Application to Graduate with Honors

Student ID: 830-25-0583

I plan to defend in: FALL / [✓ SPRING] of 2011

Personal Information:

Name: Sara Simon

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Boulder, CO 80305

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I am an: [✓ IN-STATE] / OUT-OF-STATE student

Academic Information:

☒ I plan to graduate with *Departmental Honors* in: Physics

☐ I plan to graduate with *General Honors*

Cumulative GPA:

Please attach a brief **PROSPECTUS, BIBLIOGRAPHY**, and **TIMELINE** of your thesis project t application. When summarizing your work, consider the following:

- What is the problem you are investigating?
- What is the hypothesis you are testing?
- What is the focus of your study?
- What is your goal in this study?

Primary thesis advisor: Name: Nils Halverson Dept: Physics

List the other members of your committee:
Name: John Cumalat Dept: Physics
Name: Jason Glenn Dept: Astronomy (APS)
Name: Dept:
Name: Dept:

Departmental and General Honors Committee Checklist:

☒ Applicant has a total of at least three committee members.
☒ At least one Honors Council Representative is included on committee.
☒ At least one committee member from an outside department.

APPLICATION CONTINUED ON BACK OF THIS SHEET

Please initial if you are pursuing Departmental Honors:

AML I have consulted with my department and have completed (or am completing) the requirements they have established.

For Honors Council Representative:

I have met with applicant and approve him/her for departmental honors.

Printed Name: John P. Cumalat Signature: John P. Cumalat

Please initial if you are pursuing General Honors:

_____ I have completed (or am completing) the requirements for graduating with General Honors.
Please list the courses you have or are taking toward General Honors:

For General Honors Council Member:

I have met with applicant and approve him/her for general honors. I agree to be on his/her defense committee.

Printed Name: Signature:

For the Thesis Advisor:

I have met with the applicant to discuss the proposed work and agree to provide the necessary help and direction for this thesis project.

Printed Name: Nils Halverson Signature:

For the Student:

I have read the requirements for graduating with honors at the University of Colorado. I also understand that my designation will be sent to the CU email address that I have provided and will not be given out over the phone.

Signature: Date: 09/01/10

For additional graduation information including requirements, guidelines and deadlines, you can download them online at www.colorado.edu/honors

Prospectus
Sara Simon

The cosmic microwave background (CMB) is a radiation field uniform to one part in 10^5 that permeates the Universe in all directions and peaks in the microwave section of the electromagnetic spectrum.[1,2] However, slight variations in the temperature and polarization of the CMB can reveal information about the early moments of the Universe. Polarization anisotropies can be decomposed into two groups: E-mode and B-mode. Analogous to their electromagnetic counterparts, E-mode is the curl-free component of polarization, and B-mode is the divergent-free component of the polarization. While E-mode polarization has been detected and well characterized, B-mode polarization has yet to be detected.[2]

Measurement of the B-mode signal could provide insight into a variety of cosmological questions including neutrino mass, dark energy, the discrepancy between measured and predicted baryon density, the ionization history of the first stars, and the state of the primordial Universe.[3] B-mode measurements could also provide additional evidence supporting the theory of inflation. The inflation theory proposes that the early Universe expanded superluminally at an exponential rate.[4] Inflation has yet to be proven, but models of inflation predict that both E-mode and B-mode polarization would have been produced in the expansion.[5] The amplitude of the B-mode spectrum would give a measurement of the energy scale of inflation.[4] B-mode detection would be the most direct evidence for inflation and would constrain cosmological models that are dependent on the energy scale of inflation. In order to constrain the cosmological model, it is imperative to constrain the maximum value of the B-mode polarization amplitude if not make a measurement.

Unfortunately, the amplitude of B-mode polarization is a factor of ten or more below the amplitude of E-mode polarization, making it an instrumental challenge to detect B-mode polarization.[6] While the limits of instrumentation have not allowed for the detection of B-mode polarization, several experiments have placed an upper limit on its amplitude.[1,5,7] Because the amplitude of the B-mode signal is so small, a careful and detailed knowledge of the properties of the telescope and its calibration must be quantified.[1] Some systematic errors can translate into false E-mode and B-mode detections, so low systematic and well characterized uncertainties are a necessity.[1]

In order to characterize some of the systematic errors in the next generation of CMB detectors, my research project will focus on taking measurements of the detector beams. The next generation of CMB detectors have x and y polarization sensors on the same chip. If unpolarized light is shone on a detector and one of the sensors picks up a greater response than the other, there will be a false polarization signal. By building a device with a constant, unpolarized source that will scan across the detectors, I can measure the detector output and construct differential beam maps. These beam maps will reveal if the polarization sensors see the same power. If the detectors do not see the same power, the difference can be characterized and corrected when the detectors are deployed.

Another measurement characterizing the detector response will be the cross-polarization, which is how much power from one polarization axis leaks into the other. Cross-polarization will be tested by constructing a modulating polarized source. By comparing the amount of polarized light detected by each axis of polarization when the polarization on the incoming light is known, the amount of power leakage between polarization sensors can be characterized and corrected.

These measurements will help to further characterize the systematic errors of the next generation of CMB polarization detectors. With the systematic errors of the detectors well characterized, the error can be corrected so that the detectors can possibly further constrain the B-mode polarization spectrum of the CMB.

Bibliography

[1]Y. D. Takahashi *et al.*, 2009, arXiv:0906.4069v2

[2]H. C. Chiang *et al.*, 2009, arXiv:0906:1181v2

[3]J. Aguirre *et al.*, 2009, arXiv:0903.0902v1

[4]S. Dodelson *et al.*, 2009, arXiv:0902.3796v1

[5]M. L. Brown *et al.*, 2009, arXiv:0906.1003v2

[6]W. Hu and M. White, 1997, arXiv:astro-ph/9706147v1

W. C. Jones *et al.*, A&A **470**, 771 (2007)

K. W. Yoon *et al.*, in *LTD-13 Conference Proceedings*, Palo Alto, CA, 2009

J. E. Austermann *et al.*, in *LTD-13 Conference Proceedings*, Palo Alto, CA, 2009

J. W. Appel *et al.*, in *LTD-13 Conference Proceedings*, Palo Alto, CA, 2009

J. J. McMahon *et al.*, in *LTD-13 Conference Proceedings*, Palo Alto, CA, 2009

Honors Thesis Timeline

July 2010:

Hardware: Construct unpolarized beam mapper

August 2010:

Hardware: Construct unpolarized beam mapper

September 2010:

Analysis: Background research

Hardware: Work on parts for polarized beam map set-up and ready cryostat for optical opening

October 2010:

Analysis: Background research

Hardware: Work on parts for polarized beam map set-up and ready cryostat for optical opening

November 2010:

Analysis: Background research and software development

Hardware: Work on parts for polarized beam map set-up and ready cryostat for optical opening

December 2010:

Analysis: Background research, simulated beam map data development, and work on analysis software development with simulated beam map data

Hardware: Prepare polarized beam map set-up and set up and ready cryostat for optical opening

Writing: Write introductory and background parts of thesis

January 2011:

Analysis: Analysis of unpolarized beam maps

Hardware: First unpolarized beam maps, possibly polarization measurements

Writing: Start writing first analysis and result chapters for unpolarized beam maps

February 2011:

Analysis: Analysis of polarized measurements

Hardware: Polarized beam measurements/more unpolarized maps

Writing: Continue writing first analysis and result chapters for unpolarized beam maps

March 2011:

Analysis: Analysis of polarized beam measurements

Writing: Write polarization analysis and result chapters as well as conclusion

April 2011:

Writing: Finish writing and edit thesis