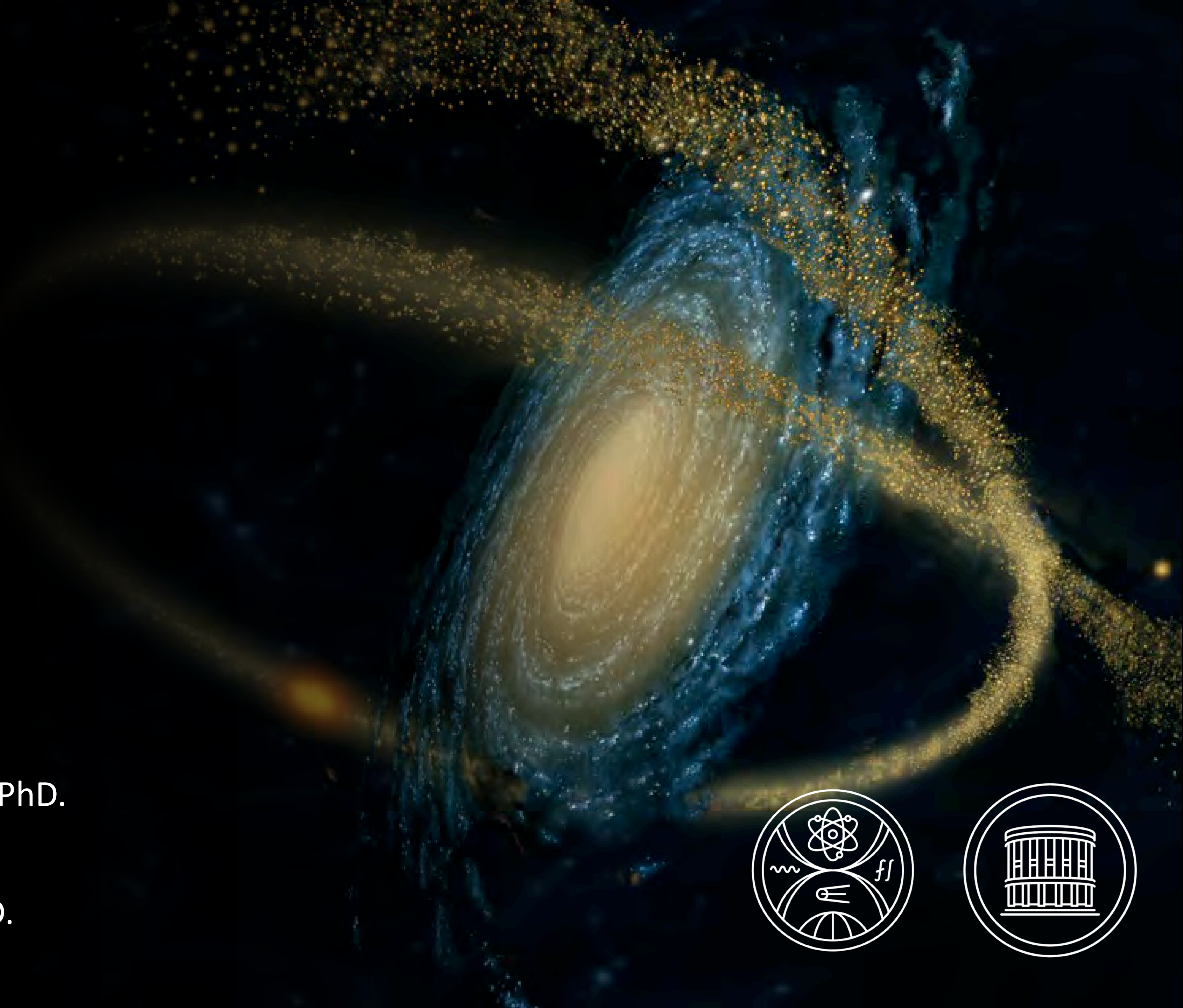
Stellar streams and galactic mergers



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Motivation of our work

- Study the properties of stellar streams is important for understanding the evolution of the Milky Way and its current structure.
- Study the shape of galactic gravitational potentials, which may help in the study of the dark matter and the gravitational interactions on the large scales.

Globular clusters and stellar streams

- Globular clusters
  - spherical clusters of the stars
  - denser than Galaxy
  - Radius about 25 pc, containing 10^4 stars
- Stellar streams
  - Result of the tidal striping of GC or dwarf galaxy

Ilustration of the stellar stream. Credit: NASA/JPL

Generating stellar stream

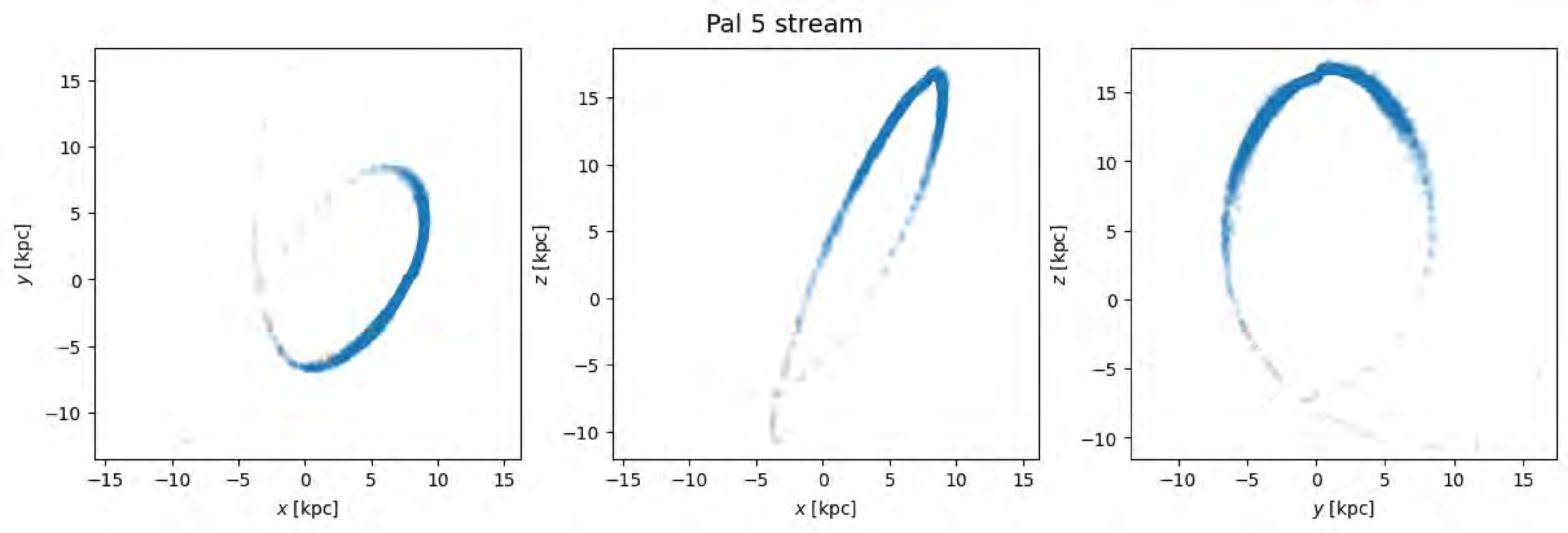
- Python gala package v 1.6.1
- Milky Way potential - default MilkyWayPotential
- Globular cluster potential – Plummer potential
- Integration back in time to find the orbit of globular cluster
- Integration to the present and generating stellar streams based on (Fardal et al., 2015)

