

Advanced Background Subtraction for Terabyte-Sized METIS/ELT Imaging Time Series Through GPU-Accelerated and Memory-Constrained Algorithms

In the search of planet-forming zones, the METIS instrument at the European Extremely Large Telescope (ELT) has the ability to detect faint signatures among noisy measurements. Traditionally, chop-nod techniques are employed to reduce high thermal background noise, but are not deemed to be practical due to the weight of the multi-ton telescope. While METIS has a dedicated chopper, the ELT might not be able to match the nodding requirements to reduce chop residuals. Therefore, we proposed a novel matrix-based model to capture spatio-temporal properties of these residuals, to separate them, and ultimately to reduce this thermal background.

Currently, we have implemented and tested two multivariate methods, i.e. principal component pursuit and stable principal component pursuit, and extended their algorithmic implementations to run on GPU. An example decomposition using principal component pursuit (Figure 1) shows that this type of methods can separate out a low-rank term (A) from the original input signal (M). We observe that genuine signal is partially captured by the low-rank term and not solely by the sparse term (B) as expected. Therefore, we are investigating further whether a more complex model is needed and/or whether separation should be based on different mathematical properties.

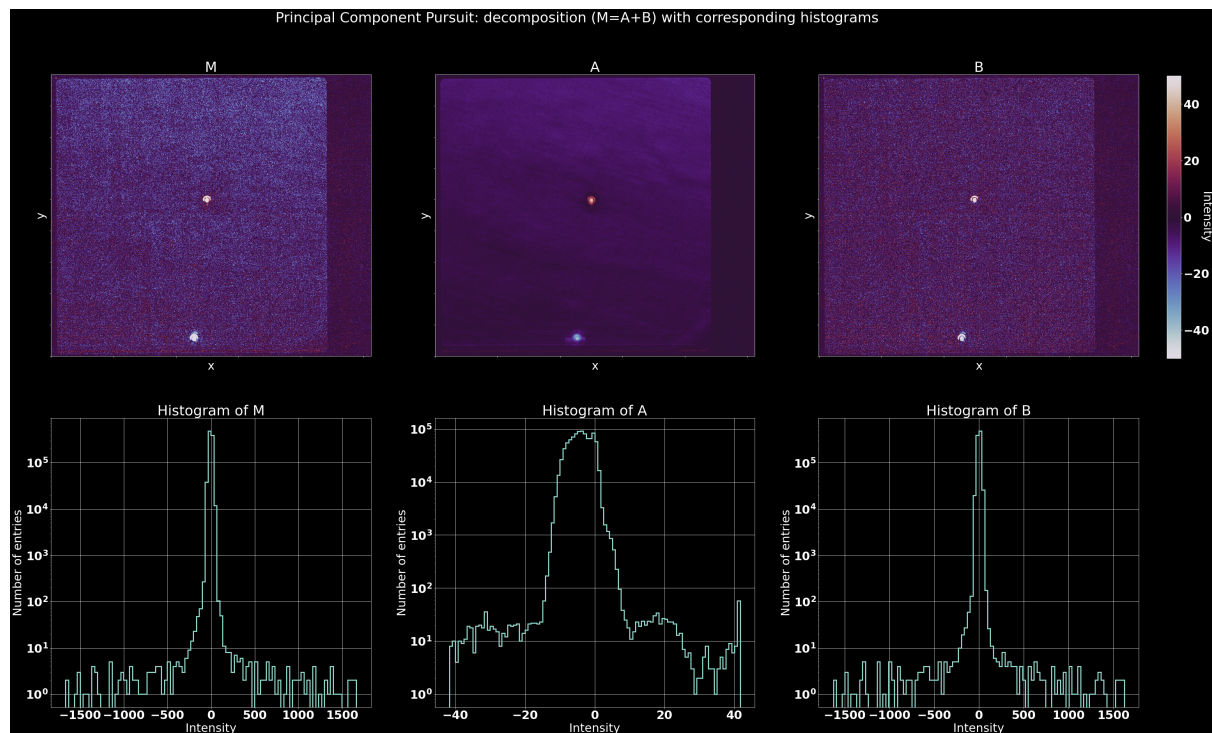


Figure 1: Example of a decomposition showing an input image with chop residuals (M, left), a low-rank approximation of the chop residuals (A, middle), and the residual term containing the genuine astronomical signal (B, right). The objects of interest consist of high-intensity circular objects that can be seen in the middle (positive intensity) and bottom (negative intensity) of each image. The objective is that these objects only appear in the residual terms, i.e. B, so that the low-rank term A only contains thermal background and can be removed entirely.