GAIA
A Galactic Revolution

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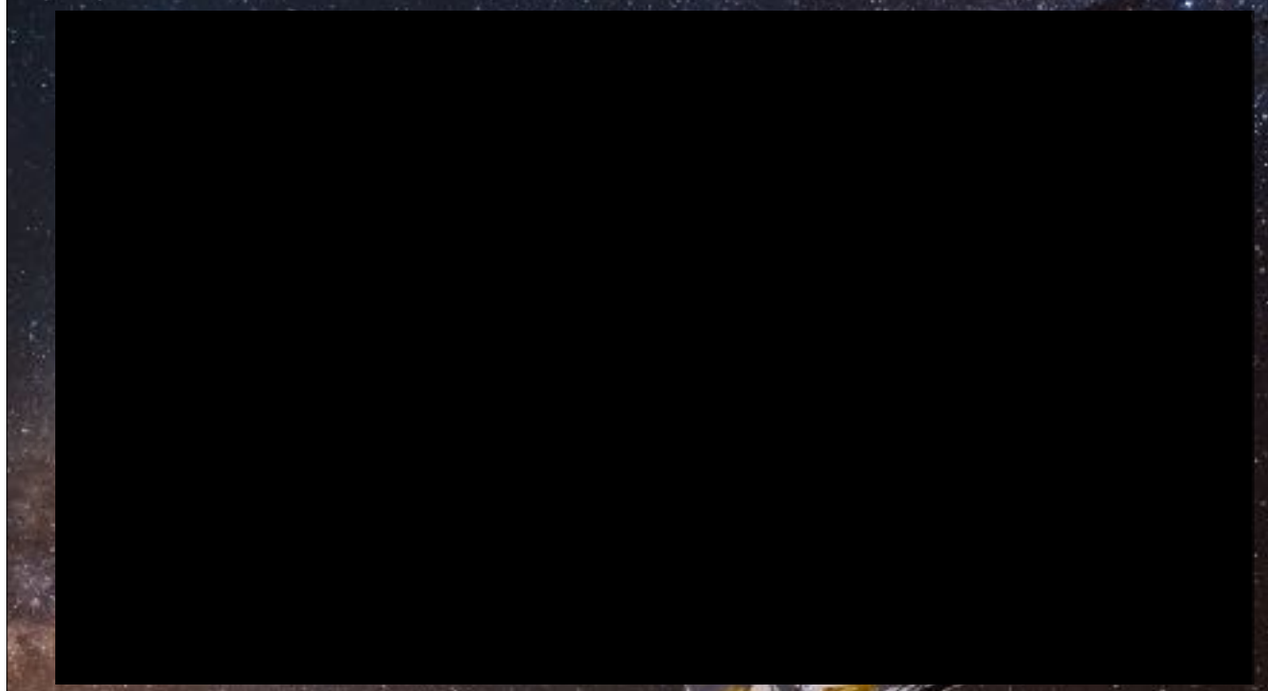
GAIA DPAC member

Good evening everybody and thanks for being here. I am Giorgia Busso and I work at the IoA here in Cambridge. As a member of one of the team processing the Gaia Data I will tell you about Gaia, what it is, what it is doing and about the big changes that will come from the analysis of this data. A revolution indeed, but a pacific revolution, as at most we are going to throw at you a bunch of stars :)

Gaia is a satellite, a space mission of the European Space Agency. Of course this is not a real picture, just an artist impression that shows you how the satellite observe millions and millions, billions! of stars in our galaxy.
In particular Gaia is an astrometric mission, which means that its main scope is to measure the positions and the movements of the stars.
To know where stars are, how they move, what properties they have, to distinguish different star populations and understand how the milky way as we see it now came to be, how it evolved and the causes, and what will be its future.

Gaia was launched in dec 2013 with a Soyuz rocket from the Kourou, in French Guyana. So really an international project. This video shows the final preparations of the mission, before launch, from the test to unfold the solar panel, to the assembly in the fairing, to the transportation
The fairing was like the candle on the top of the cake, actually the other way around, the cake on the bottom of the candle.
After the launch it took roughly a month to arrive in its final location.

WHEN: Launch 19 Dec 2013



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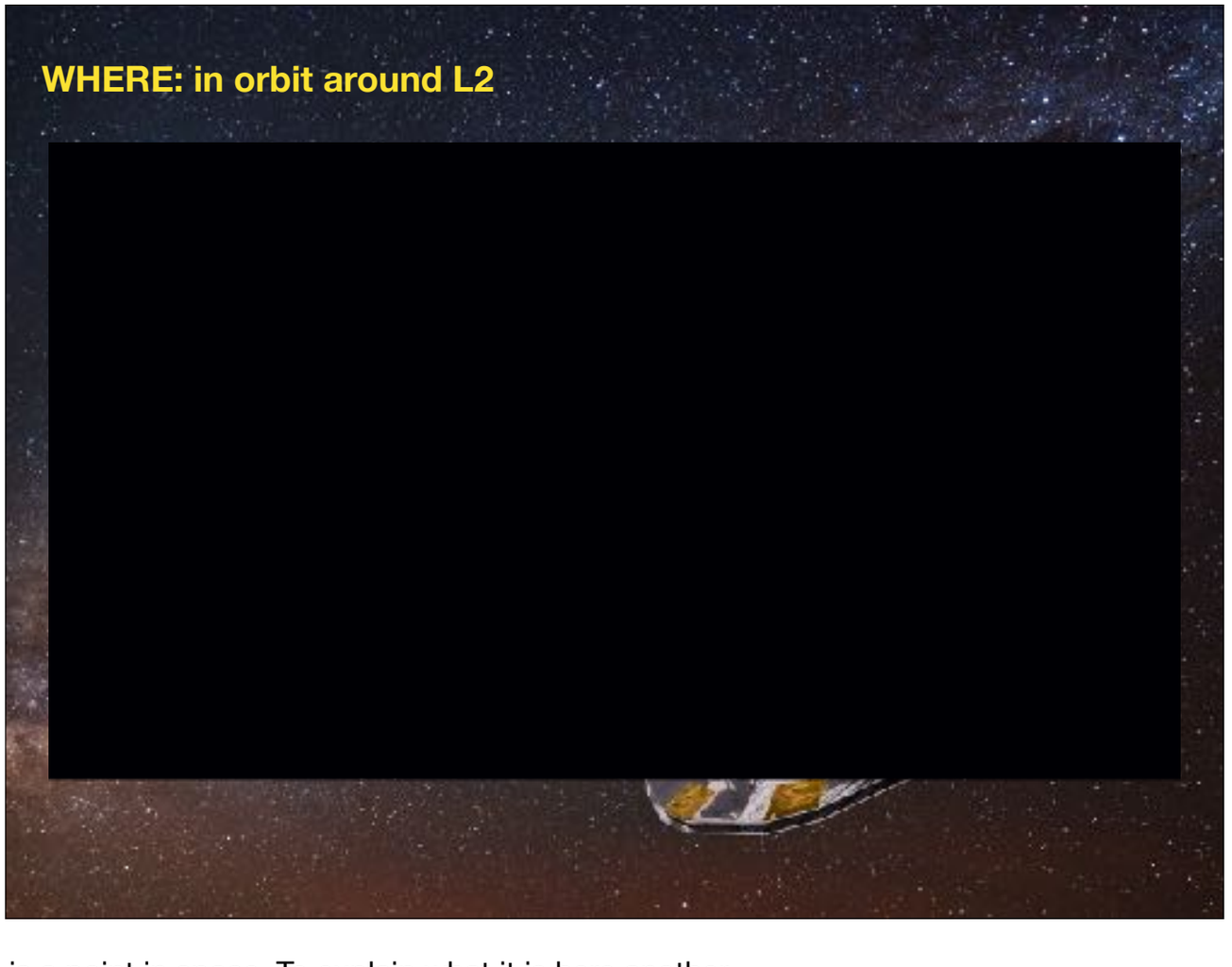
WHERE: in orbit around L2



Gaia location is in orbit around L2 which is a point in space. To explain what it is here another

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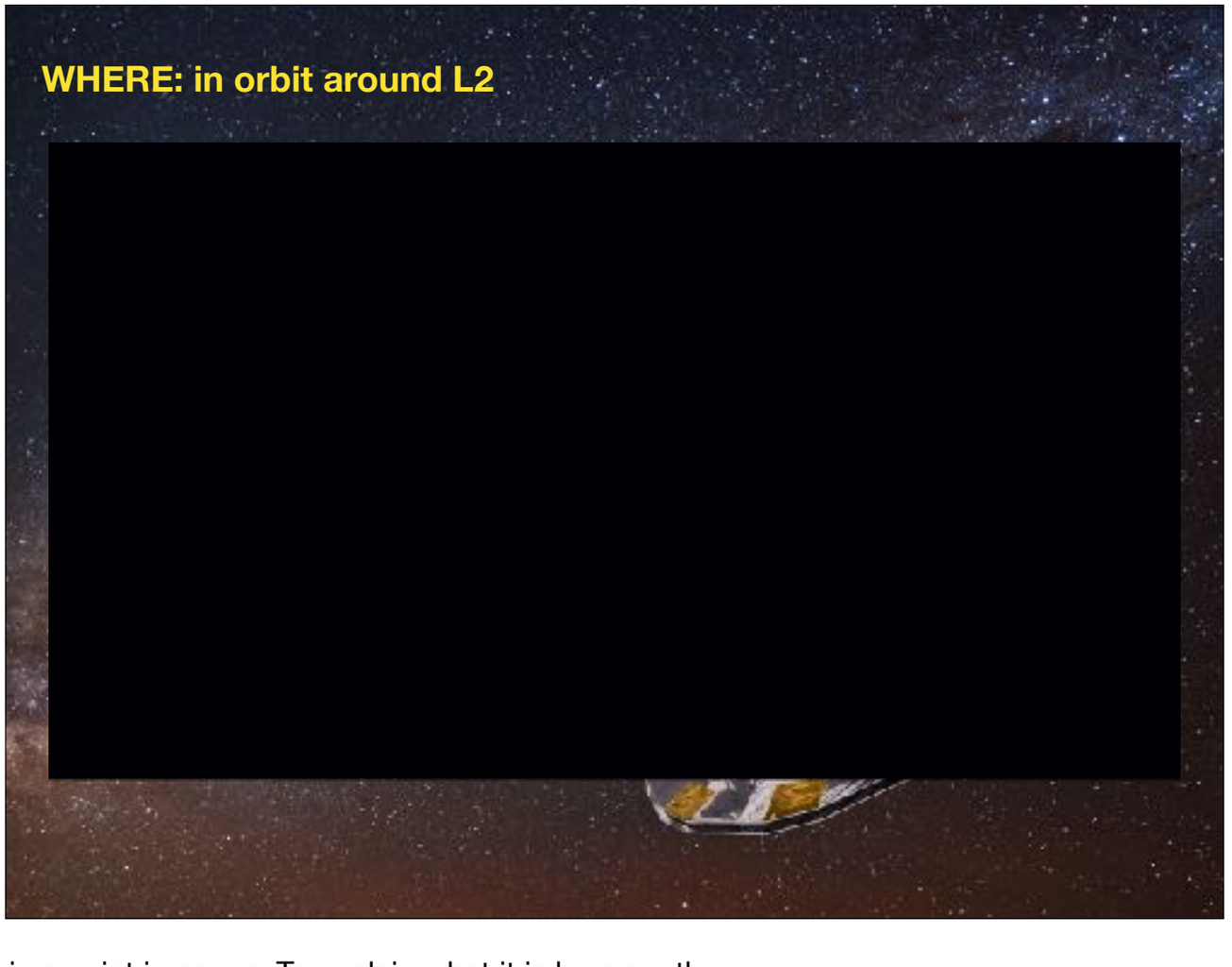

