

Regulated Research Institutional/Industrial Setting Form (1C)

This form must be completed AFTER experimentation by the adult supervising the student research conducted in a regulated research institution, industrial setting or any work site other than home, school or field.

Student's Name(s) Elizabeth Wu

Title of Project Developing Algorithmic Machinery to Explore the Cosmological Horizon Problem by Numerically Solving Maxwell's Equations in the Kasner Metric

To be completed by the Supervising Adult in the Setting (NOT the Student(s)) after experimentation:

(Responses must be on the form as it is required to be displayed at student's project booth; please do not print double-sided.)

The student(s) conducted research at my work site:

1. Did you or your proxy (e.g. graduate student, postdoc, employee) mentor or provide substantial guidance to the student researcher?

☒ Yes ☐ No

- a. If no, describe your and/or your institution's role with the student researcher and his/her project (e.g. supervised use of equipment on site without ongoing mentorship and sign below.

- b. If yes, complete questions 2 -5.

2. Is the student's research project a subset of your ongoing research or work?

☒ Yes ☐ No

Use questions 3, 4 and 5 to detail how the student's project was similar and/or different from ongoing research or work at your site.

3. Describe the independence and creativity with which the student:

- a. developed the hypotheses or engineering goals for the research project

The "Horizon Problem" is a long-standing, unsolved problem from Big Bang cosmology that researchers have studied in different ways. I suggested a particular approach to analyzing the problem, which the student considered in developing their own methodology and calculational tools for addressing these key cosmological issues. The student showed great curiosity throughout the project, and we often discussed issues complementary to the main calculations.

- b. designed the methodology for his/her research project

After my initial suggestion that the student use the Mathematica programming and plotting environment for much of the calculational work (which the student used in addition to Java, due to their prior experience with Java), the student wrote all of the programs on their own, with little guidance from me, other than general theoretical lessons on Maxwell's equations for light waves, and about how differential equations are solved using different sets of initial conditions.

- c. analyzed and interpreted data

Once I explained the theoretical background, the student understood and analyzed the results. The most notable result was that the phase velocity of a complex wave can be faster than the speed of light (unexpected, but does not violate physical laws). I questioned the student firmly on this, but after careful checks, the student stated that the calculation was correct, which turned out to be a true and interesting result.

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4. Detail the student's role in conducting the research (e.g. data collection, specific procedures performed). Differentiate what the student observed and what the student actually did.

It was entirely the student's job to write all of the programs, do all of the computations, and produce a comprehensive collection of results. I provided some theoretical background in terms of explaining the behaviors of simple harmonic motion (sine and cosine functions), and also Bessel functions, so the student could properly interpret the results. But the student had to produce all of the data for analysis on this project. I was the student's research mentor, and initially taught the student the basics of Big Bang cosmology and electromagnetic radiation; and we met regularly to discuss the student's research results. Each week, after I would describe what the general goal was, it was the student's job to find a way to get it done, working with a high level of research independence.

5. Did the student(s) work on the project as part of a group?
If yes, how many individuals were in the group and who were they (e.g. high school students, graduate students, faculty, professional researchers)?

☐ Yes ☒ No

I attest that the student has conducted the work as indicated above and that any required review and approval by institutional regulatory board (IRB/IACUC/IBC) has been obtained. Copies are attached if applicable.
I further acknowledge that the student will be presenting this work publicly in competition and I have communicated with the student research regarding any requirements for my review and/or restrictions of what is publicized.

Brett Bochner

Supervising Adult's Printed Name

Hofstra University

Institution

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Address

Brett Bochner
Signature

Professor

Title

11/13/19

Date Signed (must be after experimentation) (mm/dd/yy)

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Email/Phone