Gaia first vintage

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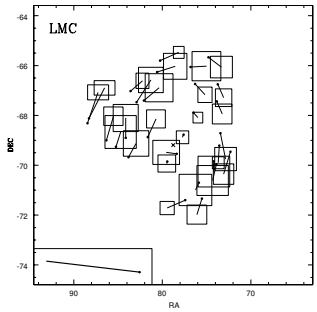
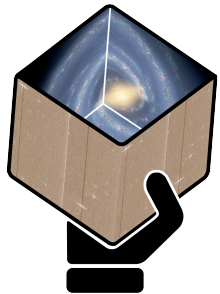
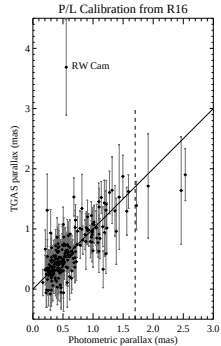


Van der Marel & Sahlmann, arXiv:1609.04395

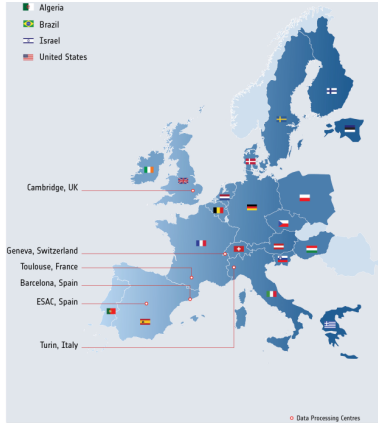


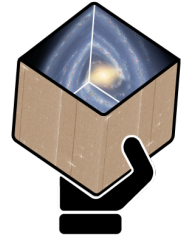


Casertano, Riess, Bucciarelli, Lattanzi, arXiv:1609.05175

Teamwork to deliver the promise of Gaia

- 10+ years of effort
- 450 scientists and engineers
- 160 institutes
- 24 countries and ESA
- Six data processing centres





gaia

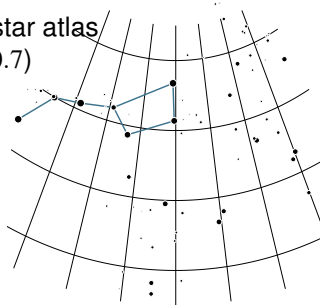
0 1 0 0 0 0 0 0 1 1 0 0 1 0 0 1 1 1 0 0 1 1 0 1 1 0 0 1 0 1 0

Gaia DPAC Data Processing & Analysis Consortium

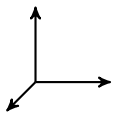
$\alpha\ \delta\ \varpi\ \mu_{\alpha*}\ \mu_\delta\ G\ \ldots$

What's in the Gaia DR1 delivery

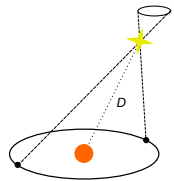
Billion star atlas
($G \lesssim 20.7$)

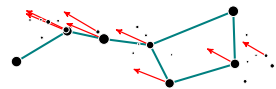


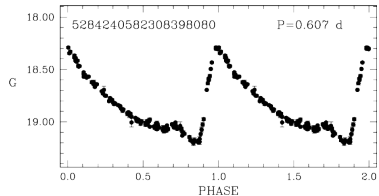
Positions and magnitudes
for ~ 2000 ICRF quasars



Tycho-Gaia
Astrometric Solution
(~ 2 million, $G \lesssim 12$)

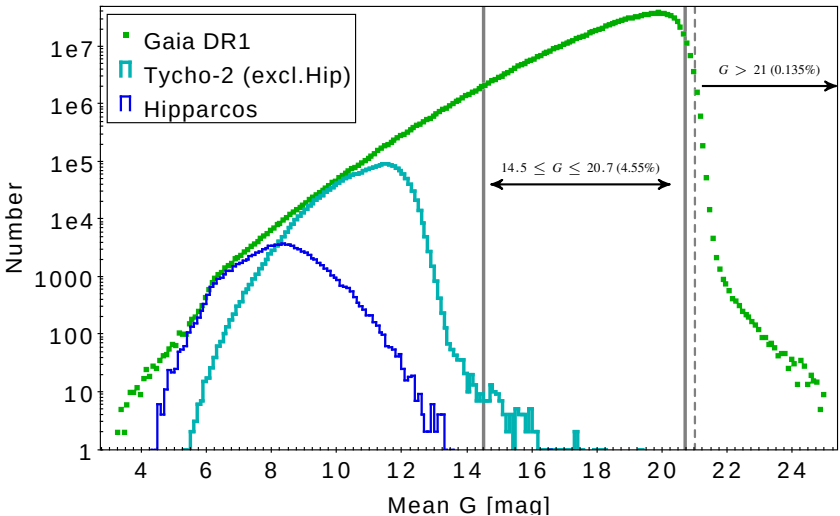






Variable stars near
south ecliptic pole
(~ 600 Cepheids,
~ 2600 RR Lyrae)

Gaia DR1 magnitude distribution

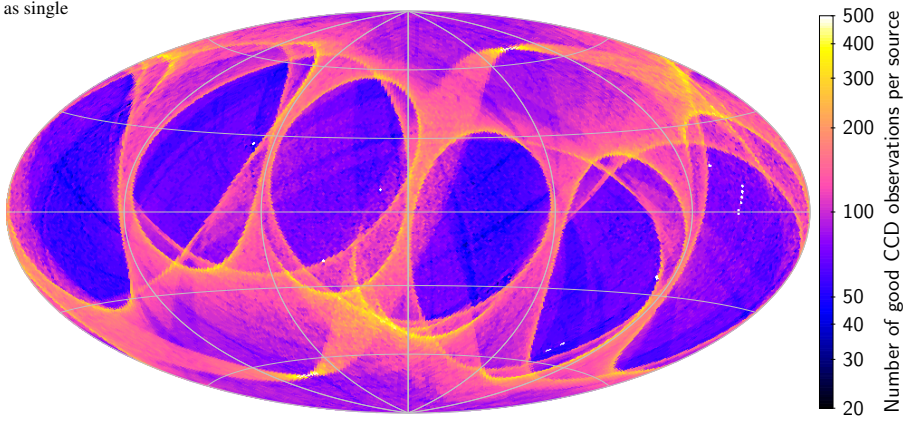


Gaia Collaboration, 2016, A&A

Gaia DR1 input data

- 14 months of input data used
- $\sim 2.3 \times 10^{10}$ transits across focal plane
- all sources treated as single

