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An Unsupervised Dive Into Gamma-ray Burst Afterglow Classification

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The Neil Gehrels "Swift" Observatory has been detecting and measuring emission from gamma-ray bursts (GRBs) and their associated afterglow for the last 17 years. Today, over 1500 bursts have been observed, with light curves displaying different morphologies in the succession of decay regimes with time. We explore prospects for acquiring physical inference from machine-learning models by investigating the presence of intrinsic classes (or lack thereof) in the morphology of GRB afterglow X-ray light curves. Ignoring the well-known divide between long and short GRBs, we carry out unsupervised classification of Swift-XRT time-series data using a convolutional variational autoencoder. The generative aspect of the model can provide physical insight by highlighting the discriminative features in the light curves.

We compare the classification results obtained with the traditional functional-form-based classification, and investigate the resulting level of segregation in the dataset. We evaluate our model's ability to identify different morphological classes by carrying out training on synthetic data. We find that the data creates over-densities in the latent-space. However, the observed gradual transition in between unifies the prevalent classification of GRBs based on their X-ray data into a single continuum, supporting the idea that light curves of different types should be unified under a single model.

In a deeper investigation of this afterglow population, we make use of variational deep embedding, where the level of clustering can be more easily quantified, for which I will present our latest results.

Presenter: AYACHE, Eliot (The Oskar Klein Centre, Department of Astronomy, Stockholm University, AlbaNova, SE-10691 Stockholm, Sweden)

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