Project Summary

Overview
It is proposed to use cosmic microwave background radiation observations deriving from a time when the universe was less than a thousandth of its present size,combined with the results of recent surveys of galaxies, to produce a comparatively low resolution, three dimensional map of the universe as it is today out to a radius of over forty billion light years, and to follow its evolution back to the time of inflation when the structure was set down. The approach that is used is predicated on recent findings that both the geometry and the starting conditions are about as simple as can be imagined, given the essential constituents that we now know must be included, and involves hierarchical inference of a set of Fourier modes given observed sky maps and a model-independent single-field inflation prior. New methods will be developed to combine heterogeneous future datasets and determine and achieve the best resolution possible. It is also proposed to determine the improvements that will be possible from new data that will become available over the next decade. Finally, we will consider the theoretical limits to making such maps using the best possible observations we can imagine making. Although our primary product is a low-resolution 3D map of our entire universe, the results will also help refine the investigation of the underlying physical processes. In particular, it will be possible to check in new ways that the initial conditions were indeed as "random" as has been inferred.

Intellectual Merit
This ambitious proposal is enabled by the quality and quantity of existing and anticipated cosmological datasets. If it is successful in making a map with linear resolution of several billion light years and connecting the observed fluctuations in the cosmic microwave background to "local" observations of galaxies on a mode by mode basis, then it should improve the interpretation of both data sets. The ensuing discovery potential will be large.

Broader Impacts
If this proposal achieves it most modest goals the results should have broad popular appeal as well as scientific utility. Even at low resolution, new images of previously unresolved cosmic structure is seen as a big step. The public presentation of the results will be a large part of this research using movies, modern graphics and three dimensional printing. The research proposed involves an unusually large number of cosmological efforts that are typically combined pairwise. In order to facilitate a broadly integrated investigation, this research project will be developed in the open at http://github.com/rogerblandford/Music, where contributions are invited from all-comers. Combining large, heterogeneous data sets optimally is raising new issues in inference, of the kind that are showing up increasingly in modern, data-driven science. There will be strong connections to many other fields which it is intended to explore.