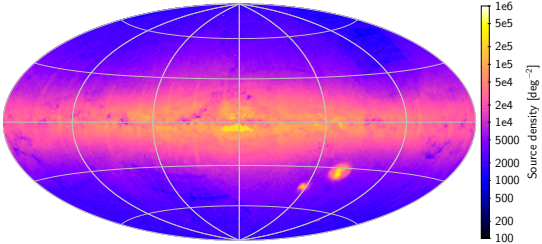
TGAS Mean no. observations per source (pixel $\sim$ 1 deg^2)



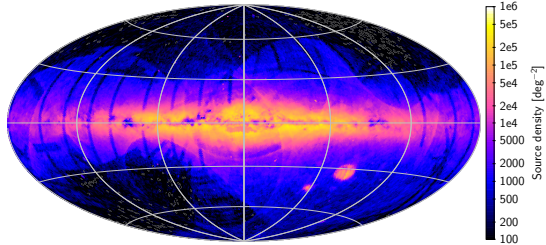
DPAC/CU3/Lindegren et al., 2016, A&A

Gaia DR1 astrometry

685 million sources matched to IGSL



456 million new sources in Gaia DR1



DPAC/CU3/Lindegren et al., 2016, A&A

- (α, δ) for ~ 1.1 billion sources to $G = 20.7$
- Epoch J2015.0, alignment to ICRF < 0.1 mas, rotation < 0.03 mas yr^{-1}
- Typical position uncertainty ~ 10 mas
- Positions of 2191 ICRF sources from special astrometric solution (Mignard et al., 2016, A&A)
  - 90% with $\sigma_{\rm pos} < 3.35$ mas
  - no systematic differences with radio positions of more than few tenths of mas

Gaia DR1 astrometry

Tycho-Gaia Astrometric Solution (Michalik et al., 2015, A&A)

- Use Hipparcos or Tycho-2 position as prior to disentangle parallax and proper motion
  - 2 million stars in common with these catalogues
- 5-parameter astrometry from $\sim$ 1 year of Gaia data
- *No Hipparcos parallaxes used*

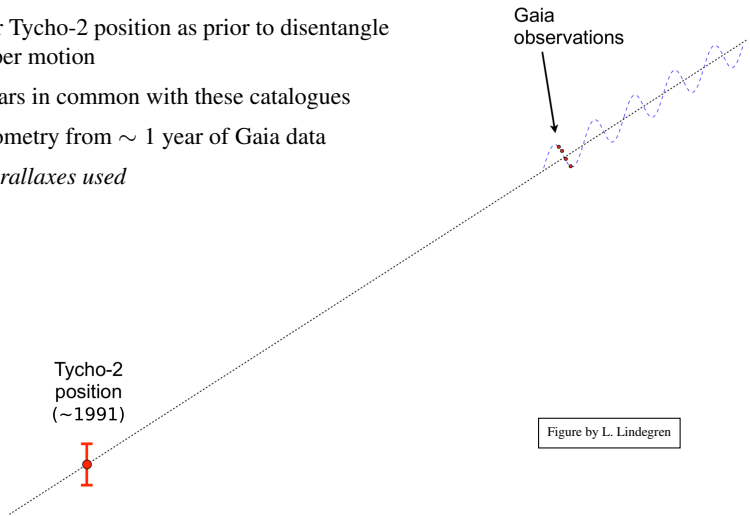
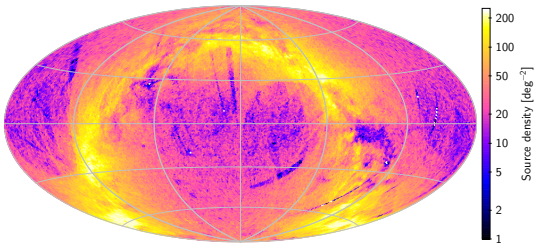


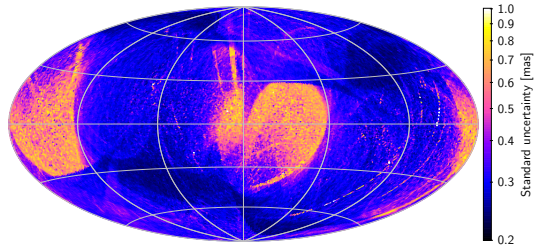
Figure by L. Lindegren

Gaia DR1 astrometry

TGAS source density over cells of ~ 0.84 deg^2



TGAS median parallax uncertainty over cells of ~ 0.84 deg^2

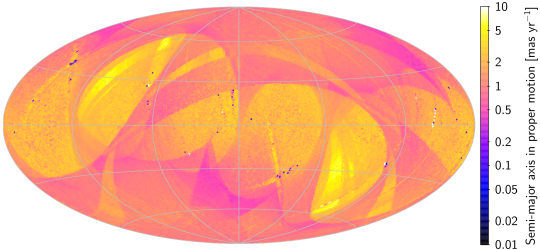


DPAC/CU3/Lindegren et al., 2016, A&A

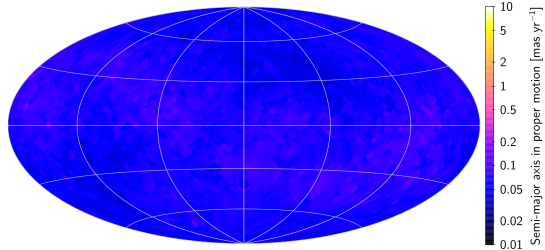
- Parallaxes and proper motions for ~ 2 million sources to $G \sim 11.5$ (TGAS)
- Realistic errors derived from Gaia-Hipparcos comparison
- Median position uncertainty ~ 0.3 mas
- Median parallax uncertainty ~ 0.3 mas; global zeropoint below ± 0.1 mas; systematics at 0.3 mas level

