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Physics

Investigations of the String Landscape and Causal Dynamical Triangulation

String Theory is the leading candidate to unify all forces in nature (gravity, electromagnetics, and the two nuclear forces) via its proposed strings (a.k.a. loops) of compact energy and its 6 or 7 extra compact (and incredibly small) spatial directions required for mathematical consistency. Elementary particles originate as distinct vibrations of these strings, in analogy to the different musical notes produced from a violin string. The specific properties of each type of particle or force are determined by the exact shape of compact spatial directions, analogous to dependence of violin sounds on the shape of the violin chamber. Verification of String Theory would impact the scientific world as nothing has before. Nevertheless, before becoming the "Theory of Everything," a profoundly deeper understanding of String Theory awaits: Prior to 1994-96, the string community estimated the number of physically distinct allowed shapes of the 6 compact directions to be around 100 trillion. Locating our universe within this parameter space was expected to be imminent. However, the supplanting of string theory with M-theory and 7th compact direction increased the estimated number of compact shapes to at least 10^{500}. Thus, string phenomenology shifted from investigating individual compact shapes (a.k.a. vacua) to better understanding the statistical characteristics within, and between, specific regions of the entire collection of compact shapes (a.k.a. the String Landscape).

Gerald Cleaver's Early Universe Cosmology and Strings (EUCOS) research team is conducting the first fully systematic investigations of a specific region of the Landscape known as the free fermionic heterotic string (FFHS). Prior groups investigating FFHS statistics used essentially random sampling of input parameters. However, a serious difficulty of random sampling is floating correlations, because not all physically distinct string vacua are equally likely to be sampled in any random search. Some vacua can be expressed in multiply more physically equivalent ways than others, resulting in statistical correlations of phenomenological properties of models that "float" as a function of sample size. To avoid random sampling problems, EUCOS developed a computer algorithm that provides an efficient solution for systematic generation and analysis of FFHS models. While systematic, the algorithm is several orders of magnitude more efficient than brute-force methods. Running on Baylor's 128-node high performance cluster, the run time for complete surveys of regions of the Landscape is anywhere from several months to about a few years.

EUCOS has commenced several systematic FFHS Landscape investigations, the shortest of which will be concluding around the end of summer. Statistical analysis of these findings will be performed by EUCOS graduate students Jared Greenwald, Douglas Moore, and Yanbin Deng. This URC application is for
conversion of 1/3 of these students' fall 2012 Teaching Assistantship hours (5 hours per week) into equivalent paid Research Assistantship hours to provide a significantly more focused study of systematic search results and the writing and submission for publication of several related papers.