the Panchromatic Hubble Andromeda Treasury (PHAT) Survey: Astrometric Calibration

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Panchromatic Hubble Andromeda Treasury

- a multi-cycle survey of the Andromeda galaxy (M31) using HST
- over 800 orbits; over 12,000 images
- over 100 million stars resolved & measured
PHAT Alignment

- **Match** all exposures with each other and a ground-based reference

- Run **foreground-background** model to get **weights** for the matches

- Compute **derivatives** of match distances with respect to **affine** transformations (shift, rotation, shear) of each image

- Solve the big **sparse least-squares** equation to minimize match distances
**Alignment – Example**

**Match** stars from one exposure’s catalog to an overlapping exposure’s catalog – within, say, 1 arcsecond.
Alignment – Example

Fit a background (incorrect matches) + foreground (correct matches) model using **Expectation-Maximization (EM)**
Alignment – Example

Flat **background** (incorrect matches) + Gaussian **foreground** (correct matches)—used to assign **weights** to matched stars

![Graph showing distribution of matched stars with flat background and Gaussian foreground.](image)
Expectation-Maximization

- Iterative method for optimizing mixture models; provably converges to local maximum.
- Alternate between:
  - E: **soft-assign** observations to mixture components
  - M: **optimize** mixture model parameters using the soft-assignment weights
Expectation-Maximization

- Initialize at $\mu = \text{peak}$ & $\Sigma = \text{made-up variance}$, foreground fraction $F = 50\%$; background distribution $\beta = 1/\text{area}$,

- Until bored:
  - $p(X_i \mid \text{foreground}) = F \cdot N(X_i \mid \mu, \Sigma)$
  - $p(X_i \mid \text{background}) = (1 - F) \cdot \beta$

  $f = \frac{p(X_i \mid \text{foreground})}{p(X_i \mid \text{foreground}) + p(X_i \mid \text{background})}$

  $\mu = \frac{1}{\sum_i f_i} \sum_i f_i X_i$

  $\Sigma = \frac{1}{\sum_i f_i} \sum_i f_i (X_i - \mu)^2$

  $F = \langle f \rangle$
Intro Tiling Alignment Datasets
Alignment Results – Mosaics

ACS coverage

ACS mosaic (F475W)
Alignment Results – Mosaics

IR coverage

IR mosaic (F160W)
Intro Tiling Alignment Datasets

Dataset advertisements

- **http://unwise.me** — higher-resolution coadds of the WISE mid-infrared imaging

- (also: SDSS/WISE photometry)

- (upcoming: multi-epoch coadds using the WISE reactivation data; ∼4-year baselines)

- **http://legacysurvey.org** — the DECam Legacy Survey — a grz optical survey of ∼6000 square degrees overlapping SDSS/BOSS spectra. DR1 is public!

- (also: viewer: **http://imagine.legacysurvey.org**)
Thanks!

Time for questions!

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