Gaia DR1 astrometry

TGAS median proper motion uncertainty over cells of ~ 0.84 deg^2



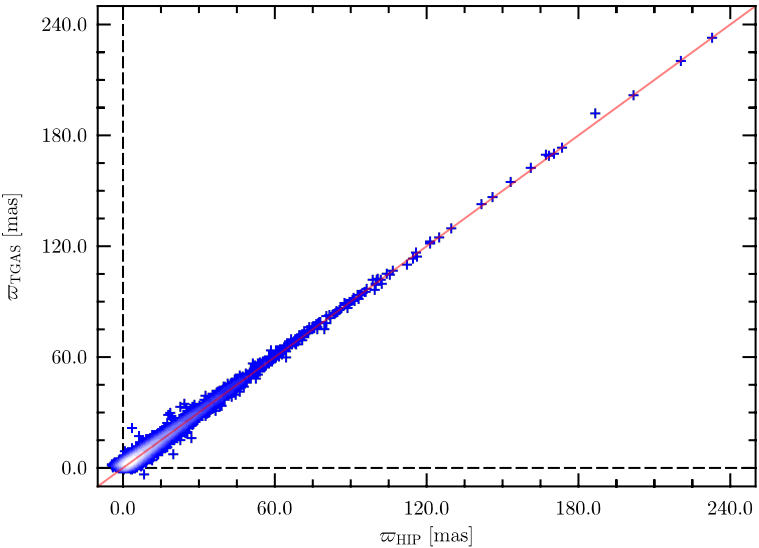
Hipparcos sub-set



DPAC/CU3/Lindegren et al., 2016, A&A

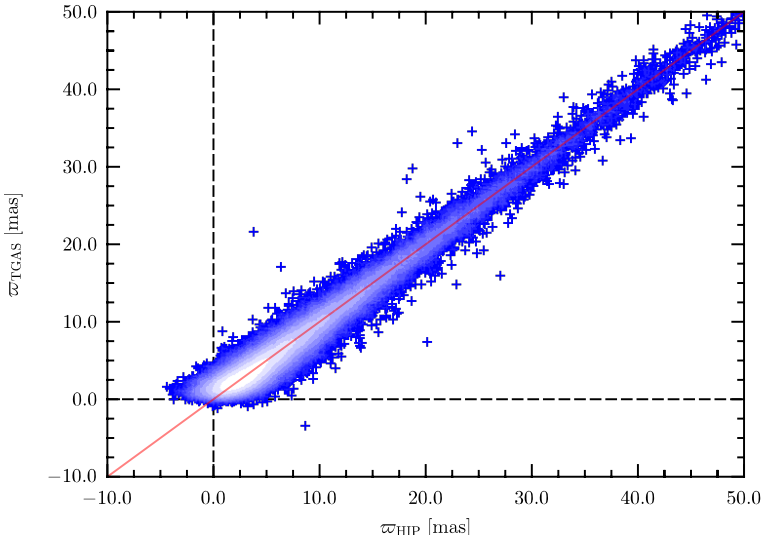
- Median TGAS proper motion uncertainty ~ 1.3 mas yr^{-1} (semi-major axis error ellipse)
  - Hipparcos subset: ~ 0.07 mas yr^{-1}

Gaia DR1 astrometry



- TGAS and Hipparcos parallaxes are independent!
- Comparison confirms global quality of Hipparcos and Gaia
- Analysis allows for derivation of realistic error estimates
- These realistic errors are published in Gaia DR1

Gaia DR1 astrometry



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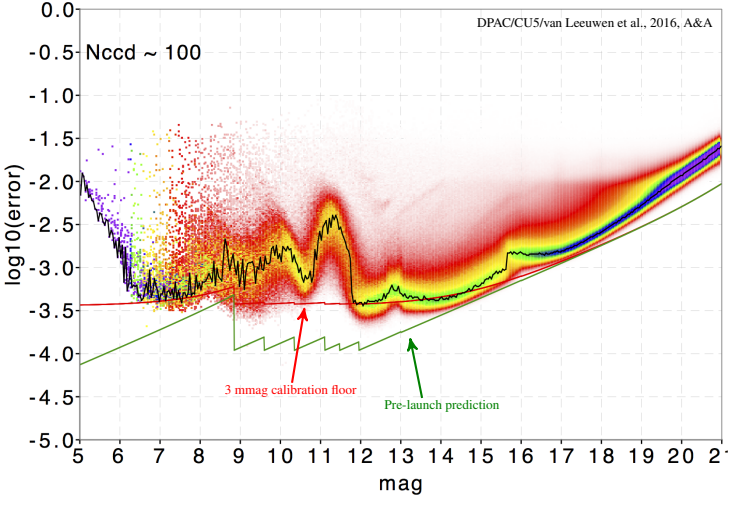
Gaia DR1 Photometry

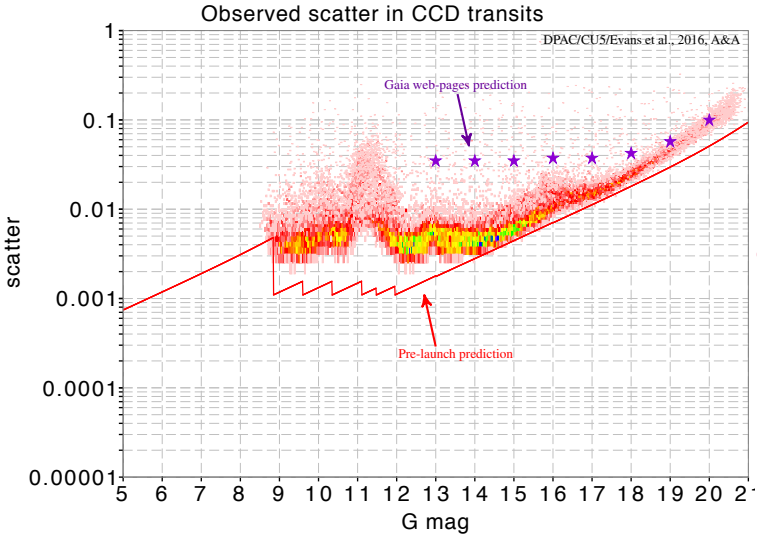
Error on the weighted mean G value for sources with $\sim$ 100 CCD transits



- Mean G-band fluxes and errors for all Gaia DR1 sources
  - G magnitudes in VEGAMAG, zeropoints for AB
  - No pass-band calibrations, transformations to other systems to be provided

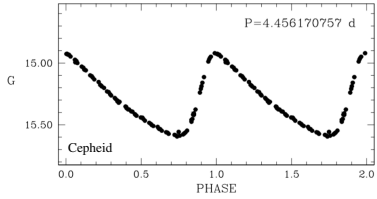
- CCD-transit G-band calibration systematics at the $\sim$ 3 mmag level
- Bright end features related to on-board instrument configuration changes
  - will be calibrated out in future releases

