A Unifying Description of Astrophysical Variability for Event Classification

Modern time–domain astronomical surveys are designed to uncover the wealth of temporal astrophysical phenomenology : extrinsic, intrinsic, periodic, and transient variability of all shapes and amplitudes. Much of our understanding of the underlying event physics comes from spectroscopic follow–up, meaning the rapid and effective classification of new event data is of clear importance. This is especially true since follow–up resources are saturated even today, and the ratio of interesting events to our ability to study them will only get worse with next–generation alert streams. The effective allocation of follow–up resources requires separating the prosaic from the novel in evolving data streams, using a holistic classification infrastructure that spans all types of phenomenology. Since modern surveys will be sampling events sparsely in time, and irregularly in wavelength, the optimal variability models will be inherently temporal *and* spectral. This proposal will build upon the current state–of–the–art in single–passband event classification to yield spectral–temporal models of astrophysical variability. Models will be built from the aggregation of photometric and spectroscopic data on variable sources uncovered by surveys in the past decade, fulfilling their promise as precursor surveys that may be used to inform future efforts. As well, theoretical priors will be used to build models for anticipated classes of new variability. These models will be applied to future real–time data streams to classify events as they themselves evolve, and as our understanding of them grows through additional photometric or spectroscopic sampling. We regard these spectral–temporal surfaces as the logical culmination of event classification efforts, which have been successfully implemented so far using contextual and single–passband metrics.

Intellectual Merit of the Proposed Activity

Our proposal will develop a classification infrastructure that includes the unifying view of astrophysical variability as an inherently spectral and temporal process. Such a broad attempt has not been made before. However, such an effort is now possible due to the accumulation of time–domain data over the past decades, and an increasingly more sophisticated adoption of statistical techniques by Astronomers. It is also necessary, given the massive volumes of data expected from next–generation time–domain surveys. The Investigators of this proposal have an extensive history in the gathering of time–domain astronomical data, and in their real–time interpretation. They are directly connected to past, current, and future time–domain surveys, and are thus ideally positioned to undertake this effort in a way that is guaranteed to be impactful.

Broader Impacts of the Proposed Activity

The derived spectral–temporal models will be provided as a resource to the astronomical community. We will also develop an automated classification resource that accepts data from time–domain event streams, compares these evolving data to the set of models, and returns probabilistic classifications that an event is of a given type. This resource will provide value–added information to the survey data, and will help the entire community to sift through these increasingly more daunting event streams. This is an inherently multidisciplinary effort, requiring astronomical domain knowledge to aggregate the acquired data and classify known phenomena, and statistical tools to build the spectral–temporal models and to use them in inference of an incoming data stream.