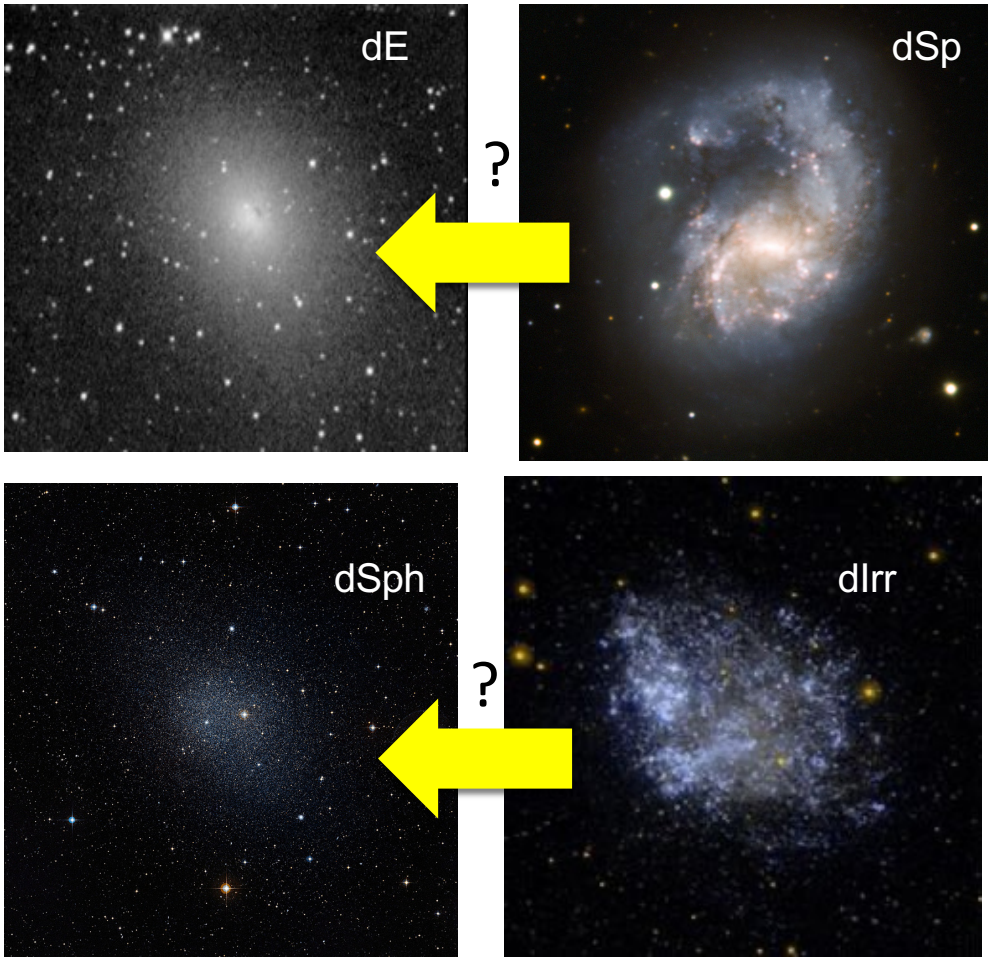
Recall: The Dwarf Galaxy Zoo:
SO HOW DOES THIS TRANSITION HAPPEN?