Pal 5 stellar stream

- Origin in Palomar 5 GC
- 11 432 particles

Parameters	Value	Units
α	229	deg
δ	-0.124	deg
d	22.9	kpc
v_r	-58.7	km s^{-1}
μ_α	-2.29	mas yr^{-1}
μ_δ	-2.257	mas yr^{-1}
m	$2.5 \cdot 10^4$	$M_\odot$
b	4	pc

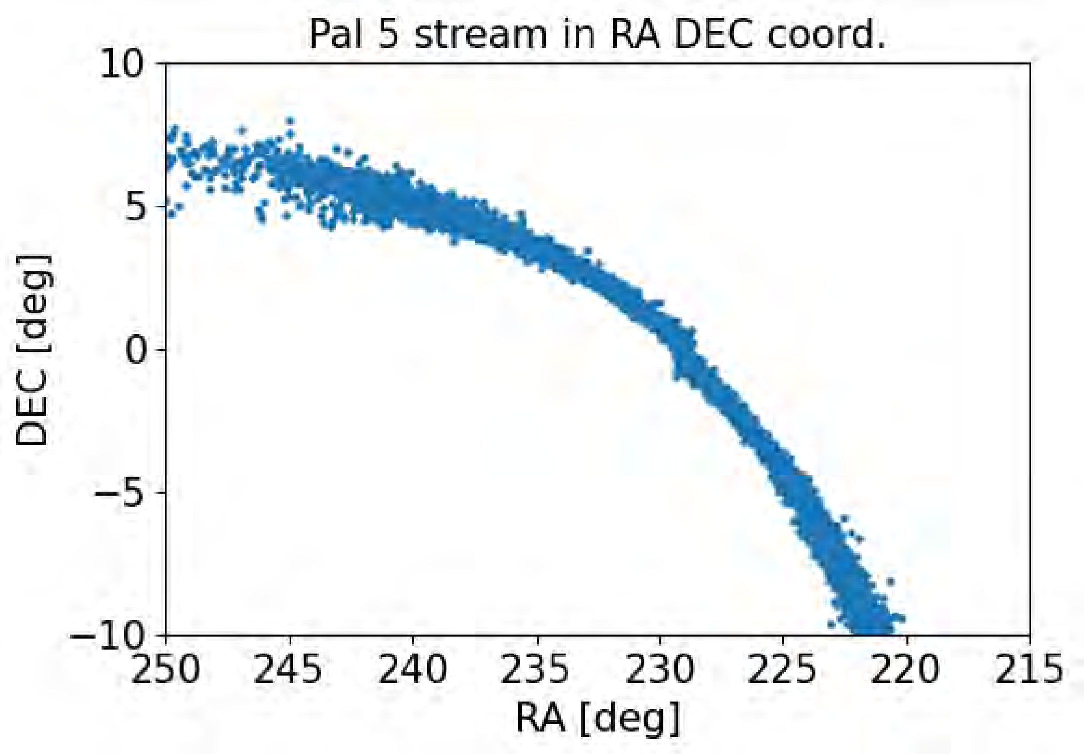
Parameters of the Palomar 5 GC used in our simulation.