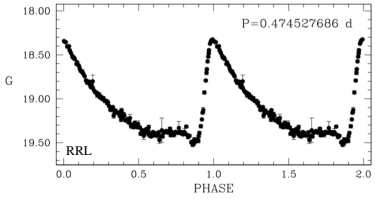
Gaia DR1 Photometry

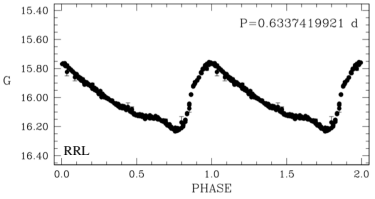


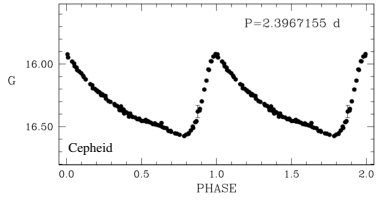
- Observed scatter in repeat measurements of constant sources demonstrates quoted uncertainties are good indicators of precision

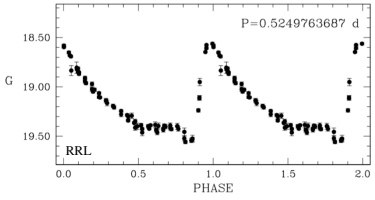
Gaia DR1 Variable Stars





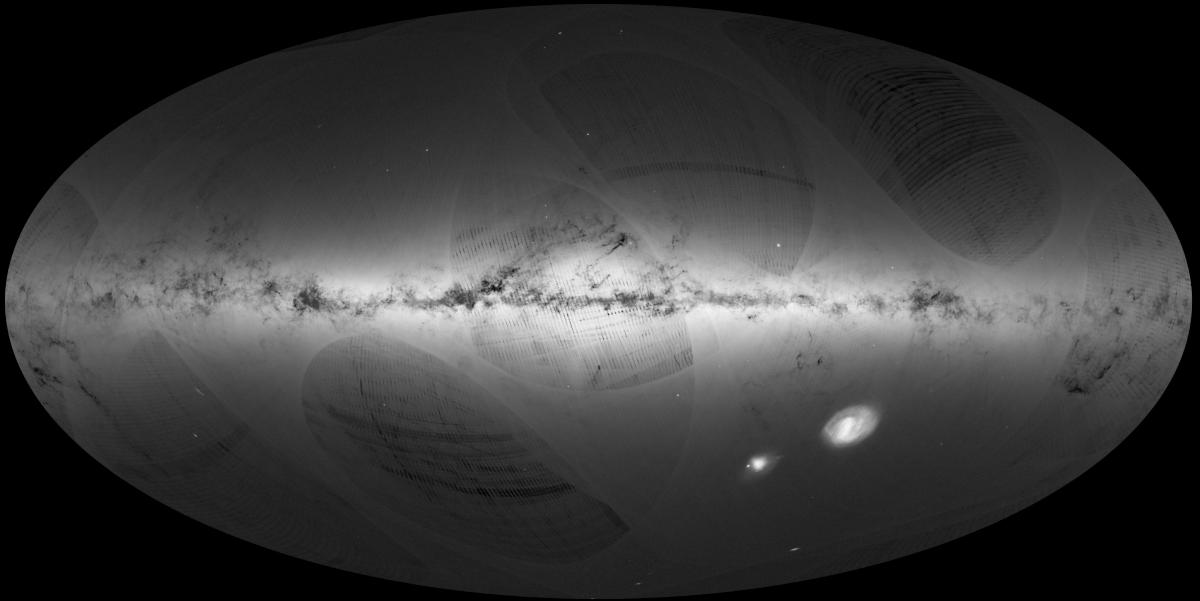




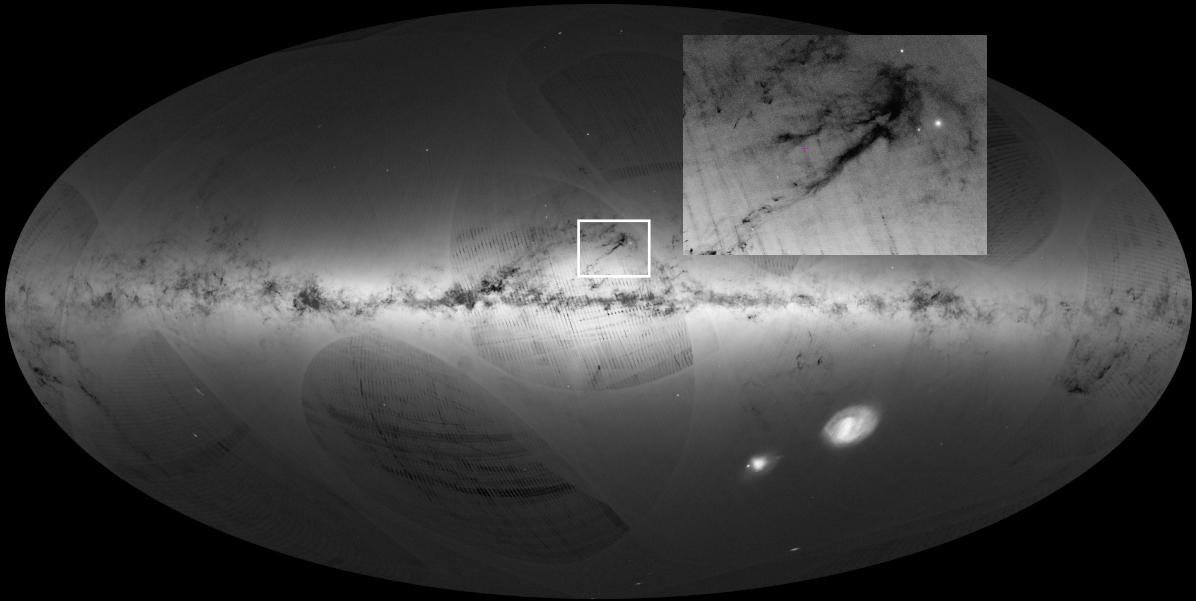


- *G*-band light curves for variables near South Ecliptic Pole
  - 599 Cepheids (43 newly discovered)
  - 2595 RR Lyrae (343 newly discovered)
- Classification information
- Statistical information on time series

