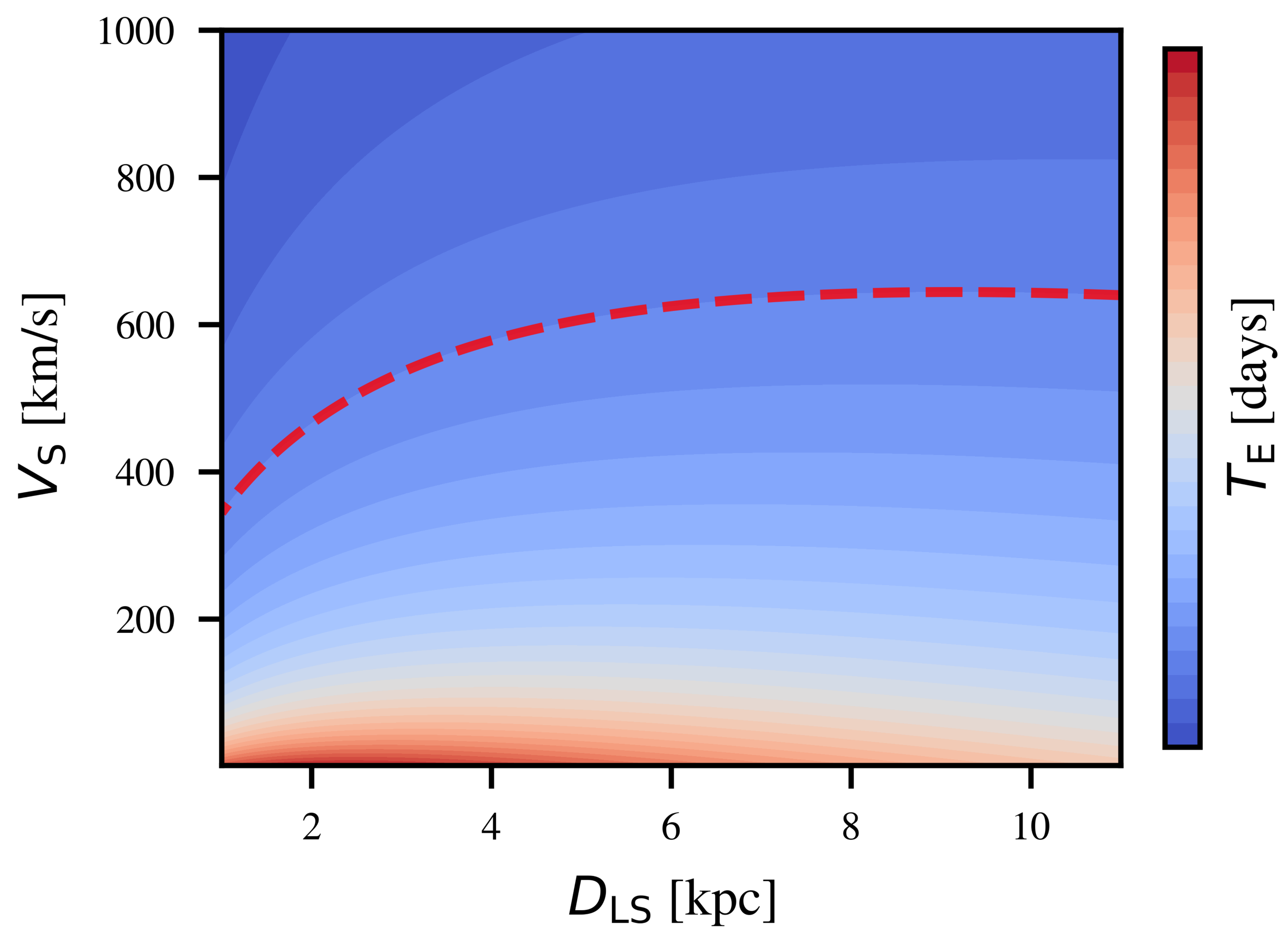


Figure 2: Terzan 1: Einstein crossing time for source velocity and lens distance; red line shows one-year traversal of the Einstein radius.

Microlensing Pattern

O3 data were divided into one-day segments and narrow frequency bands: No hardware injections, No known frequency lines, least coincidences, HL network SNR ≤ 8, then lensed signals were injected and analyzed using the time-domain $\mathcal{F}$-statistic.