No Gas/SF
Spheroids

Gas & SF
Disks/Rotation



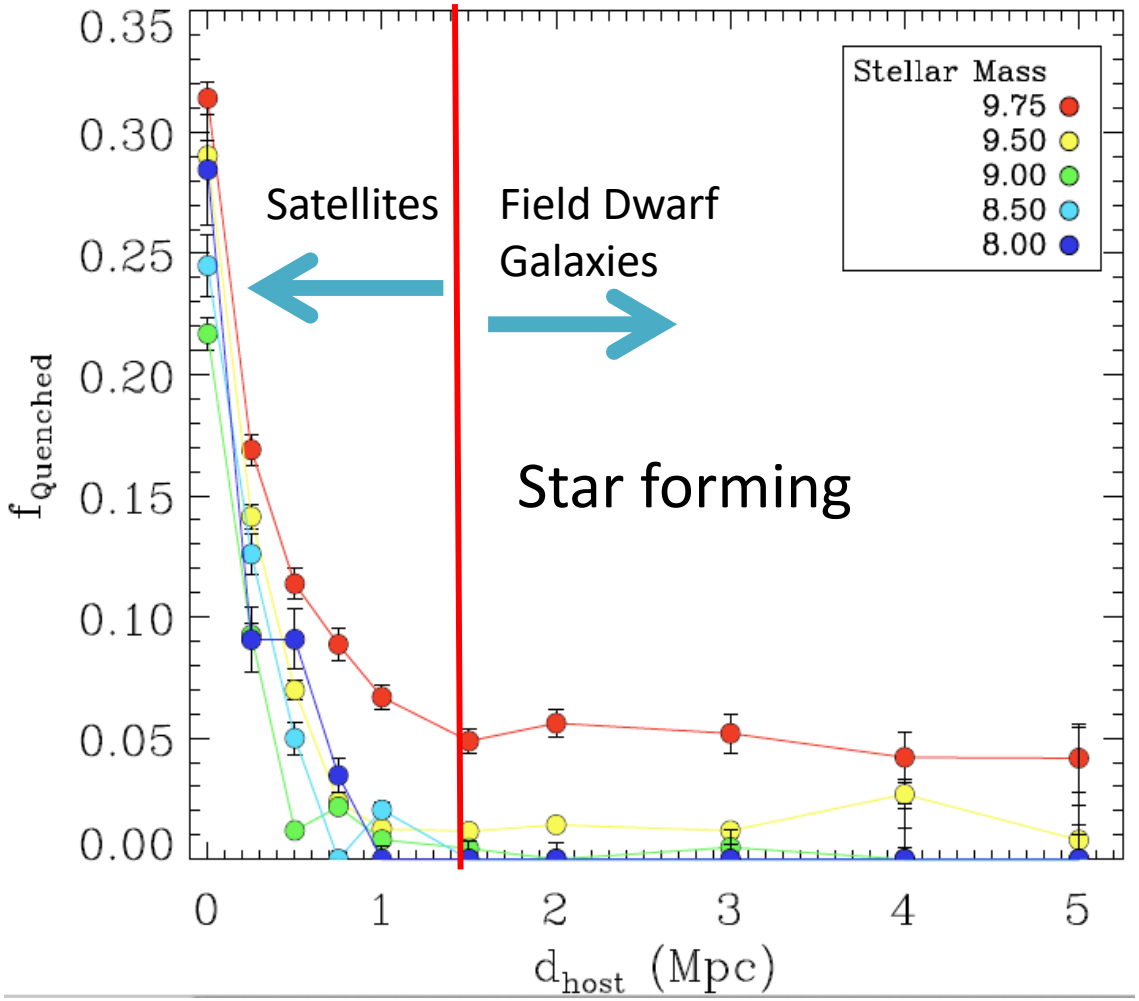
$5x10^9 > M_* > 10^7\ M_\odot$

$10^7 > M_* > 10^5\ M_\odot$

Recall: Dwarf galaxies are gas rich & forming stars

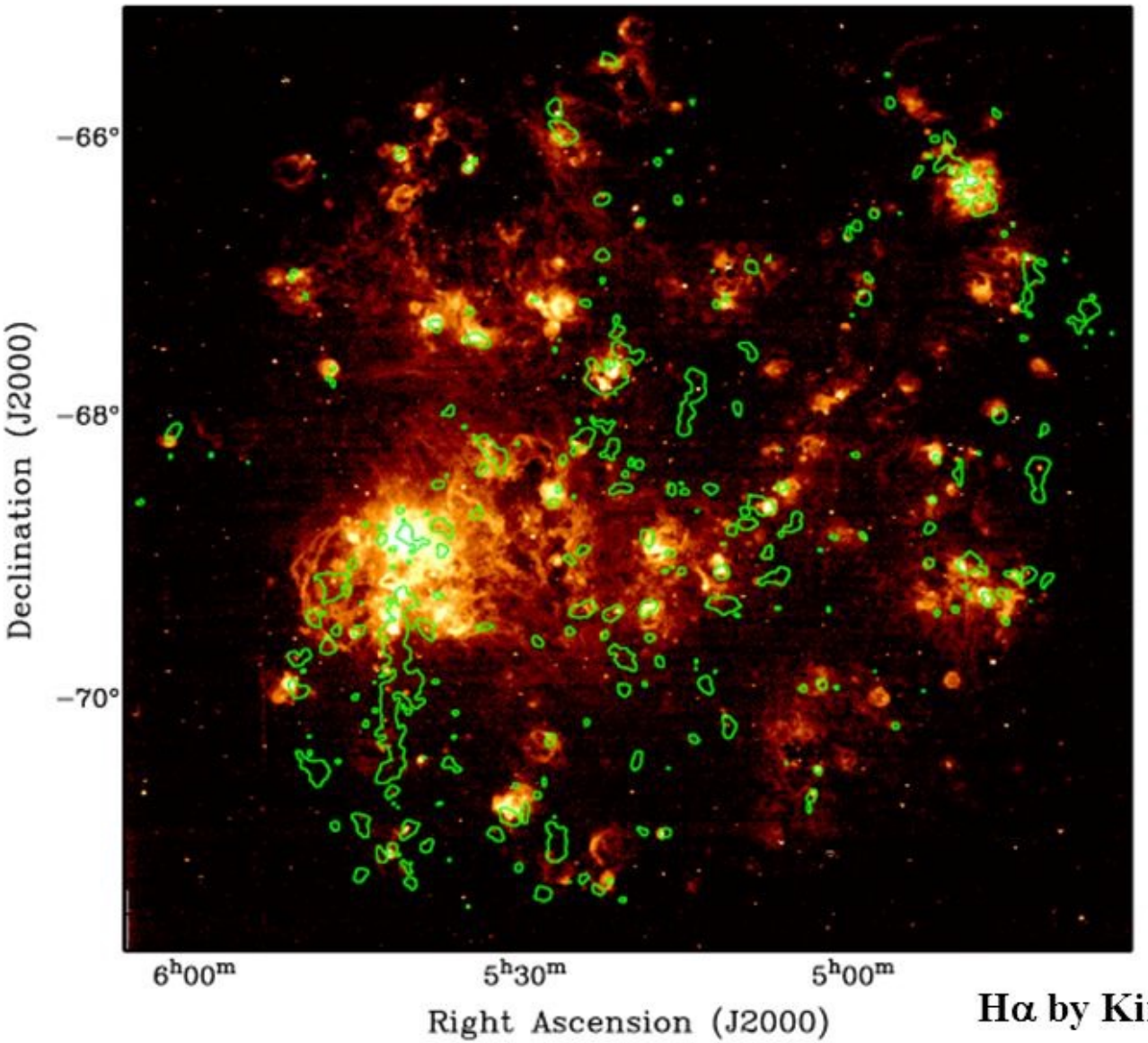
UNLESS they are close to a massive galaxy

Dwarfs (10^8-10^9 $M_\odot$) DON'T quench via secular processes



Geha+2012

Star formation is inefficient at low metallicity
LMC: CO and Hα



Most of the molecular gas in the LMC is not forming stars.

Green contour:

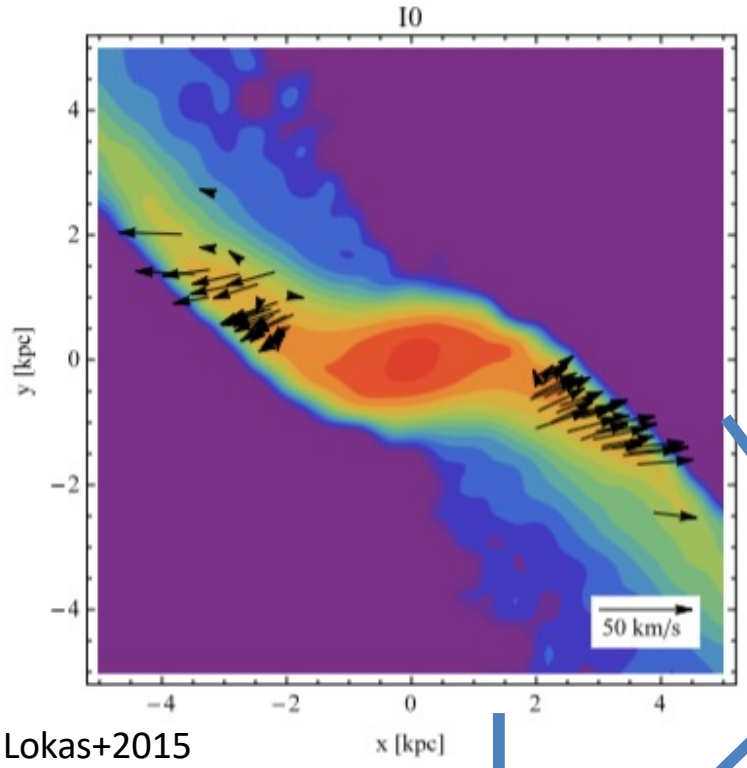
GMCs by NANTEN

Fukui et al. (2008)

Hα by Kim et al. (1999)

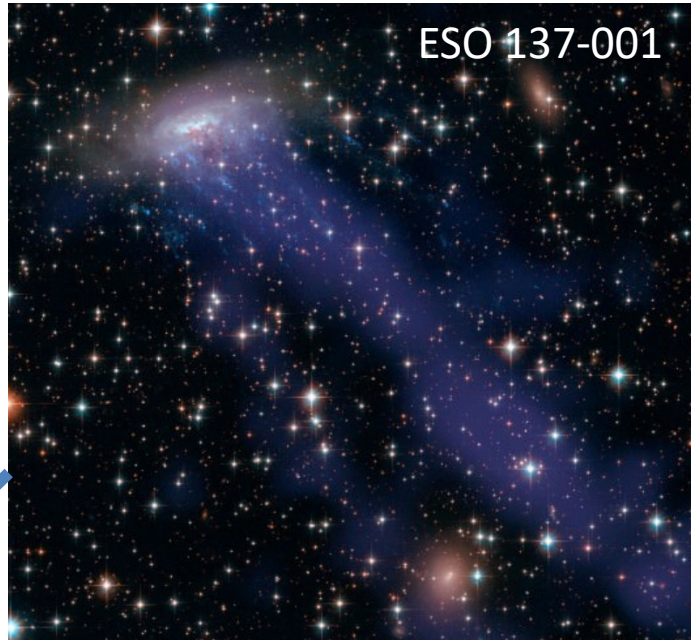
So why are the majority of dwarf galaxies near MW type hosts quenched?

