Euclid Sky

zodiacal background & galaxy: stars and extinction

The Euclid Wide Survey exclusion zones leading to the 15,000 deg.² sky area: foregrounds context

- Ecliptic plane [zodical light background]: +/- 15 deg. ecliptic latitude exclusion zone
- Galactic plane [stellar contamination]: +/- 25 deg. galactic latitude exclusion zone
- Absorption [dust]: E(B-V)<0.08

Background image: Euclid Consortium / A. Mellinger / Planck Collaboration

Plot by ECSURV (J.C. Cuillandre)

R. Scaramella-AASS lecture-18 Nov 2022
The Euclid Wide Survey: reddening/extinction from galactic dust (Planck)

Euclid Wide Survey 17 Kdeg.$^2$ region of interest: green contours
Galactic latitude threshold +/-25 deg.: thin grey isolines
Ecliptic latitude threshold +/-12 deg.: thin grey isolines

J.C. Cuillandre

Extinction map: ESA / Planck Collaboration
The Euclid Wide Survey: stellar density (Gaia)

Euclid Wide Survey 17 Kdeg.² region of interest: blue contours
Galactic latitude threshold +/-25 deg.: thin grey isolines
Ecliptic latitude threshold +/-12 deg.: thin grey isolines

Stellar density per square degree [Gaia $G_{BP} = 20$th magnitude]

10,000 20,000 50,000

Gaia stars [straylight and confusion]
The Euclid Wide Survey 17 Kdeg.\(^2\) region of interest: two mainlands (\(\sim 7200\) deg.\(^2\) each) + two islands (\(\sim 1600\) deg.\(^2\) each)

- Euclid Wide Survey 17 Kdeg.\(^2\) region of interest
- Galactic latitude threshold +/- 23\&25 deg.: thin grey isolines
- Ecliptic latitude threshold +/- 10 deg.: thin grey isolines

The main fore/backgrounds select a Region of Interest

Plot by ECSURV (J.C. Cuillandre)
The Euclid Wide Survey based on ecliptic & galactic latitude thresholds + upper limits on stellar density & extinction (Gaia/Planck)

- Euclid Wide Survey region of interest: \(17 \text{ Kdeg.}^2\) compliant with a \(15 \text{ Kdeg.}^2\) survey
- Ecliptic plane [zodiacal light background]: +/- 10 deg. ecliptic latitude exclusion zone
- Galactic plane [stellar contamination]: +/- 23&25 deg. galactic latitude exclusion zone

Last updated Euclid ROI: \(\sim 17,400\) square degrees

Plots by J.C. Cuillandre
Straylight contribution to the background can be separated into two components:

1. All images of the sources in the telescope field of view will be surrounded by a halo following the NDI profile. This background structured by the objects in the field of view is what we call In-field stray light.

2. Moreover all the sources from outside the telescope field of view also contribute globally to the background level of straylight. They contaminate the telescope focal plane by adding a diffuse and constant component depending on the direction the telescope is pointing to. This additional cumulative component is what we call Out-of-Field stray light.

Figure 5-12: Illustration of the different In-field / out field contributors to the straylight. 

Amiaux, Venancio et al
Normalized Diffusion Irradiance (NDI). Assuming the entrance of the telescope is illuminated by a distant point source (collimated light), then the NDI is defined as the ratio of light irradiance (power per unit area) on the image plane to the source irradiance in object space at the entrance of the telescope. More basically the NDI describes the profile of the scattered light in the telescope focal plane for a point-like source at given position in the field of view. The NDI was computed with the ASAP optical software, a ray-tracing program that uses a statistical Monte Carlo approach.

Figure 4-21: Telescope NDI simulated profile and agreed envelop model (with the two identified contributors In and Out of Field).