DPAC/CU7/Clementini et al., 2016, A&A



ESA/Gaia/DPAC/André Moitinho & Márcia Barros (CENTRA - University of Lisbon)



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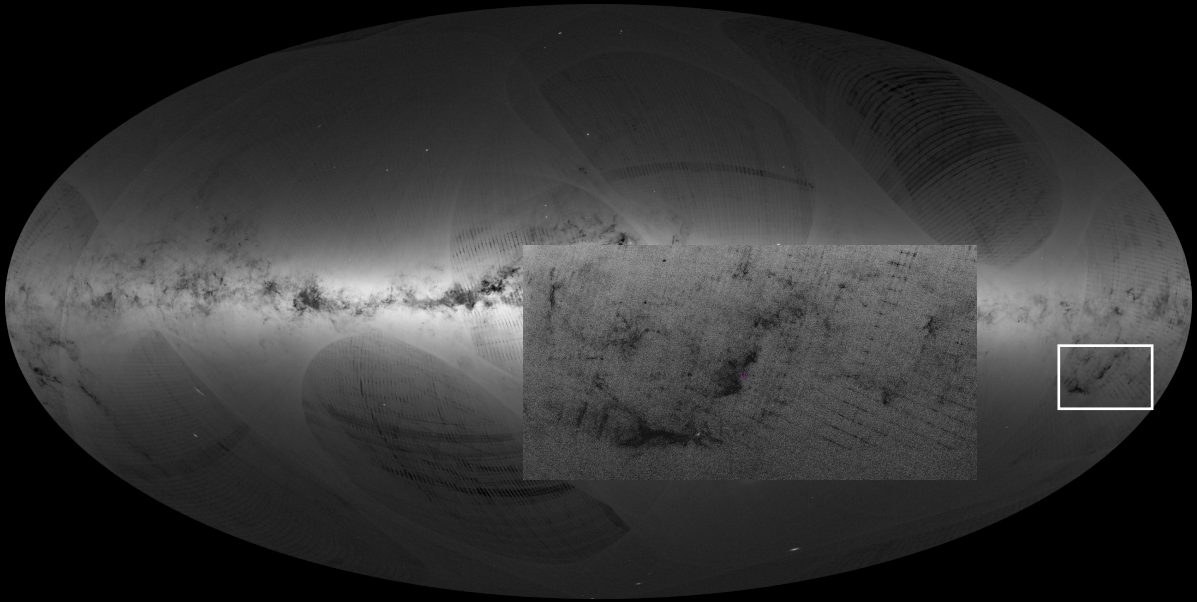

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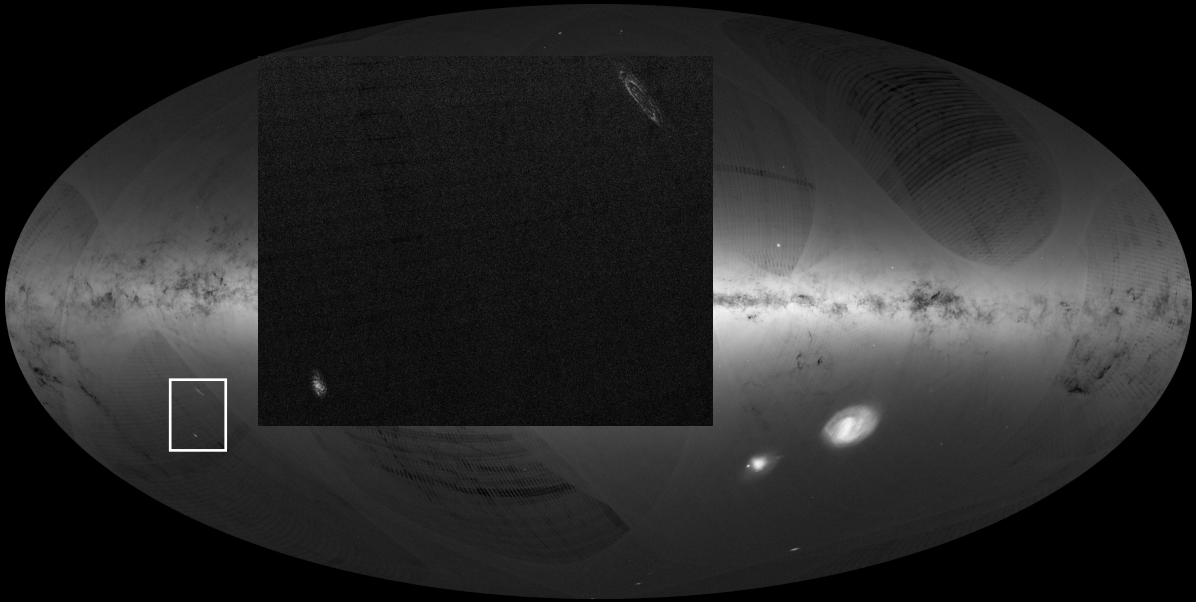