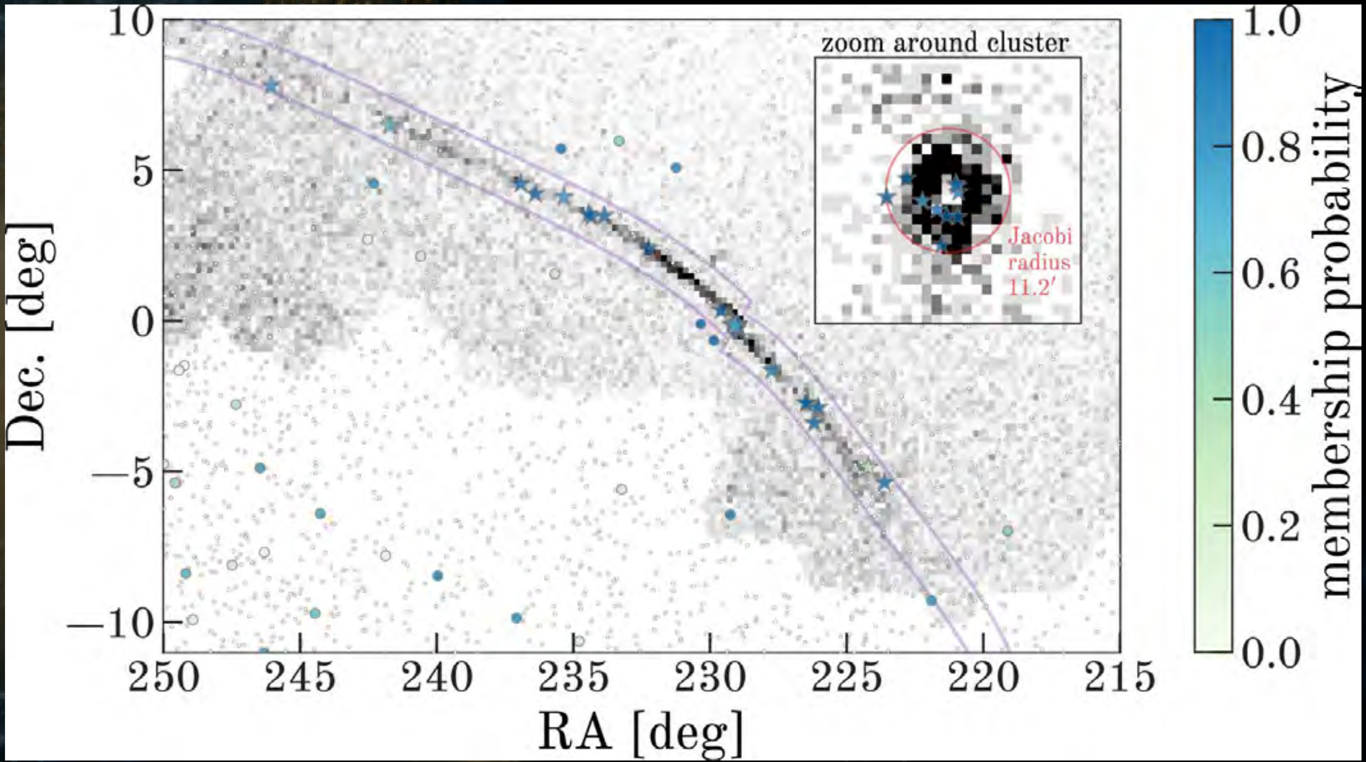
Pal 5 stellar stream in the galactocentric coordinates.

