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. Since of our understanding of the underlying event physics comes from spectroscopic follow-up, the rapid and effective classification of new imaging data, which feed spectroscopy, is of paramount importance. This urgency is felt today as follow-up resources are already saturated; the ratio of interesting events to our ability to study them will only worsen with next-generation alert streams. The challenge lies in 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 event classification to yield: 1) spectral–temporal models of astrophysical variability; 2) a new taxonomy for classification of variables that is probabilistic and statistically robust; 3) a broad range of techniques for classifying input data and an open service that will enable these classifications for the community; 4) the ability to probabilistically state what additional observations are required to improve the classification**. Models will be built using photometric and spectroscopic data from time-domain surveys of 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. These spectral–temporal surfaces are the logical culmination of the proposed event classification efforts.

Intellectual Merit of the Proposed Activity

This proposal will develop a classification infrastructure based upon the unifying view that all astrophysical variability is an inherently spectral and temporal process. 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. By deriving real-time knowledge from data, the proposed effort aims to help maximize the scientific return of (significant) NSF and national investments.

Broader Impacts of the Proposed Activity

The derived spectral–temporal models will be provided as a resource to the astronomical community. The proposed effort includes an automated classification resource that accepts data from time-domain event streams, compares these evolving data to the set of spectral–temporal models, and returns **probabilistic** classifications that an event is of a given type. This resource will provide value-added information to survey data, and will help the entire community to sift through these increasingly more impenetrable 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. Students and postdocs will be trained in this multidisciplinary approach to a modern science challenge.