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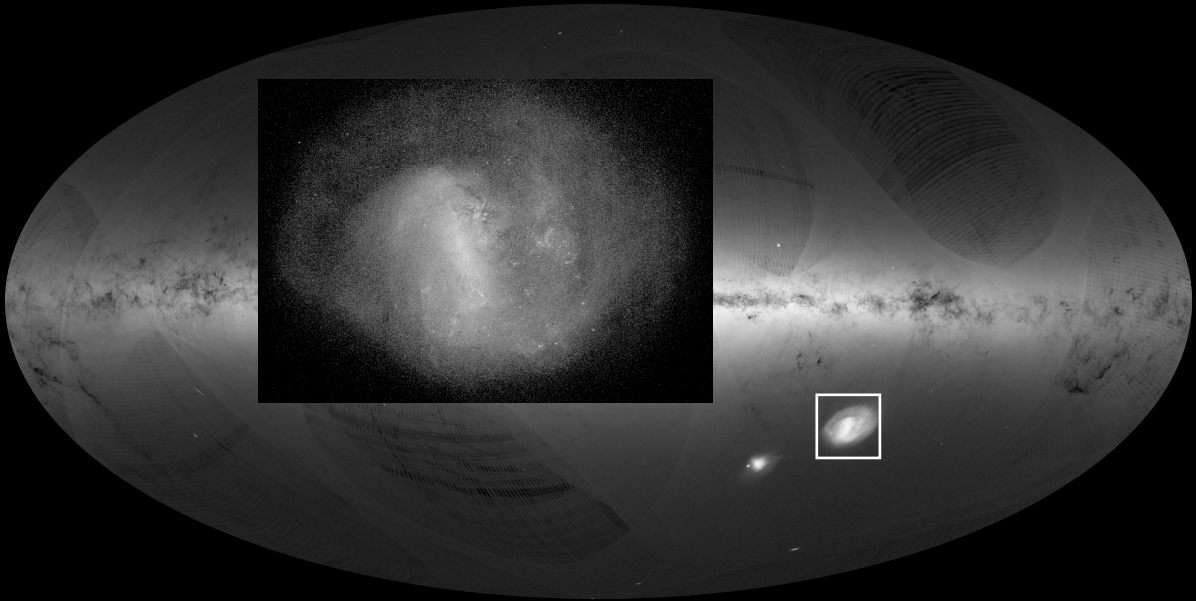
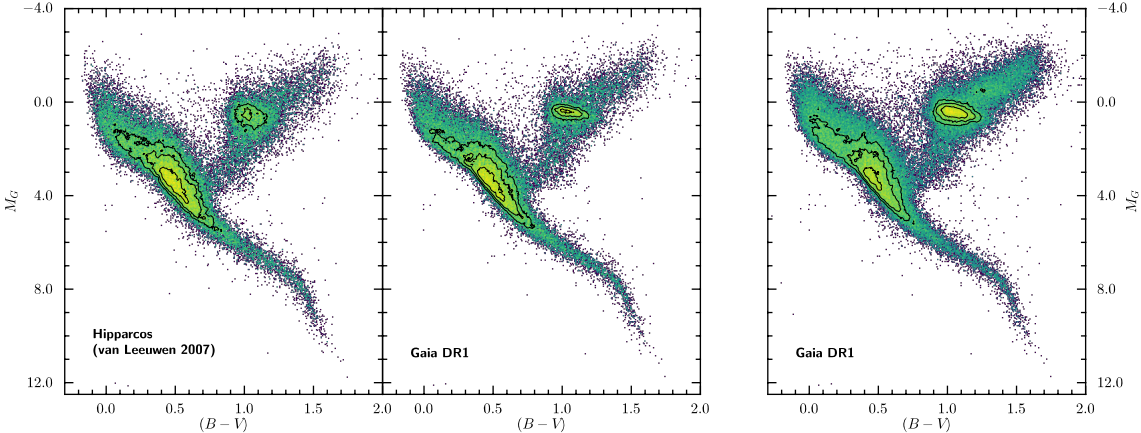


ESA/Gaia/DPAC/André Moitinho & Márcia Barros (CENTRA - University of Lisbon)

HR diagrams with TGAS

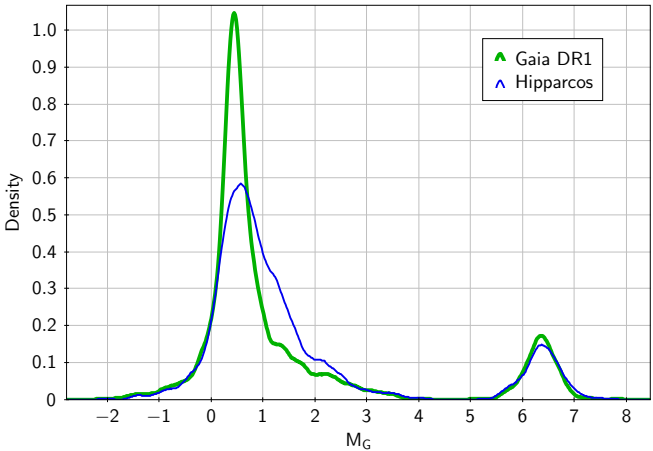
Hipparcos *and* Gaia DR1 parallaxes precise to $\leq 20\%$
43 546 stars, 90% stars inside 280 pc

Gaia DR1 parallaxes precise to $\leq 20\%$
77 771 stars, 90% inside 450 pc



All stars from Hipparcos Catalogue (figure from Gaia Collaboration, 2016, A&A)

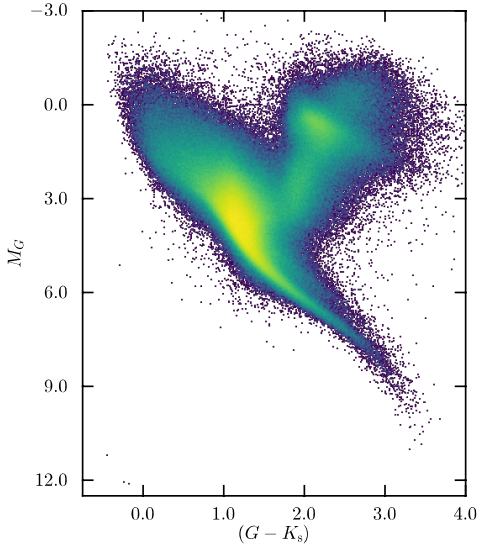
HR diagrams with TGAS



- Distribution of M_G for stars with $1.0 \leq (B-V) \leq 1.1$ and $\varpi/\sigma_{\varpi} \geq 5$
- Comparison robust scatter estimate for M_G:
  - Red clump: Hipparcos 0.5, Gaia DR1 0.3
  - Dwarfs: Hipparcos 0.4, Gaia DR1 0.3

Gaia Collaboration, 2016, A&A

HR diagrams with TGAS

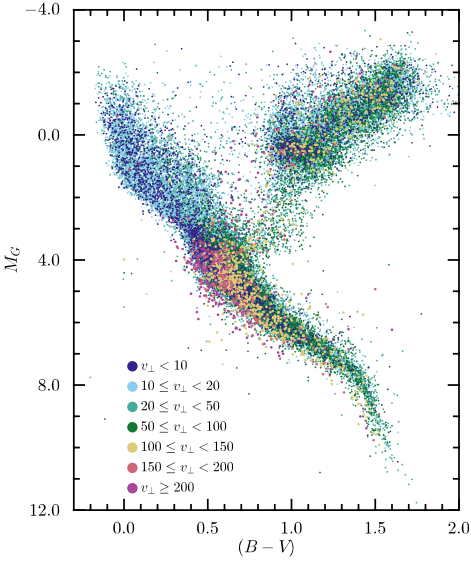


Full Gaia DR1 data set

- 1 million stars with parallaxes precise to $\leq 20\%$
- 90% inside 590 pc
- Future
  - $\sim$ 10 million parallaxes precise to 1%
  - $\sim$ 150 million precise to 10%
  - $\sim$ 280 million precise to 20%

