

# Archival Legacy Investigation of Circumstellar Environments using KLIP algorithm on HST NICMOS coronagraphic data

Elodie Choquet<sup>1</sup>, J. Brendan Hagan<sup>1</sup>, Laurent Pueyo<sup>1</sup>, Marshall D. Perrin<sup>1</sup>, Dean C. Hines<sup>1</sup>, Christine Chen<sup>1</sup>, Glenn Schneider<sup>2</sup>, John Debes<sup>1</sup>, David Golimowski<sup>1</sup>, Neill Reid<sup>1</sup>, Tushar Mittal<sup>1</sup>, Margaret Moerchen<sup>1</sup>, Mamadou N'Diaye<sup>1</sup>, Abhijith Rajan<sup>3</sup>, Sean Lonsdale and Remi Soummer<sup>1</sup>

<sup>1</sup>Space Telescope Science Institute,  
3700 San Martin Drive, Baltimore MD 21218, USA

<sup>2</sup> University of Arizona <sup>3</sup> Arizona State University

**Abstract.** The Archival Legacy Investigation of Circumstellar Environments (ALICE) project (AR-12652) is currently conducting a comprehensive and consistent reprocessing of HST-NICMOS coronagraphic survey data to search for point sources and disks using advanced PSF subtraction. The KLIP algorithm (Karhunen-Loève Image Projection) was developed for this project, and has proven very effective at processing the hundreds of selected archival images. This project has already been very successful with numerous detections of previously unseen point sources and several resolved debris disks that we are currently following up by multiple avenues. We give an overview of the project including preliminary scientific results with companion candidates and improved images of known disks

**Keywords.** techniques: image processing, planetary systems

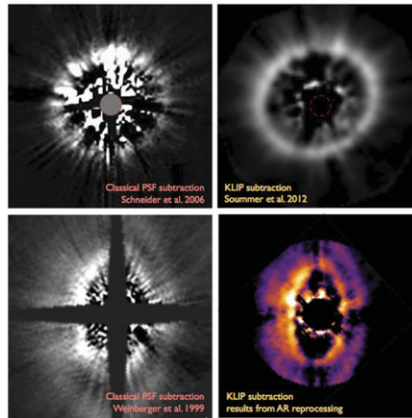
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## 1. Karhunen-Loève Image Projection (KLIP) algorithm

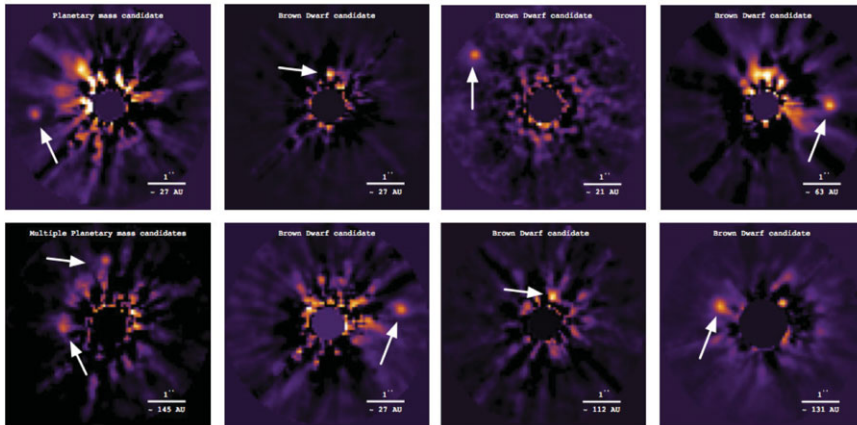
The KLIP algorithm was developed for the ALICE project. It uses a Karhunen-Loève (KL) decomposition of the library of reference PSFs, and generates a model star PSF from the projection of the target on the KL vectors (Soummer *et al.* 2012). KLIP is a Principal Component Analysis (PCA) method and is very similar to LOCI (Lafreniere *et al.* 2007). The main advantages of KLIP over LOCI is the possibility of direct forward modeling and significant speed increase.

## 2. KLIP versus Classical subtractions on NICMOS disks

KLIP also provides dramatically superior sensitivity to circumstellar disks for archival NIC2 data compared to classical PSF subtraction, as shown in Fig. 1 with the debris disk HD 181327 (top) and the young transitional Herbig Ae system HD141569 (bottom). The right panels show the KLIP reprocessing of the same data. Note that for HD141569 the KLIP processing only included the central portion of the field of view. For both targets, KLIP substantially reduces PSF subtraction residuals at small separations, enabling the inner clearings to be seen much better.



**Figure 1.** HD181327 (top) and HD141569 (bottom) processed with classical PSF subtraction (left panels) and with the KLIP algorithm (right panels).



**Figure 2.** Companion candidates discovered in the NIC2 archives using the KLIP algorithm.

### 3. Candidate point sources in the NICMOS coronagraphic archive

Previously unseen point-source candidates are now revealed by our reprocessing of NIC2 coronagraphic data with the KLIP algorithm (see Fig. 2). These sources have absolute J magnitudes from 10-17 at separations of 1-3 arcsec with age range 10-100 MYr. This makes these candidates consistent with planet to brown dwarf regimes. Statistical analyses of background source counts indicate that it is highly unlikely for all of these to be background stars.

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