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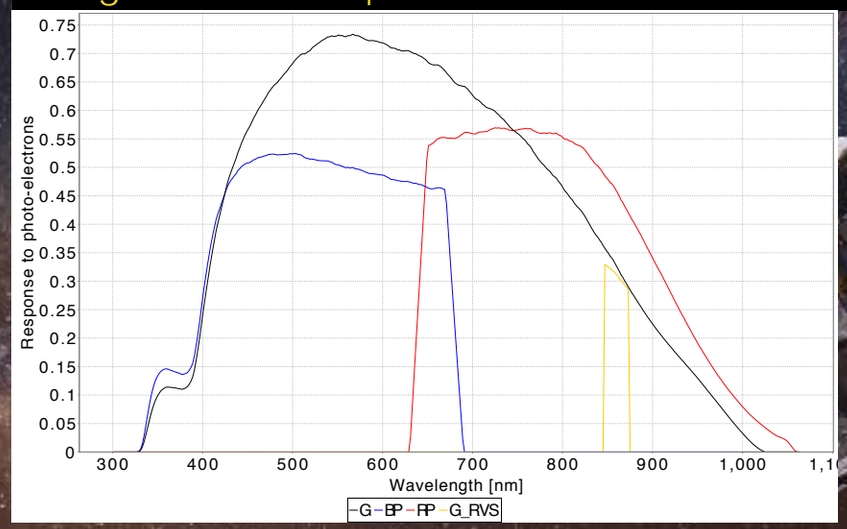
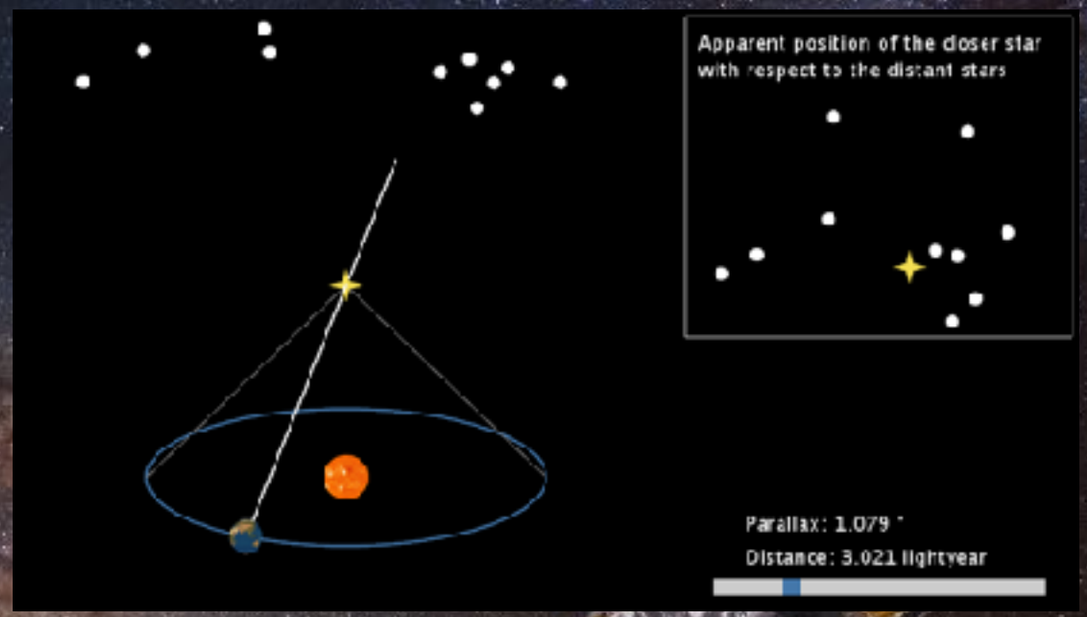
HOW: measuring positions and brightness of the stars

- 2 telescopes with 1.45 x 0.5 m primary mirrors
- Astrometric Field (White Light)
- Blue And Red Photometers
- High-Resolution Spectrometer

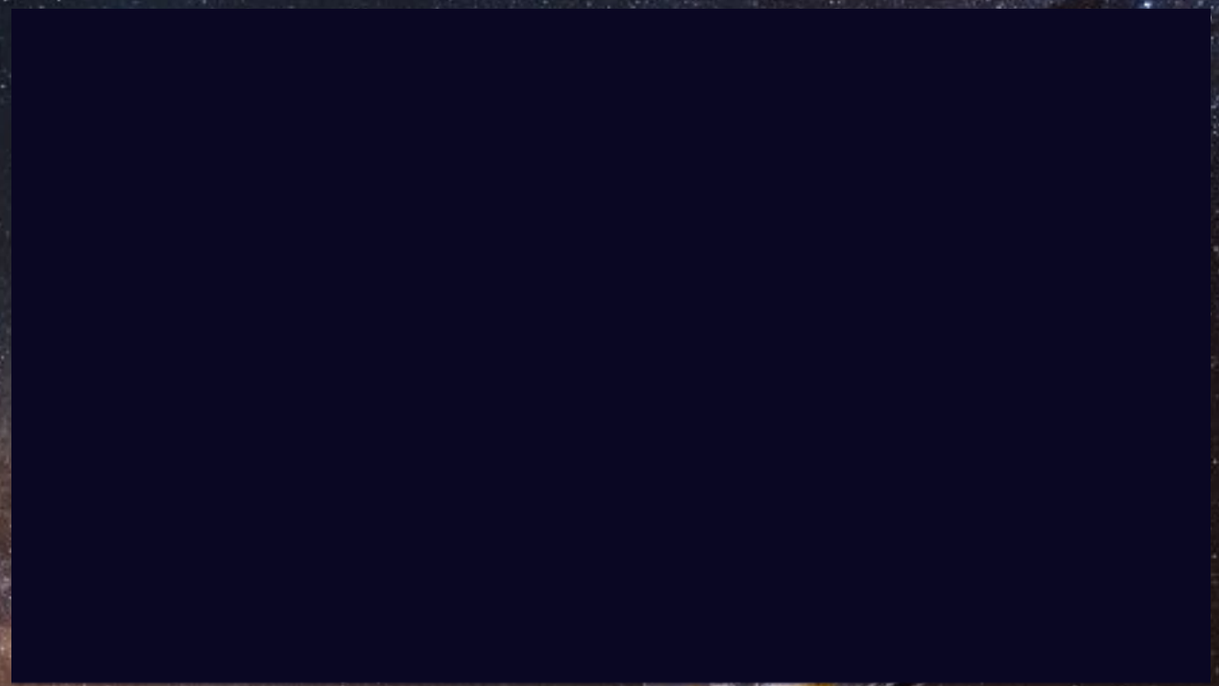


White light because we have more flux coming from the stars and this help in observing better the fainter stars. We use this to measure the position of the stars in the sky. There are also 2 phot, one observing in a Blue band, shorter wavelength, and a red one, longer wavelength, to obtain the color of the star. And finally a RVS, we can observe very accurately the lines in the spectra and from their shift we can measure the radial velocity.

HOW: using the parallax method



HOW: using many observations of the same stars



since Gaia scans the sky in a continuous way, the stars are observed many times, in average 100 time during the whole mission, meaning we can achieve great accuracies and precision. But also we are able to reconstruct the motion of the star. But what we actually see is not the circle, due to the motion of the Earth around of the star but a more complicated pattern. This video shows how.

