The Gaia Universe Model

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Abstract

The ESA Gaia astrometric mission has been designed to create an extraordinarily precise 3D map of about a bilion stars throughout our Galaxy and beyond.

The Gaia Universe Model provides the astronomical sources (position, velocity, magnitude and physical parameters), required to generate the simulated data for the development and testing of the massive data reduction software.

A full description of the Gaia Universe model can be found in Robin et al. (2012)

The Besançon Galaxy Model

Galactic objects are generated from a model based on Besançon Galaxy Model (Robin et. 2003) which provides the distribution of stars, their intrinsic parameters and their motions. The stellar population synthesis combines:

• Theoretical considerations such as stellar evolution, galactic evolution and dynamics.

• Observational facts such as the local luminosity function, the age-velocity dispersion relation, the age-metallicity relation.

The Galaxy Model is formed by four stellar populations:

• The thin disk: young stars with solar metallicity in the mean.

• The thick disk: in terms of metallicity, age and kinematics, stars are intermediate between the thin disk and the stellar hallo.

• The stellar halo (spheroid): old and metal poor stars.

• The outer bulge: old stars with metallicities similar to the ones in the thin disk.

Components

Rare objects: Oe and Be stars / Am and Ap/Bp stars / Wolf Rayet (WN/WC/WO) stars | Dwarf and classical novae

M-dwarf flares | Binary systems | Microlensig events | Exoplantes | Single stars

Variable stars: Cepheids, δ Scuti, RR Lyrae, Gamma Doradus, Rapid oscillating AP, ZZ Ceti, Miras, Semiregular, α Canes Venaticorum

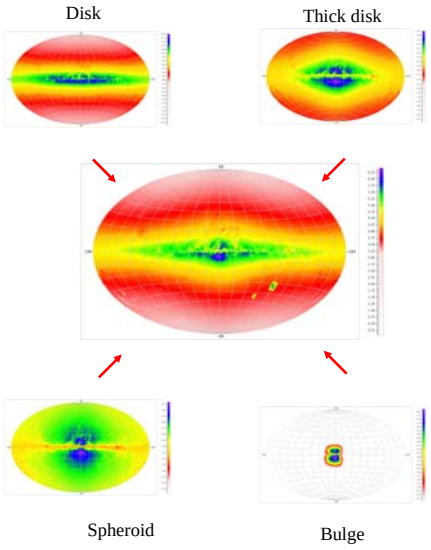
Galactic objects

Luminosity class of generated objects. Percentatges over the total number of stars in each respective column

Luminosity class	G < 20 mag	Grvs < 17 mag	Grvs > 12 mag
supergiant	0.00%	76,825	76,21%
Bright giant	0.81%	14,39%	8,75%
Giants	14.47%	0,58%	0,19%
Sub-giant	15.08%	14.38%	10.32%
Main sequence	69.40%	54.82%	15.76%
Pre-main sequence	0.18%	0.20%	0.08%
White dwarf	0.05%	0.01%	0.03%
Others	0.01%	0.02%	0.02%
Total	1,100,000,000	390,000,000	13,000,000

Number of single and multiple stars generated by the Universe Model. Percentatges over the total stars.

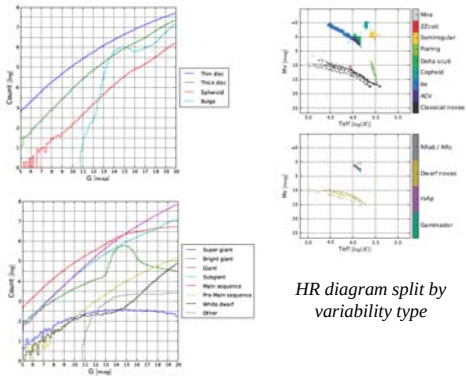
Stars	G < 20 mag	Grvs < 17 mag	Grvs < 12 mag
Single stars	31.59%	25,82%	12,91%
Stars in multiple systems	68,41%	74,18%	87,09%
=> In binary systems	52,25%	51,55%	40,24%
=> Others (terniary, etc.)	16,16%	22,63%	46,85%
Total stars	1,600,000,000	600,000,000	28,000,000
Individually observable	1,100,000,000	390,000,000	13,000,000
=>Variable	1,78%	3,06%	8,37%
=> With planets	1,75%	1,44%	0.66%



