

Studying patched spacetimes for binary black holes

An asymptotic approach

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Introduction

- An interesting astrophysical problem to consider is the treatment of circumbinary accretion disks around binary black holes (BBHs).
- Supermassive ($10^5 - 10^9 M_\odot$) and intermediate ($10^2 - 10^5 M_\odot$) mass BHs have been widely considered.
- But studies of disks around binaries in the LIGO regime (tens of solar masses) are more obscure.
- **Neither** of these cases have been observed.

Specifications

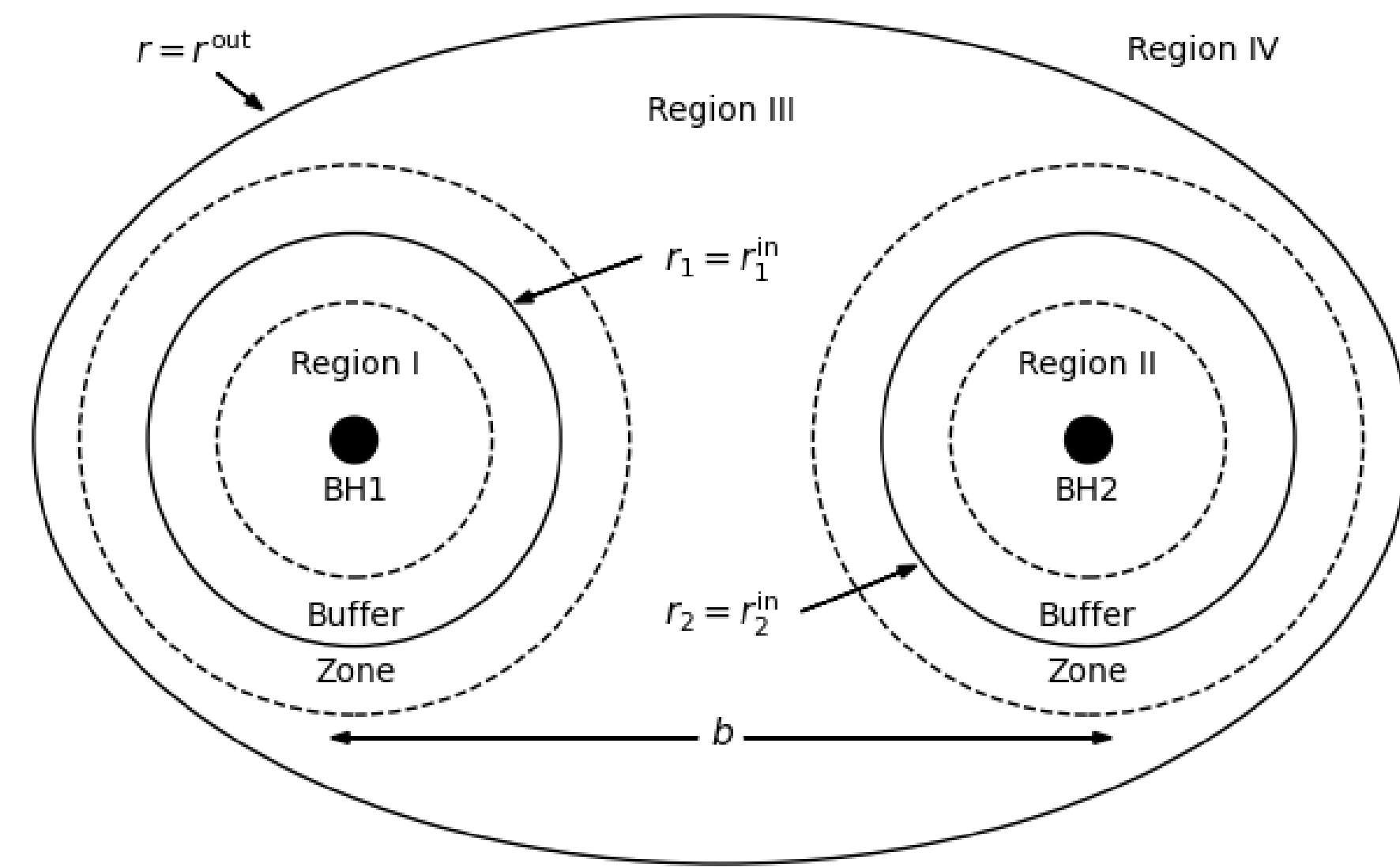


Figure 1: Global metric displaying all regions (gr-qc/991211)

1. Equal mass BHs: $m_1 = m_2 = 30M_\odot$.
2. Each BH perturbs the other.
3. Widely separated: $\sim 14M$, where $M = m_1 + m_2$.
4. The analytic spacetime metric [1, 2] is given in Fig 1.