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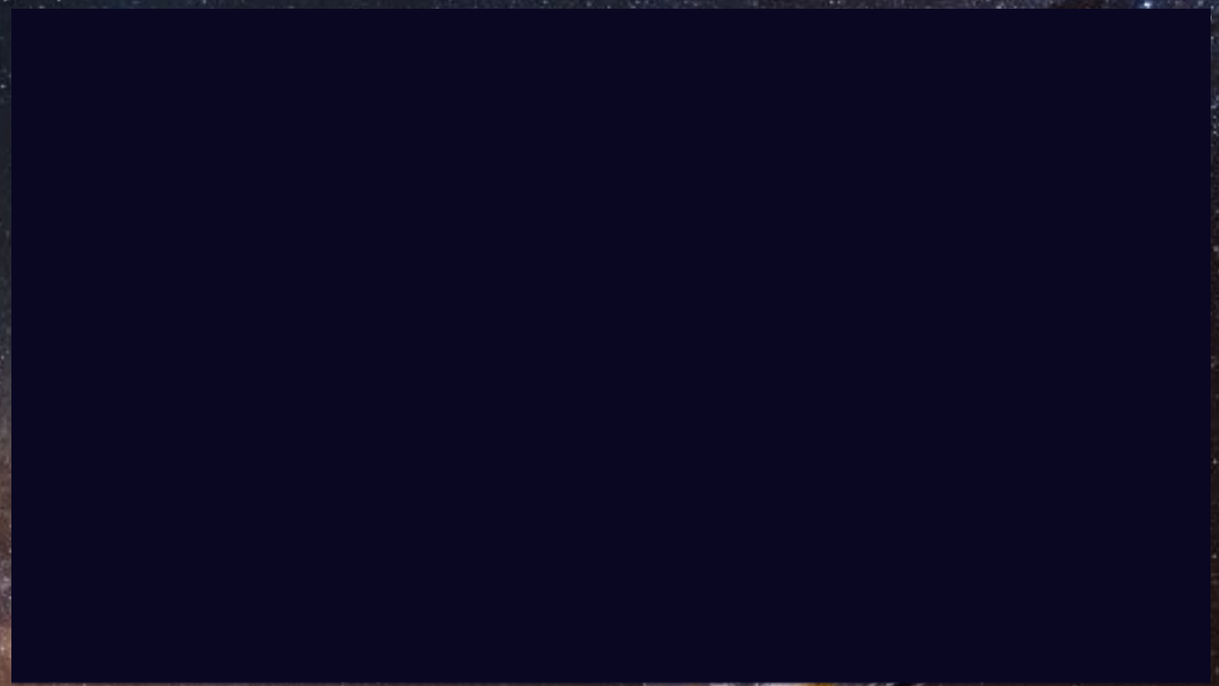

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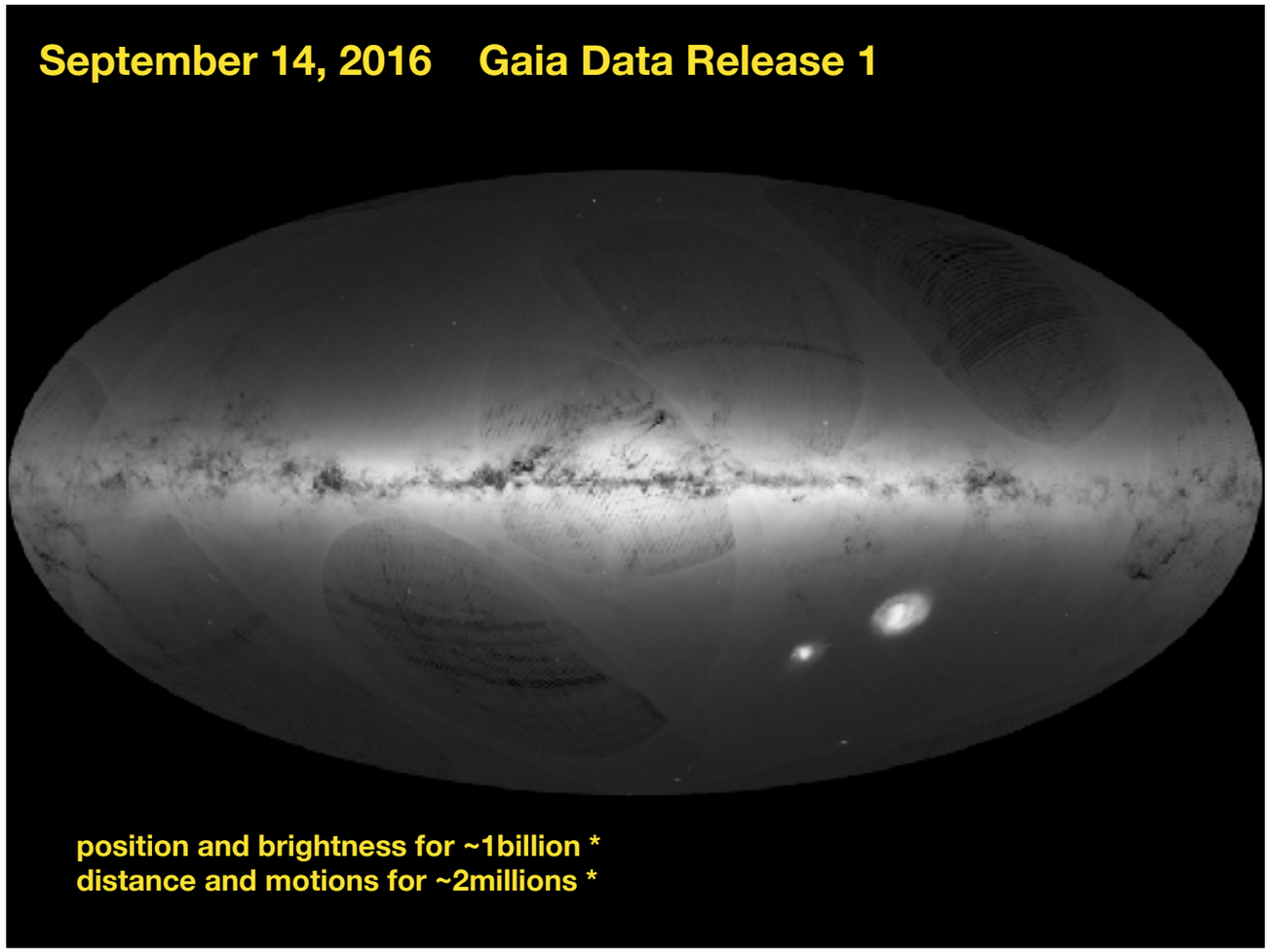
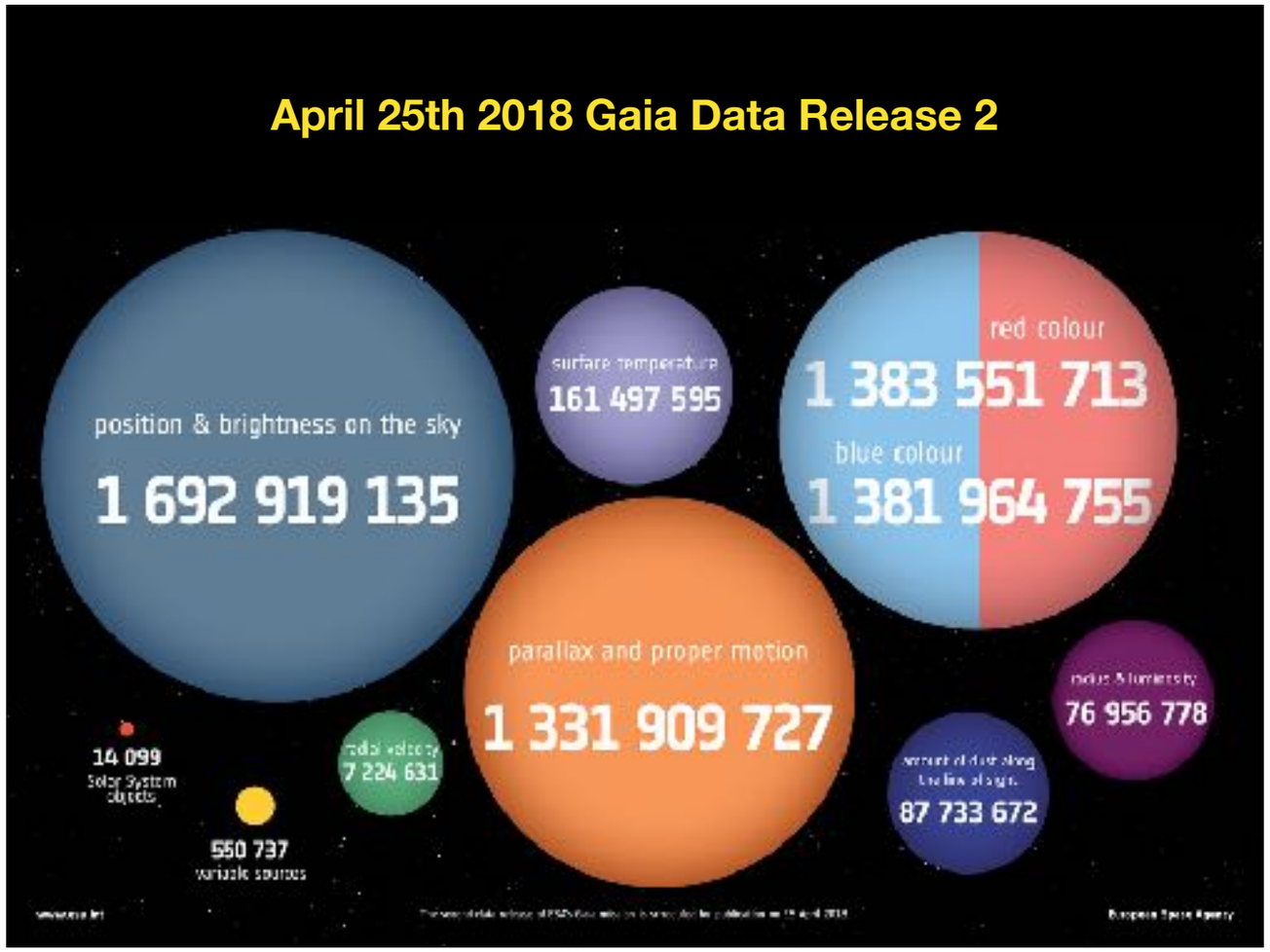
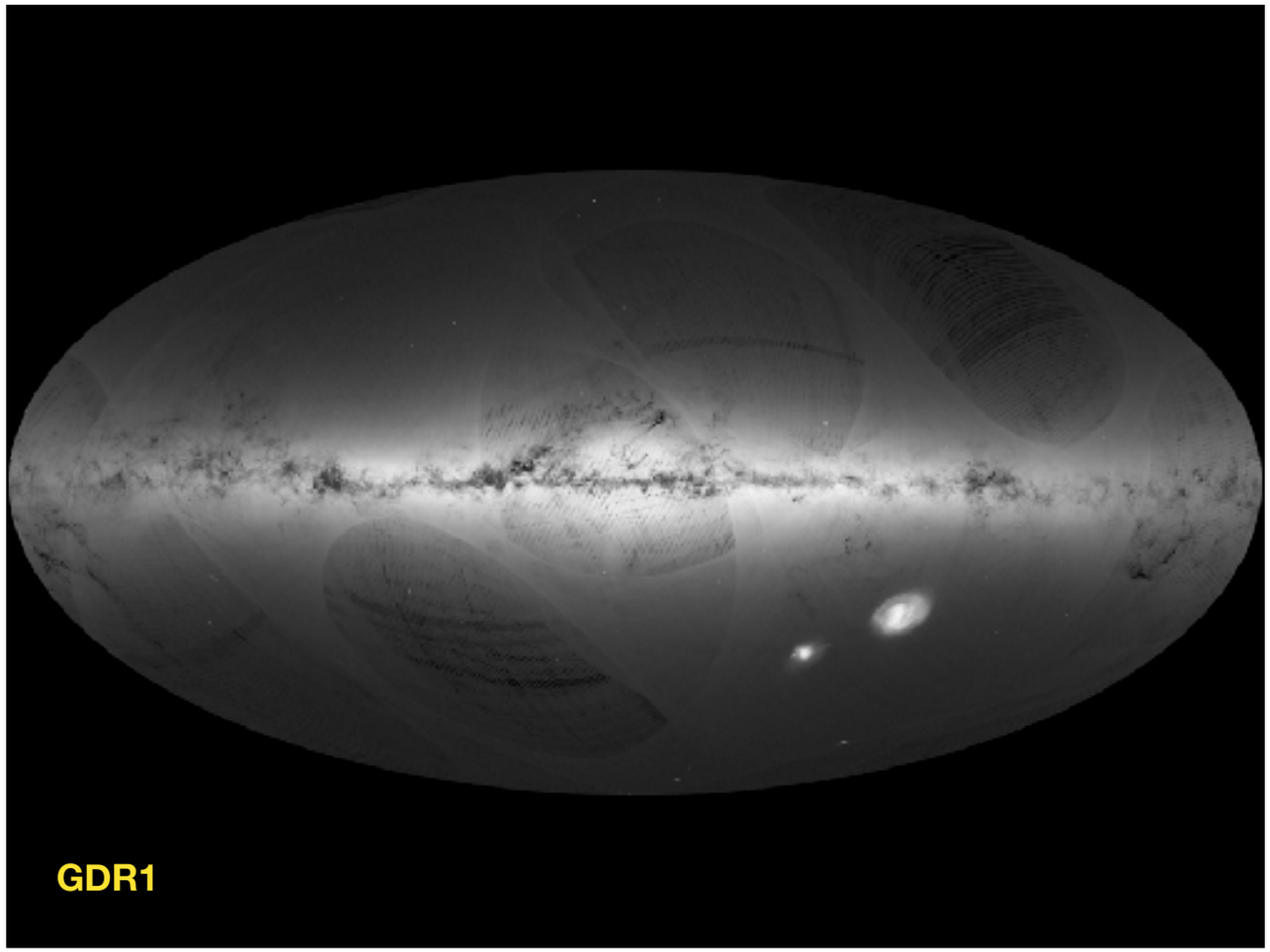
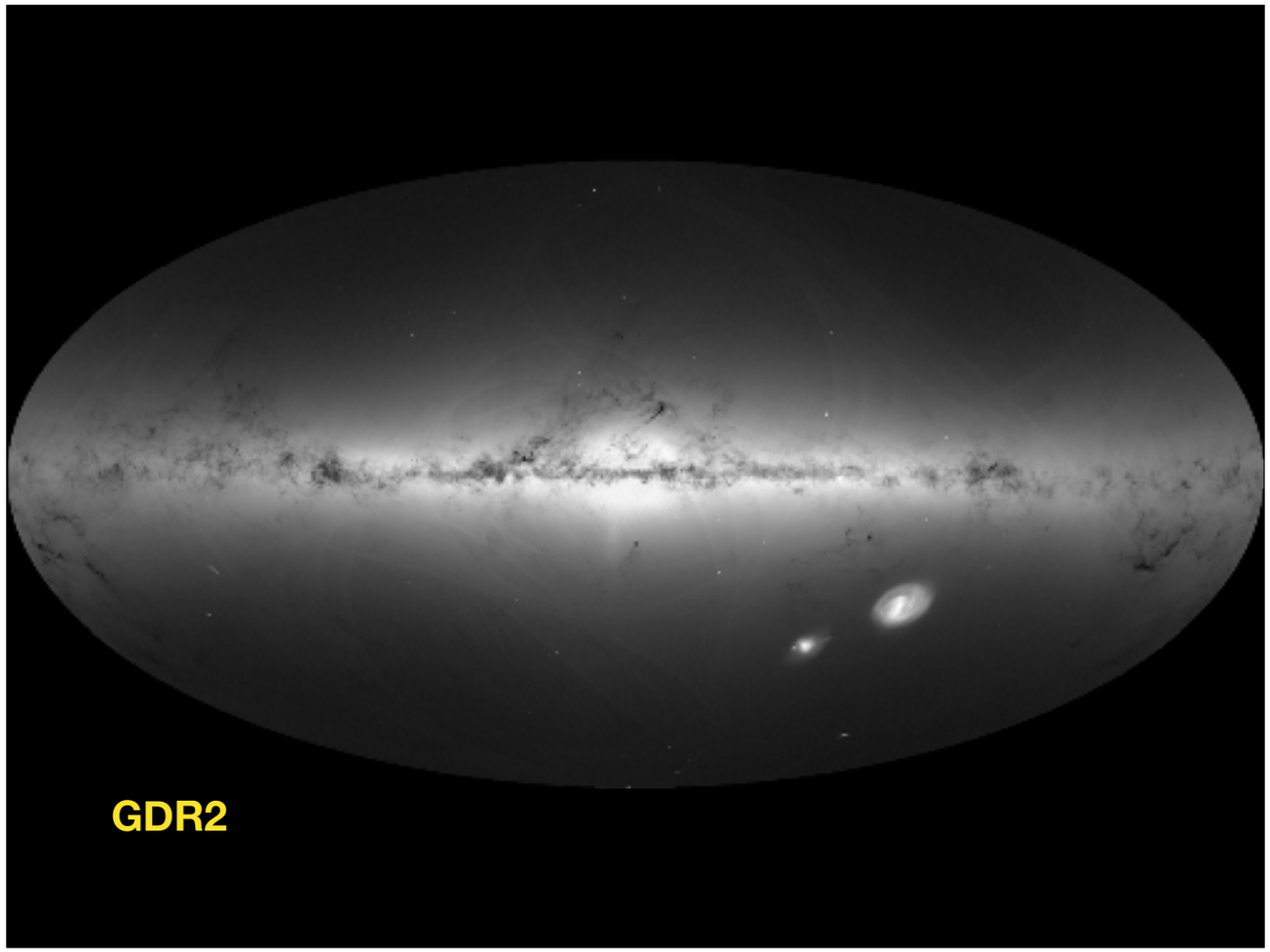
the parallax as we have seen is the size of the circle, and its size depend on the distance so we can infer how distant the stars are from us.