Comparison with the observations

- Heliocentric coordinates

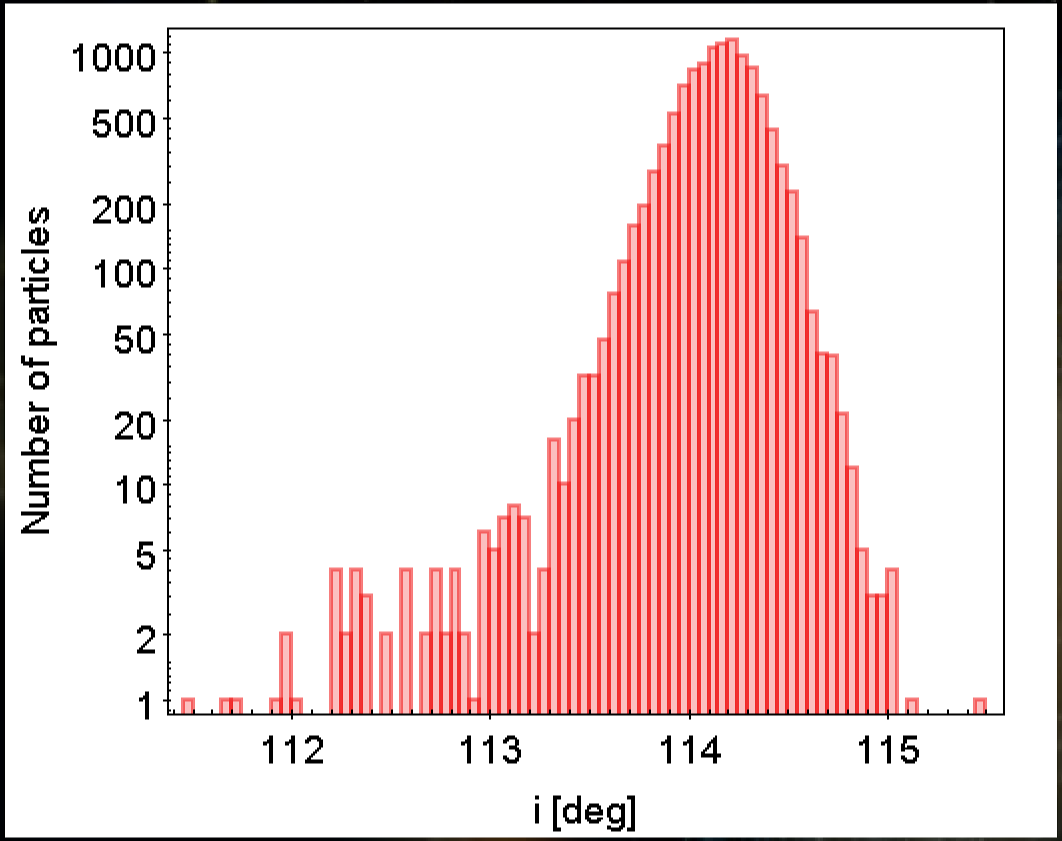


Generated Pal 5 stellar stream in the heliocentric coordinates

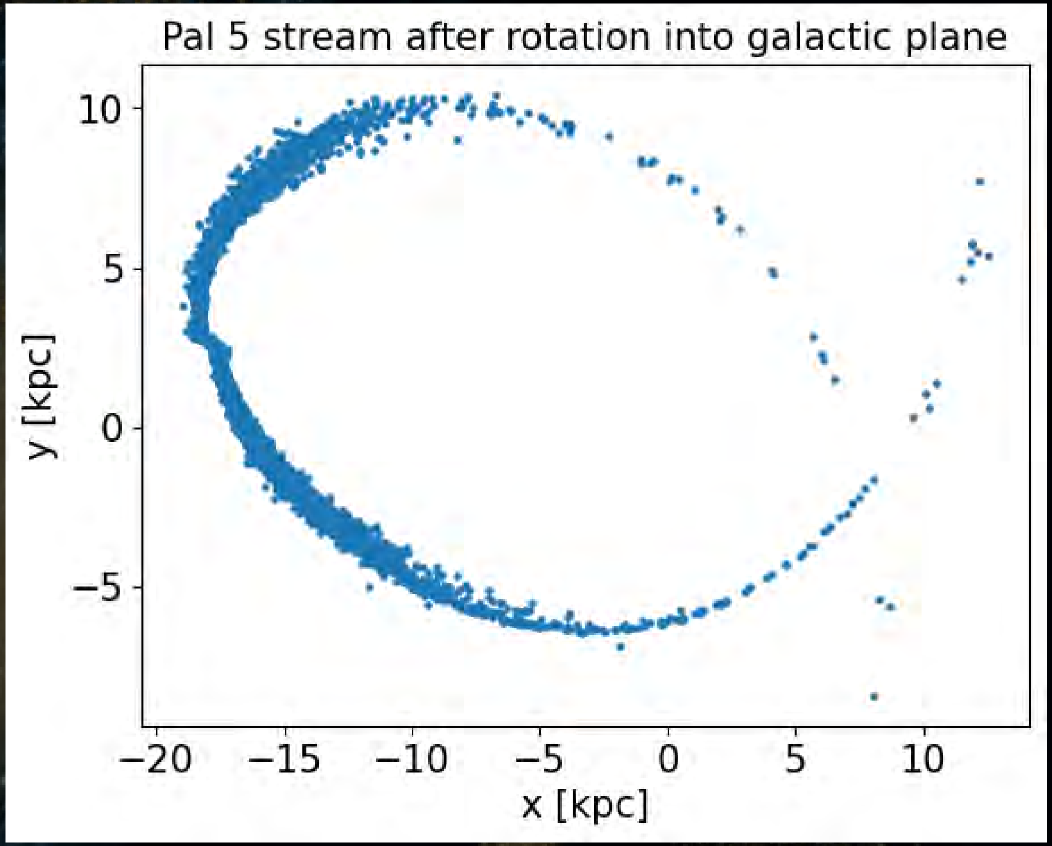


Sky positions of RRLs with Pal 5 colored by membership probability. Price-Whelan et al., 2019

Rotation of the coordinates



Dispersion of the stream particle inclinations. Y-axis is in logarithmic scale. Inclination of the Palomar 5 globular cluster is 114.2 deg.

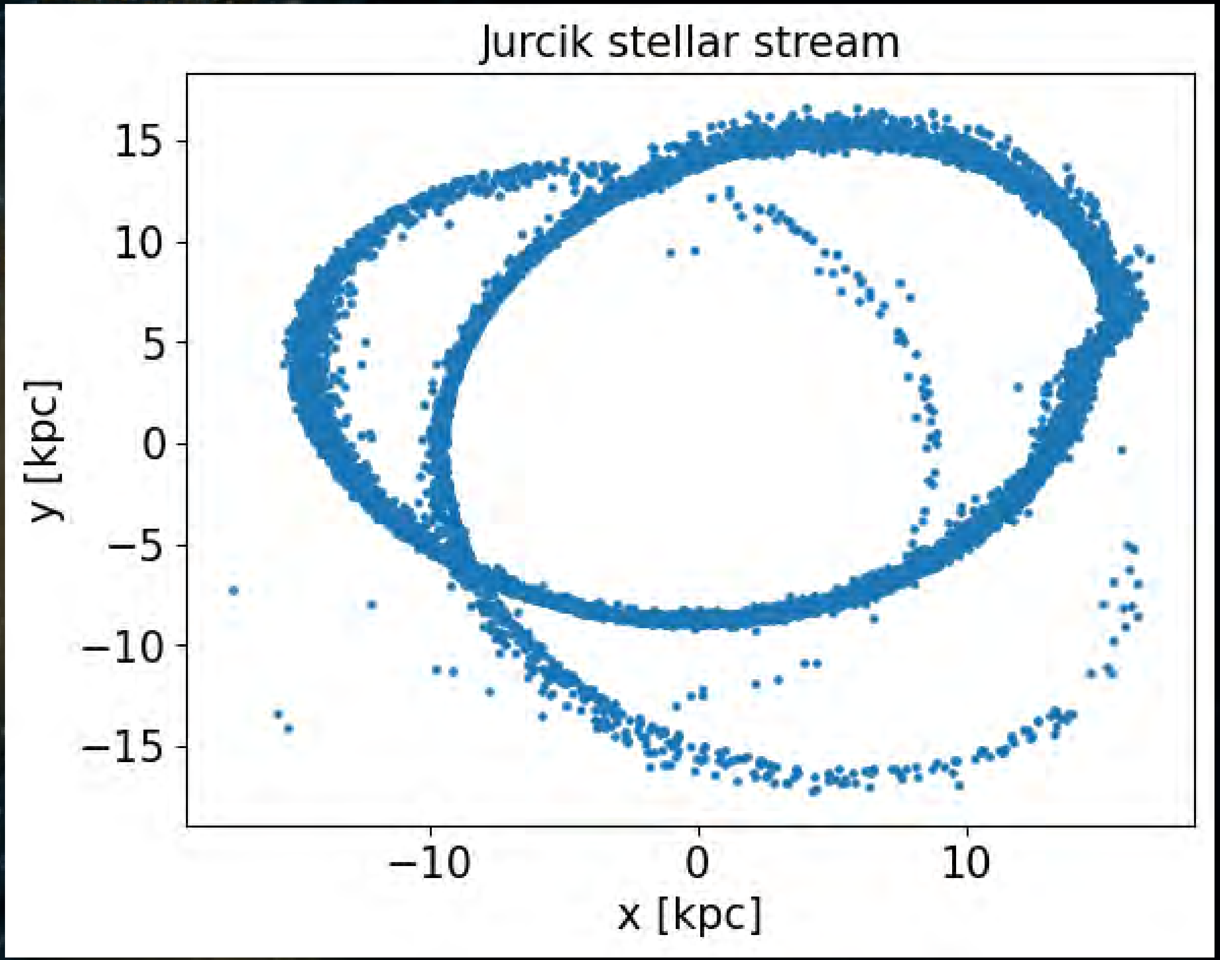


Pal 5 stream after rotation into galactic plane. z and v_z coordinates are small enough to be neglected.

Jurcik stellar stream

- Generated in Galactic plane
- 16 002 particles

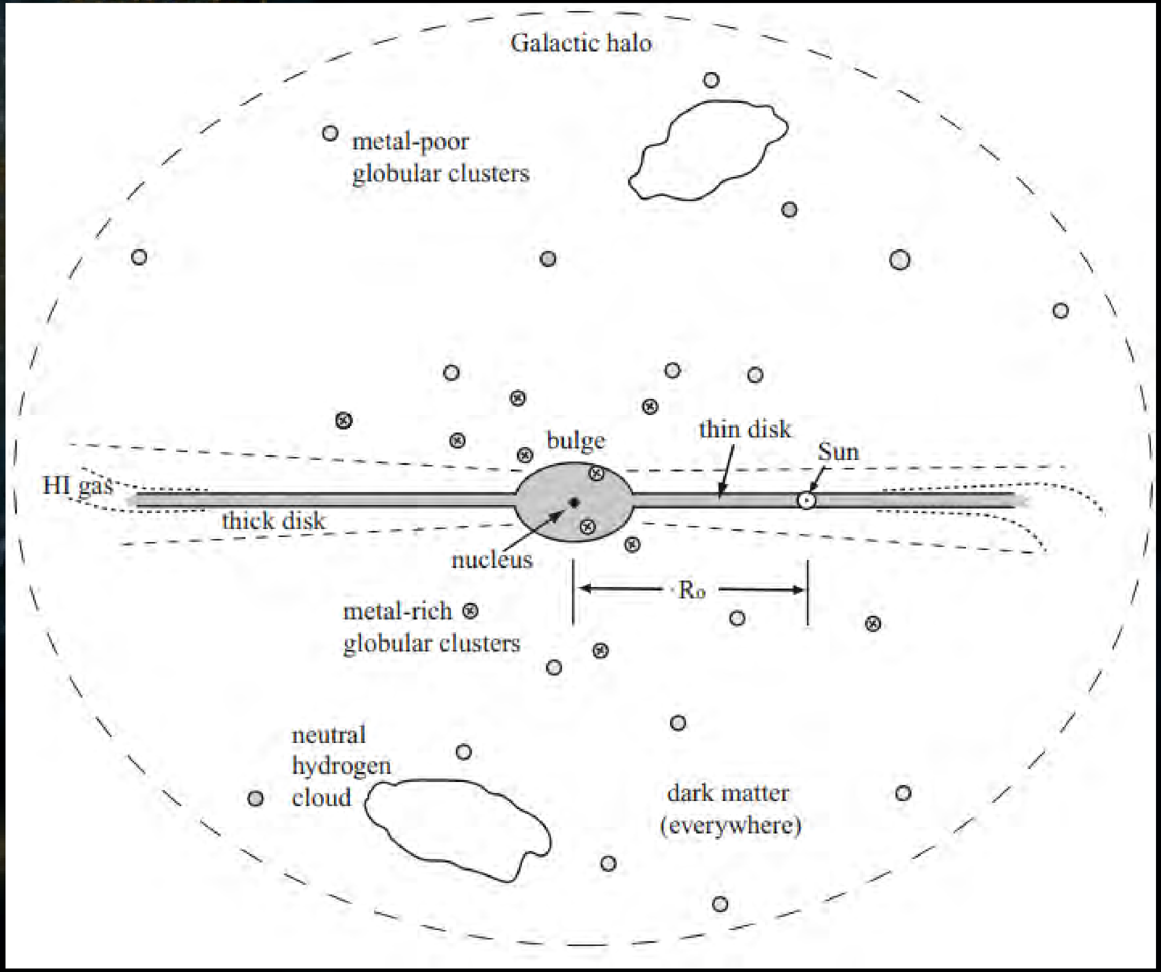
Parameters	Value	Units
x	15	kpc
y	5	kpc
z	0	kpc
v_x	0	km s^{-1}
v_y	-180	km s^{-1}
v_z	0	km s^{-1}
m	$6.24 \cdot 10^5$	$M_\odot$
b	4	pc



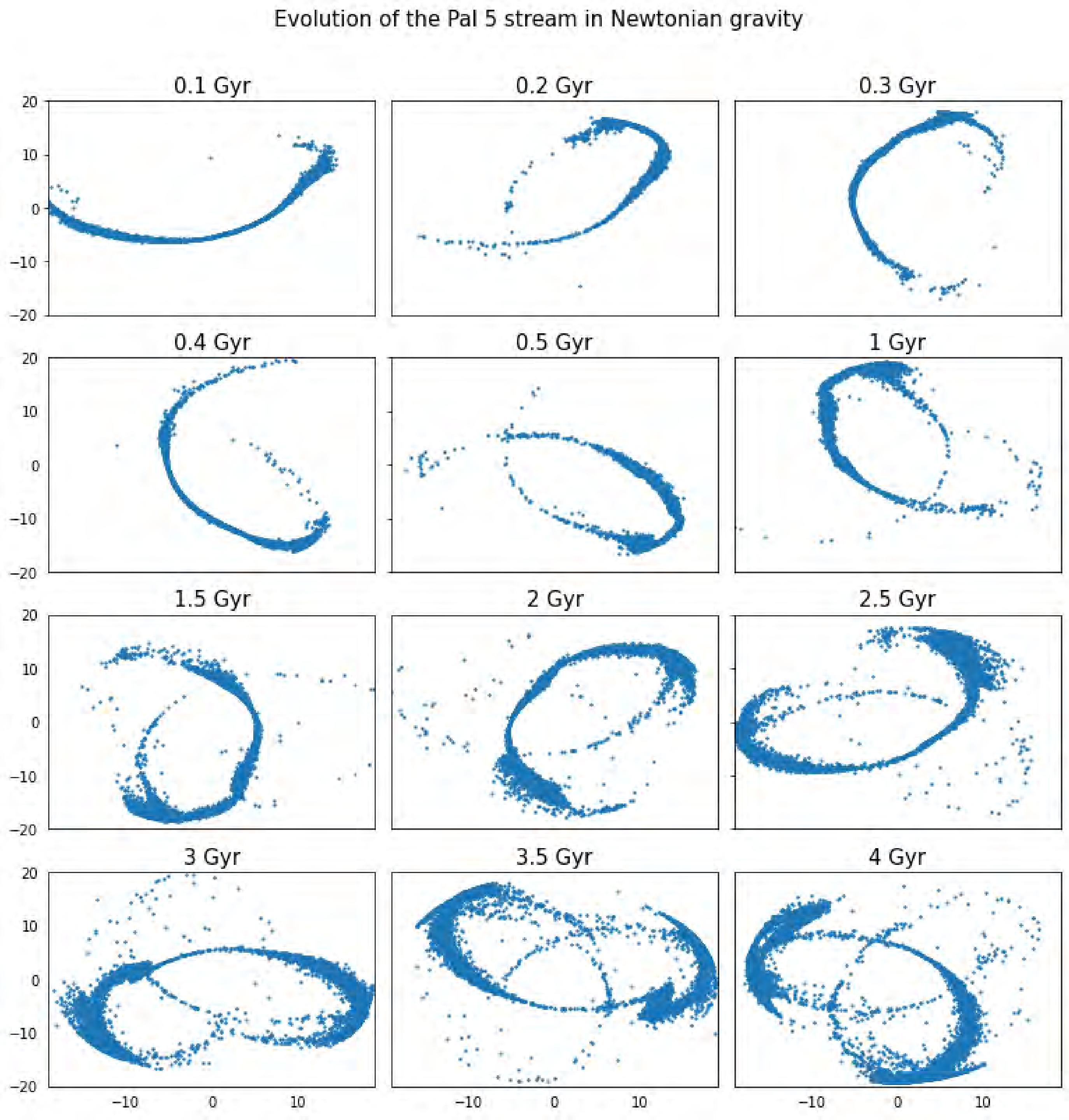
Jurcik stellar stream in the galactocentric coordinates