Venancio, Amiaux et al

At 10 degs \( \mathcal{O} \left( 10^{-6} \div 10^{-7} \right) \) factor
Spectra on the WIDE: weight map from sims

Ecliptic plane: large zodiacal

Galaxy plane: too many stars etc

Bright stars
The Euclid Wide Survey (EWS) with the Euclid Deep Survey (EDF) and the deep Euclid Calibration Fields [Mollweide Celestial]

- Euclid Wide Survey region of interest: $17 \text{ Kdeg.}^2$ compliant with a $15 \text{ Kdeg.}^2$ survey
- Euclid Deep Fields: North=$10 \text{ deg.}^2$, Fornax=$10 \text{ deg.}^2$, South=$20 \text{ deg.}^2$
- Euclid deep calibration fields marker (diamond not to scale)
Best areas are within green dashed lines

North and south galactic caps highest SNR areas of the Euclid Wide Survey region of interest [extinction + zodi + stellar density]

- Euclid Wide Survey region of interest: 17 Kdeg.² compliant with a 15 Kdeg.² survey
- Best SNR areas (2600 deg.² each)
- Ecliptic plane [zodiacal light background]: +/- 10 deg. ecliptic latitude exclusion zone
- Galactic plane [stellar contamination]: +/- 23&25 deg. galactic latitude exclusion zone

Background image: Euclid Consortium / A. Mellinger / Planck Collaboration
Local galaxies

Euclid Foregrounds (6/8): galaxies from the local group and the nearby universe (z<0.01)
- Euclid Wide Survey: 15,000 deg.$^2$ [with E(B−V)<0.08, up to 0.15 to avoid holes/islands]
- Euclid exclusion zone: 26,000 deg.$^2$ [galactic+ecliptic planes + reddening]
- Euclid Deep Fields: North=10 deg.$^2$, Fornax=10 deg.$^2$, South=20 deg.$^2$

Total K-band magnitude: 3 5 7 9 11
The supergalactic reference is overplotted in light purple
Galaxy catalog: The 2MASS Redshift Survey (2MRS), Huchra et al. 2012

J.C. Cuillandre
Nearby galaxies

Euclid Foregrounds (7/8): nearby galaxies beyond the local universe (0.01<z<0.06)

- Yellow: Euclid Wide Survey: 15,000 deg.² [with E(B-V)<0.08, up to 0.15 to avoid holes/islands]
- Light blue: Euclid exclusion zone: 26,000 deg.² [galactic+ecliptic planes + reddening]
- Green: Euclid Deep Fields: North=10 deg.², Fornax=10 deg.², South=20 deg.²

Total K-band magnitude:

- z=0.02
- z=0.03
- z=0.04
- z=0.05
- z=0.06

Galaxy catalog: The 2MASS Redshift Survey (2MRS), Huchra et al. 2012

J.C. Cuillandre
Clusters of galaxies

Euclid Foregrounds (8/8): distant clusters of galaxies (0.06<z<0.40)

- Euclid Wide Survey: 15,000 deg.$^2$ [with E(B−V)<0.08, up to 0.15 to avoid holes&islands]
- Euclid exclusion zone: 26,000 deg.$^2$ [galactic+ecliptic planes + reddening]
- Euclid Deep Fields: North=10 deg.$^2$, Fornax=10 deg.$^2$, South=20 deg.$^2$

J.C. Cuillandre
Within RoI the radiometric SNR is good.

VIS goes deeper (~25.7 @5σ) for point like

J. Amiaux, J.-C. Cuillandre
Blinding stars: you do not want to expose on them

In principle only NISP is harmed by persistence (but some “lighthouses” in VIS could give difficulties to FGS CCDs)

Skip tile if mAB < 4 star (~1E3 in RoI) falls in one of the (exaggerated) dithers

for mAB < 0 there is an exclusion radius (this is much worse for ground telescopes)
**Blinding stars: being close to us their distribution is ~uniform on the sky**

The Euclid Wide Survey exclusion zone final extra definition component: blinding bright stars (2/3) [Mollweide Celestial]

Euclid stray light contamination by in field stars: skipping 1034 pointings with i, or Y, or J, or Y AB < 4 mag stars

- Yellow Euclid Wide Survey region of interest: 17 Kdeg.$^2$ compliant with a 15 Kdeg.$^2$ survey
- Blue Euclid exclusion zone: 24 Kdeg.$^2$ [stellar density + extinction + zodiacal light]

眼球 AB magnitude: -2 0 2 4

- J-band: Two Micron All Sky Survey (2MASS, Skrutskie et al. 2006)
- I-band: ATLAS All Sky Catalog (Tonry et al. 2018)

**Blinding star compilation by J.-C. Cuillandre**

~1E3 blinding stars for Euclid in its RoI

R. Scaramella-AASS lecture-18 Nov 2022
Coverage from ground based telescopes

4 surveys, UNIONS

(if?) northern extension

Rubin → main

(if?) southern extension

Best areas in South (first two years are in DES)

**Complementary Observations Group**
The adopted "S" dithering pattern as seen projected on the sky for a leading pointing.