Results

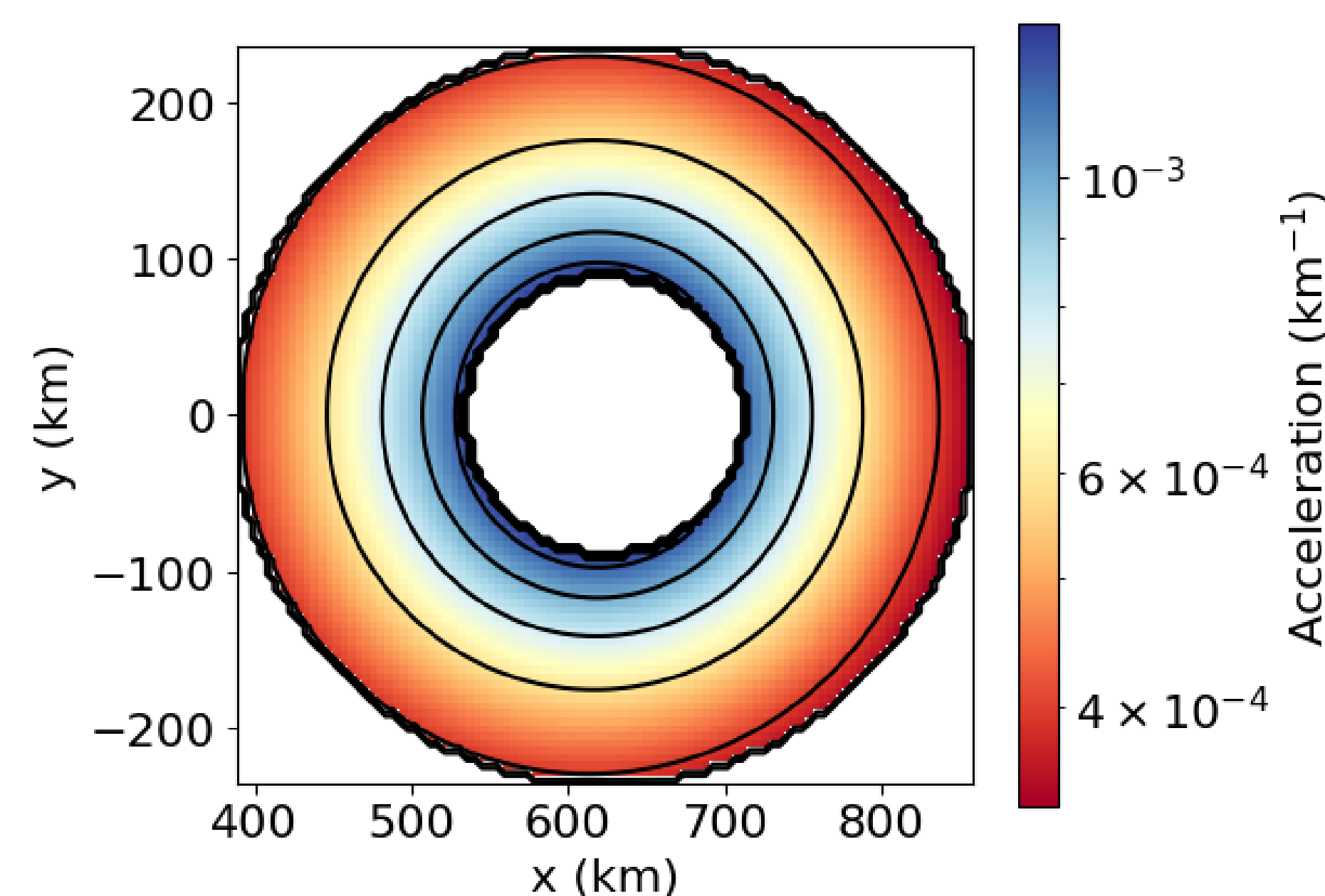


Figure 2: Acceleration map covering Regions I and II

1. Acceleration map for region I and II (Fig 2):

- Contours become more circular when moving away from BHs (pull of gravity diminishes further out).