TIDAL STRIPPING



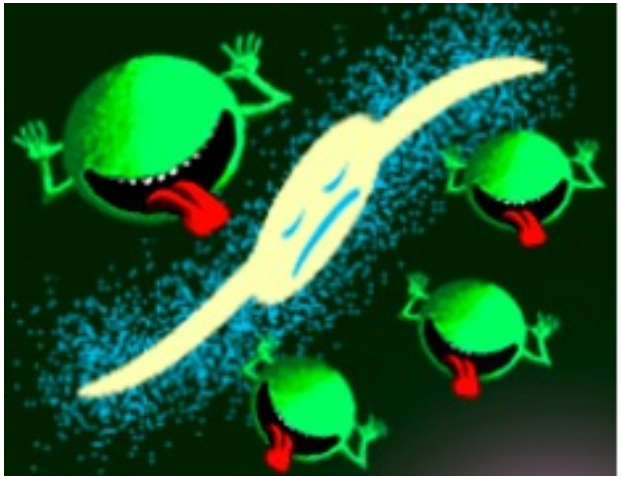
Lokas+2015

RAM PRESSURE STRIPPING



+

HARRASSMENT



STRANGULATION/STARVATION

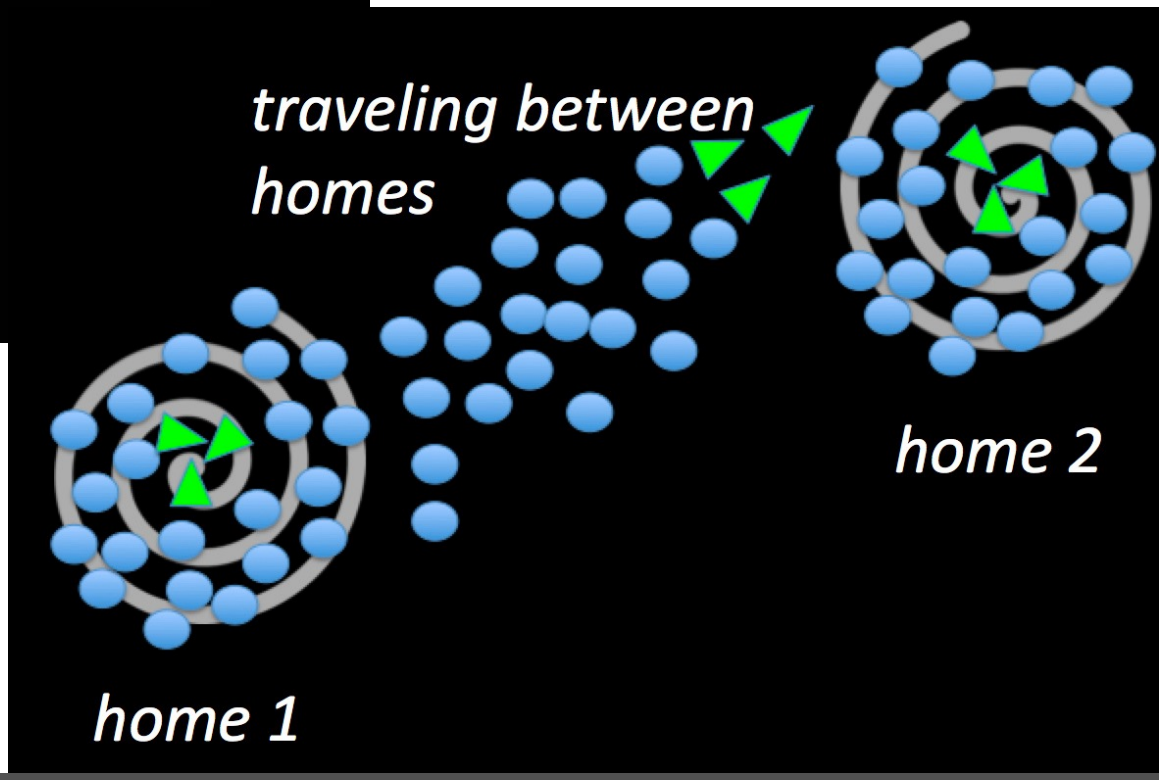
"out of fuel"

(gas supply cut off, stars form passively)

images: Dr. Aeree Chung

Simulation of interacting spiral galaxies.
Image adapted from Moreno + 2018

Dr. Jorge Moreno



A diagram of dancing that occurs during Hatun Puncha, where groups of dancers and musicians travel from home to home, dancing in spirals that change directions. Smaller groups merge to form larger dance troupes throughout the festival.

