LEARNING MORE ABOUT BLACK HOLES, SIMPLY BY LOOKING AT STARS.

And the other way around.

UNIVERSITY OF CAMBRIDGE

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Introduction – I wanted to study black holes...

Usually, the study of black holes requires a gravitational wave detector. But in the galactic centre, stellar motions are influenced by the gravity of small black holes. Precisely, these black holes modify the stars' orbital planes. This lets us detect them with a telescope.

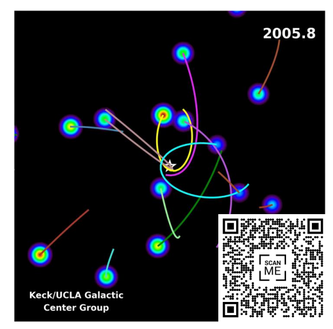

Fig. 1: SgrA* was detected through the motion of S2

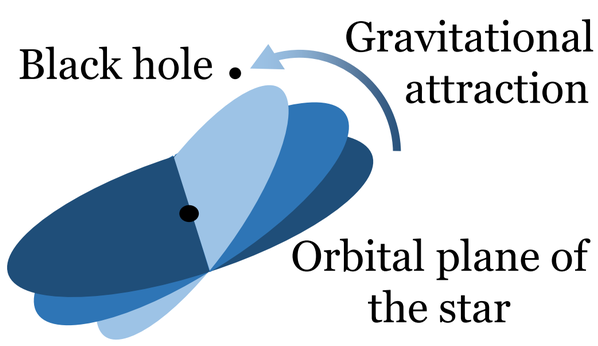

Fig. 2: A black hole modifies a star's orbital plane

Methods – ...at an affordable price.

The traditional way to compute the end result of this process is slow, and expensive. My new open-source code speeds the calculations up a thousandfold, thanks to an idea from thermodynamics. This allows me to pay for many simulations and explore the impact of the parameters, for the first time.

Results – So I designed two new experiments...

Main result: In every simulation, all the black holes and heavy stars live in a thin disk.

From stars to black holes

I've found that the thickness of the disk of heavy stars is related to the black holes' mass – a figure of great interest to theorists, because it indicates how black holes grow.

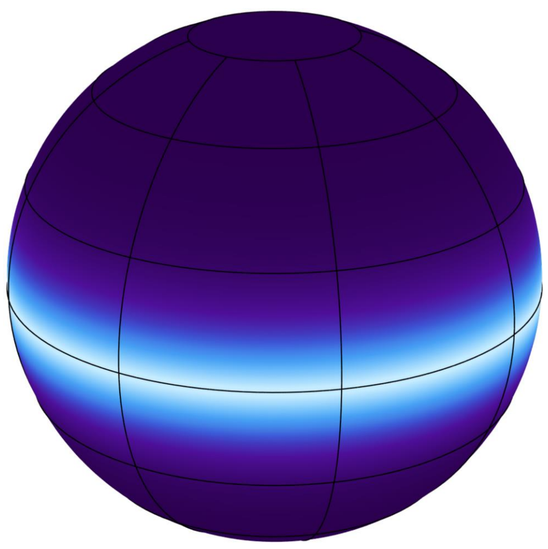

Fig. 2: Typical position of the heavy stars. They form a disk.

In 10 years, we will quantify this thickness with 30-m telescopes.

From black hole mergers to stars

No one knows where galactic centre stars are formed. The leading theory presumes a gas disk. I've found that under this hypothesis, the disk of black holes is thin, leading to more frequent collisions.

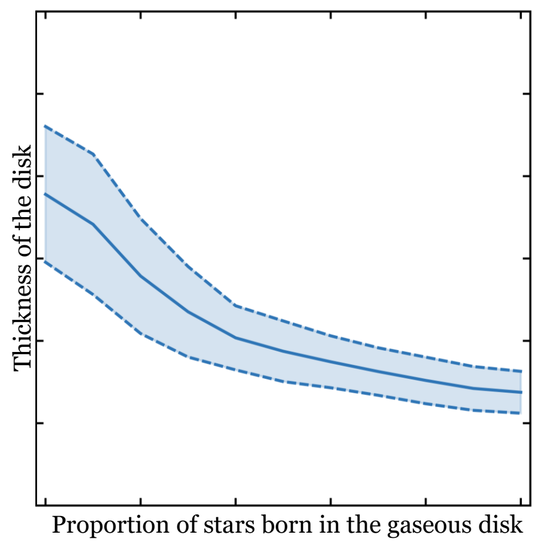

Fig. 3: The thickness of the disk of black holes, as a function of how many stars were born in the gaseous disk. The noise is smaller than the signal.

In 20 years, we will quantify this collision frequency with LISA.

Conclusion – ...that could be performed in the near future.

My code makes it easier to simulate the impact black holes have on the galactic centre's stars. I use it to demonstrate two concepts, both counter-intuitive: telescopes could study black hole growth, and gravitational wave detectors could study star formation. These effects are large, they might be accessible to the next generation of instruments!