2. Acceleration map for region III (Fig 3):

- Centre shows several nodal regions where acceleration is very small compared to the rest of the space.
- Acceleration gets larger as we move away from the centre: Due to use of co-rotating coordinates:

$$g_{00} \propto \omega^2(x^2 + y^2)$$

3. Using 100 geodesics, we found that 24 (Fig 4) potentially accreted.

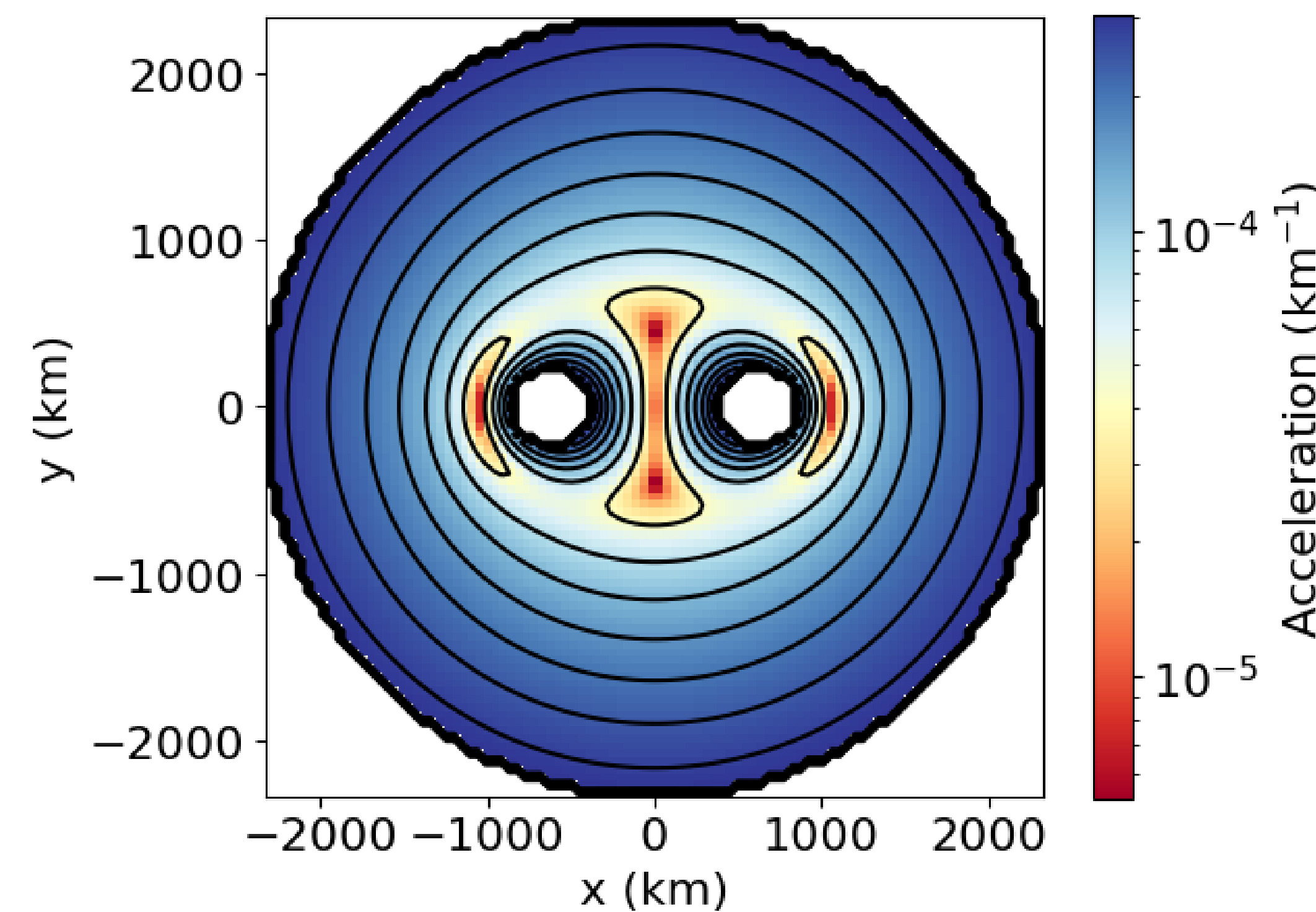


Figure 3: Acceleration map covering Region III.