Stellar distribution (G<20). Colour scale indicates the log10 of the number of stars per square degree

Star by population. Percentatges over the total number of stars in each respective column

Population	G < 20 mag	Grvs < 17 mag	Grvs > 12 mag
Disk	66,59%	76,825	76,21%
Thick disk	21,88%	14,39%	8,75%
Spheroid	1,25%	0,58%	0,19%
Bulge	10,28%	8,22%	14,85%
Total	1,100,000,000	390,000,000	13,000,000



HR diagram split by variability type

Star distribution split by stellar population (top) and by luminosity class (bottom)

Extragalactic objects

Resolved galaxies

Magellanic clouds have been simulated from catalogues of stars and their characteristics (magnitudes B, V, I, T_{eff}, log *g* and spectral type) (Belcheva et al. 2011).

Unresolved galaxies

Most of the galaxies observed by Gaia will not be resolved in their individual stars. Unresolved galaxies are simulated using Stuff (catalog generation) and Skymaker (shape/image simulation) codes from Bertin (2009), adapted to Gaia by Dollet (2004) and Krone-Martins et al. (2008).

Quasars

QSOs are simulated from the scheme proposed by Slezak & Mignard (2007). Lists of sources have been generated with similar statistical properties as the SDSS, but extrapolated to G=20.5 and taken into account the flatter slope expected at the faint-end of the QSO luminosity distribution.

Supernovae

A set of supernovae are generated associated with galaxies, with a proportion for each Hubble type.

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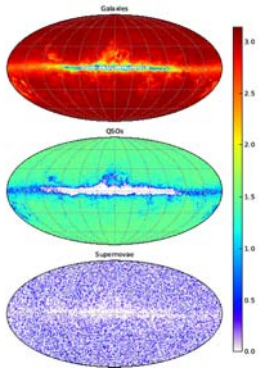
Overview of extragalactic objects

Stars	G < 20 mag	Grvs < 17 mag	Grvs < 12 mag
Stars in LMC	7,550,000	1,039,000	5,600
Stars in SMC	1,250,000	161,000	950
Unresolved galaxies	38,000,000	3,000,000	4,320
QSO	1,000,000	5,200	11
Supernovae	50,000	-	-

Spectral types of stars from LMC/SMC

Spectral type	G < 20 mag	Grvs < 17 mag	Grvs < 12 mag
O	0.25%	0.17%	0.39%
B	3.24%	3.40%	1.85%
A	17.20%	5.01%	4.83%
F	0.00%	0.00%	0.00%
G	45.98%	23.16%	55.19%
K	32.62%	64.82%	35.33%
M	0.71%	3.44%	2.41%
Total	8,800,000	1,200,000	6,600



Total sky distribution of unresolved galaxies, quasars and supernovae. Colour scale indicates the log10 of the number of objects per square degree

The extinction model

The extinction model. Applied to galactic and extragalactic objects, is based on the dust distribution model of Drimmel et al. (2003). It's an 3D extinction model that includes both a smooth diffuse absorption distribution for a disk and the spiral structure and smaller scale corrections based on the integrated dust emission measured from the far infrared.

References

•Belcheva et al. 2011, private comunication

•Dollet, C., 2004, PhD Thesis, Tech. rep., Université de Nice

•Krone-Martins, A. G. O., Ducourant, C., Teixeira, R., & Luri, X., 2008, in IAU Symposium, Vol. 248, IAU Symposium, ed. W. J. Jin, I. Platais, & M. A. C. Perryman, 276-277

•Robin, A. C., Reylé, C., Derriére, S., & Picaudm S. 2003, Astronomy and Astrophysics (ISN 004-6361), 409, 253

•Robin, A.C., Luri, X., Reylé, C., Iasasi, Y., Grux, E., Blanco-Cuaresma, S., Arenou, F., Babusiaux, C., Belcheva, M., Drimmel, R., Jordi, C., Krone-Martins, A., Masana, E., Mauduit, J.C., Mignard, F., Mowlavi, N., Rocca-Volmerange, B., Sartoretti, P., Slezak, E. & Sozzetti, A., 2012, Astronomy and Astrophysics (in press)

•Slezak, E. & Mignard, F. 2007, A realistic QSO Catalogue for the Gaia Universe Model, Tech. rep., Observatoire de la Côte d'Azur, GAIA-C2-TN-OCA-ES001-1

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