NASSP Master's Project Proposal :

Searching for Parity Violation in the Planck Full-Sky CMB Maps

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Parity (spatial inversion) symmetry is badly broken in the Standard Electroweak Model and CP symmetry is also broken to a lesser degree. The New Physics that was responsible for generating the primordial cosmological perturbations lies beyond the Standard Model and little is known concerning its symmetries although simple inflationary models have been put forth. The European Space Agency Planck mission, which was launched in 2009, has provided all-sky maps of the cosmic background anisotropies both in temperature and polarization, and these maps, which are now publicly available, to date remain the best maps of CMB anisotropies. These anisotropies probe the initial conditions of the universe, possibly imprinted during an earlier epoch of inflationary expansion, and are to a large extent free of complications from more recent highly nonlinear astrophysical processes.

This project involves searching for parity violation in the CMB temperature maps (and possibly also the polarization maps) by measuring the parity-odd component of the CMB bispectrum (i.e., the spectrum of the 3-point correlation functions on the celestial sphere) using a model independent approach developed by Prof. Martin Bucher. The parity-even component of the CMB bispectrum has already been analyzed by the Planck Collaboration, and many of the techniques in that analysis will need to be adapted to the parity-odd case. This includes dealing with a cut sky, from which point sources and the regions of highest parasitic galactic emission near the galactic plane have been masked, which introduces a linear bias.

The Master's student recruited will implement an estimator of the parity violating bispectrum of the Planck maps provided in Healpix format. This estimator will be tested using randomly generated mock data, first under the assumption of idealized uniform sky coverage and then taking into account the masking of the sky to remove the regions of large galactic emission around the galactic plane and around bright point sources. The estimator will also be tested on models for the expected foreground emission. This project will result in a publication establishing constraints on parity violation from the analysis of the Planck maps.

It is highly desirable that the student recruited have some familiarity with Python programming and basic statistics as well as some background in cosmology. Martin Bucher was member of the team that analyzed the data from the European Space Agency Planck space mission. Anslyn John is an expert in general relativity.

Interested students are encouraged to contact Prof. Bucher and Dr. John for any further inquiries or informal discussion concerning this project. References to the literature in this area can be provided upon request.