- Step 1: dx1=25 arcsec, dy1=50 arcsec
- Step 2: dx2=50 arcsec, dy2=100 arcsec

Therefore one has for the current baseline:

- VIS: 568 s + 3 s (shutter)
- NISP: 574 s + 3 s (shutter)

The reference survey is computed based on the nominal Joint Field of View. The orientation of the fields' orientations. In the presented document is Proprietary information of the Euclid Consortium.
Euclid Wide

Evolution of ECTile (J. Dinis) so to cope with all constraints

Look-ahead algorithm

Diffusion algorithm

skewed threads cause excursions on ALPHA range

diffusion algorithm keeps threads as vertical as possible

Evolution of ECTile (J. Dinis) so to cope with all constraints
Tiles skipped because of blinding stars
Ecliptic polar caps need an ad hoc treatment because of the local convergence of meridians.

J. Dinis

North

South (ellipse is LMC)
Look-ahead algorithm

an extreme patch: 23 days
two misplaced inversions (aligned in longitude) make the skewness more severe

besides many skewed threads also has horizontal zig-zags

double horizontal moves

NEW algorithm

Much smaller variations in alpha

RSD_2020B

Minimise variations in angles for a better thermal stability; new algorithm (J. Dinis)

RSD_2020A
97% of area; OK if expected
FoM > 412
(now ~500)

Lack of available wide areas
~10 months to be allocated

yearly quality of fields: on average best areas first
Euclid Deep Fields

Requirements

- cover at least 40 square degrees in at least two fields (one in Northern, one in Southern Emisphere)
- at least 2 magnitudes deeper (→ 40 visits)
- growth in time like the survey
- Completeness Purity Calibration fields [CPC]: at least 40 square degrees of spectroscopy, 10 visits with large angular separation for spectral dispersion

CPC example:
Updated purity calibrations:
- none within 5 degs from others
- main pointing no within 10 deg from other mains
- no gap larger than 30 degs

3 Red Grism configuration
0-90-180 deg.
90 is orthogonal to the sun and // to y_sc

rotation on the Focal Plane observed at different epochs so to disentangle spectra overlaps
Completeness Purity Calibration (CPC)

Two fields (northern and southern) of ~20 sq deg each. Observed 10 times with different orientations to minimise spectral confusion. Coincident with EDF-N (center) and EDF-S (full).

NEW pattern “K”
0,184,-4,180

North is easier to observe
South has limited visibility (smaller range for angle)
Three Deep Fields

We currently have:

- a two tier EDF-North [EDFN] (20 sq deg x 10 visits + inner sq deg 10 x 30 visits more); + self-cal (4 sq deg, monthly visits, partial random cover)
- an EDF-Fornax [EDFF] (10 sq deg x 56 visits) comprising the Chandra Deep South
- an EDF-South [EDFS] (23 sq deg x 45 visits); collaboration with LSST

limiting AB mag 5σ pointlike: VIS ~27.7, NISP  y, J, H ~26

Also ”blue” [0.92-1.25μ] grism can be used to observe the deep fields
Center is offset by ~1 deg from geometric NEP to maximise overlap with Spitzer (P. Capak)

Euclid Deep Field North (EDF-N)
R.A. 17:58:55.9, Dec. +66:01:03.7, J2000, 10 sq. deg.
Equatorial: 269.73 +66.02
Ecliptic: 258.69 +89.45
Galactic: 95.76 +29.92

CPC-N=20 sq degs (10 visits); cocentered EDF-N 10 sq degs (+30 visits)