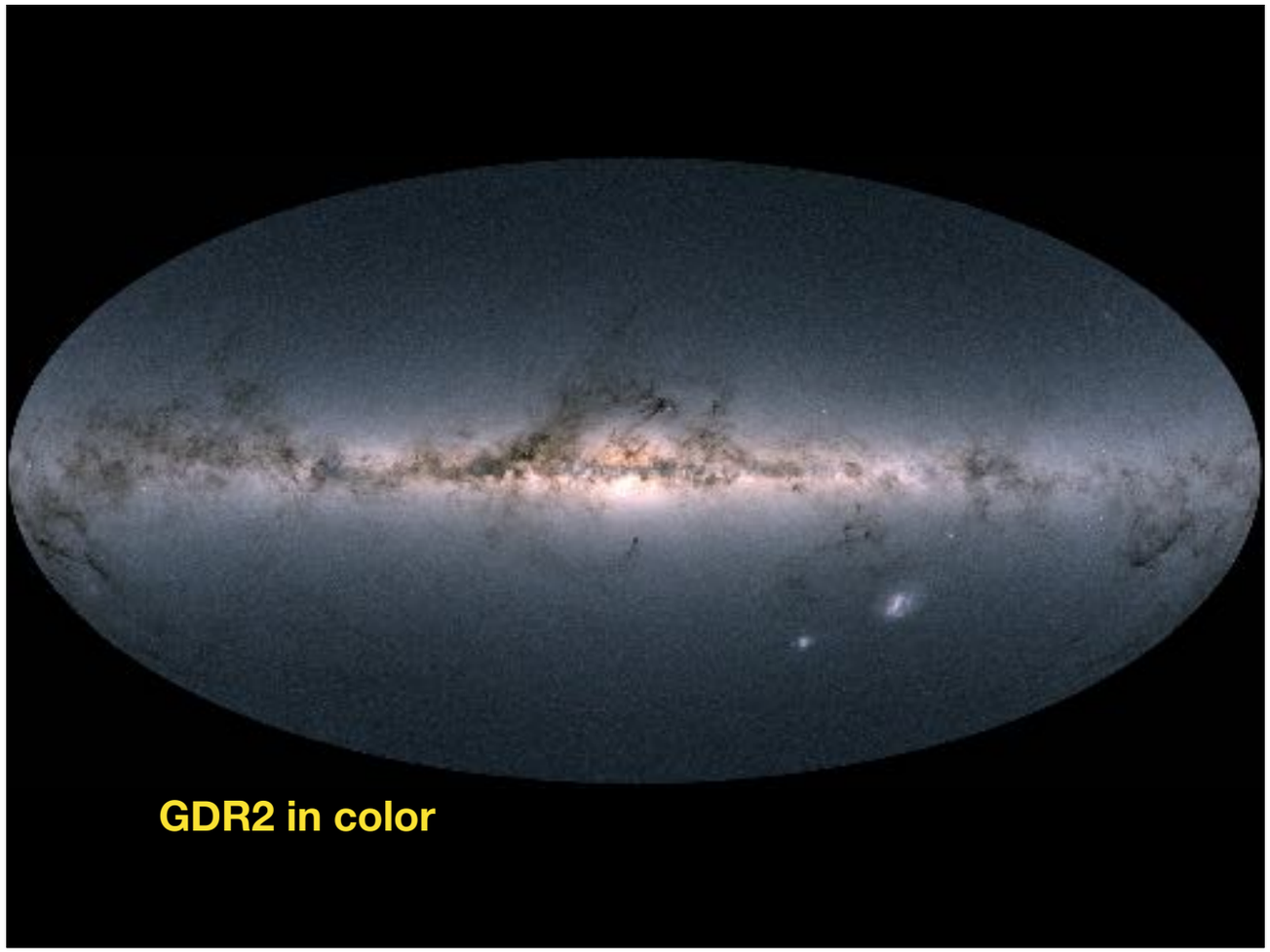
- preliminary DR
- not a real picture, it is made with all data points

