



Stellar Proper Motion Studies Through Joint Processing of WFIRST, LSST, and Euclid Observations

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JOINT SURVEY PROCESSING (JSP)



- Joint Survey Processing of Euclid, LSST, and Euclid data at the pixel level has the objectives of: producing multiwavelength images and catalogs of precise agreement in the sky areas of overlap, and provide a science platform where these images and catalogs can be processed and analyzed by the community.
- As part of these objectives, the astrometry and photometry of these surveys will be reconciled and standardized. In turn, precise, deconfused, extinction corrected photometric catalogs will be generated.
- The science platform will enable generation of other catalogs with ancillary data (e.g., HyperSuprime Camera), astronomical analysis (e.g. multiwavelength model fits), and integration with existing lower-resolution surveys (e.g. WISE)

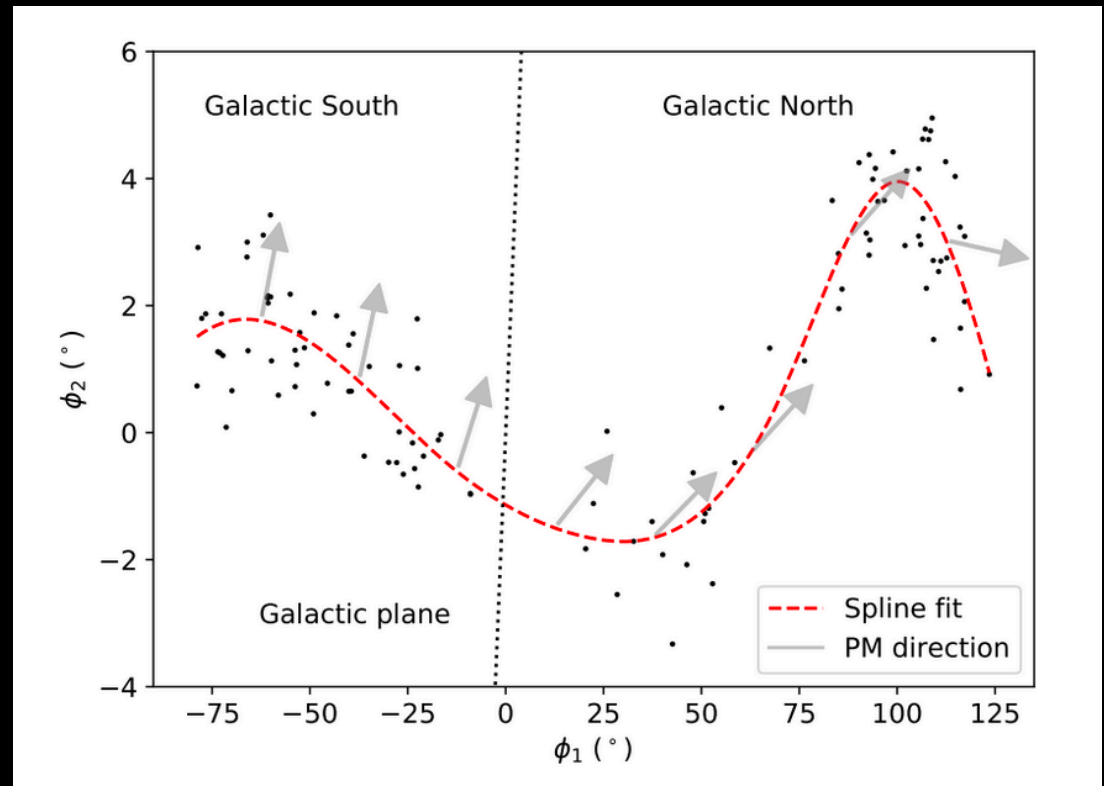
GALACTIC SCIENCE WITH JSP



- Observations with Euclid, LSST, and WFIRST of the faintest Gaia-measured stars will allow multi-epoch cross-identifications. These observations will then yield improved proper motions and photometry, allowing for deconfusion of sources in the Galaxy and in external galaxies.
- Photometry and proper motions of sources much fainter and more distant than those measured with Gaia will be possible with these facilities.
- Goal is to achieve single-epoch astrometry $\sim 10\text{-}20$ mas. Very small bulk proper motions can be measured by averaging over many stars much fainter than Gaia, in a 10-yr Euclid-LSST baseline.