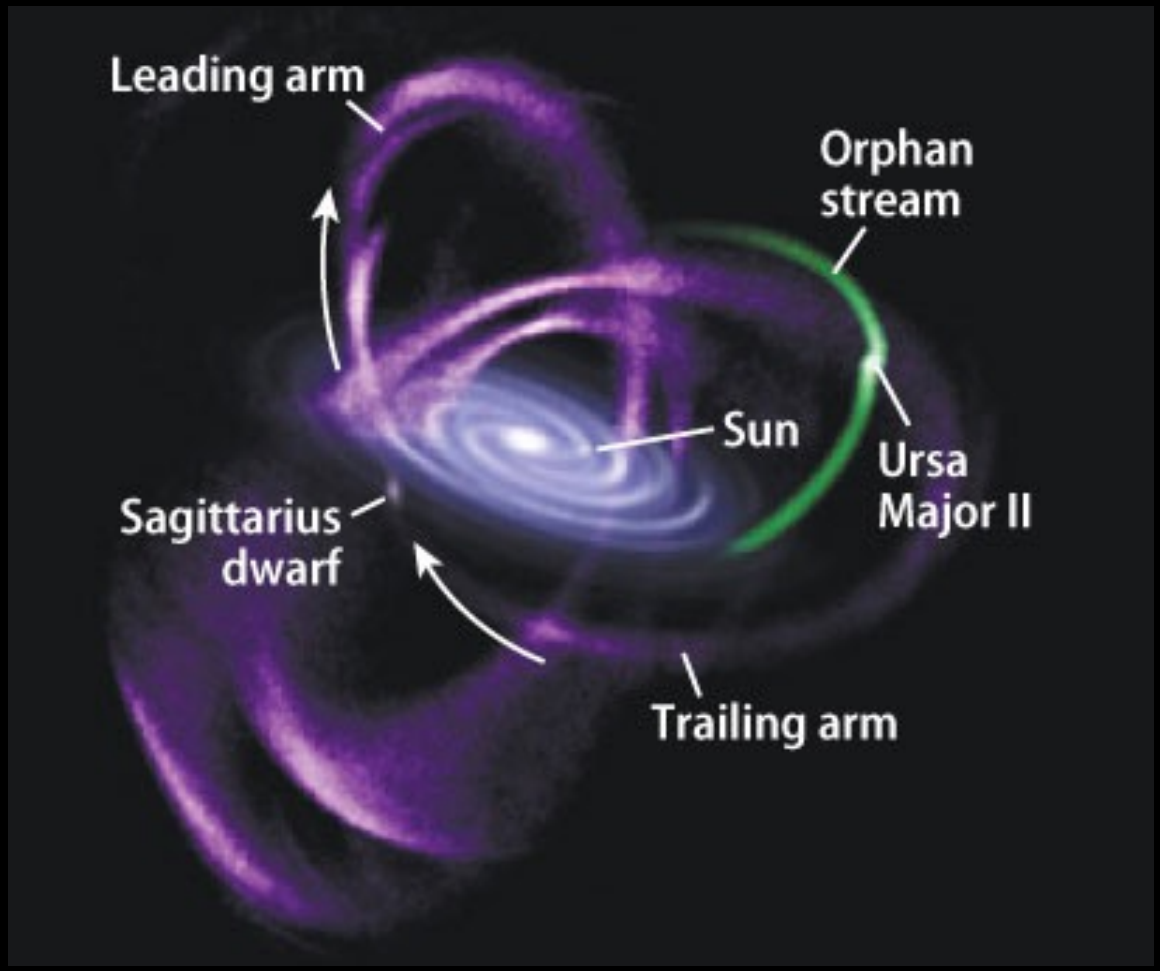
Diagram by Jessie M. Vallejo

Jorge Moreno's Suggested Change of Language

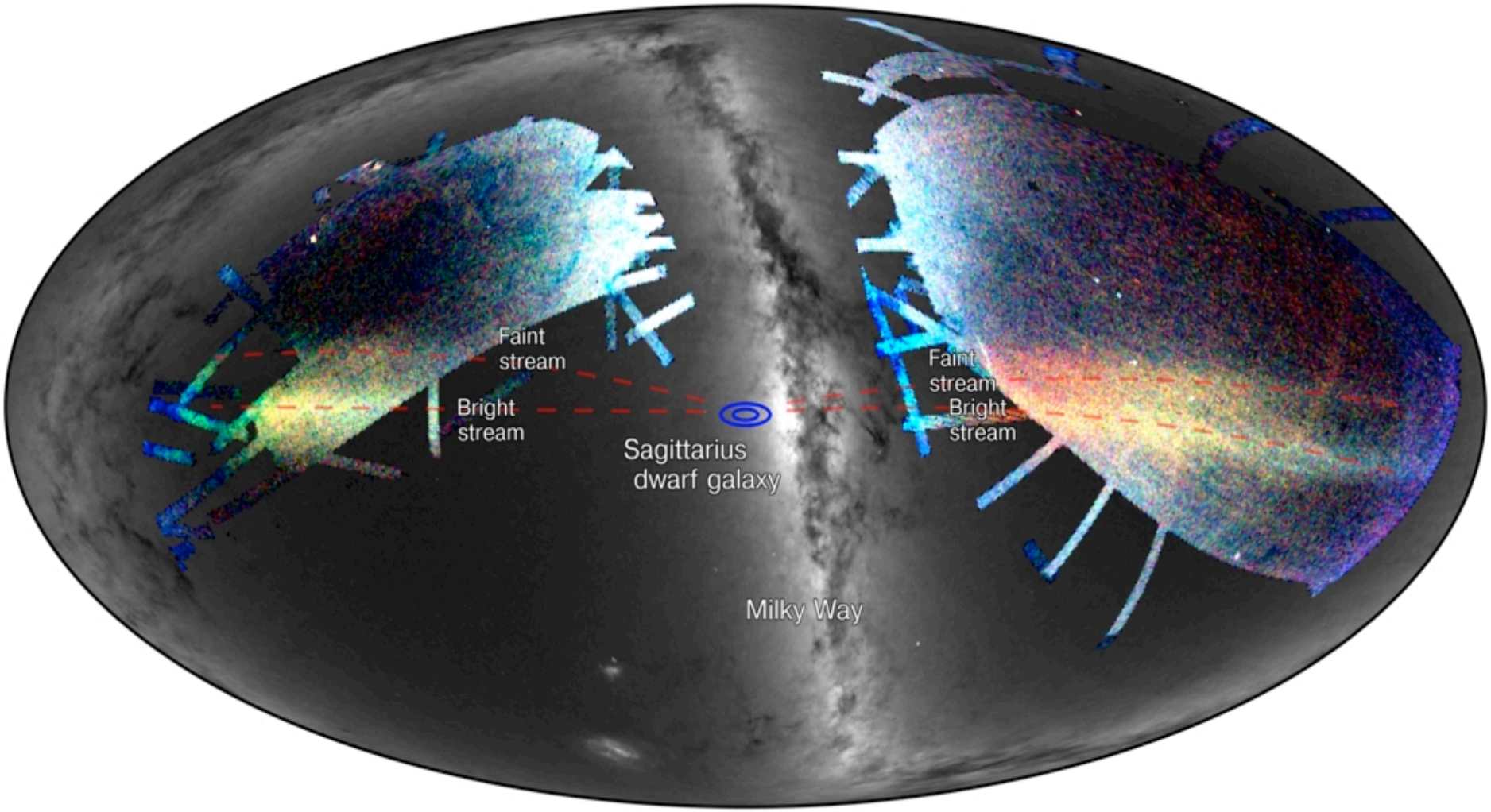
hierarchical scenario	*ancestral scenario*
devouring	*including*
cannibalism	*collectivism*
harassment	*communion*
stripping	*sharing*
strangulation	*collaboration*
starvation	*preservation*
disruption	*incorporation*

https://folklife.si.edu/magazine/intergalactic-pachamama-kichwa-cosmology-vs-western-astrophysics

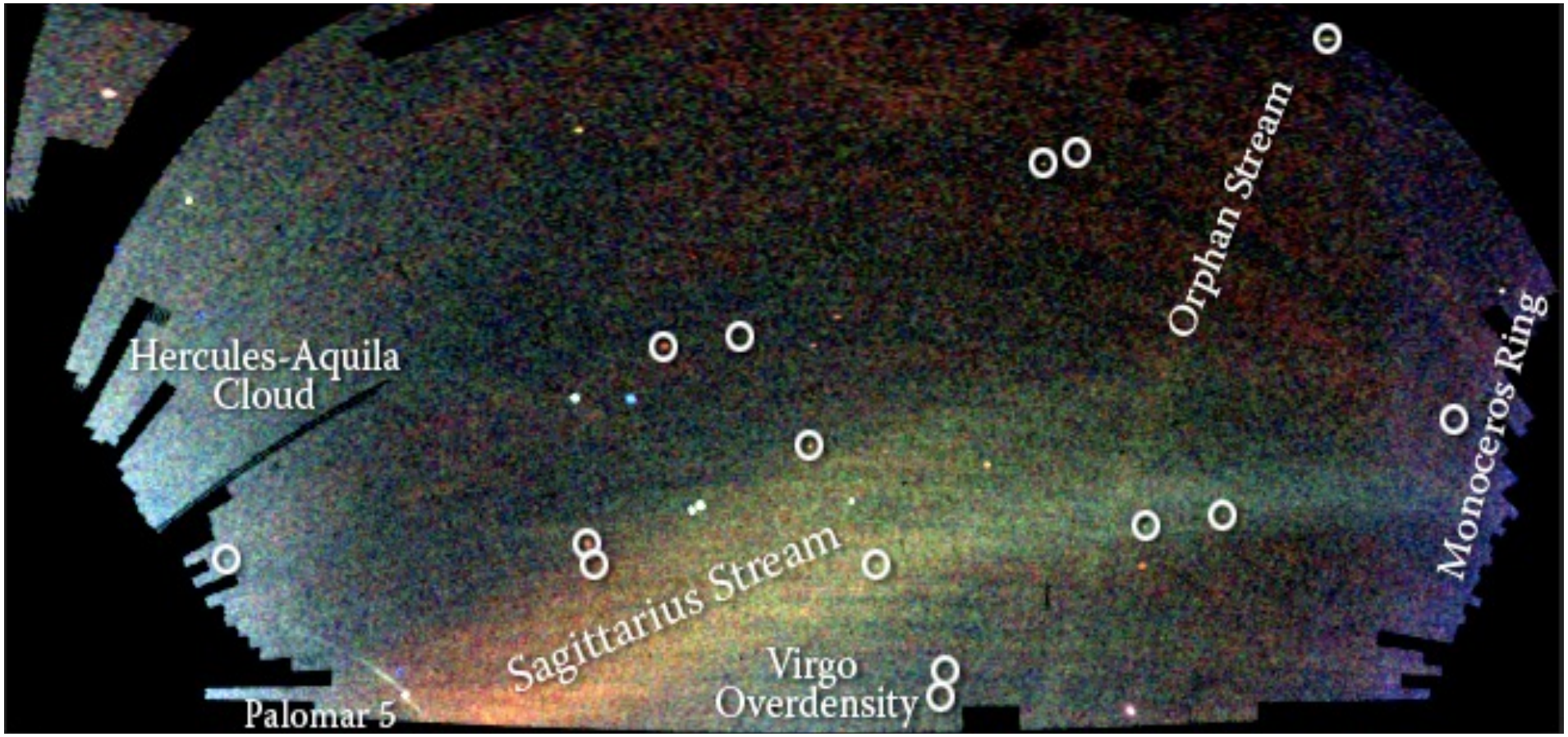
The MW Stellar Halo contains stellar streams, remnants of the tidal sharing process



