Formation of discs around supermassive black hole binaries

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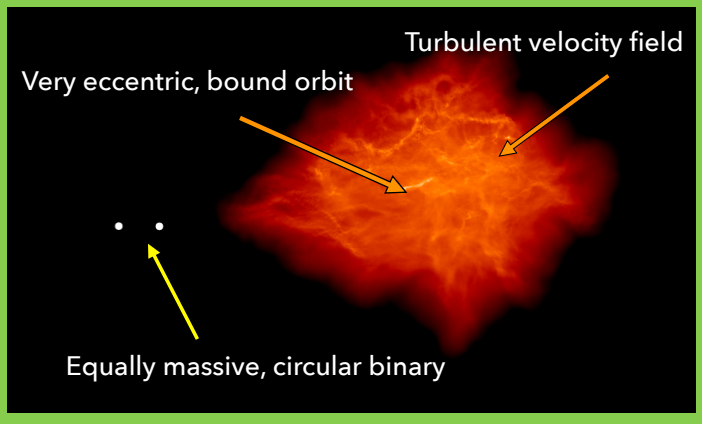
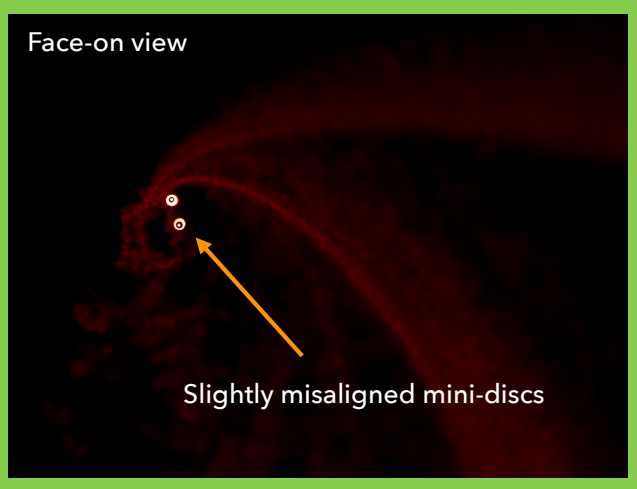
Supermassive black holes are ubiquitous in galactic nuclei, and binaries of these massive objects are an inevitable product of the hierarchical evolution of structures in the universe. In gas-rich systems, like a remnant of a major merger, it is expected an abundance of gas funneled to the galactic nuclei, where it can drive the evolution of the binary and produce electromagnetic signatures, but how the gas interacts with the binary as it reaches its influence radius is still unclear. If the interstellar medium is turbulent and gravitationally unstable, an efficient mechanism to fuel the galactic nuclei with gas is through the formation and infall of clumps or molecular clouds.

The numerical model

We use a modified version of the SPH code GADGET-3 to model numerically the evolution of gas clouds in near-radial infall onto binary SMBHs.
As we expect the clouds to approach the binary from different directions, we investigate the different gas structures formed depending on the **impact parameter** and **relative inclinations** between the binary and the cloud orbits.
In this poster we present the particular results of the mini-discs formed in the aligned orbits and the circumbinary disc in the perpendicular orbit with the larger impact parameter.





Misaligned mini-discs

In all the cases when the cloud and the binary are aligned we observe the formation of the so-called "mini-discs" around each SMBH. The particular feature with these is that in every case we have at least one of them that is slightly misaligned with the binary, as in the projection shown in Fig. 2.

The evolution of the mini-discs then is a combination of 2 movements: a steady precession around the aligned position (Fig. 2) and a super-imposed wobbling (Fig. 3). Both movements are produced by the presence of the "secondary" SMBH.