AN EXAMPLE OF PROPER MOTIONS AND GALACTIC STRUCTURE

- Orphan Stream exhibits proper motions along the stream in its northern part, and \perp to the stream in its southern part.
- These “sideways” motions are ~ 0.5 mas/yr.
- May be related to the flyby of the LMC, if it has a mass 10% that of the Milky Way.



Erkal et al. (2019, MNRAS, submitted)

EXAMPLE PROPER MOTION STAR IN COSMOS FIELD HUBBLE ACS & SUBARU HYPER-SUPRIME CAM (HSC)

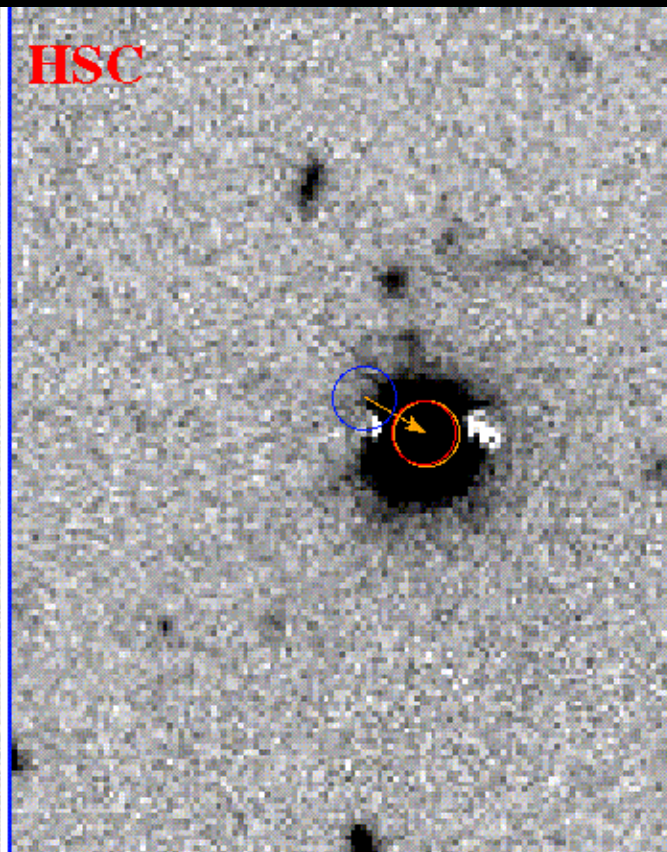
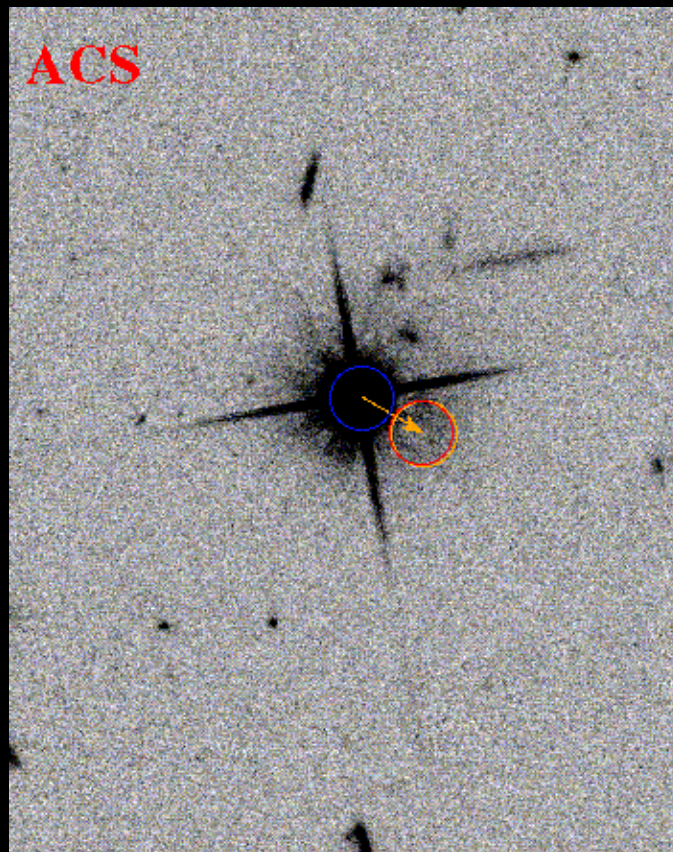


- Proper motion measured by Gaia (~ 200 mas/yr).

