An edutainment tool for visiting our Galaxy

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Motivation

In a few years from now, the Gaia survey will deliver a 3D survey of our Galaxy. In advance to the actual data, our project, "Real-Time & Interactive Galaxy for Edutainment" (RTIGE), is using simulations for allowing a full 3D visit of our Galaxy. We aim at developing a tool, as up-to-date and as rigorous as possible, allowing to visit the Milky Way with real-time rendering, despite the difficulty of representing the huge number of objects. This tool intends to be used for both educational and outreach purposes, in particular in planetariums, allowing to show what happens behind our 2D scene. We describe here how the astronomical part of this tool is being constructed.

Dynamical model

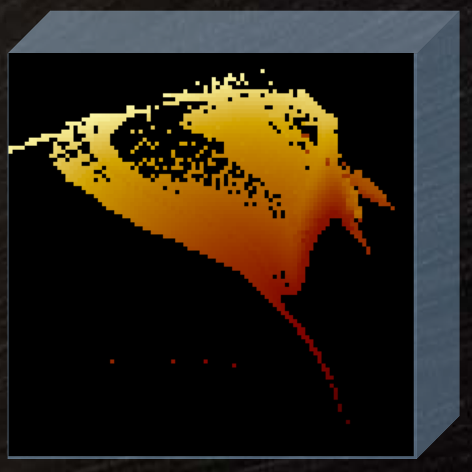
This is the deepest layer of our simulation. The Milky Way simulated data comes from one of the GalMer-HR models, a considerable smoothed-particle hydrodynamics computational effort to provide to the scientific community a very large set of colliding galaxy pairs, and the evolution of the corresponding galaxies in isolation as well, in order to study statistically the impact that interactions and mergers have on the chemodynamical evolution of galaxies.

The model that we are using is made of three parts with 10 million particles each: star particles, hybrid (gas+stars) particles and dark mater particles. Each particle has information about mass, position, velocity and metallicity.

Intrinsic star parameters model

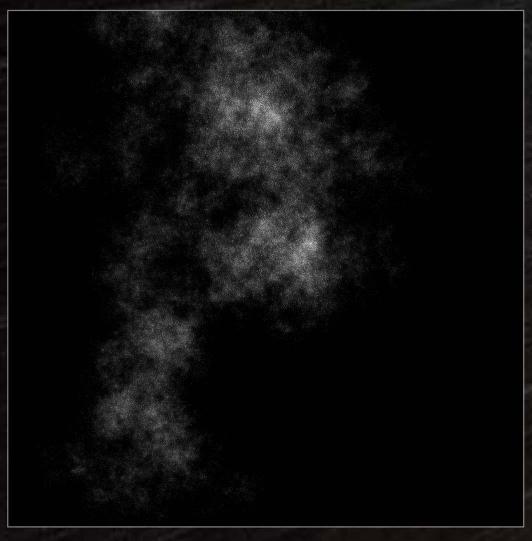
This layer gives both the intrinsic parameters of all stars in a particle or cluster, and the luminosity and color of a particle seen from a distance. We use Padova isochrones and discretize them to build a data cube of H-R diagrams, I.e. Log(T_{eff}) vs Log(L_{bol}), made of single isochrones, for 354 ages, from Log(age) = 6.6 to 10.1.

We also derive for each position in the H-R diagram several additional data such as mass, radius, absolute magnitudes, spectral type and a synthetic spectrum. Summing luminosities, weighted by color and number of objects, we get the appearance of a particle seen from a distance. Simulated instrumental filters and interstellar extinction are applied to the spectra before image production. This set of data is available for several metallicities.



Gas layer

For each of the hybrid particles, its history up to 1.2Gyr in the past is known, thanks to the GalMer model. This gives us the amount of gas that turned into stars at each stage, for any of these particles. We currently use a time step of 50Myr, then we use 25 successive GalMer models.



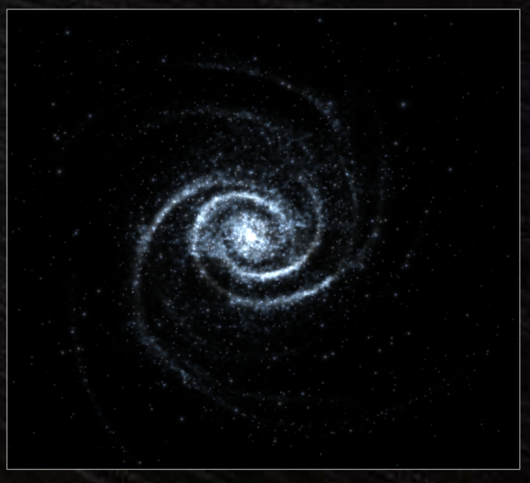
Also available is the metallicity of new born stars and the remnant gas at each stage. The gas part of these particles is simulated as a fractal when the observer zooms. When seen from a distance, noise is added to represent the great scale structures. Work is still ongoing for this part. Interstellar extinction is derived on the line of sight from the mass and metallicity of gas, giving the amount of dust along the line of sight.

