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Principal Component Analysis of Long-Lag, Wide-Pulse Gamma-Ray Burst Data

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Abstract. We have carried out a Principal Component Analysis (PCA) of the temporal and spectral variables of 24 long-lag, wide-pulse gamma-ray bursts (GRBs) presented by Norris *et al.* (2005). Taking all eight temporal and spectral parameters into account, our analysis shows that four principal components are enough to describe the variation of the temporal and spectral data of long-lag bursts. In addition, the first-two principal components are dominated by the temporal variables while the third and fourth principal components are dominated by the spectral parameters.

Key words. Gamma-rays: bursts—method: statistical.

1. Introduction

The origin of gamma-ray bursts (GRBs) still remains unclear. The analysis of GRB pulses of prompt emission provides us valuable clues. The relatively simple, long spectral lag, wide-pulse bursts may have simpler physics and are easier to model (Norris *et al.* 2005). They used a pulse model and band spectral model to model 25 pulses in 12 long-lag bursts. Employing this temporal and spectral data, Norris *et al.* (2005) analysed the correlations between them and found that at least ∼5 parameters were needed to model burst temporal and spectral behaviour.

The Principal Components Analysis (PCA) is a statistical method that can simplify the data analysis in the multidimensional data. The primary objective of PCA is to reduce the total number n of observed variables to a lower value m ($m < n$) or the dimensionality of the data set without any essential loss of information by performing a covariance analysis between factors (e.g., Jolliffe 2002; Murtagh & Heck 1987). In order to further understand the temporal and spectral behaviour of GRB pulses we shall use PCA to reinvestigate long-lag, wide-pulse bursts studied by Norris *et al.* (2005).

2. Principal component analysis of temporal and spectral variables

We employ the sample presented by Norris *et al.* (2005) to investigate the temporal and spectral behaviour of long-lag, wide-pulse bursts. It is already known that the pulses of GRBs show a self-similarity tendency across BATSE energy bands (e.g., Norris *et al.* 1996). Thus, we study the temporal parameters in channel 2 because the number in this band is maximum (the number is 33, see Table 2 in Norris *et al.* (2005)). We first carry out a PCA of these temporal variables, T_{peak}, τ_1, τ_2, w and k. Our analysis suggests that we should retain the first-two PCs because they can account for 99.2% of the variation and τ_1 and k are undoubtedly important quantities. While analysing the three band spectral parameters, α, β and E_{peak}, PCA shows that two PCs are clearly important. When we perform PCA of temporal and spectral parameters of these long-lag pulses, our analysis suggests that we can retain safely the first-four PCs, since these PCs are far above the rejection level. While the fifth PC accounting for 4.26% of the variation is already far below the Jolliffe level (8.75%) even if this PC might be also important.

3. Conclusions

Our analysis shows that: (1) PCA for the five temporal variables identifies two PCs that can account for ∼99.2% of the variation and are unambiguously important. In addition, k is the most important variable among the five temporal variables. While for the band spectral parameters, α, β and E_{peak}, PCA shows there might be three important components; (2) when we perform PCA of the eight same temporal and spectral variables as in Norris *et al.* (2005), we find that at least four PCs meet the criterion of Jolliffe. It is shown that only four PCs can explain the behaviour of temporal and spectral parameters of long-lag, wide-pulse bursts.

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