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Spring Research Project: Mentor Rubric

Mentor Name(s): Melanie Zaidel

Mentee Name(s):

Project Title: Constraining the Electron Neutrino Mass using SN1987a

In a short paragraph, explain the project and its learning objectives:

In this project, Student will learn about neutrinos, basic special relativity, and order-of-magnitude calculation techniques to place limits on the mass of the electron neutrino using data from Supernova 1987a. Student will first read about then discuss with me the basics of neutrinos and why they are interesting both as supernova products and as fundamental particles. Discussions of the neutrino mass problem will naturally lead to a short introduction to special relativity, after which Student will be able to explain $E = \gamma mc^2$. Next, I will guide Student to derive an equation for an upper limit on the mass of the electron neutrino using astrophysical arguments. Finally, student will gain some practice using matplotlib to plot neutrino detection data from the original 1987 paper. If time permits, Student will also read about and discuss contemporary work regarding the neutrino mass problem and other astrophysical constraints.

What are the deliverables? (i.e. plot/figure/image/equation mentee will reach)

Student's deliverables include:

1. A scaled equation describing the upper bound of the mass of the electron neutrino in the form $m_{\nu_e} \sim a \text{ eV} \left(\frac{\text{E}}{b \text{ MeV}}\right)^{\text{x}} \left(\frac{\Delta \text{t}}{c \text{ s}}\right)^{y} \left(\frac{d \text{ kpc}}{\text{D}}\right)^{z}$,
2. A value for the upper bound on the mass of the electron neutrino using (1) and the original SN1987a neutrino detections,
3. An energy/time plot of the original SN1987a neutrino detections.

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Project Calendar: Indicate what the mentee will be expected to do each week. Work days are indicated in the left column. Include estimated time, resources, in/out of class work, and whether it is completed on their own or with you. The project should take 8-10 hours in total.

Dates:	Tasks:
Week 1 (2/12) Intro to Project	1 hr on own: Read/watch videos about neutrino basics and neutrinos from supernovae
Week 2 (2/19) Outside of Class Work	1hr with mentor: Discussion about reading material
Week 3 (2/26) In class work day	1 hr with mentor and other mentee: Discuss supernovae 1 hr with mentor: Intro to Special Relativity
Week 4 (3/4) Outside of Class Work	30 mins with mentor: Review of Special Relativity 30 mins with mentor: Setting up the neutrino mass limit constraint problem
Spring Break	None
Week 5 (3/18)	1 hr with mentor: Deriving the neutrino mass limit
Week 6 (3/25) In Class Work Day	1 hr with mentor: Calculate neutrino mass limit using SN1987a neutrino detection data
Week 7 (4/1) In Class Work Day	1 hr with mentor: Plot SN1987a neutrino detection data
Week 8 (4/8) Poster Work Day	1 hr on own: Start working on poster 1 hr with mentor: Continue working on poster and rehearse presentation
Week 9 (4/15) Present!	

Reading List: (Make sure material is level appropriate.)

Core reading materials:

- YouTube videos on neutrino basics, supernovae
- Fermilab's Neutrino University lectures on neutrinos and supernovae
- Historical SN1987a neutrino detection papers

Time permitting:

- YouTube videos on neutrino mass and mixing
- Contemporary review articles on the neutrino mass problem

Resource List: (This should include lab space, instruments, and software. Note that mentees are not allowed to complete research projects that require safety training operation of lab equipment. If you feel this is detrimental to your project, please petition Polaris leadership.)

- Personal computer with an installation of Anaconda Navigator

Other Notes: