

# Seminar I: The black hole at the centre of the Milky Way

---

## General instructions

This document provides instructions for the second of the four seminars forming part of the examination for the course *Physics of Galaxies* in 2019. This is an exercise in the use of a virtual reality interface for running and analyzing numerical simulations of a complicated astrophysical situation. In this exercise, you will be using the Universe Sandbox<sup>2</sup> software, along with a Oculus Rift headset, to explore what happens to stars as they venture close to the supermassive black hole at the centre of the Milky Way.

This exercise is held in the Ångström Visualization Lab (room 11240), which is located within the [Ångström library](#) on the first floor in house 1 of Ångström Laboratory. The exercise will be carried out in teams of up to four students at a time – please make sure you sign up for one of the available time slots and remember to show up for the right one. It may be useful to bring pen and paper to the exercise session.

The point of this seminar is to:

- Learn more about the interaction between stars and supermassive black holes
- Get hands-on experience in running on-the-fly simulations in a virtual reality setting
- Practice collaborating within a team when planning, running, documenting and analyzing numerical experiments
- Get a feeling for how the limitations of a numerical simulation (in terms of computational accuracy, the physics included or the representation of the astrophysical situation) may affect the results

In preparing for the seminar, you should:

- Read section 2.6 (*The Galactic Center*; pages 89-99) and section 3.8 (*Black holes in the centers of galaxies*; pages 144-148) in the textbook to get acquainted with how astronomical objects (stars, gas clouds etc.) interact with supermassive black holes in the centers of galaxies

Please note, that unlike seminar IV in the *Physics of Galaxies* course, this seminar will only be graded pass/fail. If you are actively taking part in the virtual reality simulations and complete the exercises assigned to you during the seminar session, then you will pass.

**Note on the use of eyeglasses:** Using eyeglasses inside the Oculus Rift headset can feel somewhat uncomfortable, especially when using glasses with large frames. I still haven't encountered a single case where this hasn't worked out in the end, but if you are alternating between eyeglasses and contact lenses, you may want to consider using the contact lenses during the seminar (that's what I myself do when using the headset).

**Note on photosensitive epilepsy:** Simulations in Universe Sandbox<sup>2</sup> can occasionally result in rapidly flashing lights, especially before one is able to fully master the controls. For instance, locking onto an object in orbit and speeding up time can feel like being on some pretty intense, stroboscope-illuminated merry-go-round, as stars rushes past your field of view several times per second. If you suffer from photosensitive epilepsy, please make your teacher aware of this well before coming to the exercise session, and we'll try to find some workaround.

**Erik Zackrisson, March 2019**