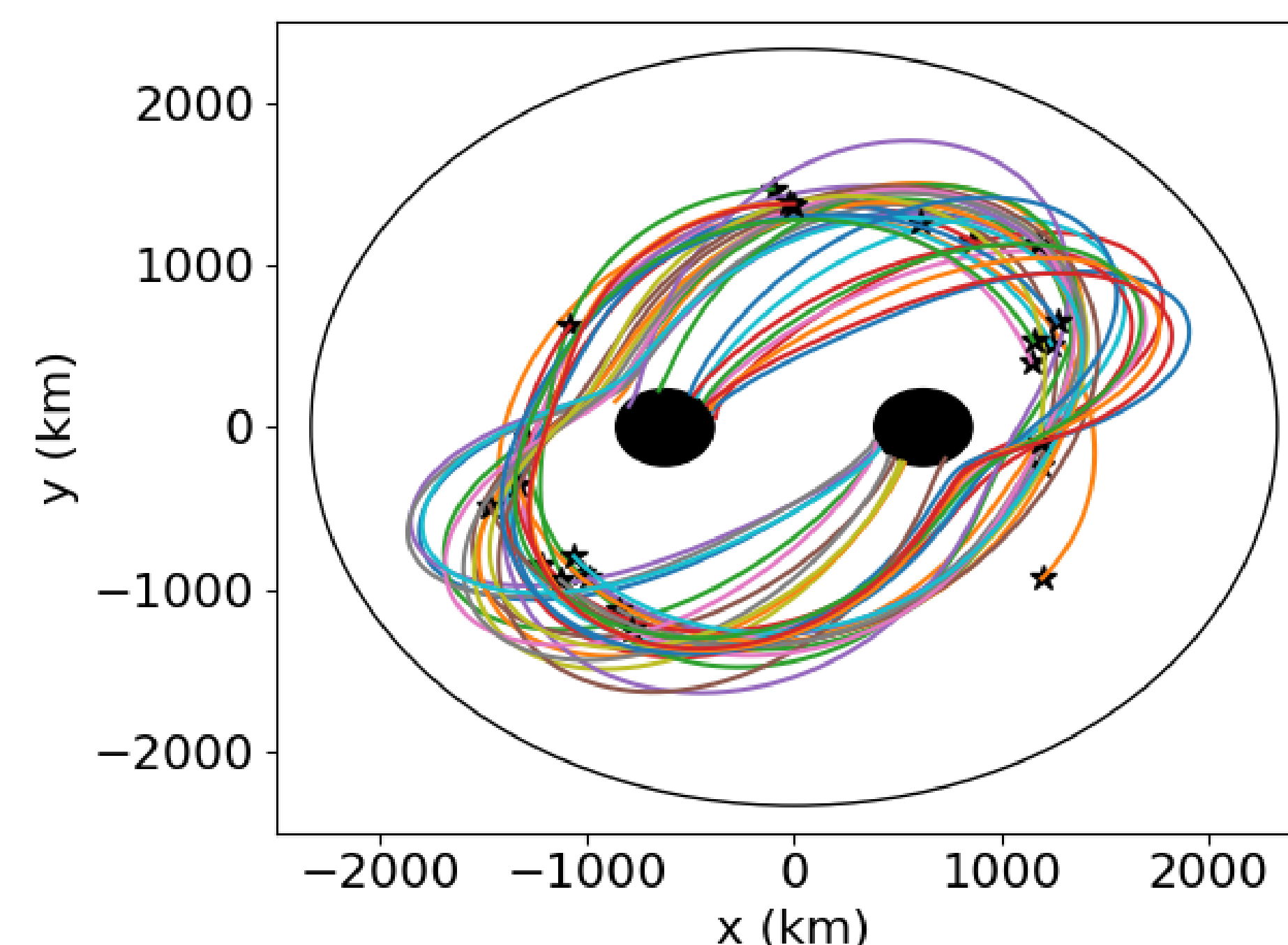


Figure 4: Potentially accreting geodesics. Star markers indicate the origin of the particle and the black ellipse demarcates region III.