SDSS: Field Of Streams

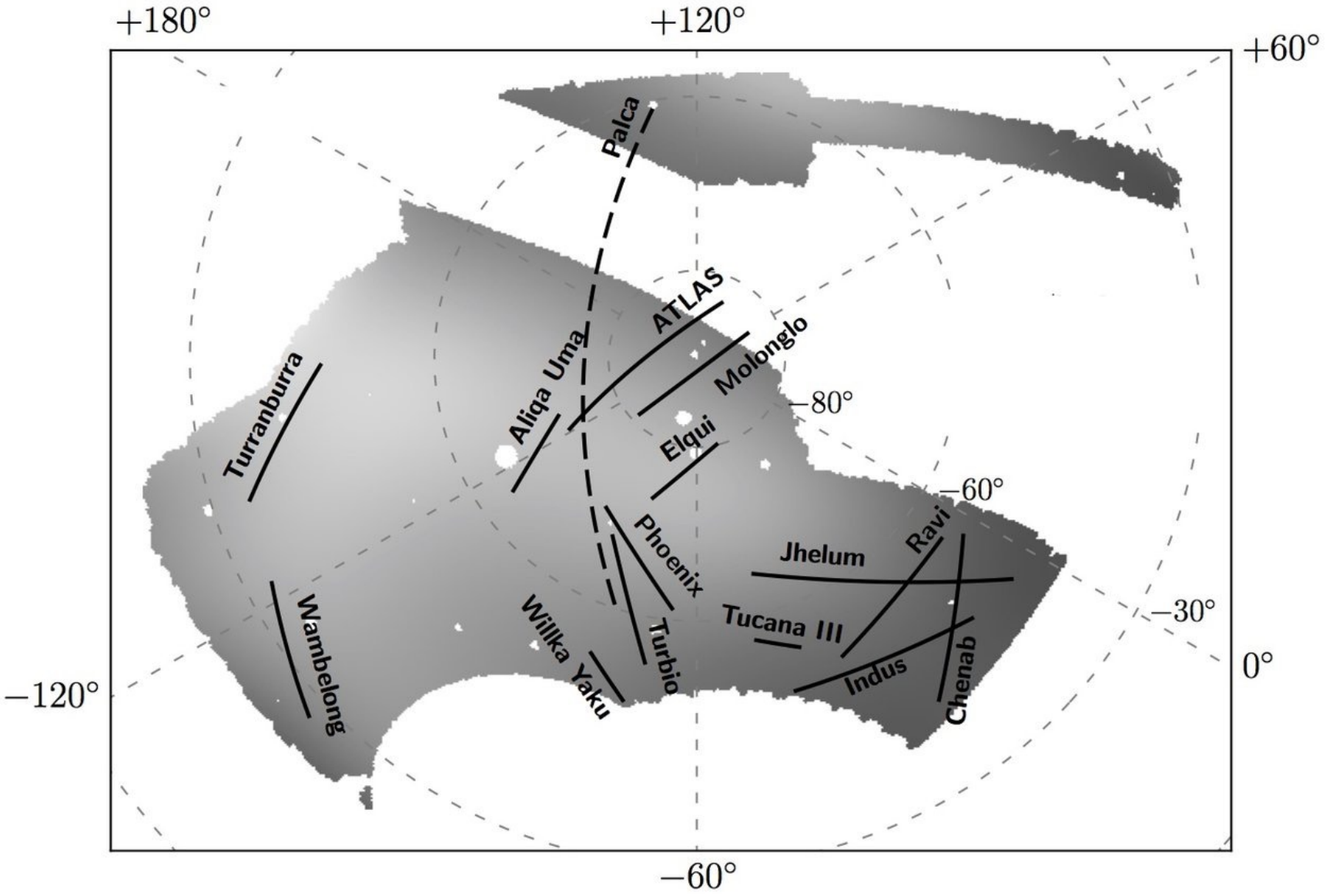


SDSS Field of Streams: Northern Hemisphere

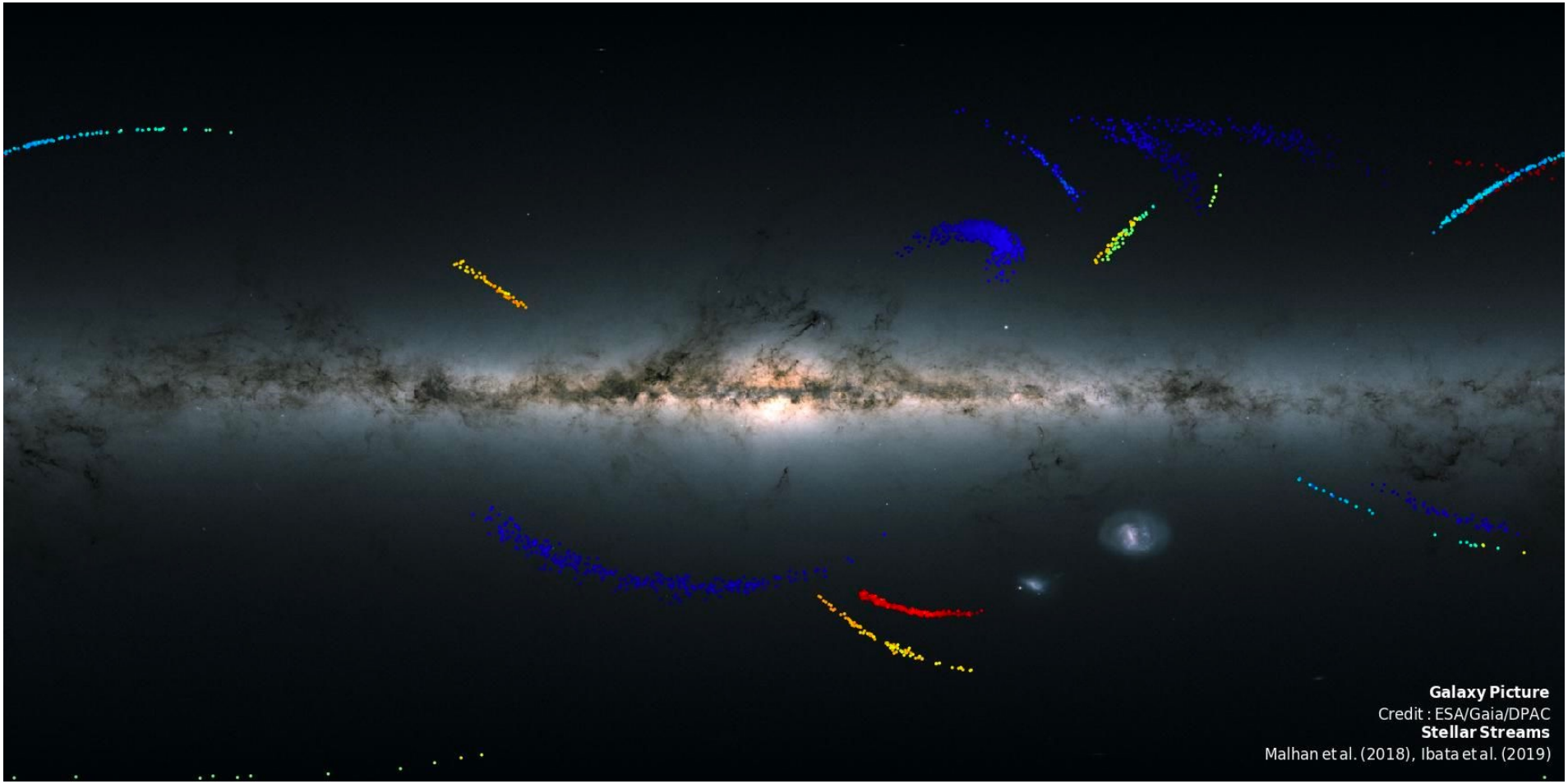


Color coding indicates radial velocity

