The million of tiny galaxies that Gaia is observing

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The Gaia mission

- Astrometry of stellar content of Milky Way

- Hipparcos distances
- 10 kpc: distances at 10%
- 20 kpc: proper motions at 1 km/s
Gaia will observe many extragalactic objects

**Systematic Survey (G<20)**

- Galaxies (never observed/resolved from earth)
- QSOs (link with ICRF)
Is it possible to extract the morphology of galaxies from Gaia observations?

- What is the sky extragalactic content (GUMS)?
- Which galaxies will be detected (VPA)?
- The science (galaxies, QSOs, gravitational lenses)
The Gaia mission

Nominal Scanning Law

- Observation in **Drift Scan** mode
- **All objects** brighter than $G=20(\text{or } 21?)$ will be observed
The Gaia mission

End of Mission Number of transits

Ecliptic coordinates
The Extragalactic Objects

Treatment by:

- CU3 as any stellar object: \( \alpha, \delta, \mu_\alpha, \mu_\delta, \pi \) + GoF
- CU5 as any stellar object: \( G + GoF \)
- CU8: \textbf{Aps} = Classification

\( \rightarrow \) No morphology

(size of bulb, extension of disc, b/a, ...)

Edwin Hubble's Classification Scheme
The observation

Sky Mapper
Astro Field

Transmission of windows centered on detections
The observation of a galaxy: 1 transit

- Complementarity
- Limitation of window size < few arcsec
- Concern about the possible reduction of the AC size for G<21
The observation of a galaxy: end of mission

- **70 observations** with different transit angles
- Information of **morphology** depending on **coverage fraction**.
The angular coverage

- Light **dependence** on ecliptic longitude
DU470 - Extended Objects treatment

**Galaxies**
- Extended Object flag (issued by CU5 DU18)
- Image Reconstruction
- Image Measurer
- Morphological Classification-SVM
- Morphological & Astrometric Analysis

**QSO**
- QSO flag (issued by CU8)
- Image Reconstruction
- Multiple images
- Morphological & Astrometric Analysis

### r < 2.5"

- Morphology
- Morphological and astrometric parameters

**MDB**
- Host galaxy morphology
- Multiple images flag

Krone-Martins et al. 2013
What is the extragalactic sky content?

• How many Galaxies to process?
• Which types of galaxies in which proportions?

Gaia Univers Model Snapshop (GUMS) (Robin et al. 2012)
Hubble types

Number density distrib in each Hubble type (Schechter's LF) (Fioc & Rocca-Volmerange 1999)

- 58% Spiral
- 25% Irregular
- 13% Elliptical
- 4% QSFG
Most galaxies are smaller than Gaia transmitted window
Bulge to galaxy flux

Bulge/Total flux

- QSFG-Im
- Sd
- Sc
- Sb-Sbc
- Sa
- E2-E-S0

Graph showing the distribution of galaxy types from Sd to E2-E-S0 with their respective flux densities.
Number of galaxies at the reach of Gaia

- **38 Millions** galaxies
  - **Various spread of light**
    - $0 < \frac{\text{Bulge}}{\text{Total}} < 1$
  - $R_{\text{Bulge}} < 2''$
  - $R_{\text{disc}} < 3''$

➡ morphologic analysis possible by DU470
How many galaxies detectable by Gaia? Which?

- Complex filtering based on light profile and flux: VPA
- Galaxies have various light profiles for a same integrated magnitude

- Theoretical approach
- Simulations
Which galaxies will be detected?

Pure discs of spiral galaxies

Fig. 1. Central brightness distribution of spiral disk in the samples of Kent 1985, Courteau, 1996, MacArthur et al, 2003 and Gadotti, 2009. The two dashed lines corresponds to spiral disks having absolute G magnitude of -18 and -22 mag. The solid inclined line corresponds to the limiting surface brightness magnitude for object detection in SM, at a fiducial distance of 10 Mpc, indicating that spiral disks will not be sampled by Gaia.

De Souza et al. 2014
Fig. 3. Central brightness distribution versus effective radius of spheroids of the same data sources used in fig 2. The black lines indicate the predicted position of profiles obeying the Kormendy relation for different values of the exponent $n = 2, 3, 4$ and $5$ of the Sersic profile. The blue lines correspond to the Gaia limiting surface brightness for Sersic spheroids at a fiducial distance equal to 10 Mpc.
Simulation of pure disc and pure bulge galaxies

(A. Krone-Martins)

- 10,000 galaxies
- \( R_D = 0.2'' - 2.0'' \), step: 0.1''
- \( G = 14 - 20 \), step: 0.2 mag
- Nominal scanning law

obs: no additional effects (CRs, CTI, etc.) are being considered in these simulations
Which galaxies will be detected by VPA?

**Discs** (exponential profile) vs. **Elliptics** (Sersic profile)
Which galaxies will be detected by Gaia?

Confirmation of theoretical evaluation of detectability

- <1 million of tiny galaxies (rad<3")
- Mostly elliptic galaxies + S0-Sb
- Few spirals
- Very few irregular
- From local Univers (<600 Mpc)

Very dependent on VPA parametrization
The extragalactique science

• **Morphology of galaxies never observed**
  ➡ Study the local Univers content
  ➡ Luminosity profiles

• **Quasars + host galaxy**
  ➡ Structure optic/radio of QSOs
  ➡ Quasi-Inertial reference system
  ➡ Galactocentric acceleration of solar system

• **Gravitational lenses**
  ➡ Cosmological constraints
Quasars and host galaxy

- 500 000 QSOs observable by Gaia
- Mandatory for the link with ICRF (radio)

➡ Structure of quasars in optic

➡ Perturbation of quasars' astrometry by host
Gravitational lenses

- 1-5% = few thousands detectable by Gaia G<20
- 2 or 3 components (arcs not detectable)

Gravitational lensing statistics of multiply imaged quasars will constrain the cosmological parameters ($H_0$, $\Omega_0$, $\lambda_0$)

Surdej et al. 2010
Operation Plan

- Cycle 4,5,6 : Engineering tests (CU5 + CU8 data)
- Cycle 7 : Start to feed MDB
Thank you!