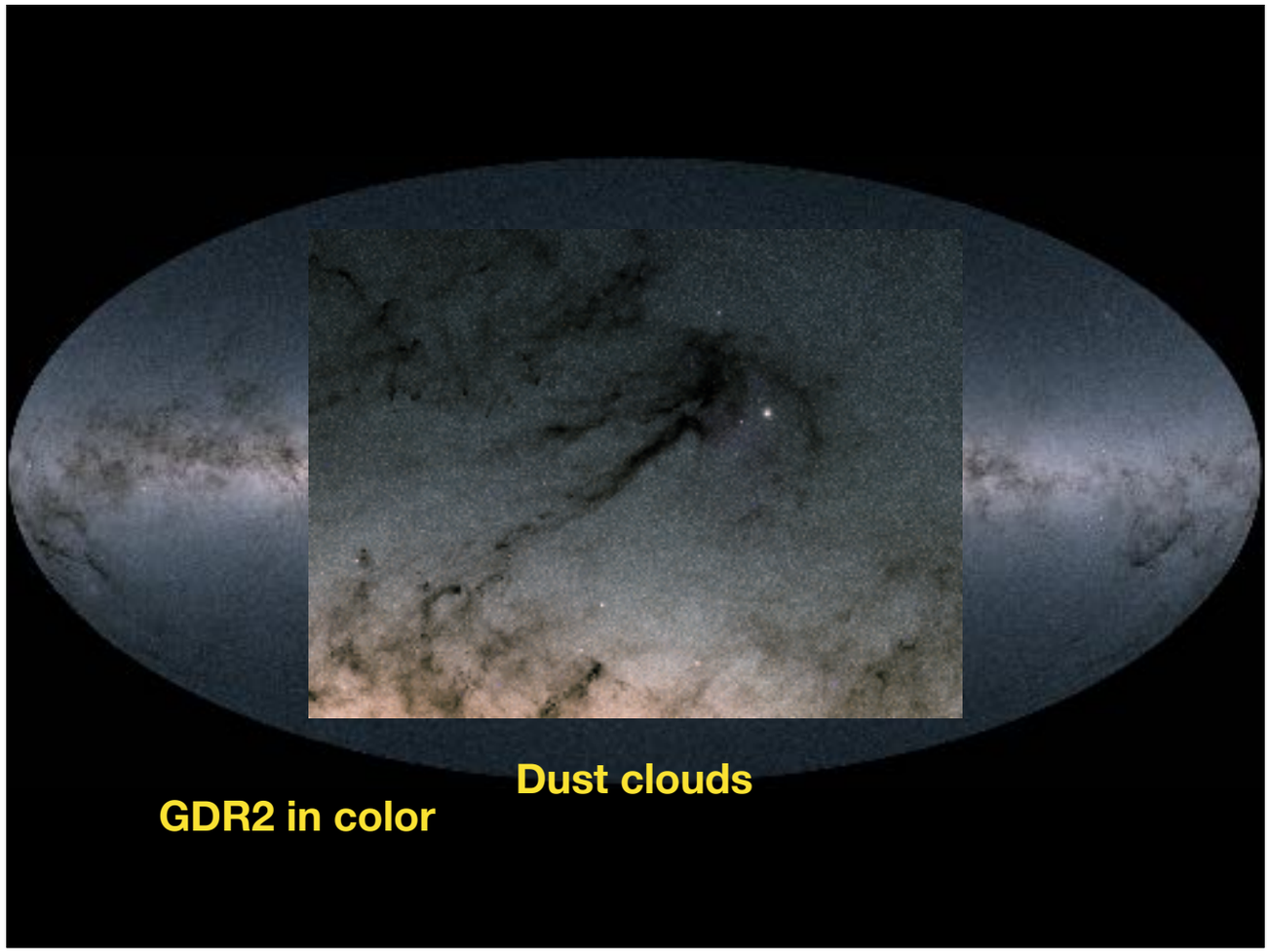

April 25th 2018 Gaia Data Release 2
position & brightness on the sky
1 692 919 135
surface temperature
161 497 595
red colour
1 383 551 713
blue colour
1 381 964 755
parallax and proper motion
1 331 909 727
76 956 778
14 099
Solar System objects
550 737
variable sources
7 224 631
87 733 672