Self-cal is also here, visited once per month, no ROS. (Schirmer, plot by P. Rheimberg)
Deep fields: CPC-North

Covering moves for the CPC & EDF-N: small relative motion to have best thermal stability

Final stacked exposure for the CPC EDF-N: geometrical patterns due to FP partial coverage still present (10 rotations of 4 dithered exposures)

J. Dinis
Imprint of geometrical patterns

CPC 10x4 exposures in which:
~1/2 of area exposed 3 times
~1/2 of area exposed 4 times

for total T
expect 30 < T< 40,
<T> ~ 35 ,
observed mean =36

Want a smoother coverage: need to off center different passes (how?)

Some work to do
Figure 4.4.9 Left panel: the basic pattern of relative shifts aimed to have a more uniform coverage. Right panel: the covering of CPC after the first visit of the ten planned.

Figure 4.4.10 Left panel: the coverage of CPC after the first two visits of the ten planned. Right panel: coverage after the ten visits.

Deep fields: CPC-North

Final stacked exposure for the 10 CPC & EDF-N visits after having inserted a bit of randomness in the initial point of each visit: the imprint of geometrical patterns decreases.

Figure 4.4.11 Left panel: the profile passing through the center. Some residual large scale patterns are still present but the median exposure has a value of 36, close to the expected 35, the average of 3 and 4 exposure for each visit. Right panel: the histogram of visits for subregions.

Smearing strategy

Deep-fields are smeared by decentering each visit to it:
- A visit is decentered by shifting a pattern in block;
- First visit is placed with no decentering;
- Subsequent visits are decentered by the smear-shift that maximizes overlap;
- Smear-shifts, 25 in total, are located in the middle four VIS sensors.

Smearing CPC-North

Subsequent visits are decentered by the smear-shift that maximizes overlap.
EDF-Fornax

4x5+1 fields, 56 visits (+16 compensate for larger zodiacal), no much smearing at borders

Change from rectangle (Euclid optimal) to a circle to better cover Spitzer (Capak) and LSST

Chandra Deep South inside it

Rubin drilling field
Euclid Deep Field Fornax (EDF–F)


Wide view context:
- Reddening: E(B–V)
- Contamination: bright stars

Covered by Spitzer, Rubin drilling field

EDF-South & Rubin

For Euclid a simple circle is best, covered with 43 tiles

LSST possible ways of covering 20 sq deg: spatially varying completeness

Since LSST goes much deeper than required by Euclid this solution would match well Euclid needs but it has **too low efficiency for LSST**

**LSST prefers this binocular shape because it is optimal and has 100% efficiency for it**

Need LSST ~33 hrs for Euclid photoz depth
To cover the LSST shape need 46 tiles instead of 43 (~ +7%)

“Stadium” shape (pill-like)

Radius, Perimeter, Area \[ R = 1.78° \]

\[ P = 2R(2 + \pi) \quad A = R^2(4 + \pi) \]

But need some more fields when tilted on the sky:

On average need ~51+ fields depending on covered fraction (~ + 19%)

Need to also add ~ +12% time for larger Zodiacal, i.e. from 40 to 45 visits. Total is ~ 102 days for a circle, in total add ~ 3 weeks for stadium shape]. TBD
Euclid Deep Field South (EDFS)

23 square degrees stadium geometry field

- $a = 2r$
- $r = 1.78$ deg
- Position angle = 61.3 deg.

Equatorial: 61.28 $-48.42$
Ecliptic: 36.56 $-66.60$
Galactic: 256.05 $-47.14$

Looks very good for extinction, fine for bright stars and large objects

Stadium (‘pill’) shape chosen for better synergy with Rubin

Covered by Spitzer, Rubin will observe it deeply
EDFs status

(square deg x visits; number of latters will be increased to compensate for larger zodiacal background)

- EDFN (20 x 10 + inner 10 x 30) = (1/2) CPC + (1/4) DEEP; offset 1 deg from NEP; observed by Spitzer
- EDFF (10 x 40) = (1/4) DEEP; Fornax region; observed by Spitzer; Rubin drill field
- EDFS (23 x 40) = (1/2) CPC + (1/2) DEEP; observations done for Spitzer; Rubin optical coverage requested