Our models of the Milky Way

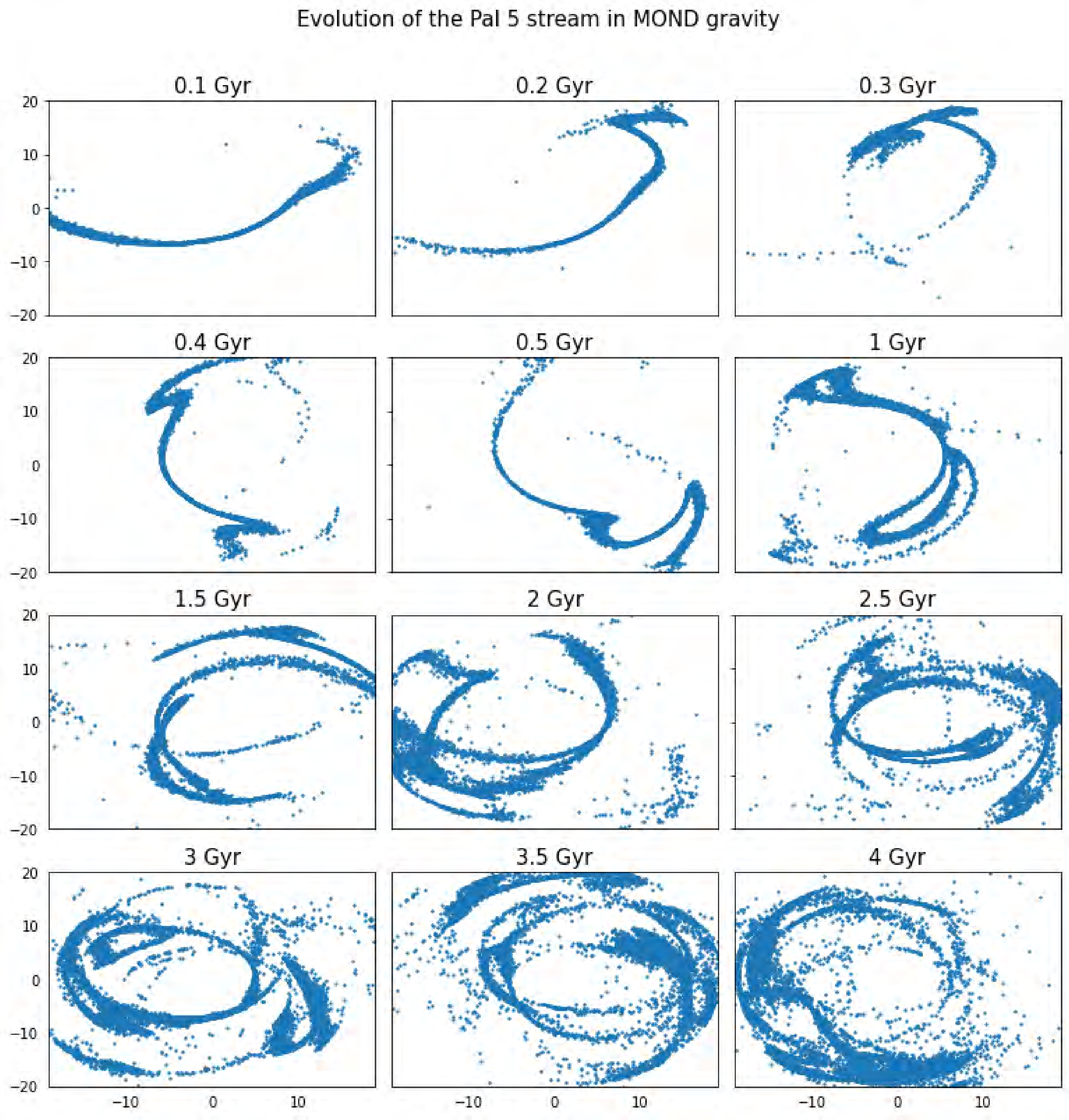
- Newtonian approach:
- MOND model :



