

Phys 88 Black Hole Simulation Project Proposal

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1 Introduction

Our proposed capstone project is a 3D/2D simulation modeling the trajectories of photons surrounding a black hole accounting for general relativity. The results will be compared to images generated from the data provided by the Event Horizon Telescope(EHT).

Our visualization of how light behaves surrounding a black hole will allow us to better understand images of black holes taken by telescopes (such as the image of the SMBH at the center of M87). With more accurate simulations, you could also create theories about the properties of black holes. / overall appearance of black holes to outside observers

The code will simulate black holes of varying masses and how the initial conditions of light interacting with the gravity of a black hole and draw assumptions from the results. The visualization will occur by tracing the path of photons along the curvature of space-time around the singularity.

2 The Simulation

2.1 Visualisation Code

First we will need to create two classes of objects: Black Holes, and Photons. Then add in Formulas from Relativity in order to mimic actual interaction between objects. After setting the objects up, the data from the simulation will be taken through recording the position of the photon during a different points in time and storing to a list. These simulations could possibly lead to animations being made given enough time.

2.2 Repetitions and Data Analysis

After running the simulation a large number of times from varying positions, the positions can be plotted using Matplotlib. The higher the amount of particles passing through a point, the brighter orange the location will be. If adding in particles coming from a source, e.g. a planet, we can model how particles move around a black hole through "real" time. From there we can analyze things

what criterion is required for a photon to escape, to get sucked in, and to be stuck in an orbit.

3 Comparison to EHT Data

First, a black hole will be selected from the EHT website. Then, the black hole would be simulated in the simulation and its data created into a graph. Then, the data from EHT will be analyzed using the Astro.py library. The data will be used to create a picture of the black hole, and then will be compared to the picture generated from the simulation. Judging from the difference, our simulation of a black hole could be altered and the process run again. Things we could experiment include spin, and amount of mass entering the black hole's accretion disk. A large difference between the data that the telescope provides and the simulation provides, is red/blueshift, how much radiation is being produced, and the plasma jets that are being released. If there is enough time, these differences could also be modeled in a unique simulation to see if we can recreate the results the actual results from the telescope.

4 Resources

4.1 Black Hole

www.youtube.com/watch?v=fu3645D4ZII

www.asc.ohio-state.edu/orban.14/stemcoding/blackhole.html

rantonels.github.io/starless/

4.2 Relativity

arxiv.org/abs/0804.4572

iopscience.iop.org/article/10.1086/346103