Open clusters layer

At each of the 25 stages of the model, we then have the amount of new star masses in each hybrid particle. We also have the amount of star mass created in previous stages, therefore made of older stars. Each particle then contains stars spread into 25 age classes. We turn these 25 galaxy models into 25 voxel grids, each box containing a mass of newly born stars.

An algorithm that runs through this 3D grid then fills an empty 3D grid with open clusters, following an initial cluster mass function, until the two grids are similar in their mass content. Each cluster of each age class is associated to one of the particles in the host voxel. This gives us a simulated 3D catalogue of open clusters for each of the 25 age classes.

For the case of an observer zooming on a cluster, we also developed models of star distributions inside the (open and globular) clusters.



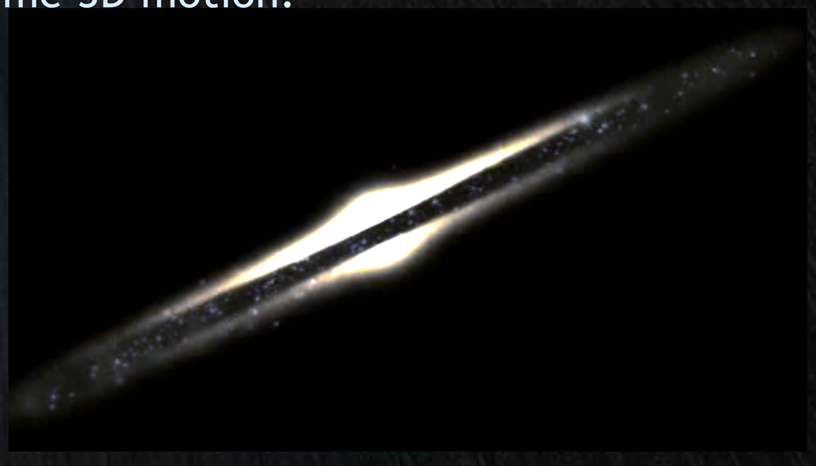
Known stars

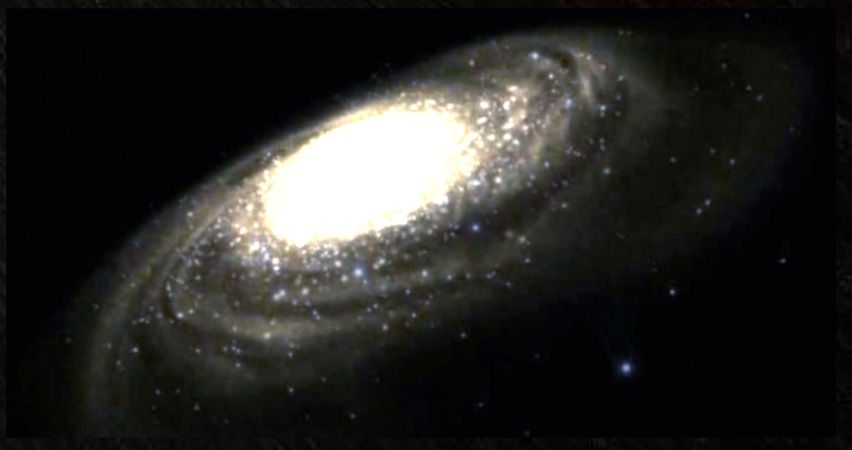
This is one difficult part of the project: implementing real stars to replace the simulated stars in the "bubble" surrounding our Sun, in order to achieve a smooth visible transition between the "real" and the "simulated" Galaxy.

Work is still in progress for this part of the project, but it is planned to set a limit in apparent magnitude, refilling the catalogue of real stars with model stars beyond the completeness limit of the catalogue. We use current indirect distance estimations made by various studies, but the catalogue will be replaced in the future by Gaia, with much precise distance estimates.

Current status

The distant vision of the Milky Way is now implemented, with stars, open and globular clusters and gas. Unfortunately, this 2D poster will hardly show the real-time 3D motion.





Project partners

- Observatoire de Paris-Meudon
  Established in 1667, the largest national centre for research in astronomy
- INRIA
  Created in 1967, the only public research body fully dedicated to computational sciences
- RSA Cosmos
  Since 1985, manufacturer of optical & digital solutions for planetariums.

Some references

- Our ANR funded project (#10-cord-006): http://wwwhip.obspm.fr/RTIGE
- GalMer: http://galmer.obspm.fr (intermediate resolution)
- Fractal clouds: http://adsabs.harvard.edu/abs/1996ApJ...471..816E
- Padova isochrones: http://stev.oapd.inaf.it/cgi-bin/cmd
- Initial cluster mass function: Parmentier et al., 2008, ApJ 678, 347
- Known stars: Pickles & Depagne, 2011yCat..61221437P

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