Gaia Collaboration, 2016, A&A

HR diagrams with TGAS

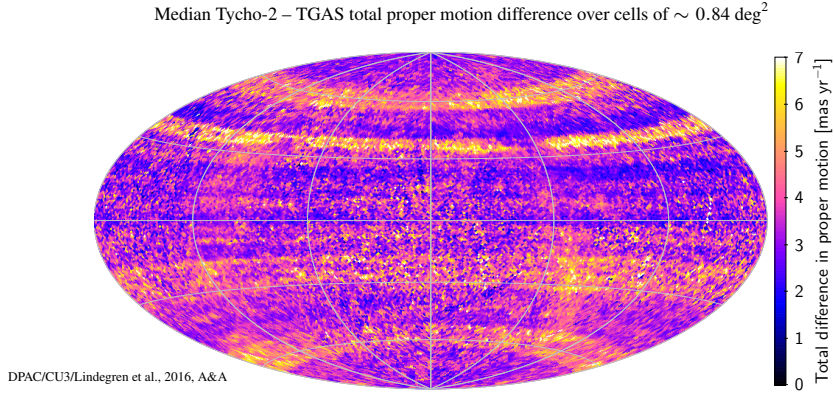


HR diagram colour coded by tangential velocity

- 41 136 stars with $(B-V)$ photometry selected according to: $G \leq 7.5$ or $\mu \geq 200$ mas yr^{-1} or $\varpi \geq 10$ mas
- 90% inside 360 pc

Gaia Collaboration, 2016, A&A

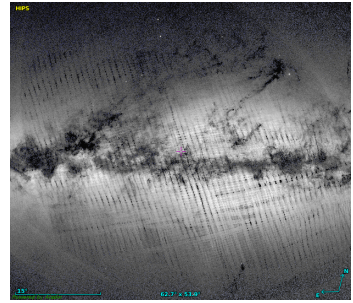
Proper motions Gaia DR1



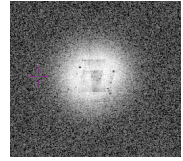
- Declination zones visible in map indicate systematics in Tycho-2 proper motions
- Beware large Gaia DR1 – Tycho-2 proper motion discrepancies
  - likely a problem in Tycho-2

Remarks on Gaia DR1 completeness

- Gaia DR1 not complete in any sense
- Ill-defined and celestial position dependent faint limit
- Scanning law + filtering on data quality $\longrightarrow$ source density artifacts
- Many bright stars missing at $G \lesssim 7$
- High proper motion stars ($\mu > 3.5$) arcsec yr^{-1} missing
- High density regions (few 100 000 stars/deg^2) affected by:
  - onboard resource limitations
  - no treatment of overlapping observation windows
  - completeness limit can be several magnitudes brighter
  - Effective angular resolution of catalogue not yet at end of mission (HST-like) levels
- below 4 arcsec separation many secondary components of binaries missing

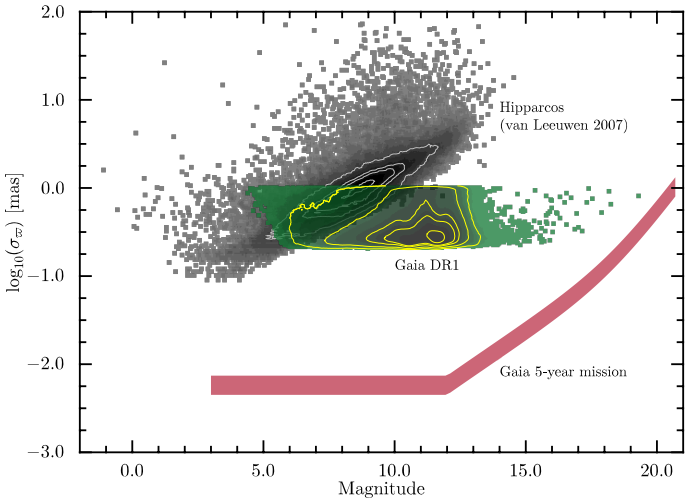


Bulge region



ω Centauri

First vintage: may have some off-tastes



Recommendation: consider the quoted uncertainties on the parallaxes as $\pm\sigma_\varpi$ (random) ± 0.3 mas (systematic).

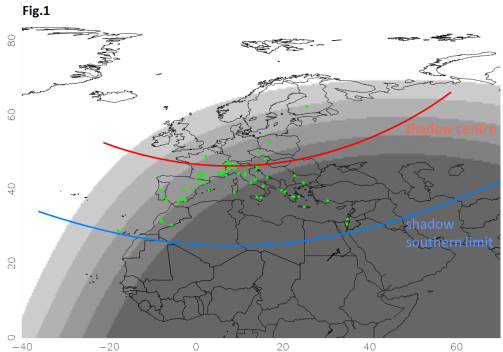
Averaging parallaxes over small regions of the sky will not reduce the uncertainty on the mean below the 0.3 mas level.

All shortcomings will be addressed in future data releases with substantial improvements already foreseen for Gaia DR2

Gaia Collaboration, 2016, A&A

Gaia and Pluto

Pre-Gaia

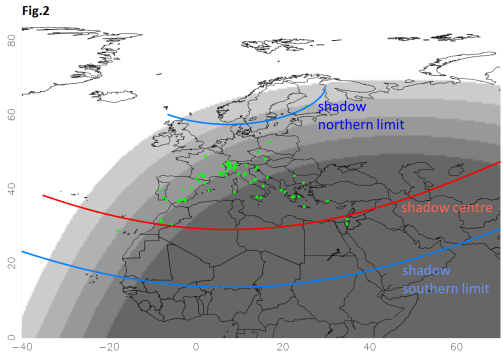


Occultation of UCAC 345-180315 by Pluto on July 19 2016 by

- Gaia position of UCAC 345-180315 released in summer 2016 (Gaia DR0)
- Occulation prediction improved
  - also using improved Pluto ephemeris from New Horizons flyby
- Successful occultation campaign thanks to Gaia position