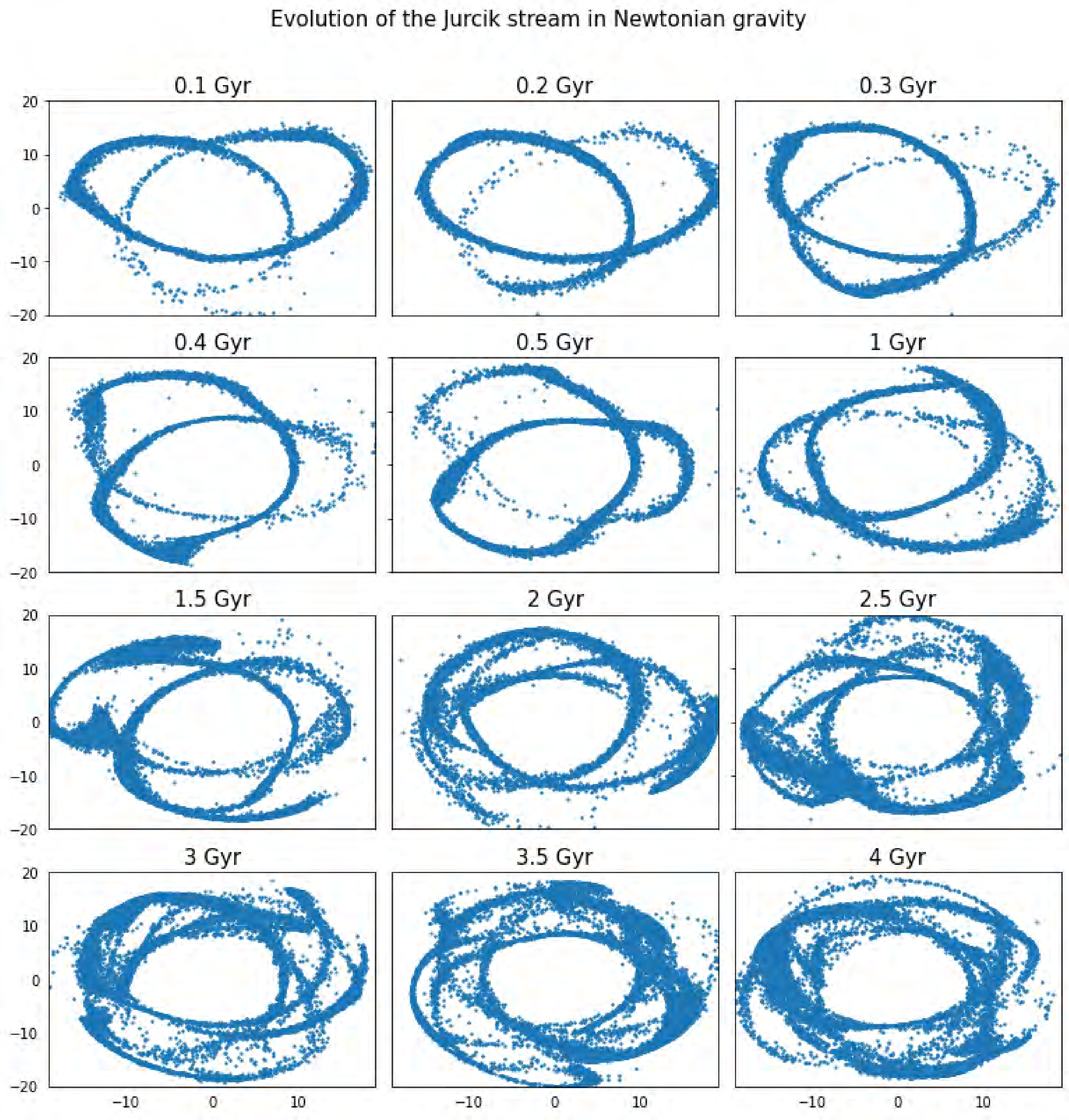
Scheme of the Milky Way
Credit: (Sparke and Gallagher III, 2007, p. 26)



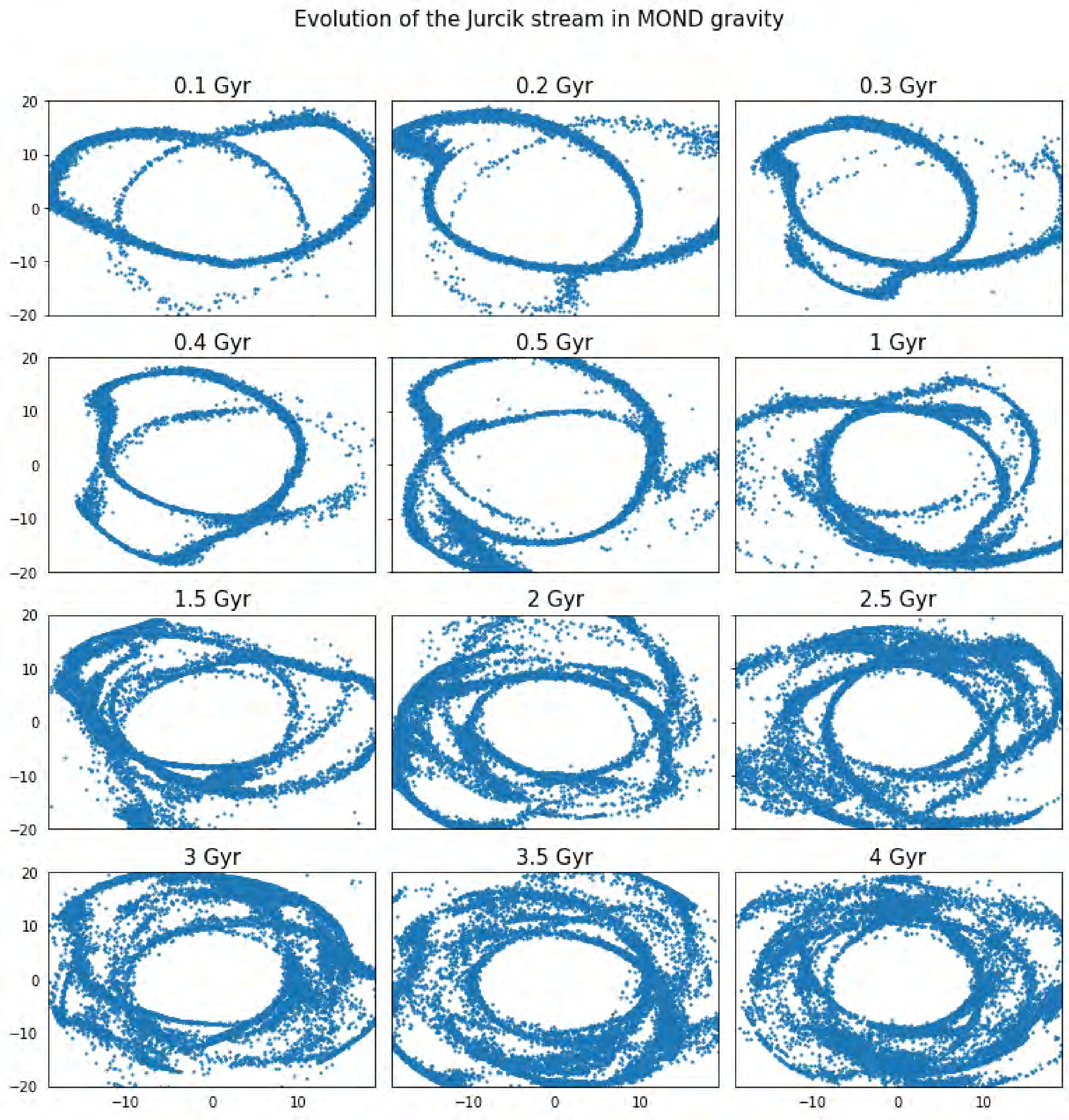
Evolution of the Pal5 stellar stream in the classical Newtonian gravity.