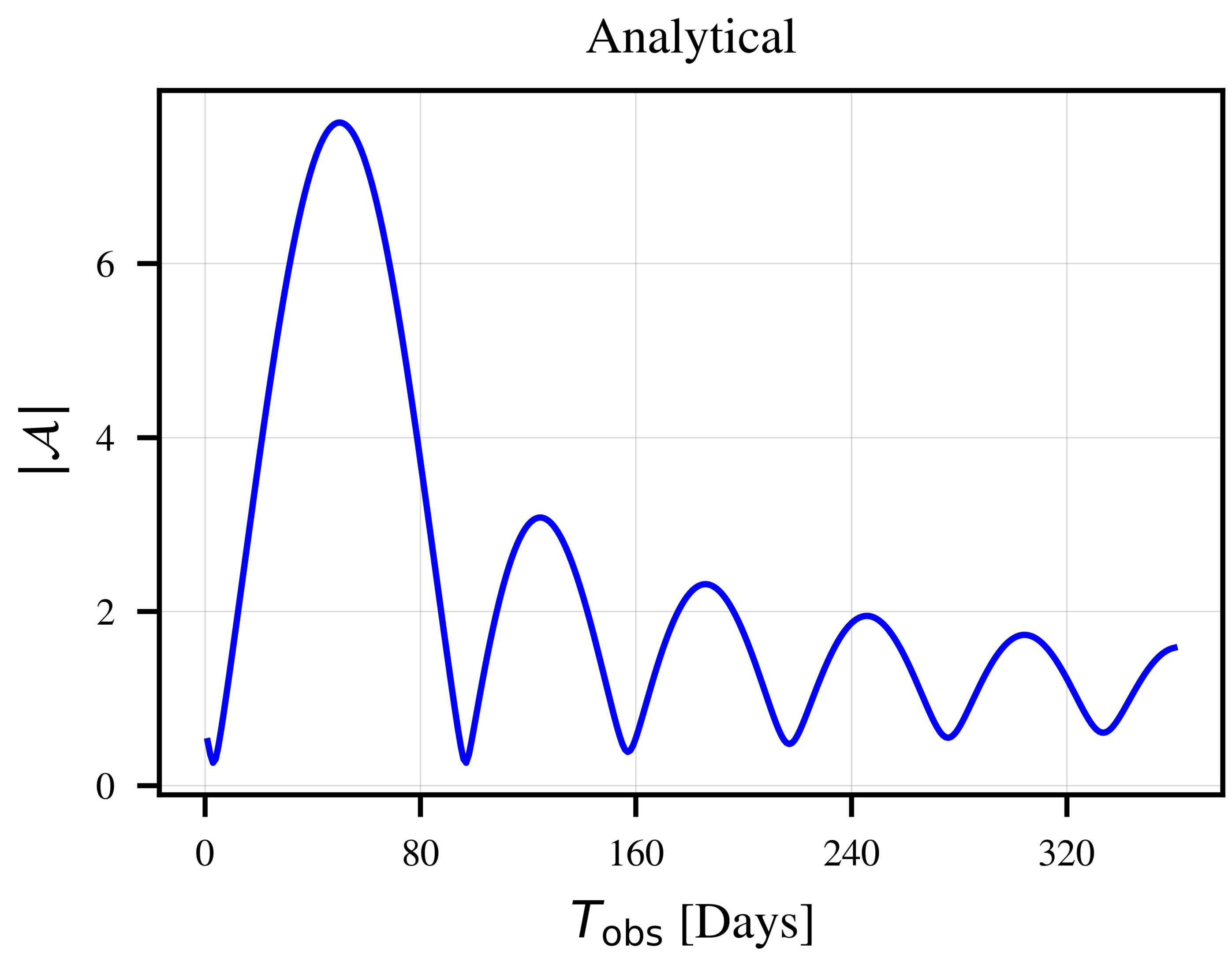


Figure 3: Analytical amplification for the Terzan 1 IMBH candidate at 124.4 Hz

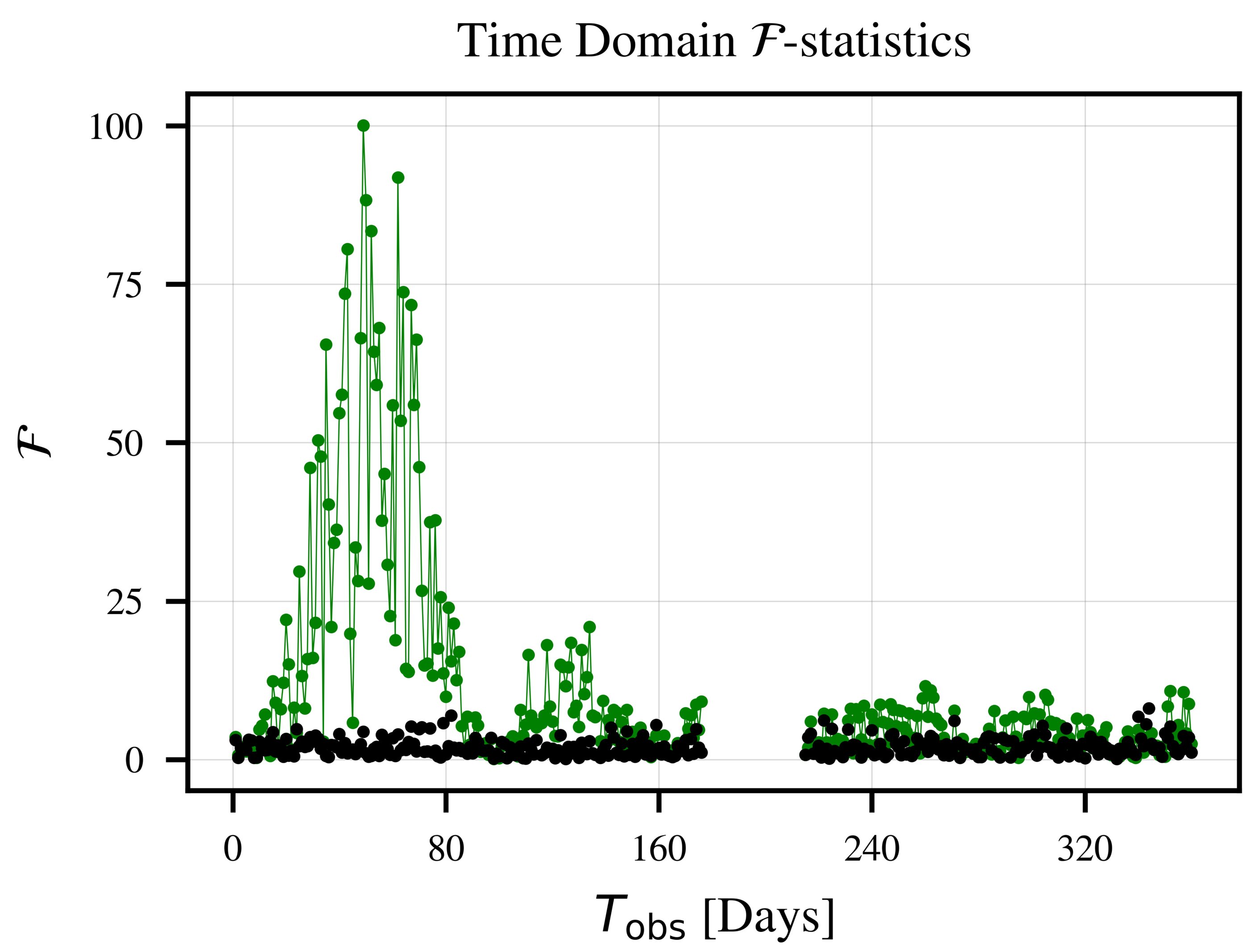


Figure 4: One-day segment analyses with the lensed signal injected into O3 data; black circles indicate time-domain $\mathcal{F}$-stat results without any signal injection.

Summary

- Terzan 1 IMBH lensing rate ≈ 2.4 per million neutron stars in the Galactic bulge.
- Galactic microlensing events are detectable by ground-based detectors.
- The lensing event allows estimation of lens and source parameters.
- Framework supports studying long-duration lensing with current and future detectors for different lensing systems.

References

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Acknowledgments

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