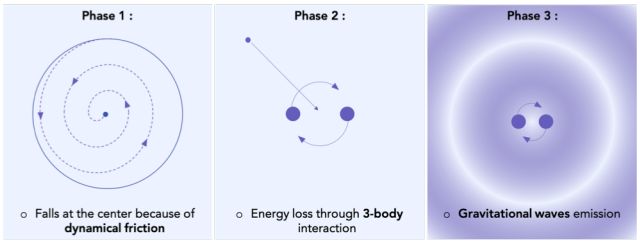
Forming off-centered massive black hole binaries with core stalling

Thibaut FRANCOIS, Christian BOILY & Jonathan FREUNDLICH

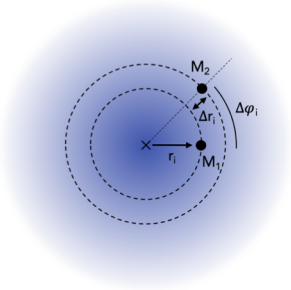
Introduction :



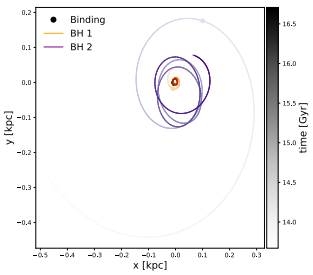
The standard picture of massive black holes mergers unfolds in three stages following a galaxy merger. In the first phase, massive black holes are driven at the centre of the newly formed galaxy because of dynamical friction. They are expected to meet there but numerical simulations have shown that in the presence of a constant density core, dynamical friction stops and black holes stall outside the center[1,2,3]. So the question is: is it still possible for these black holes to find each other despite the stalling phenomenon that prevents them from reaching the centre? Is it then possible to form off-centered black hole binaries and what are the consequences for the BH mass assembly and the emission of gravitational waves?

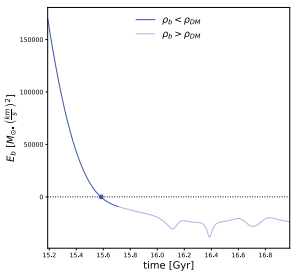
Method :

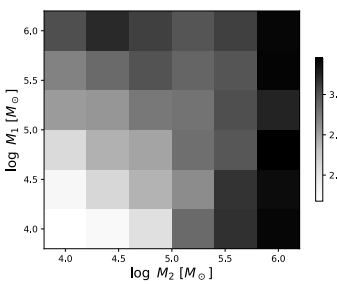
We use a simplified model in which the two black holes are first brought to their core stalling radius and then interact and merge. We integrate them in a smooth potential representing a spheroidal dwarf galaxy. We then **probe the phase space of the initial conditions** to determine the proportion of binding configurations and to quantify the effect of each parameters: $M_1, M_2, r_i, \Delta r_i$ and $\Delta\varphi_i$ on the binding probability.

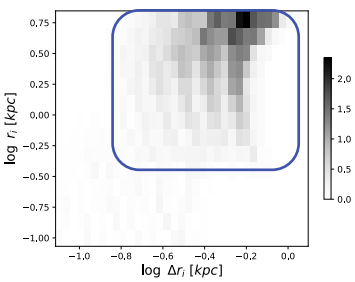


Results :









We integrated 158 760 initial configurations over 14 Gyr ⟶ 11.1% of binding
More likely to form a bond if :

- M_1 & M_2 large + $M_2 > M_1$
- High probability island on figure r_i / Δr_i (blue square)

We then put black holes on there theoretical stalling radius[4] ⟶ 20,2% of binding

Conclusion :

It is possible for massive black holes to catch up outside the galactic centre, once they have been brought to their core stalling radius. We now want to evaluate the effect of such off-centered mergers on BH mass assembly using a cosmological sequence of mergers and sampling blach holes masses using a PDF based on cosmological model.

References :

1. Read, J. I., Goerdt, T., Moore, B., et al. 2006, MNRAS, 373, 1451
2. Inoue, S. 2011, MNRAS, 416, 1181
3. Petts, J. A., Gualandris, A., & Read, J. I. 2015, MNRAS, 454, 3778
4. Kaur, K. & Sridhar, S. 2018, ApJ, 868, 134

Observatoire astronomique de Strasbourg | ObAS