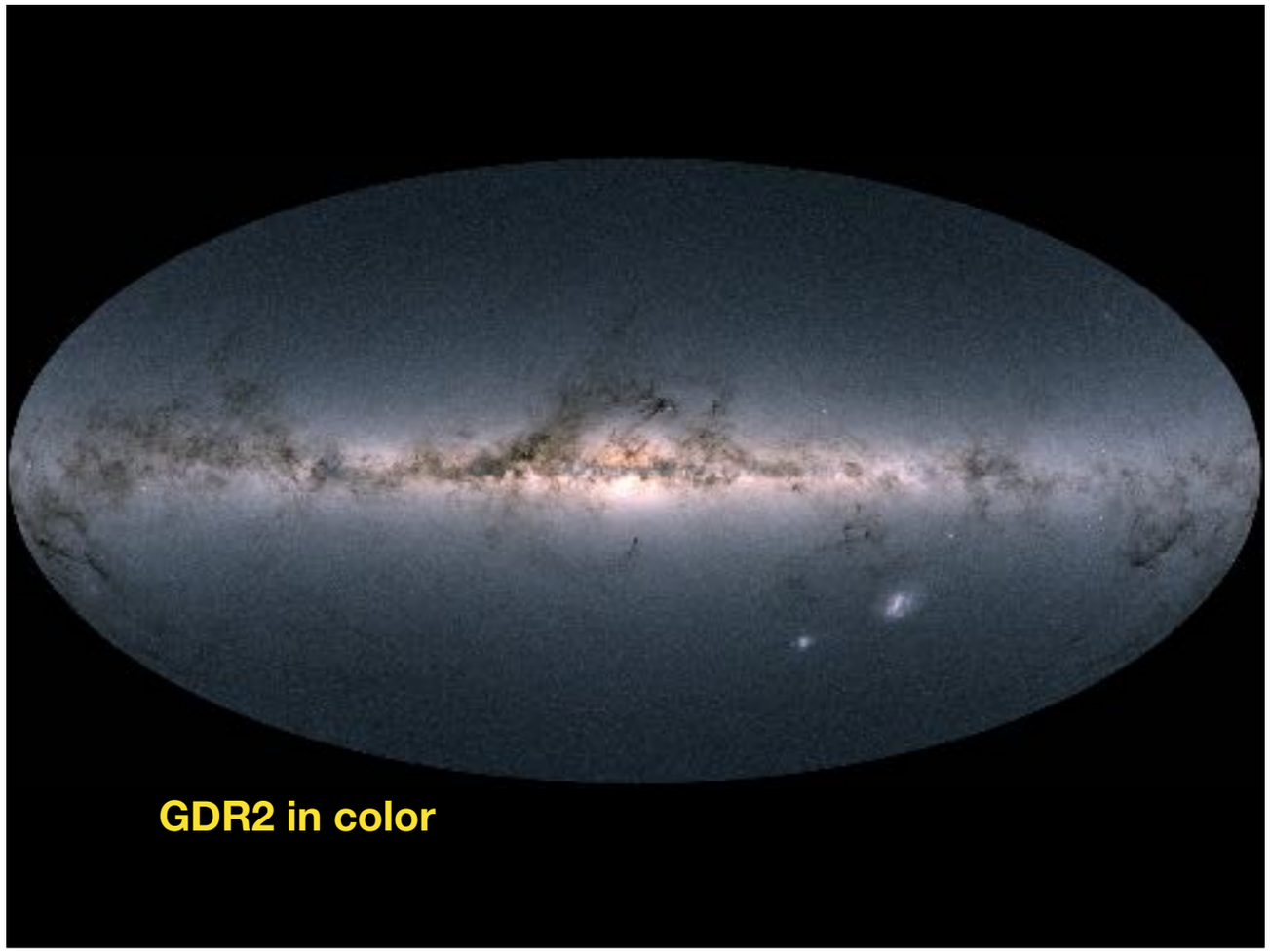

GDR1

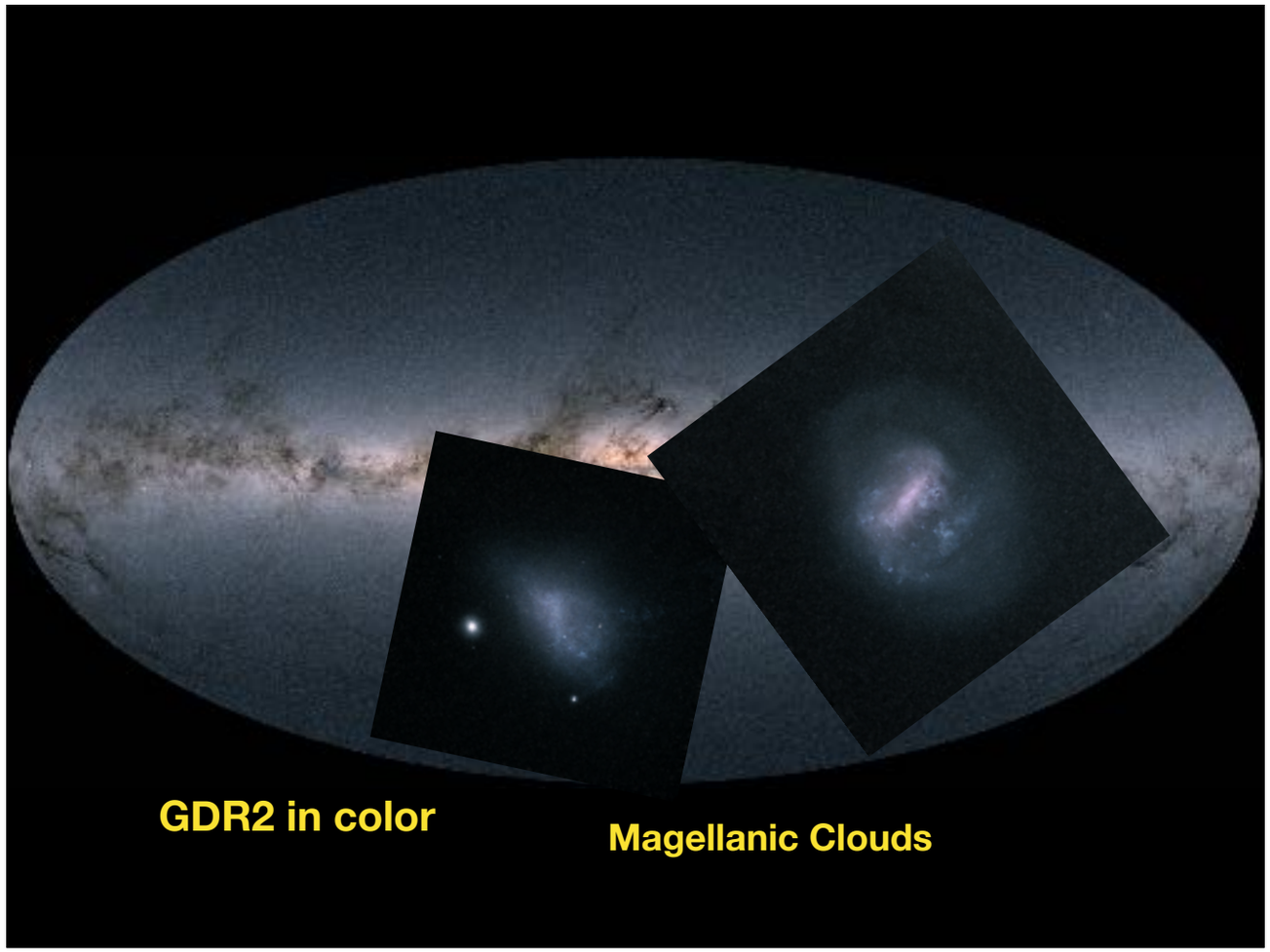


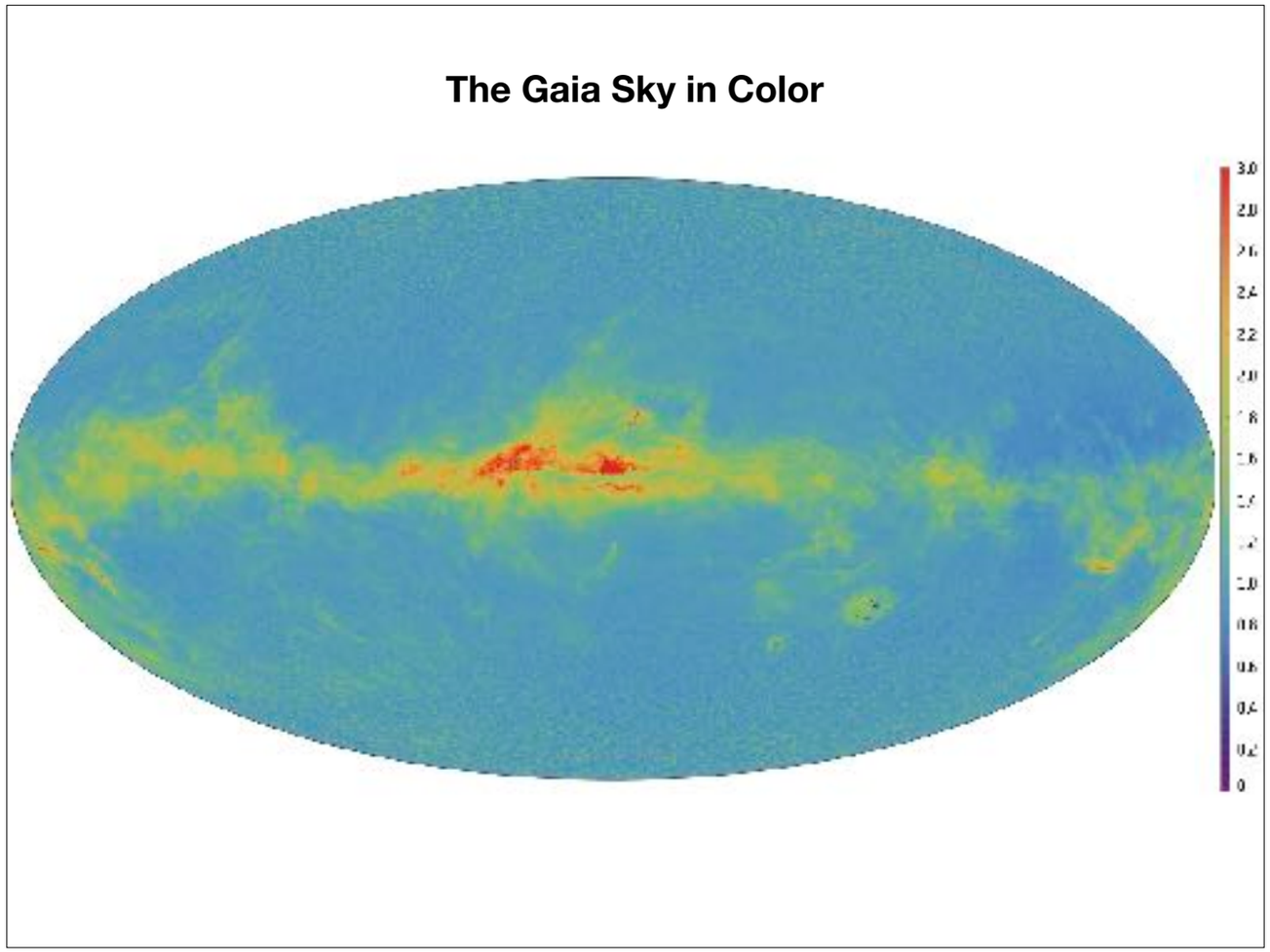
galactic plane; bulge, mag.clouds.
dark features show the dust clouds: since it is not a real picture, it means that in those regions you see less stars, but they are there, only their light is absorbed by the dust clouds on the line of sight.

