Preparing the Besancon Galaxy Model for the comparison with Gaia data

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Abstract

The construction of a dynamical model of our Galaxy is one of the primary goals of the Gaia mission. Kinematic and star count data, together with the physical parameters of the stars - ages and metallicities-, will allow to characterise our Galaxy populations and, from that, the overall Galactic gravitational potential. One of the promising procedures to reach such goal will be to optimise the present Population Synthesis models by fitting, through robust statistical techniques, the large and small scale structure and kinematics parameters that best will reproduce Gaia data. We present here the comparison between the data from the Tycho-2 catalogue and the Besancon Galaxy Model simulations.

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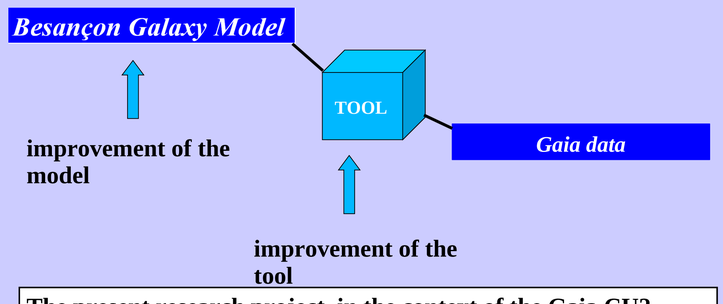
Kinematic and star count data, together with the physical parameters of the stars - ages and metallicities, will allow to characterize our Galaxy populations, and from that, the overall **Galactic gravitational potential.**

Observables
- → kinematics ↔ local gravitational potential ↔ dark matter
- → Stellar counts ↔ IMF SFR ↔ total mass in stars

To be prepared for an optimum exploitation of the huge amount of Gaia data.



Aim of the project:

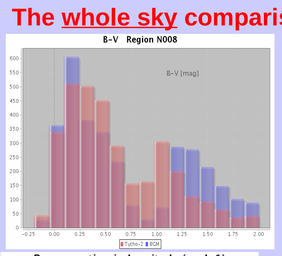
1. Improve the kinematics of the Besançon Population Synthesis model.

2. Examine different IMF and SFR scenarios.

The present research project, in the context of the Gaia CU2 coordination unit, will allow refining the simulation of the sky as observed by Gaia. The current Gaia simulator is based mainly on Besançon Galaxy Model. Further evolution and complexification of this model is desired!

Tycho-2 catalogue ? **Besançon Galaxy Model**

The whole sky comparison for a magnitude limited sample!



Stars up to V = 11 mag
(catalogue completeness ~ 99%)
Apprx. 860 000 stars in 472 fields

Comparison of
- **Star counts**,
- **(B-V)** colour and
- **proper motion**

distributions.

First analysis

All Sky Plots and more detailed examinations:

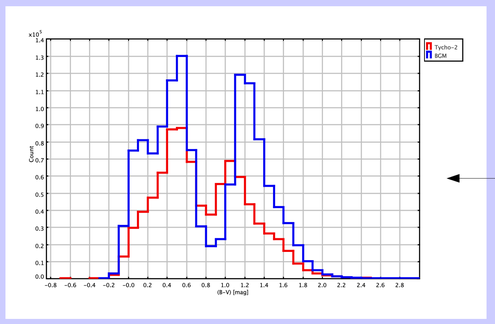
Extinction models comparison;

Star counts analysis;

Proper motion analysis;

BGM and Tycho show significant differences.

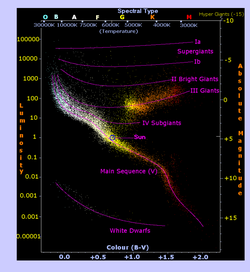
OUR FUNDAMENTAL PROBLEM we met while working with Tycho-2



BGM vs. Tycho-2

B-V distribution

Cumulative all sky histograms, but the same tendencies are present in every single field analysis.



Three main discrepancies we have to deal with are:

1) **The shift of the red peak** when comparing model and data **~0.2** mag.

2) The proportion of number of objects in each peak between model and data.

3) **The difference in the total number of objects.**

The list of possible scenarios which could be responsible for what we see in B-V distribution:

- Extinction law
- Photometry transformation
- Binarity
- Evolutionary tracks
- IMF & SFR.

At present a particular IMF, SFR and evolutionary tracks are frozen inside the BGM without a possibility to modify them.