Position at the ACS epoch (2004.58).

Position at the HSC epoch (2015.06).

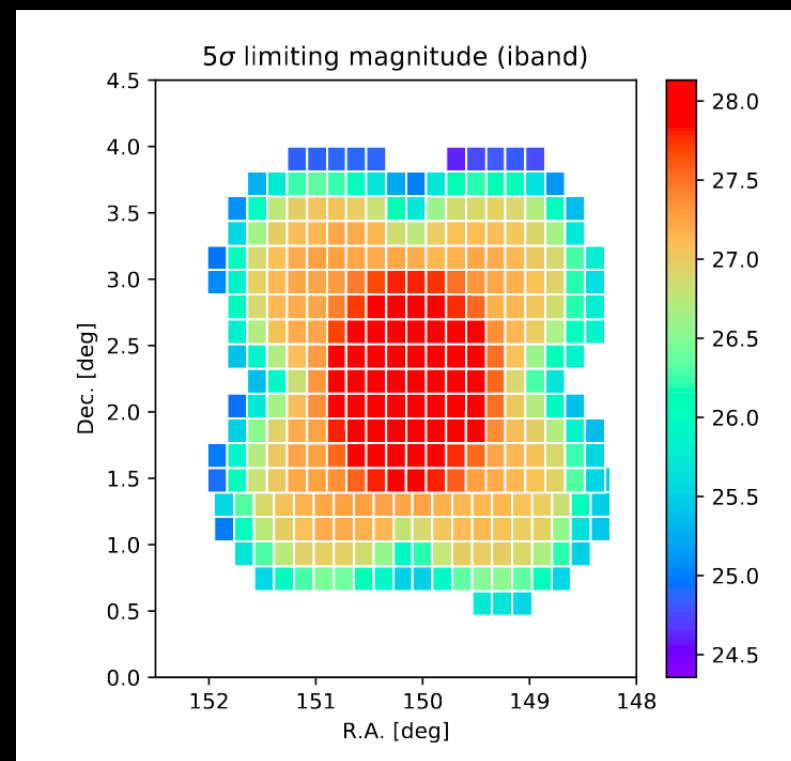
JSP will verify Gaia proper motions, & will obtain them for much fainter stars over long baselines.



COSMOS ULTRA-DEEP FIELDS: SUBARU HSC STARS AND GAIA PROPER MOTIONS



- COSMOS Hubble ACS astrometry being jointly processed with Subaru HSC. Here we discuss the latter.
- Gaia stars (single, non-variable) matched to stars in 4,989 single-exposure HSC i-filter frames. Typically ~ 30 matches per frame.
- There is good agreement in Gaia stars' proper-moved positions and HSC sources.
- However, depth of Gaia is ~ 21 mag, vs. ~ 28 mag for HSC i-filter in the COSMOS fields.
- Gaia stars brighter than ~ 19 mag saturated in HSC I-filter.