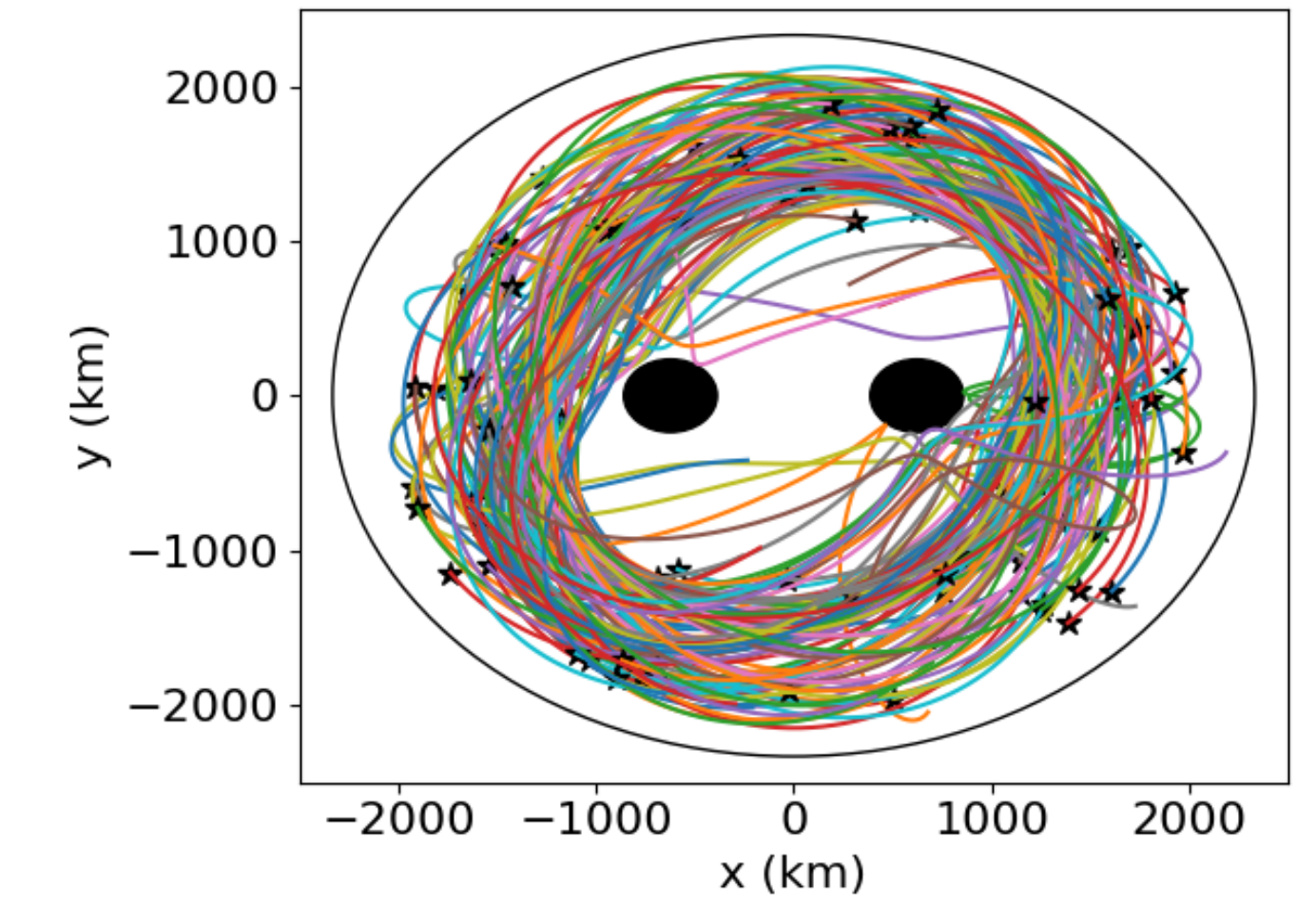


Figure 5: Non-accreted particles.

Conclusions

- Using the geodesic equation to find trajectories and accelerations, provides a unique means to search for precursor EM signals that could herald the release of gravitational waves.
- Acceleration maps indicate where possible radiation would be most intense.

Forthcoming Research

The case where the environment around the black holes is magnetised, synchrotron radiation is likely to occur with any flow of particles towards the black holes, producing radio emissions which may be detectable by MeerKAT. Though this is more probable for larger black holes than studied here as such small regions may not be resolvable. Magnetized environments will also require additional dynamical corrections, as strong magnetic fields will affect the particle geodesics. The effect of such fields will be considered in future work.

References

- [1] Kashif Alvi. Approximate binary-black-hole metric. *Phys. Rev. D*, 61:124013, May 2000.
- [2] Kashif Alvi. Note on ingoing coordinates for binary black holes. *Phys. Rev. D*, 67:104006, May 2003.

Acknowledgements

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