Gaia and Pluto

Post-Gaia



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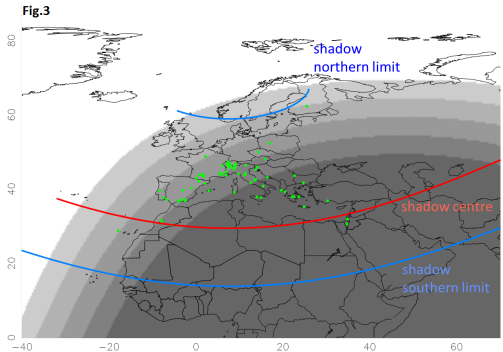
Gaia and Pluto

Actual



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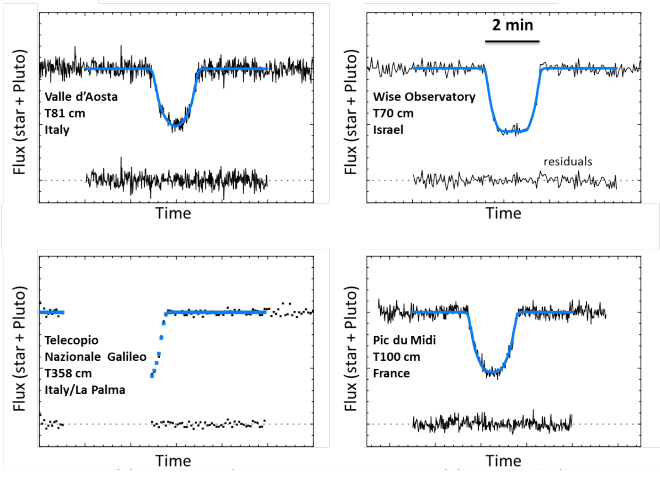
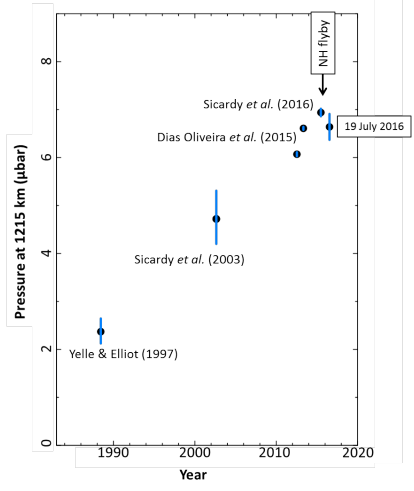
Gaia and Pluto

See http://www.cosmos.esa.int/web/gaia/iow_20160914





Data access

Main portal at ESDC: `http://archives.esac.esa.int/gaia`

- online documentation, VO compatible, TAP interface, visualization apps
- Pre-computed cross-match to large catalogues
- Fast visualization and analysis entire DR1: `http://vaex.astro.rug.nl`
- Command line access: `https://pypi.python.org/pypi/pygacs`

Partner data centres

- Centre de Données astronomiques de Strasbourg (CDS): `http://cds.unistra.fr/gaia`
- ASI Science Data Center (ASDC): `http://gaiaportal.asdc.asi.it`
- Astronomisches Rechen-Institut (ARI): `http://gaia.ari.uni-heidelberg.de`
- Leibniz-Institut für Astrophysik Potsdam (AIP): `http://gaia.aip.de`

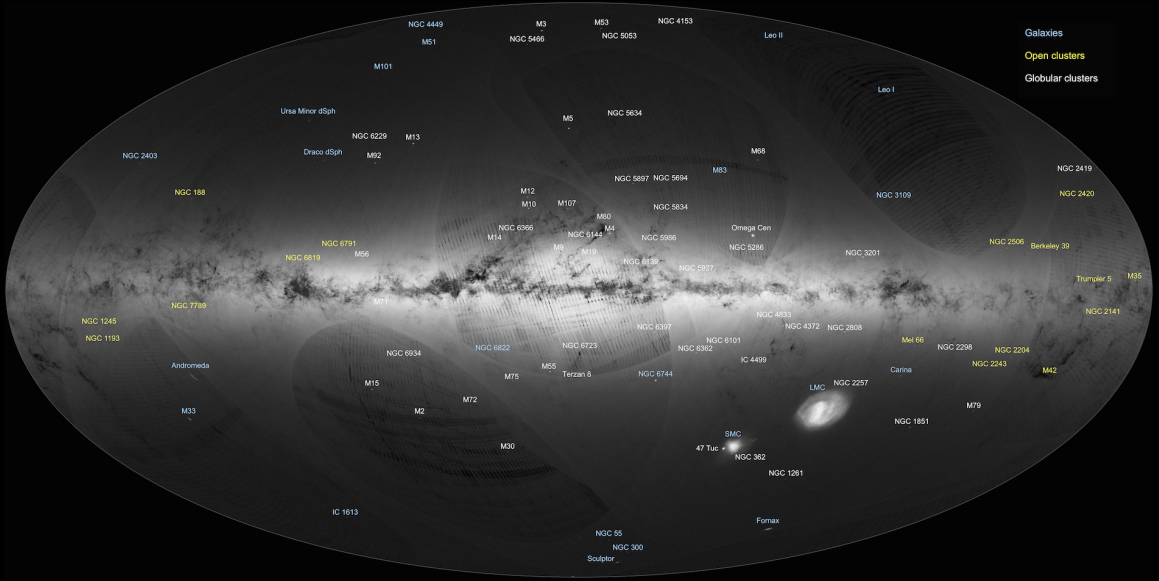
Affiliate data centres

- US Naval Observatory (USNO), Space Telescope Science Institute (STScI), Infrared Science Archive (IRSA)
- National Astronomical Observatory of Japana (NAOJ)
- South African Astronomical Observatory (SAAO)
- Observatoire the Paris-Meudon (ObsPM)

Gaia Data Release 1

- Major advance in mapping of the heavens
- Significant increase in the amount and precision of available fundamental stellar data
- Documentation online and in Astronomy & Astrophysics Special Feature
- Scientific use of the early data will improve quality of future data releases
- Major improvements already planned for Gaia DR2
- Have fun with the data!

ESA/Gaia/DPAC/André Moitinho & Márcia Barros (CENTRA - University of Lisbon)



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