Visibility from Ground facilities has increased enormously, enabling much more science to be done on EDFs

wanted depth: 2 mags deeper than average

75% synergy between CPCs and EDFs

CPC visits are counted also as EDF visits

After one year can have 1 visit (all red spectra) on both CPC + EDF-F = 50 sq degs for Q1 release
Detailed coverage of Deep and Auxiliary fields, unified visits to use ROS (here single visit plots)

- **CPC-NORTH**
  - time-per-visit: 2.1 days
  - visibility-window: 10 days
  - periodicity: 180 days

- **DEEP-SOUTH**
  - time-per-visit: 2.6 days
  - visibility-window: 46 days
  - periodicity: 135/230 days

- **DEEP-FORNAX**
  - time-per-visit: 1.1 days
  - visibility-window: 12 days
  - periodicity: 180 days

- **POLAR-CAP NORTH**
  - time-per-visit: 4.3 days
  - visibility-window: 7 days
  - periodicity: 180 days

Details on special fields: an up to date paper is in the cooking

J. Dinis
We define a tile as the largest rectangle in latitude–longitude that
satisfies the constraints for the EWS optimisation algorithm, and briefly review
steps and concepts required for the computation of the
calibrations & deep & auxiliary fields & wide

Details are in a ‘wide paper’ in press
now writing a ‘deep paper’

More work to do on
PSF cadence, rest OK

time: 2/3 on wide survey, 1/3 on rest

time for instrument calibrations: ~5%

R. Scaramella-ADS
Nov 2022
Fig. 46: Reference Survey Definition 2021A (14,514 deg²) chronology shown in celestial coordinates. Red boundaries are shown as solid red lines. Blinding stars cause 780 avoidance areas within the reference survey. Dashed lines (1300 deg² in white per Galactic cap) delimit the highest SNR areas. The ecliptic referential is over-plotted in red. The three EDFs (bright green) and the six EAFs (red diamonds, not in size) are shown.
Lots of science topics in Euclid Consortium

- **Cosmology** (WL, GC, XCMB, Clusters, SL, Theory, Simulations)
- **Legacy** (galaxy evolution, primordial galaxies, nearby universe, local galaxies, SN)

All done in Italy as well. (inquire if interested)

At Rome Astronomical Observatory we work on
— data reduction pipeline OU-MER
— WL and theory
— Survey
— Local stuff
Topological properties of shear maps

- Vicinanza + Physical Review D, Volume 99, Issue 4, id.043534

Super Sample Covariance (SSC)

- Euclid will resolve small angular scales → need to include more complex systematics, not yet taken into account
- SSC is believed to be the dominant source of non-Gaussian statistical error for upcoming WL surveys (Lacasa+ 2018)

What is SSC?

- A form of sample variance
- The volume of the universe observed is limited both in depth (z) and sky fraction
  → matter density fluctuations with wavelength $\lambda$ larger than the linear survey size $L$ are not sampled

Results

- $\sigma_g, \Omega_m, W_0, W_a$ most affected
- They control the amplitude of the matter power spectrum
- $\delta_b \sim$ unknown shift in bg. density
- Similar results found in Barreira+ 2018 (for a 5-parameter cosmology)
- Lower impact for GCph:
  - EC analysis cuts the GC signal at larger scales, less affected by SSC
  - Significantly less overlapping redshift bins (lower inter-bin correlation)

D. Sciotti (PhD student)

SSC impacts WL uncertainties
There is much information still unexploited in the primary data of Euclid

Increasing the Lensing Figure of Merit through Higher Order Convergence Momenta

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Report of the Referee -- DZ12050/Vicinanza

"Minkowski Functionals of Convergence Maps and the Lensing Figure of Merit" by Vicinanza et al. investigate the use of Minkowski functionals with lensing convergence maps.

They show such an approach helps to break the $\Omega_m - \sigma_8$ degeneracy leading to an overall increase in the Figure of Merit.

The paper is excellently written for the following reasons:

1. The authors do a wonderful job reviewing complex material. For example they review both the Minkowski Functional and Fisher Matrix formalisms.