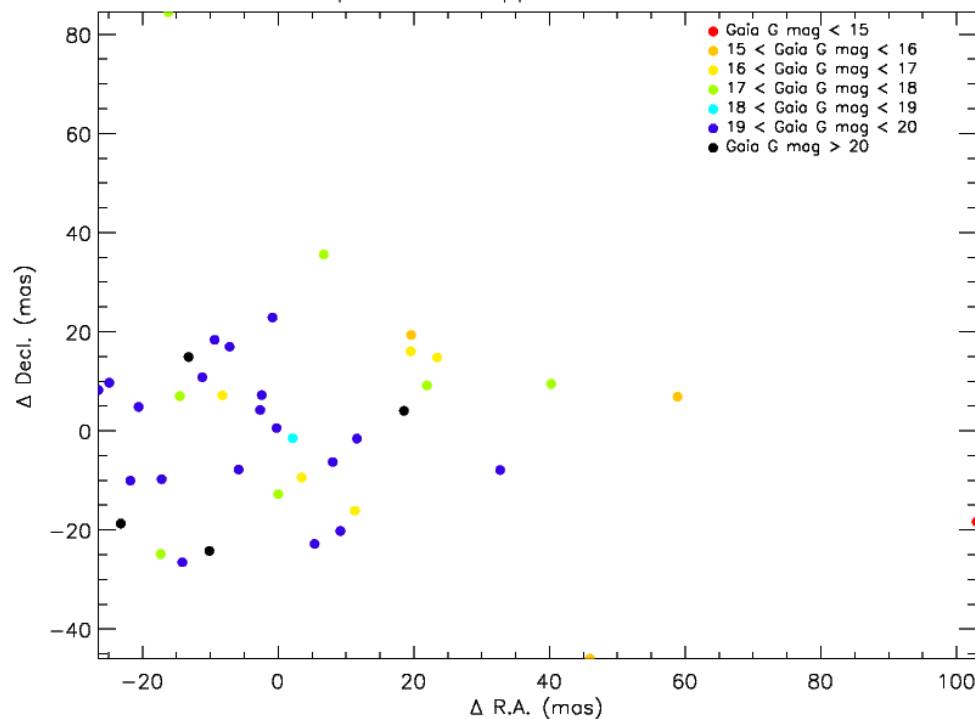


EXAMPLE MATCHES OF GAIA STARS & HSC I-FILTER IN SINGLE EXPOSURE



- HSC Astrometry from SExtractor.
- Gaia stars proper-moved to epoch of HSC frame.
- Matching radius = 0.2 arcsec.
- Gaia stars ~19-20 mag matched to within ~20 mas to HSC sources.

Differential Positions in SExtractor CALEXP-0001226-051.fits w.r.t. Gaia DR2 Sources
Proper Motion Applied To Gaia Sources