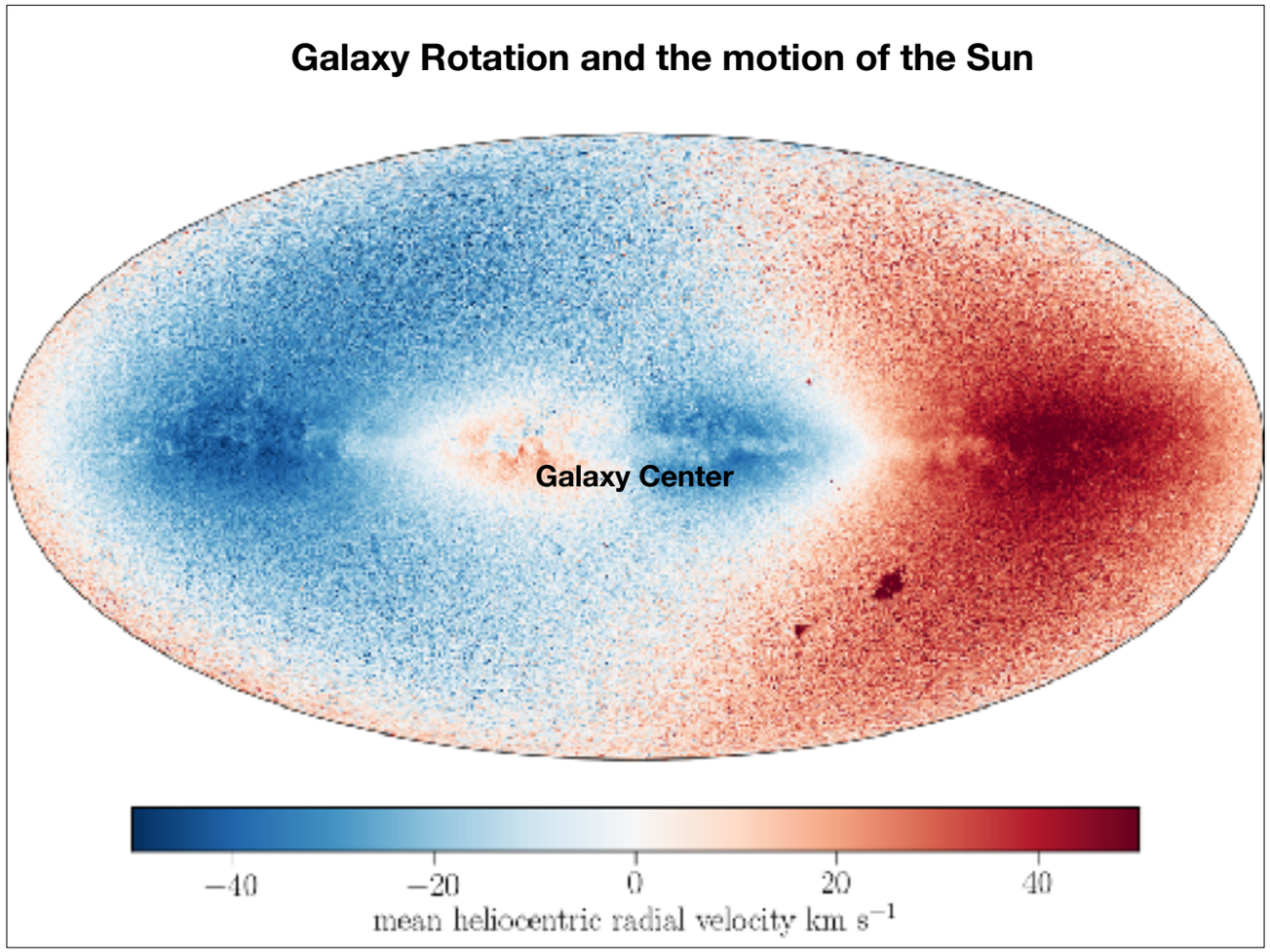

GDR2 in color


GDR2 in color
Dust clouds


GDR2 in color

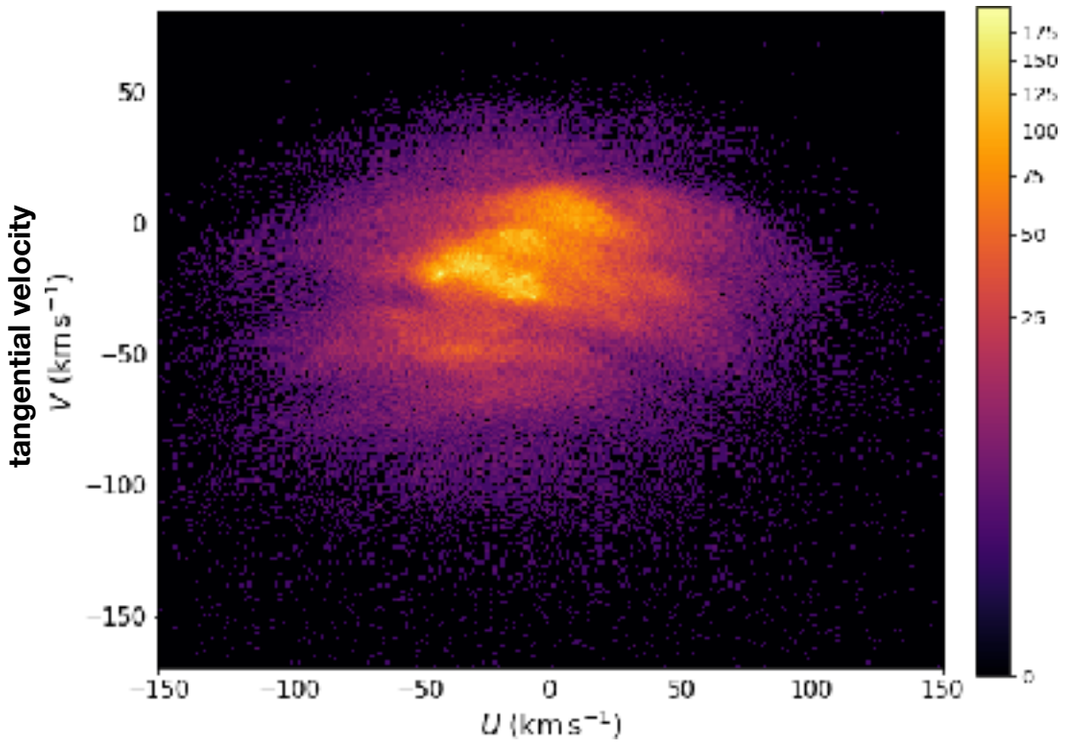

GDR2 in color
Magellanic Clouds


The Gaia Sky in Color



doppler effect; sun is moving toward left side; stars between sun and GC move faster; outside move slower. So we are moving in the same direction, but the blue one appears like they are moving toward us. White -> same velocity as the sun. Red: faster than us so it looks like they are running far from us (they have a Ferrari while we have a Ford). Then there is the centre, but it's not white because we cannot see it.
Then blue on the right are moving toward us, they are catching up. White again. Moving toward us but slower, so they look like they are going far from us.

Galaxy Kinematics:
Patterns in the distribution of the Solar neighbour stars

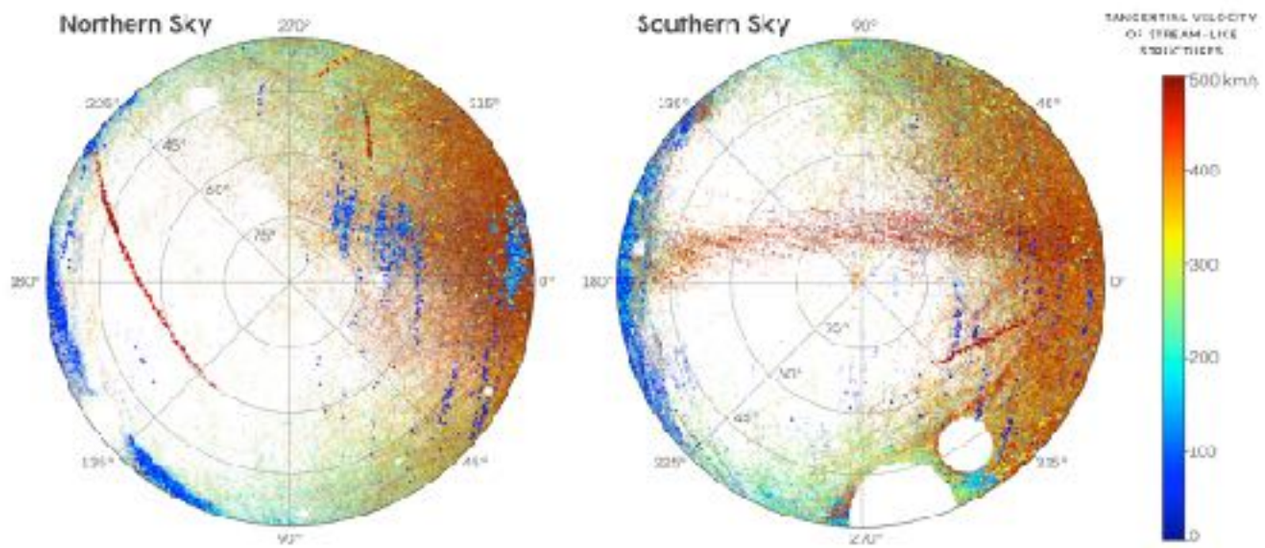


velocity in the direction of the Galactic Centre

how big is the neighbour? explain the velocities

Sun is about 8kpc, i.e. 26,000 light-years from the center, half-a-way to the disk
The solar neighbour is formed by the stars that have a distance closer than 200pc (650 light-year, ~40millionx1AstroUnit) Color scale is the number of the stars.
The distribution is not continuous, meaning that are disturbances that alter the systems.

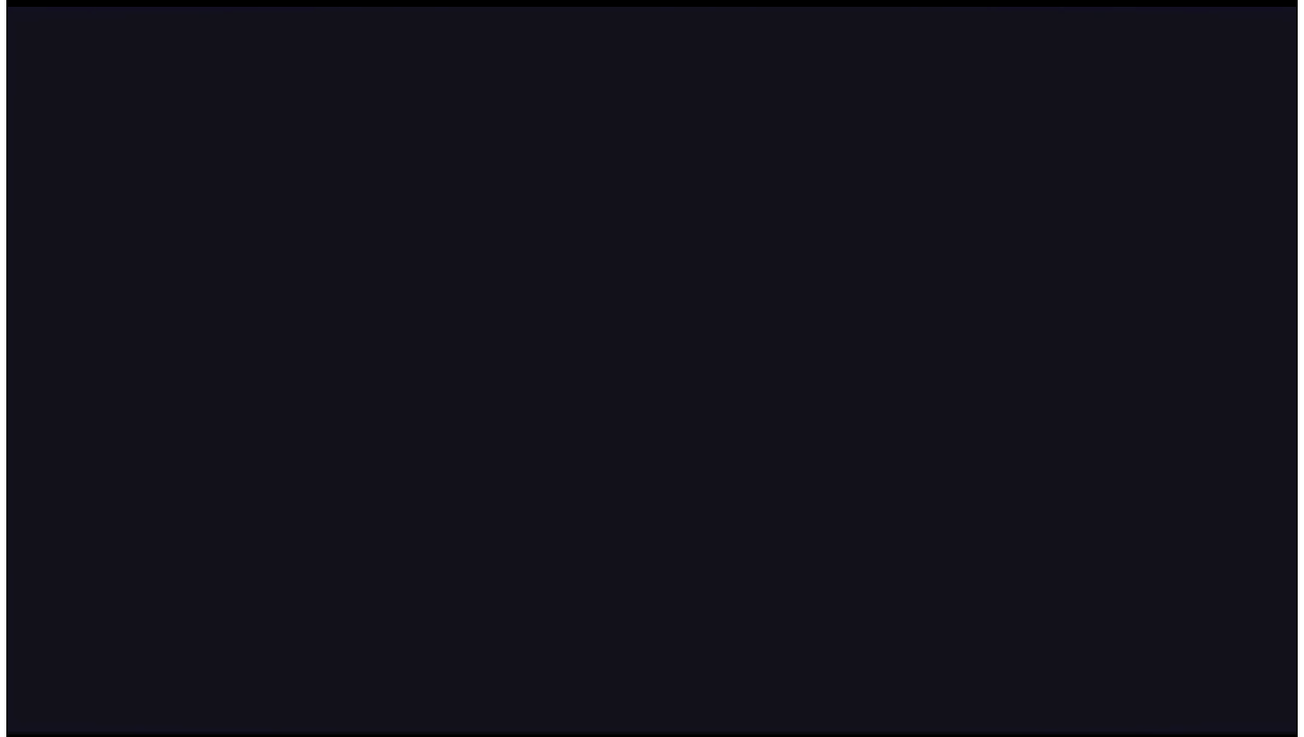
Galaxy Kinematics



Stellar Streams -> galaxies and clusters remnants

The profusion of stellar streams — believed to be remnants of small satellite galaxies and star clusters that were drawn in by gravity — could potentially resolve the “missing satellite problem,” which asks why only 50-odd satellite galaxies currently orbit the Milky Way, despite hundreds arising in computer simulations of galaxy formation.
important we have the velocity information.