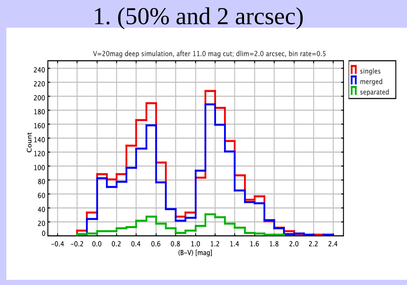
- age – metallicity distribution (Haywood, M. 2006)
- Teff, log g, metallicity → B-V

3. Binarity. Our tests.

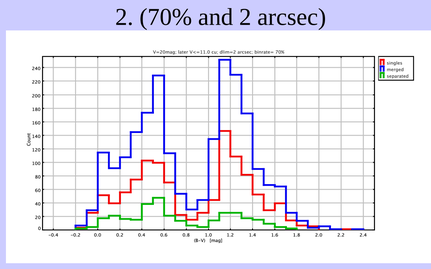
single stars color distribution vs. multiple stars color distribution

The shift of the red peak could be caused by the fact that the BGM produces only individual stars !? while in the real data there must be many multiple systems.

1. (50% and 2 arcsec)



2. (70% and 2 arcsec)



We have developed a code which transforms a factor of our simulated sample into double systems.
The user specifies two parameters:
binarity rate and angular separation limit of the catalogue.

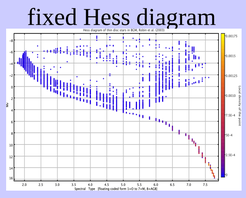
Changing the separation limit would change the proportion between merged and separated stars.
Separated double have the same (B-V) distribution as singles!
Changing the binarity rate changes the star counts of each three groups of stars.

None of this two parameters has an impact on the peaks positions in the (B-V) distribution.

Besançon Galaxy Model – turning the **IMF**, **SFR** and **evolutionary tracks** into **free user specified parameters.**
This coding task is actually an important change in star production philosophy.

Present stars production

fixed Hess diagram



For all volume elements on the line of sight,

for each population separately,

summation on whole Hess diagram.

reading input data : **SFR, IMF and evolutionary tracks**

In a volume element:

calculate **the total mass reservoir** according to the density laws (parameters + gradients) +**SFR**

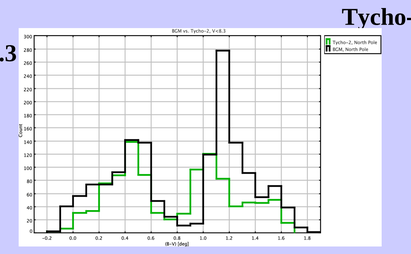
generate star by star until there is **mass available, mass reservoir > 0**

The mass of each individual star is being drawn according to the shape of **IMF**

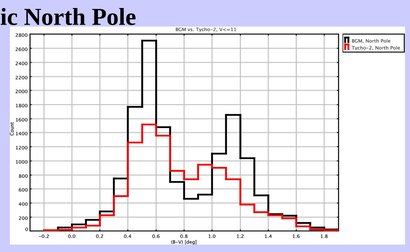
when age, mass and metallicity of a star are known we find its position (Teff, log(g), Luminosity) on HR diagram from **evolutionary tracks.**

Tycho-2 vs. BGM, Galactic North Pole

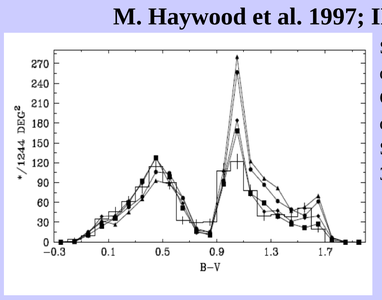
V<8.3



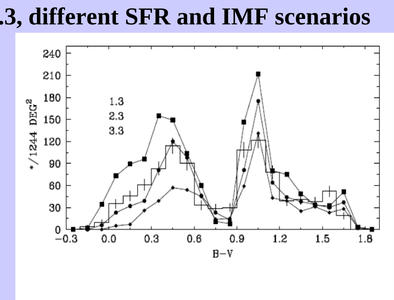
V<11.0



M. Haywood et al. 1997; INCA stars with V < 8.3, different SFR and IMF scenarios



Squares - increasing SFR,
diamonds - constant,
Circles and triangles for decreasing
SFR with amplitudes
3.5 and 7 respectively.



SFR-constant,
3 different slopes of the IMF
in the mass range from 1 to 3 solar masses.