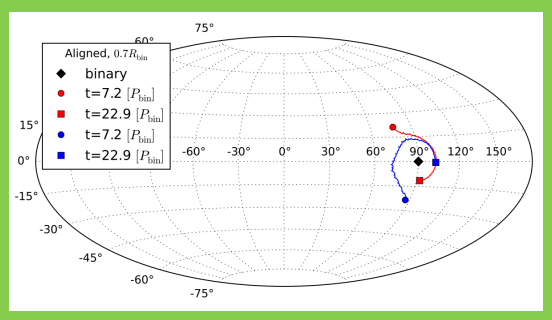


Figure 1

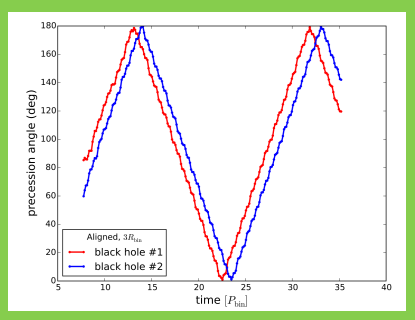


Figure 2

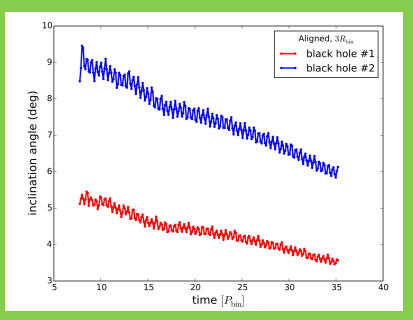
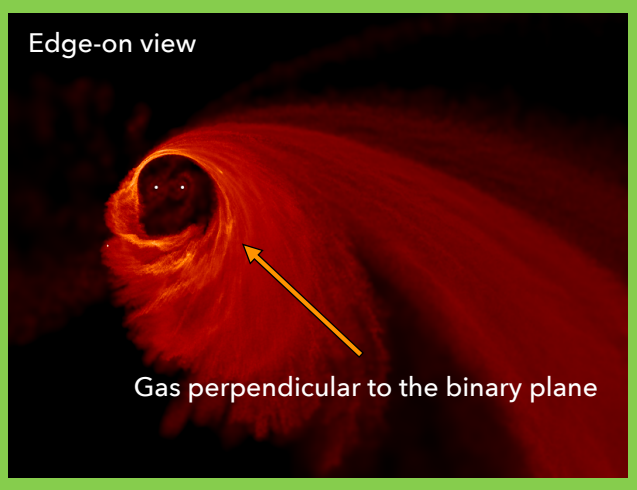
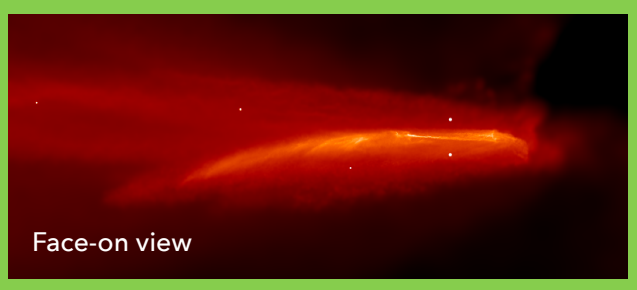


Figure 3





Perpendicular circumbinary disc

For the perpendicular simulation, when the pericenter distance of the cloud's orbit is 3 times the radius of the binary, a circumbinary disc is form, although is completely perpendicular to the binary plane. Due to the interaction with the binary potential the disc slowly drifts towards the aligned position.

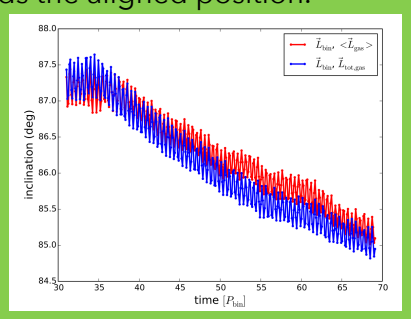


Figure 4

Implications

- If a jet is produced attached to a misaligned mini-disc, it will precess with a period several times the binary period and wobble with half of the binary period.
- A misaligned circumbinary disc will tend to align or counter-aligned with the binary, but the star formation time-scale will determine the orbits of the star around the binary.
- All these distinctive electro-magnetic signatures are likely to have important implications on the future multi-messenger studies of SMBH binaries.

Acknowledgments

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