2. The consider application do data such as the MICE catalogue and surveys like Euclid.

3. They demonstrate and improvement in the figure of merit and the ability to help with the above stated degeneracy.

I see no reason not to recommend this paper for publication. I will say that I think the authors should seriously consider adding a table with forecast numbers for the several future surveys that will use this information. The one failing of the paper is that people who work on surveys want bottom line numbers for their survey they can use in their analysis/proposals and the lack of a table they can just read off these numbers from not only makes the paper less helpful than it could be, more importantly for the authors it means less citations from these surveys.

However, given the paper is well written, scientifically sound, they both consider data and at least Euclid, I will only offer such a helpful table as a suggestion.

R. Scaramella-AASS lecture-18 Nov 2022
This is optimistic wrt real case but there is a justified improvement

A Fisher matrix analysis has then shown that, while as standalone probe moments are unable to put meaningful constraints on \((\Omega_M, \sigma_8)\), the joint use of shear tomography and HOM can boost the FoM by up to a factor 14 and no less than a factor 2. Such an astonishing result is due to HOM breaking the \(\Omega_M - \sigma_8\) degeneracy which makes it possible to strengthen the constraints on all the cosmological parameters. This degeneracy breaking takes place whatever smoothing angle range and sampling step is used, but we advocate the use of the full \((2, 20)\) arcmin range with sampling \(d\theta = 1\) arcmin since this choice guar-
2. Euclid: photometry
- OU-MER just went through Scientific Challenge 8; the pipeline was run on simulated data produced by OU-SIM and processed by OU-VIS, NIR, EXT
- Photometry (in 3 flavours) is reasonably good but still needs optimization (must be good enough for photo-z requirements)
- Currently working on finding the best way to improve the accuracy

3. Euclid: Morphology Challenge
- OU-MER in collaboration with Morphology SWG (M. Huertas-Company)
- Official challenge to compare model-fitting codes and algorithms
- EM and M. Castellano produced a full set of simulated images (9 bands images + RMS maps + PSFs) consistent with mission imaging data using EGG (Schreiber, EM+2017) and GalSim
- Images were distributed to 8 developers of model fitting codes including SE++, Galfit and others
- 5 / 8 sent results; only 2 fully completed the challenge
- Analysis of the results is ongoing; 2 publications to be submitted in 2022

Deblending: Current Situation

- One of the sequential series of steps in the OU-MER pipeline

- How do we benchmark the performance of the deblending process?
LSB: OAR (R.S., V. Testa, MER), OAC (Iodice+), UniSal (Nucita+), (Canarie, Akhlaghi), Cuillandre (CEA)

SFB: OAT (Cantiello), OAR (R.S.)
Automated search for LSB galaxies on the DPOSS survey and first results from CCD follow-ups

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G. Longo, Univ. Napoli, ITA
R. de Carvalho, Obs. Nacional, Rio de Janeiro, BRA

Plate

original image

Cleaned image

Filtered Image

Plate

Follow up

CCD Follow-up (TNG)

R. Scaramella – Sorrento September 2003

The dwarf LSB galaxy population of the Virgo cluster – I. The faint-end slope of the luminosity function

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IN TRO D U C T I O N

The Virgo cluster is the nearest (~17 Mpc) cluster with several hundreds of galaxies (~1015 M pc−3) and the largest dominant structure of the Local Supercluster. It is an irregularly shaped region of 17 Mpc radius, with a high abundance of spiral galaxies. It is the nearest (~100 M L⊙) and largest (~100 × 100 × 80 kpc) cluster, with a high abundance of spiral galaxies among the bright cluster members, Binggeli, Sandage & Tarenghi 1984) and the largest dominant structure of the Local Supercluster. It is an irregularly shaped region of 17 Mpc radius, with a high abundance of spiral galaxies. It is the nearest (~100 M L⊙) and largest (~100 × 100 × 80 kpc) cluster, with a high abundance of spiral galaxies. It is the nearest (~100 M L⊙) and largest (~100 × 100 × 80 kpc) cluster, with a high abundance of spiral galaxies.
Iodice, VEGAS survey

NGC 1052-DF2 as a UDG

Danieli et al., 2019

A lack of dark matter?

