September 16, 2021

Dear Prof. Chad Finley,

We propose a 7.5-ECTS credit Research Internship in Physics (FK5023) on the development of broadband metamaterial absorbers for mm-wavelength radiation. Such absorber technologies are being considered for next-generation telescopes measuring the polarization of the cosmic microwave background (CMB). The project involves the study of potential plastic resin candidates doped with conductive particles to increase mm-wavelength absorption properties as well development of code that generates geometries suitable for 3D printing. As part of the project, the student will develop a familiarity with a resin 3D printer and test fabrication of absorbing geometries. The project will conclude with measurement of material properties and comparison with expectations.

Rough project timeline:

- Read about the science goals motivating current work in observational cosmology
    - Reference: https://iopscience.iop.org/article/10.1088/1361-6633/aa94d5
- Read a review article describing key aspects of telescopes studying the CMB
    - Reference: arXiv:1206.2402v1
- Read about mm-wave absorbers:
    - Reference (collection of articles): https://www.dropbox.com/sh/2wj2cd8hhm8q6ae/AAAgWJSXLqbjcVIKnl1PE2Oaa?dl=0
- Obtain familiarity and expand upon an open source Python code that generates geometries suitable for 3D printing
    - Reference: https://zenodo.org/record/1322839#.YUGm5J0zYuU
- Learn how to use the Form 3 3D printer to print your custom shapes
    - Reference: https://formlabs.com/eu/3d-printers/form-3/
- Design resin needed for mm-wavelength absorption
    - Reference: https://www.3dresyns.com/collections/conductive-materials
- Quantify density, material hardness, brittleness, and other easily-measurable material properties of candidate geometries and 3D printed resins
- Measure surface resistivity of candidate materials at room temperature and 80-100 K

**Assessment:** The course is examined through a written logbook, written feedback by the supervisor, and an oral presentation at the end of the course.

**Supervision:** Work will be supervised through regular scheduled meetings (at least once per week and of duration 30-60 min) as well as through discussion taking place in weekly group meetings and impromptu discussion with other group members.

**Proposed timeline**

- 30% (12h/week) for approx 17 weeks, corresponding to 7.5 hp (ECTS)
- Start- end date: 20 September 2021 – 21 January 2022
- Presentation/defense in January 2022

At the end of this project, the student should be able to clearly summarize his work and its relation to the science goals of upcoming experiments studying the cosmic microwave background.

Sincerely,
Dr. Jon Gudmundsson