PH403 Thesis Proposal Cover Page Date

Project:

Project Working Title: Differential Scattering of Neutrinos about a Schwarzschild Black Hole

Project End Date: 7 May 2022 (The end of week 6 of spring term)

Student:

Name: Thomas Knudson
Affiliation: Department of Physics, Oregon State University

Statement: I will work regularly and diligently on this project throughout the year and initiate meetings with my advisor to seek feedback and guidance on the research. I understand that a significant portion of the research should be completed by the end of winter term to enable me focus on the writing process in the PH403 class.

Student Signature: _____

Advisor:

Name Dr. Kathryn Hadley
Affiliation Department of Physics, Oregon State University

I have read this thesis proposal. I agree that the scope is reasonable for completion by May 7, 2021 and that sufficient progress can be made by early winter term 2021 to allow significant revision of the thesis during the winter and spring terms of 2021.

Advisor Signature*:* _____

All this content will be scrapped; Project has changed

Project Summary

Using various models of spacetime, we will endeavor to determine the minimum stable orbit for a collection of neutrinos above the event horizon of a series of increasingly complicated black holes. By solving the geodesic equations for each spacetime, we can discuss the trajectories of the neutrinos and whether or not they correspond to a stable and circular orbit. There already exists the notion that light can establish a stable circular orbit just above the event horizon, where each wave/photon will remain until the black hole expands/contracts and alters the trajectory of the trapped light. In an equilibrium situation, this light will be trapped for eternity and form a complete spherical shell that an observer could only grasp a flash of as they descend into the black hole. This will be analyzed by plotting the impact parameter versus the angle of incidence to discover valid geodesics for neutrinos.

Project Description

Introduction

Neutrinos, given their small mass and weak interaction with matter, form an excellent test particle for use in examining orbital behaviour. The deeper understanding we have of interactions of particles near the event horizon of a black hole, the better we can improve and/or optimize our models and numeric solutions to multi-body systems in the framework of General Relativity. The treatment of neutrinos in a Schwarzschild geometry sets an excellent stage for comparing the results of the more complicated models against and will begin by exploring valid parameters of energy and orbital angular momentum for a circular geodesic[1] described by Equation 1 below:

$$\left(\frac{dr}{d\tau}\right)^2 = \left(\frac{E}{m}\right)^2 - \left(1 - \frac{2M}{r}\right)\left(1 + \frac{(L/m)^2}{r^2}\right) \quad (1)$$

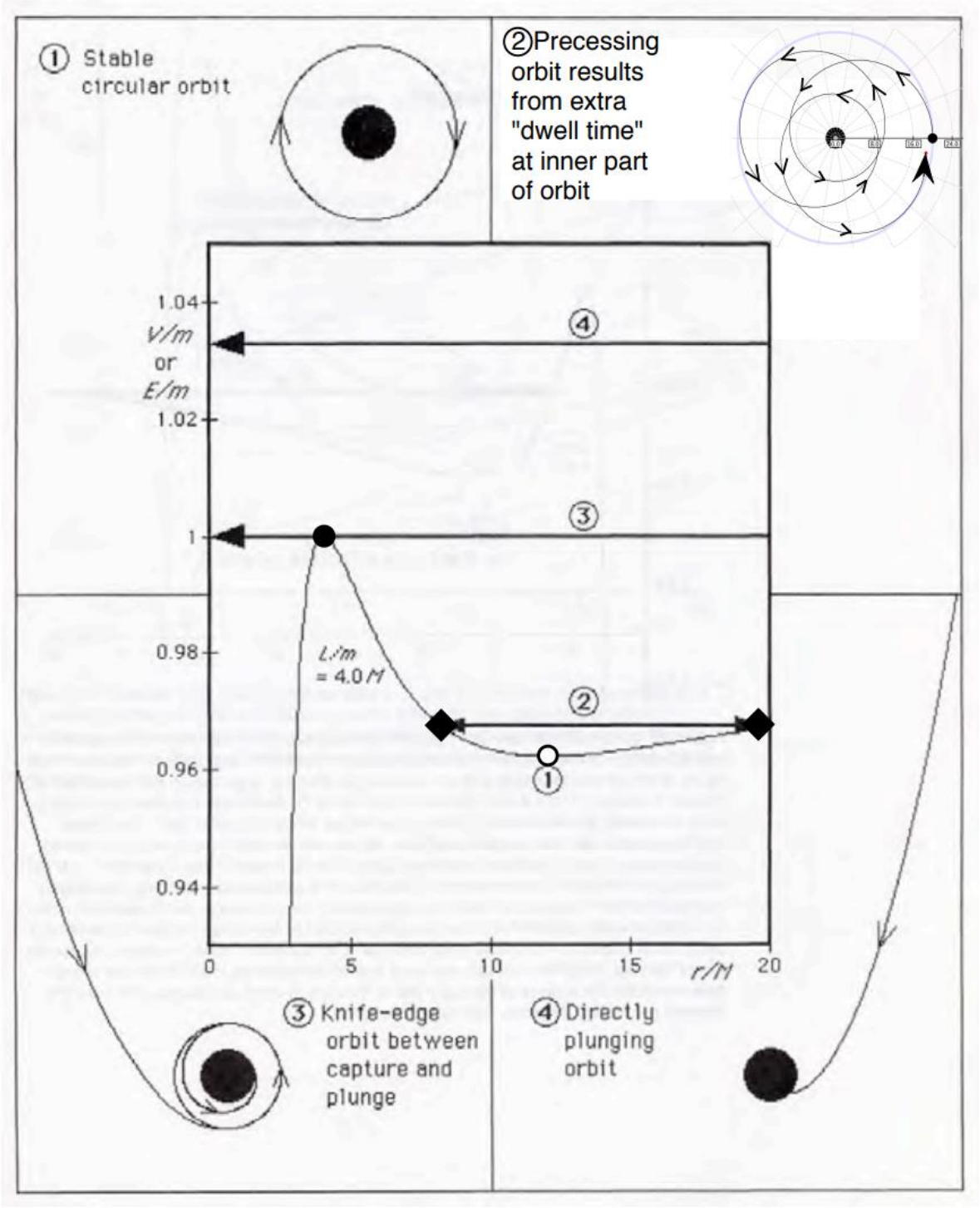

Figure 1. A visualization of the effective potential and the corresponding orbit type for an object based on initial conditions. Figure Credit: "Exploring Black Holes" by Edwin F. Taylor and John Archibald Wheeler.

Plan of work

- Is this not just a rehash of the timeline, but in words?

Timeline

Stage 1: Background Research

- Duration
  - Spring 2020 - Present
  - The project is currently at the end of Stage 1 and is expected to be completed by the second week of July.
- Goal(s)
  - Perform background research on General Relativity (to understand question and be able to interpret results)
- Literature
  - [*Exploring Black Holes: An Introduction to General Relativity*](https://www.eftaylor.com/exploringblackholes/) by Edwin F. Taylor and John Archibald Wheeler
- Additional references:
  - Gravitation* by Misner, Thorne, and Wheeler
  - Spacetime Geometry* by Sean Carroll
  - Gravity: An Introduction to General Relativity* by James Hartle
  - Differential Forms and the Geometry of General Relativity* by Tevian Dray
  - Oregon State University
    - MTH 434: Differential Geometry
      - Further expansion of mathematical knowledge and prerequisite course for MTH 437/537
    - MTH 547: General Relativity
      - Introduction to curved spacetime from understanding underlying geometry. Discusses both the static and maximally extended solutions to Einstein's equations.
  - PH 401: Research
    - Weekly/Bi-monthly meetings during the/each Term to discuss concepts and establish knowledge

Stage 2: Prototype Model

- Duration
  - July 2021
- Goal(s)
  - Solve equations for Light and verify model is consistent with known results and expectations
  - Document construction method of model and capabilities

Stage 3: Use Model

- Duration
  - August 2021
- Goal(s)
  - Use Model with parameters for Neutrinos
  - Analyze Results
  - Construct initial set of figures and caption
  - Meet with Dr. Hadley
    - Present model and brief write up of findings
    - Assess results and sense making

Stage 4: Draft of Thesis

- Duration
  - Fall 2021
- Goal(s)
  - Complete a Lab Report-like write up of model and findings

Stage 5: Expand and Refine

- Duration
  - Fall 2021 - Winter 2022
- Goal(s)
  - Any additional research to provide background for the Thesis
  - If before Winter Term: Begin progress towards Additional Goals
  - February 2022 will mark the freeze on new content (any outstanding additional goals will not be added to the draft)

Stage 6: Finalize

- Duration
  - Winter 2022
- Goal(s)
  - Complete adjustments to Thesis
  - Create and complete PowerPoint presentation

Data management

- Theoretical work: Redundant offsite storage of thesis work and derivation/application of equations?
- GitHub?

Facilities, Equipment and Other Resources

- If I'm just using my own resources, I just list that here?
    - "We'll need to procure my laptop from myself in order to facilitate the creation of plots.."

References Cited

[1] E.F Taylor and J. A. Wheeler, "Exploring Black Holes: Introduction to General Relativity".

This list of references cited includes at least 4 or 5 papers or text books that are relevant to your project. References must be in the example format and must include the title of the article.

What actually is the formatting style used here?