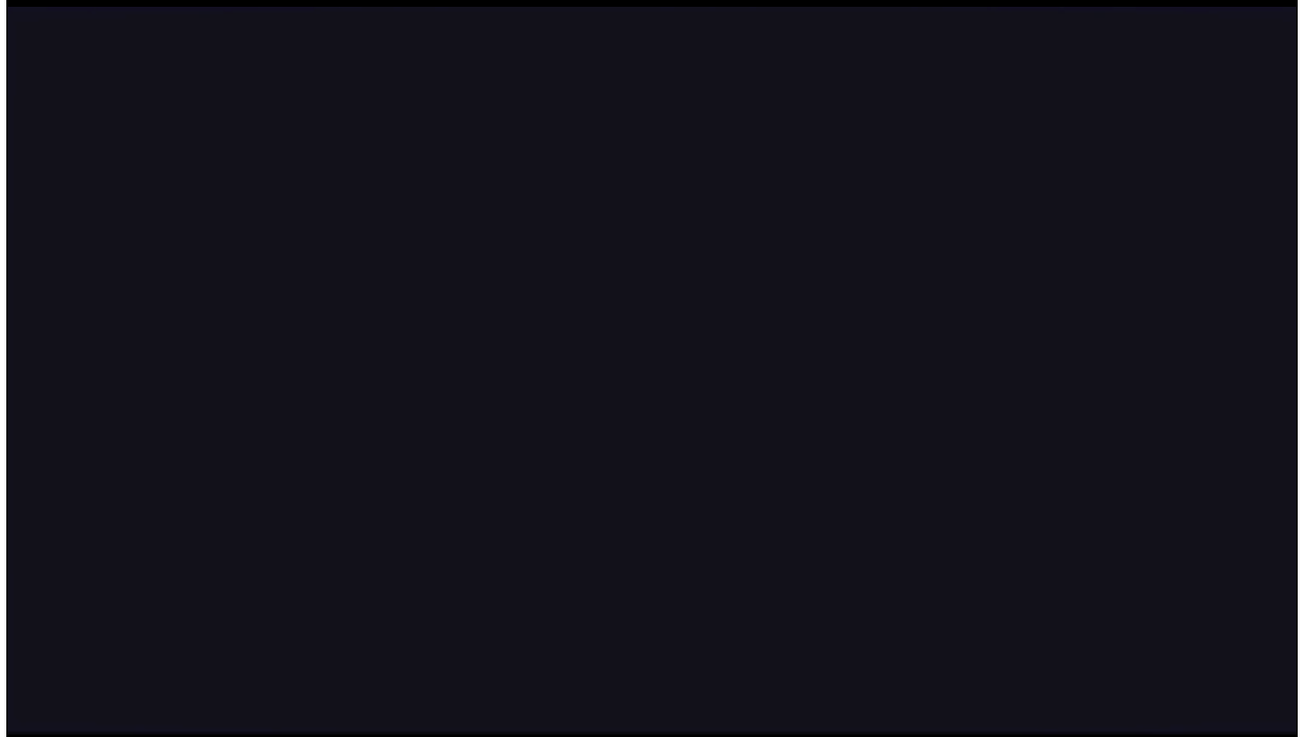
Hypervelocity stars in the Solar neighbourhood



As we have seen, the Stars are not motionless in the Galaxy but move around its center with a variety of velocities depending on their location — for example, the Sun orbits at about 220 km/s, while the average in the halo is of about 150 km/s. Occasionally, a few stars exceed these already quite impressive velocities.
Some are accelerated by a close stellar encounter or the supernova explosion of a stellar companion, resulting in runaway stars with speeds up to a few hundred km/s above the average.
A new kind of these stars were observed awooping through the Galaxy at several hundred of km/s, and they are the result of past interactions with the supermassive black hole that resides at the center of the Milky Way and, with a mass of 4 million solar masses, governs the orbits of stars in its vicinity.

Discovered 30 new extreme velocity stars in the Gaia-DR2 archive. Old and metal poor, similar to the stellar populations in globular clusters or in the stellar halo. Computing the orbits, up to three of the stars are consistent with having been ejected from the LMC, one or two stars are consistent with having been ejected from the Galactic center, and the rest are halo objects of currently undetermined origin. More study to be done.

Hypervelocity stars in the Solar neighbourhood



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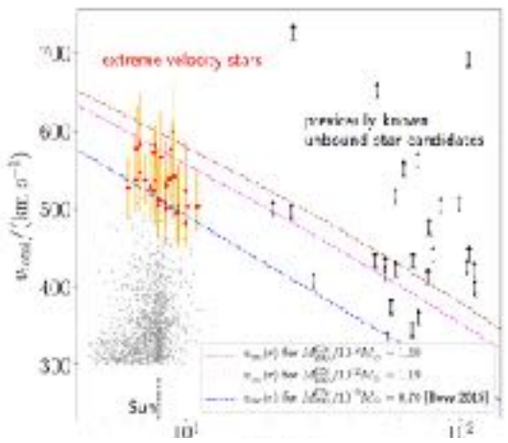

distance from the Galactic Centre

Previously known:
~20 Young stars (2.5-4 M_{Sun})

Gaia found:
~30 new objects old and metal poor stars
2 ejected from the Galactic Centre (BH)
3 ejected from LMC

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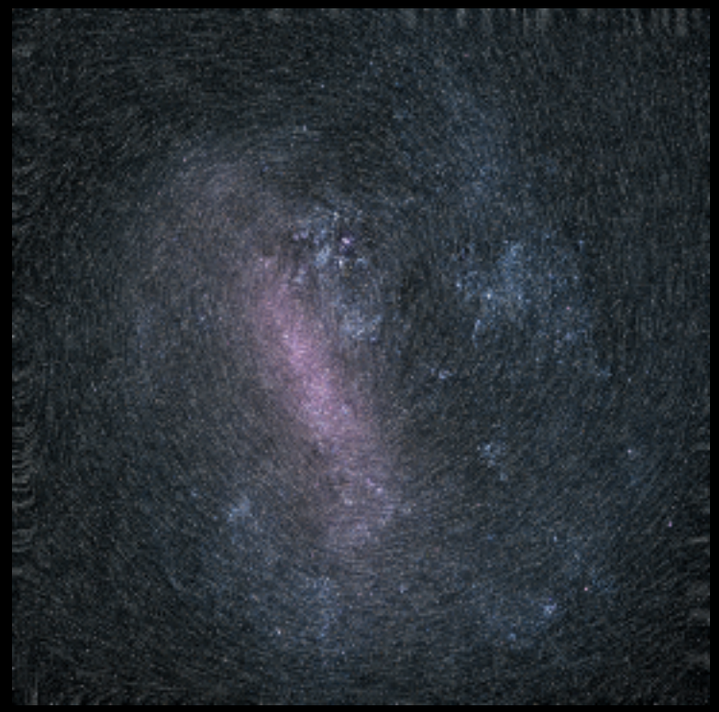
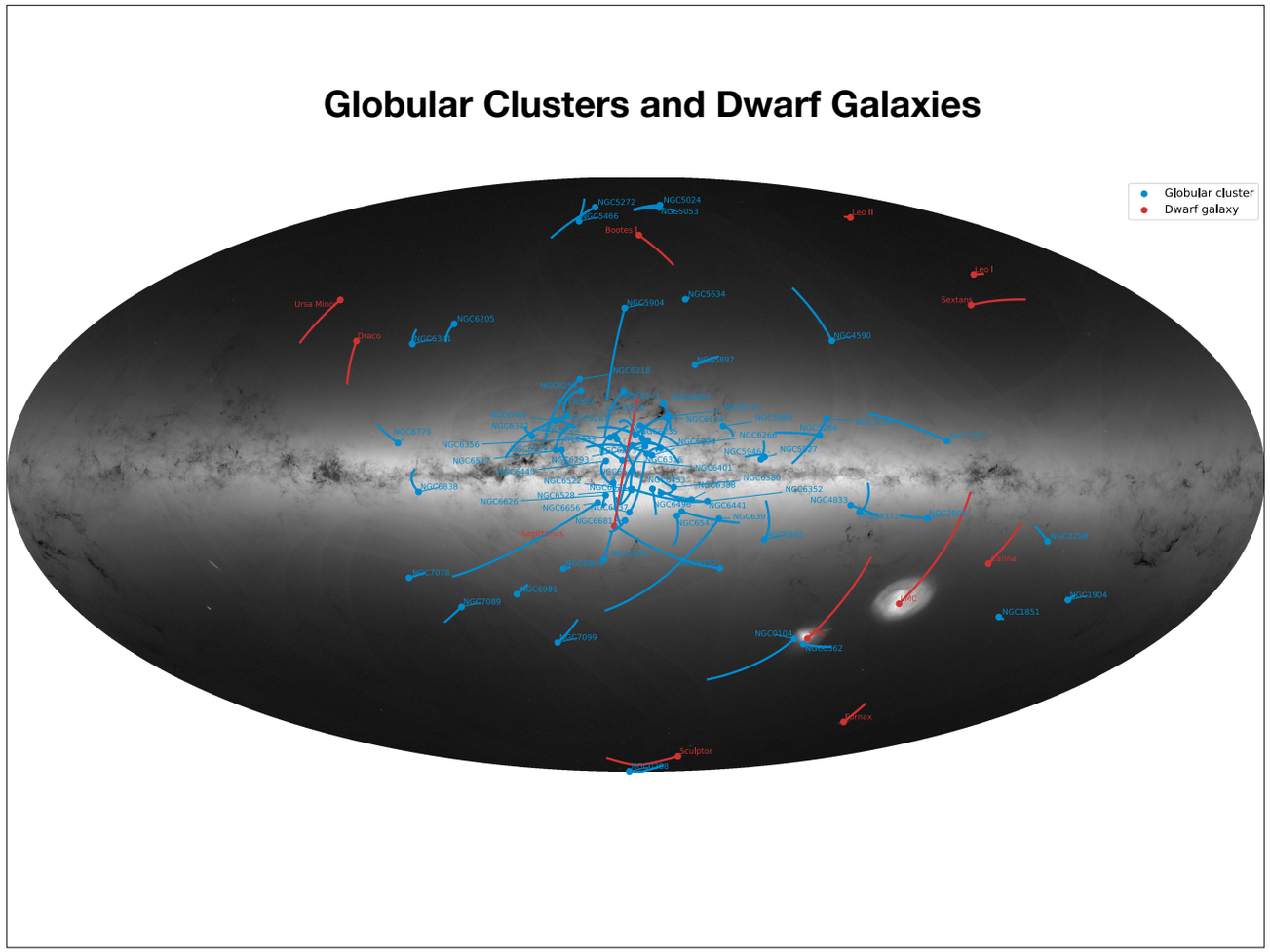
Rotation of the Large Magellanic Cloud



…also Hypervelocity Stars -> Black Hole in the Centre 4000-40000 M_{Sun}

proper motions consistent with being ejected from the very centre of the LMC. People studied how this could happen and the only valid scenario is requiring a black hole mass of at least 4 × 103 – 104M. This provides strong direct evidence that the LMC harbours a massive black hole. Some of the 26 HVS did not originate in the LMC.



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Dwarf galaxies are satellites of the Milky Way

Globular Clusters and Dwarf Galaxies

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Stellar encounters

Gliese 710

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Gaia DPAC

THANKS!

gaia