Evolution of the Pal5 stellar stream in the MOND gravity.



Evolution of the Jurcik stellar stream in the classical Newtonian gravity.



Evolution of the Jurcik stellar stream in the MOND gravity.

Newton vs. MOND

- dispersion of the particles in MOND model of gravity is much broader than in the Newtonian gravity
- Excluding spherical halo -> MOND does not suppress the effects caused by the rest of the Galaxy.
- MOND model more sensitive to small perturbations and errors. Resonances will show up more for this reason.

Benefits of our work

- Comparison of the classical and MOND approach
  - New approach for testing alternative approaches / classical approaches
  - Helps in understanding of the dark matter
- Integration of the large numbers of the particles
  - Parallel computing
  - Usage of the clusters
- Model of the Galaxy which can be used in the future

Acknowledgment

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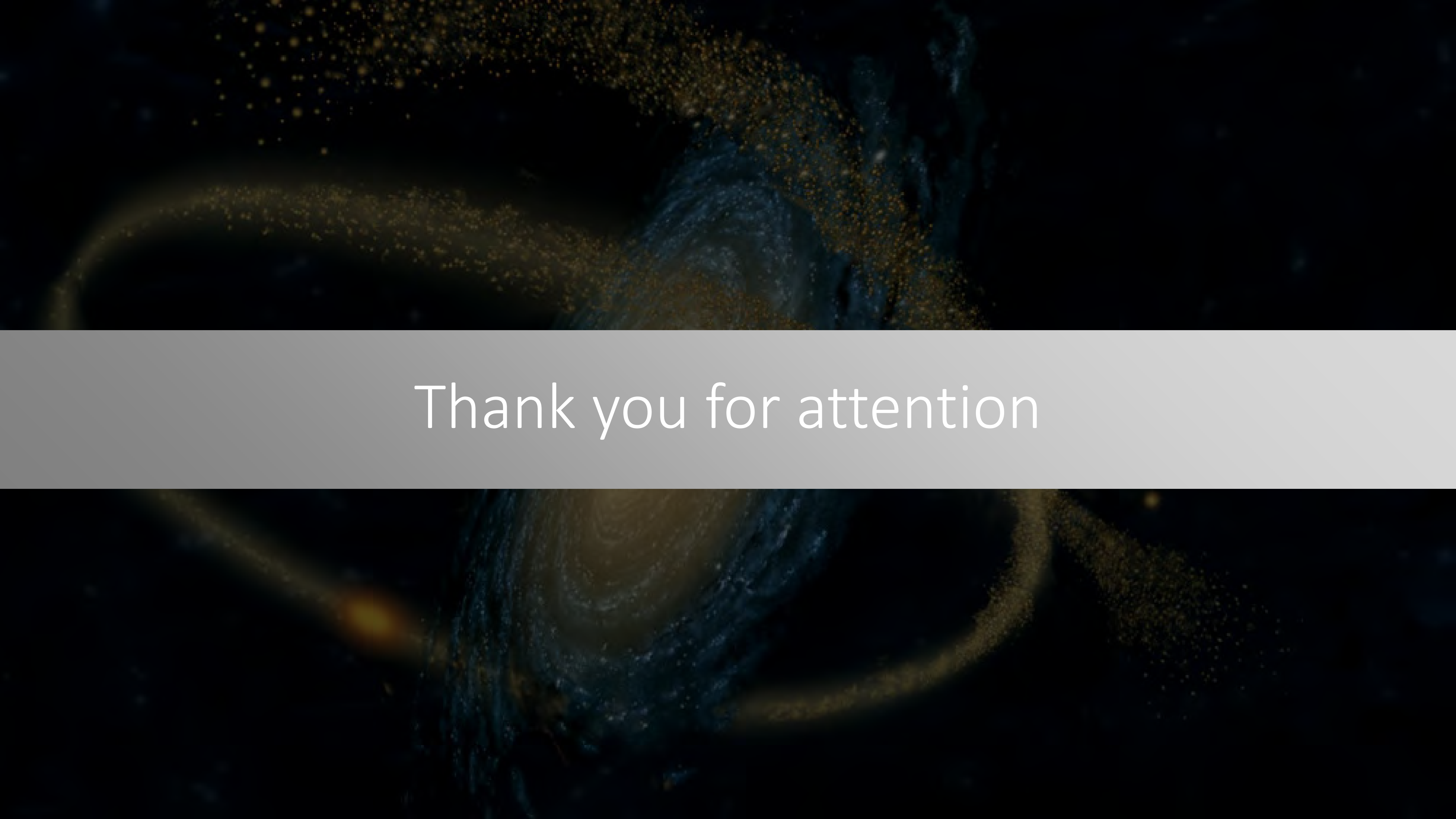
Thank you for attention