Van Dokkum et al., 2018

DF2 @ HST

A sub-category with a special attention: the ultra diffuse galaxies, challenging cosmology?
Faint LSB features need:
— deep data
— ad hoc treatment of data

With a gain of 2 mag in surface brightness: deep imaging at 29 mag arcsec$^{-2}$
The well-studied Blanco 1 open cluster lies on the boundary of the Galactic component. For this population, proper motion measurements will be crucial to separate kinematically a local WD population. Of the seventeen open clusters in the DES footprint, three have well-determined distances and are closer than 500 pc, whereas all sub-stellar objects (brown dwarfs) and degenerate compact objects (white dwarfs) are far below the detection threshold. However, based on SV data, all higher-mass stars (earlier than G0V) are saturated in low-extinction DES fields out to 3kpc (which if perpendicular to the Galactic plane, is about three times the thick-disk scale height). At that distance (neglecting interstellar extinction), all cluster G, K, and M-dwarfs are detected (S/N > 10), whereas all sub-stellar objects (brown dwarfs) and degenerate (if outside) objects are saturated. Thus, the down-turn of the WDLF and estimate the age of each cluster will still fall below the survey’s magnitude limit. Of the seventeen open clusters in the DES footprint, only three of these seventeen clusters have well-determined physical properties, tending to be relatively nearby (\( z < 500 \) pc).

Galactic open clusters are unique astrophysical laboratories for understanding stellar evolution. Their ages can be fairly accurately determined by isochrone fitting of cluster colour-magnitude diagrams (e.g., Cargile & James 2010), by determining the lithium burning-age (Barnes 2003, 2007; James et al. 2010). In Figure 6, we plot the positions of globular clusters and Local Group dwarf galaxies, which will be discussed in Section 4.4 Membership and luminosity functions of Galactic open clusters

Globular clusters are marked with “+” symbols (Harris 1996, 2010 edition), two faint outer halo clusters are marked with “×” symbols (Luque et al. 2015), Local Group galaxies known prior to DES are marked with blue squares (McConnachie 2012), dwarf galaxy candidates discovered in Y1 DES data are marked with red outlined circles, while the Y2 stellar systems are marked with red triangles. Open clusters from the WEBDA database are shown as green diamonds. The periphery of the LMC can be seen in the southeast corner of the footprint, while the Galactic stellar disk can be seen on the eastern and western edges. This figure was adapted from Drlica-Wagner et al. (2015b).
In the realm of the Hubble tension—a review of solutions

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Received 26 March 2021, revised 28 May 2021
Accepted for publication 4 June 2021
Published 9 July 2021

Abstract

The simplest ΛCDM model provides a good fit to cosmological data but harbors large areas of phenomenology and ignorance. With the improvement of the number and the accuracy of observations, discrepancies have been found, both among different astronomical missions and groups performed over the years.

Figure 1. Whisker plot with 68% CL constraints of the Hubble constant $H_0$ through direct and indirect measurements by different astronomical missions and groups performed over the years. The cyan vertical band corresponds to the $H_0$ value from SHOES Team [2] (R20, $H_0 = 73.2 ± 1.3$ km s$^{-1}$ Mpc$^{-1}$ at 68% CL) and the light pink vertical band corresponds to the $H_0$ value as reported by Planck 2018 team [11] within a ΛCDM scenario. A sample code for producing similar figures with any choice of the data is made publicly available online at github.com/lucavisinelli/H0TensionRealm.
Surface Brightness Fluctuations with Euclid (4 bands and high angular resolution)

Distance indicator: $H_0$ tension, cosmic flows

Figure 1: **Left**- Possible Euclid pointing on Fornax (ecliptic coordinates). Red rectangle: Euclid FoV; blue rectangle: HST/ACS FoV; the galaxies within the proposed FoV and with red labels, have HST SBF data. **Right**- Positions of galaxies with high-quality space- (green) or ground-based (grey) SBF measurements.
Summary:

★ **Best** science  (cf Decadal)

★ **Enormous** Legacy

★ **Tough** but feasible

*Stay tuned!*