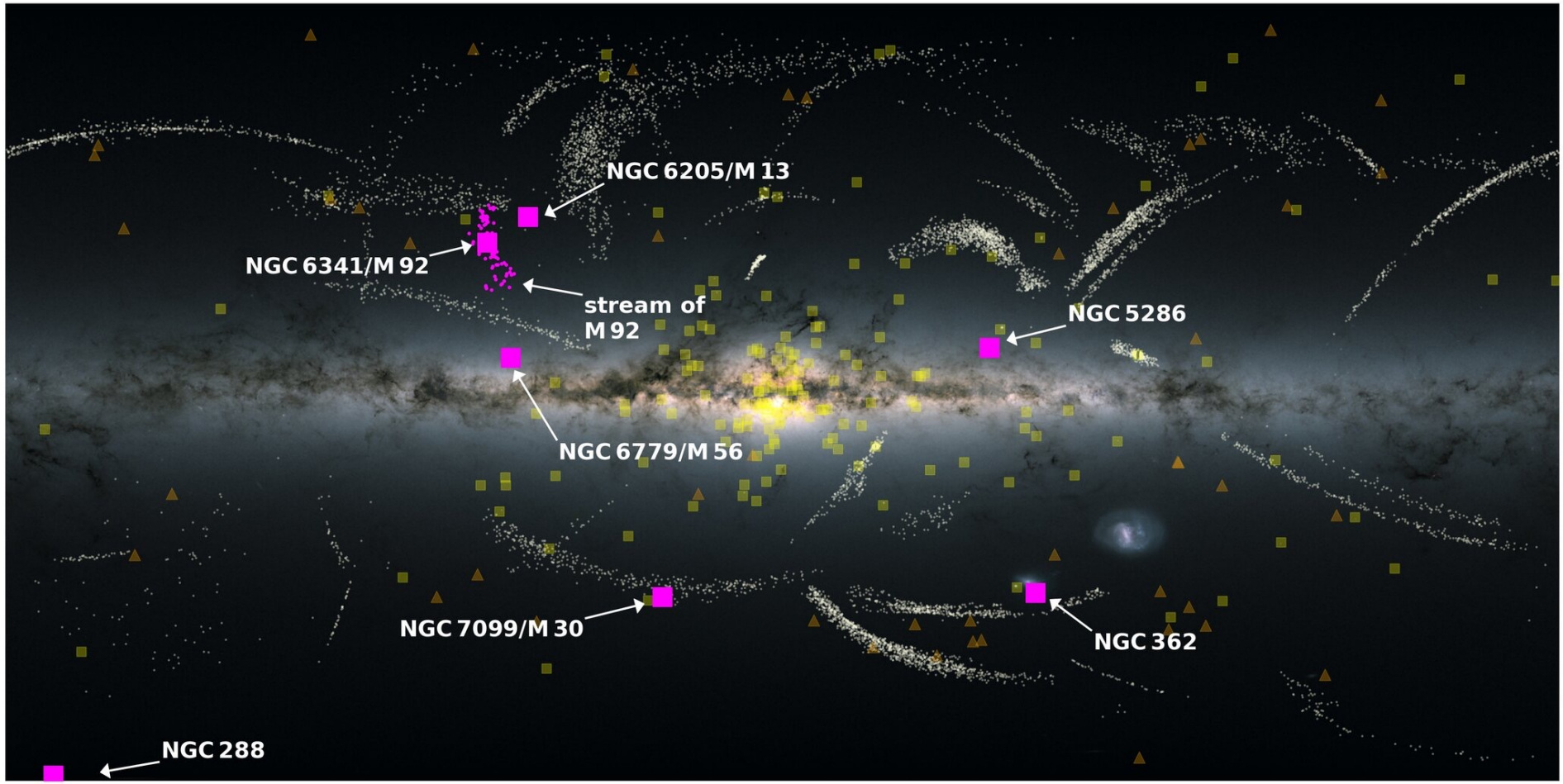
Dark Energy Survey



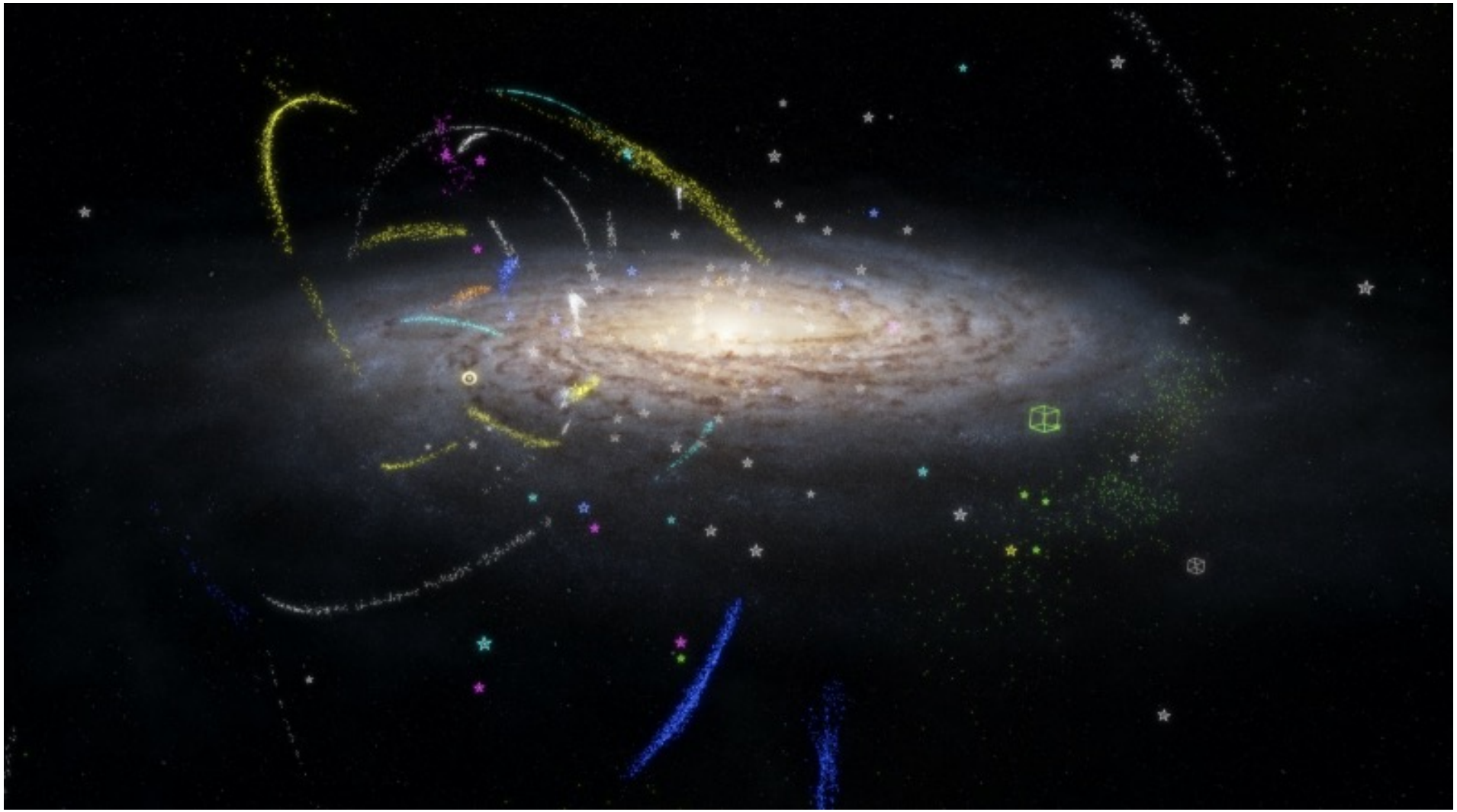
Gaia Streams: EDR2



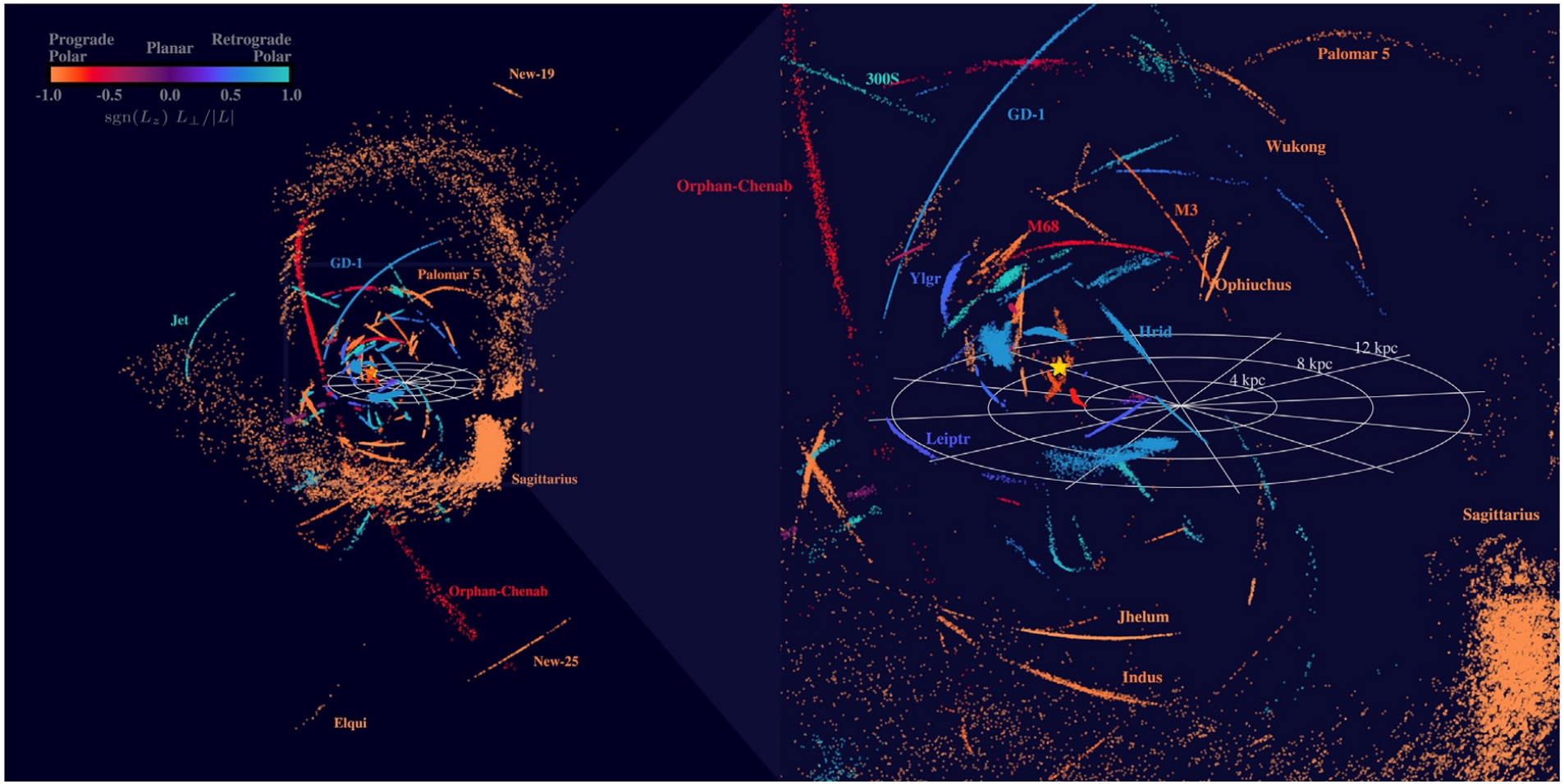
Gaia Stream : EDR3



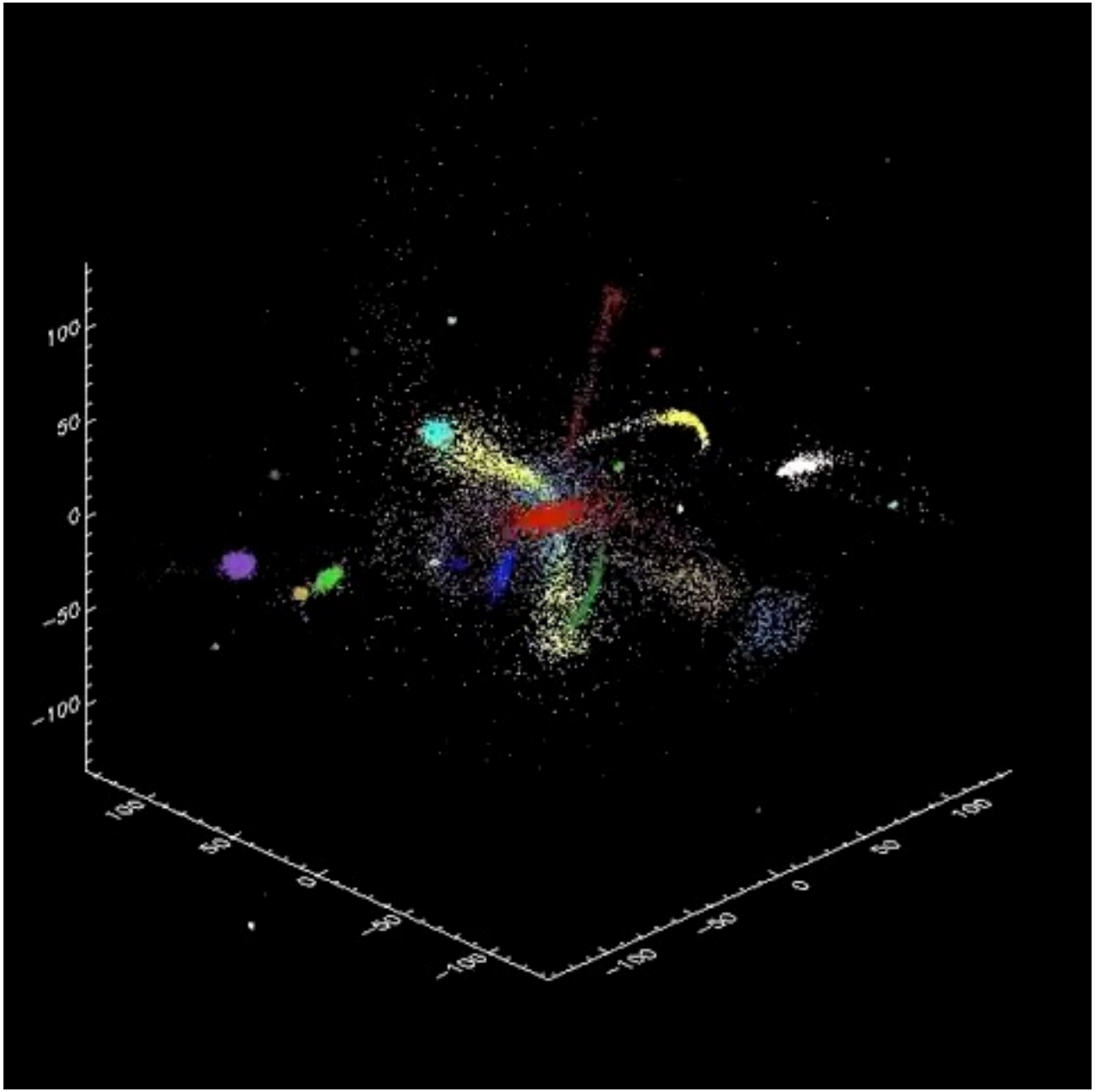
This image shows the Milky Way as seen by Gaia. The squares represent the location of globular clusters, the triangles the location of satellite galaxies, and the small dots are stellar streams. (Malhan+2022)