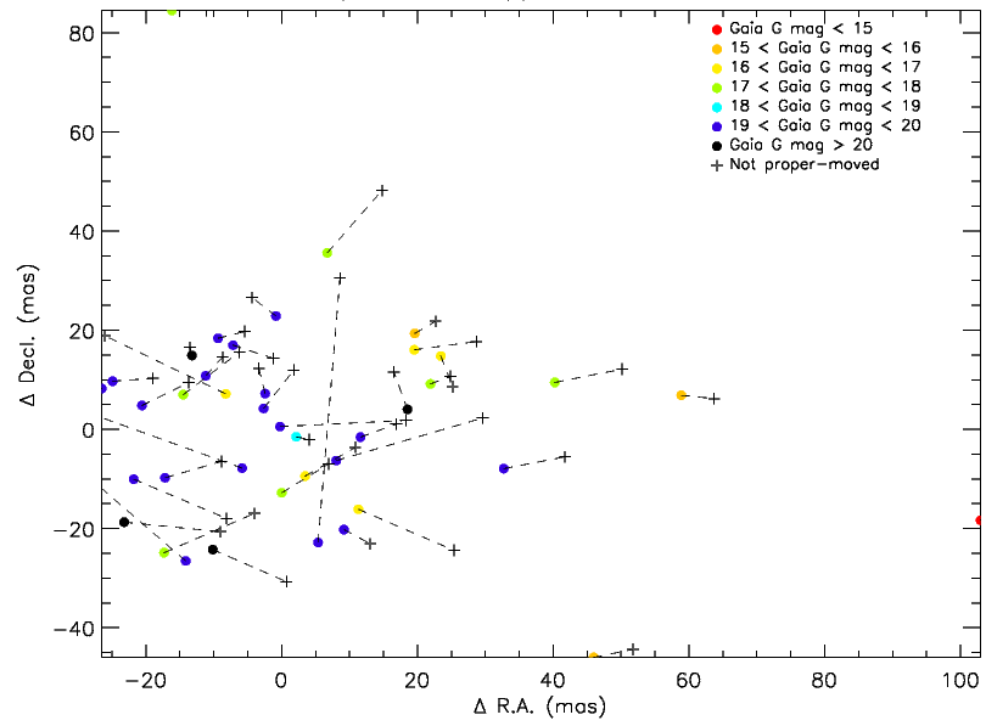


EXAMPLE MATCHES OF GAIA STARS & HSC I-FILTER IN SINGLE EXPOSURE



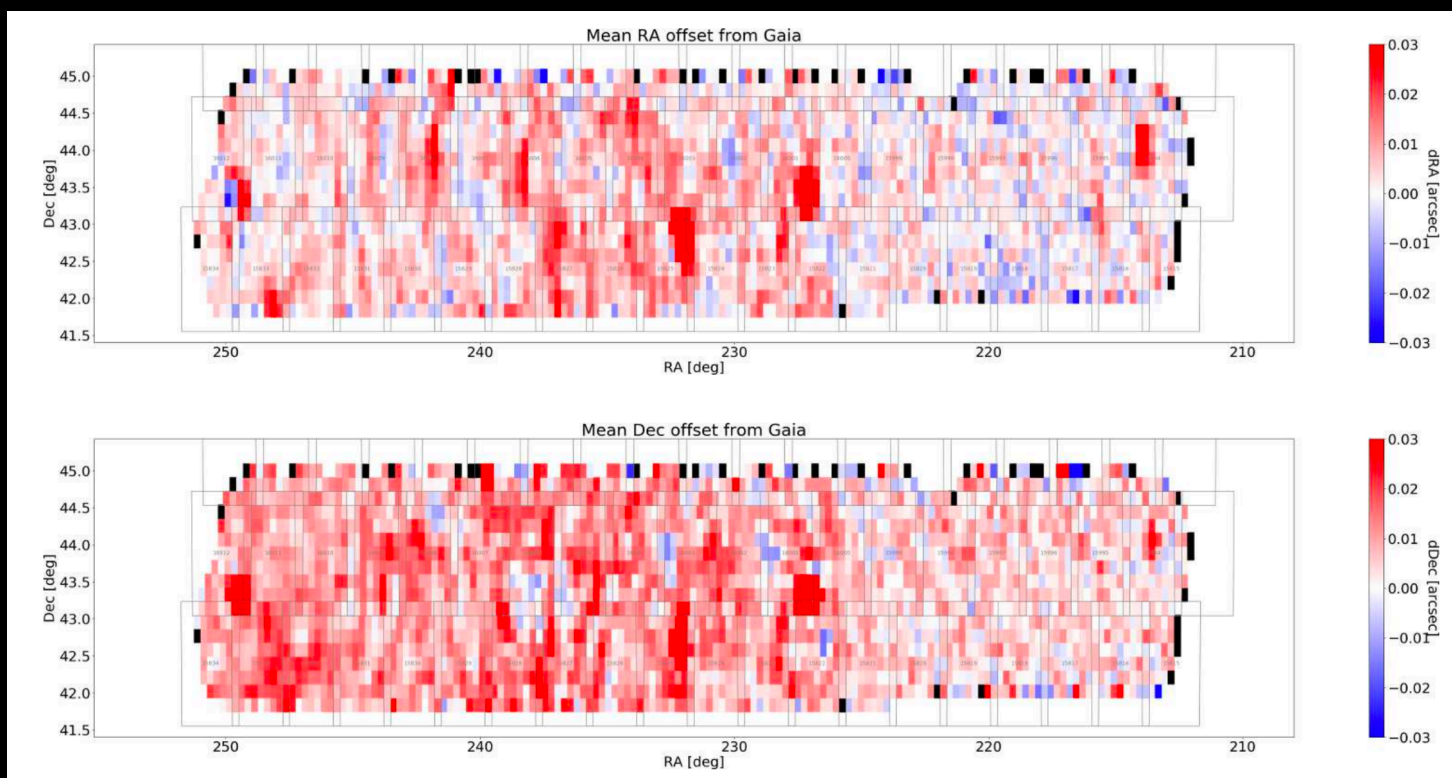
- Same single-exposure frame...
- Compared with null Gaia proper motions.
- Gaia proper motions are verified to be quite good.

Differential Positions in SExtractor CALEXP-0001226-051.fits w.r.t. Gaia DR2 Sources
Proper Motion Applied To Gaia Sources



MATCHES OF GAIA STARS & HSC I-FILTER

- Representative astrometry estimated by the HSC Project (DR2, shown in a different field).



CONCLUSIONS



- As a precursor to joint processing of Euclid, LSST, and WFIRST, we are analyzing the proper motions and photometry of Gaia stars in the COSMOS field, as imaged by the HST ACS and Subaru HSC cameras.
- Joint processing of these datasets allows a verification of the Gaia proper motions, as well as measurements of proper motions of fainter stars (with an expected single-epoch astrometry of ~ 10 mas, and better handling of confusion from nearby sources) over a long baseline of about ten years.
- Photometry and proper motions of sources much fainter and more distant than those measured with Gaia will be possible with Euclid, LSST, and WFIRST. They will yield absolute luminosities from optical to infrared photometry, and improved derived stellar radii, Galactic structure studies, and measurements of the mass distribution in external galaxies.

2-D GAUSSIAN FITS TO MATCHED HSC SOURCES



- Goal is to improve the astrometry of HSC sources, by detecting and discarding saturated and extended sources among the a-priori selection of stars.