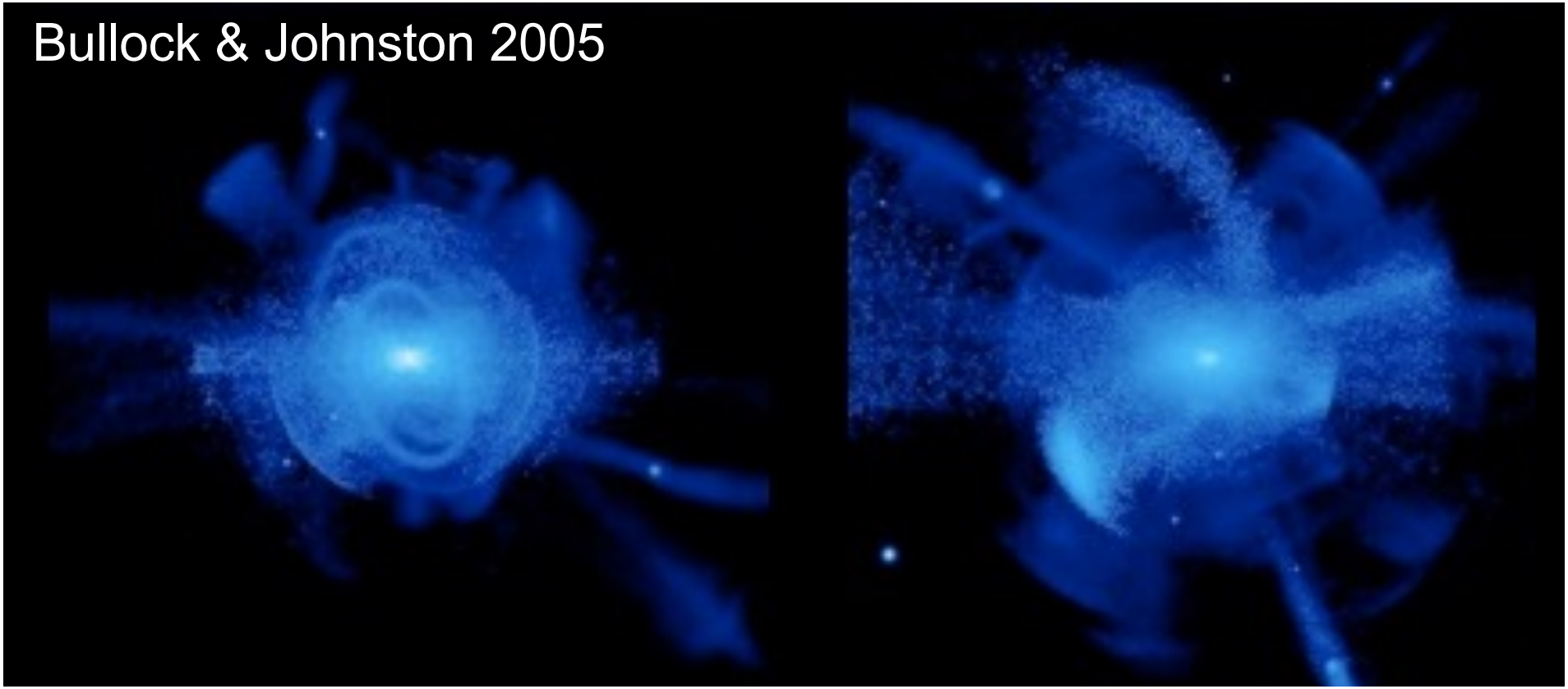
The Milky Way galaxy and the stellar streams (colored dots), globular clusters (star symbols) and dwarf galaxies (small cubes)
© S. Payne-Wardenaar / Khyati Malhan, MPIA. Malhan+2022



Bonaca & Price-Whelan 2025 New Astronomy Reviews, Volume 100, id.101713



Bullock & Johnston 2005


Bullock & Johnston 2005


Elliptical Galaxy
NGC 474
P-A Duc
CFHT

Tidal Radius: Point mass host, no rotation

$$r_t \sim (m/4M)^{1/3} D.$$

Accounting for centrifugal forces:

$$\mathbf{v}' \equiv \frac{d\mathbf{x}'}{dt'} = \mathbf{v} - \Omega \times \mathbf{x}.$$

Angular speed

Jacobi Constant:

$$E_J = \frac{1}{2}\mathbf{v}'^2 + \Phi_{\rm eff}(\mathbf{x}'), \quad \text{where } \Phi_{\rm eff}(\mathbf{x}') \equiv \Phi(\mathbf{x}') - \frac{1}{2}(\vec{\Omega} \times \mathbf{x}')^2$$

For a satellite (m) orbiting a host (M) :

$$\Phi_{\rm eff}(x) = -\frac{GM}{|D-x|} - \frac{Gm}{|x|} - \frac{\Omega^2}{2}\left(x - \frac{DM}{M+m}\right)^2.$$

$$\frac{\partial \Phi_{\rm eff}}{\partial x} = 0 = -\frac{GM}{(D-x)^2} \pm \frac{Gm}{x^2} - \Omega^2 \left(x - \frac{DM}{M+m} \right)$$

Solutions: Lagrange points L1 and L2 are

$$x = \pm r_J, \quad \text{where } r_J = D \left(\frac{m}{3M+m} \right)^{1/3}$$

For an extended host (Isothermal Sphere):

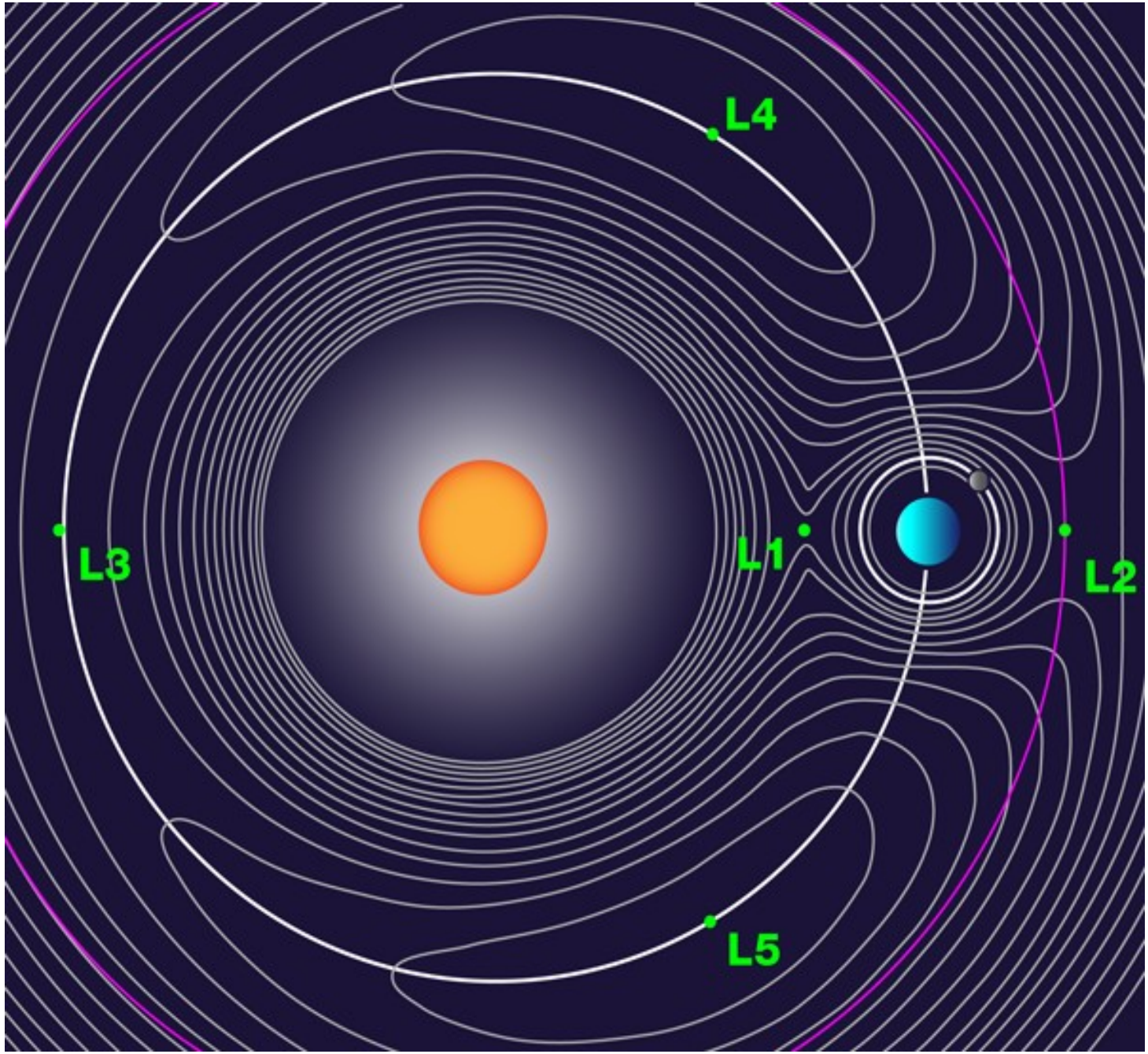
Szebehely 1967,
Valtonen & Karttunen 2006

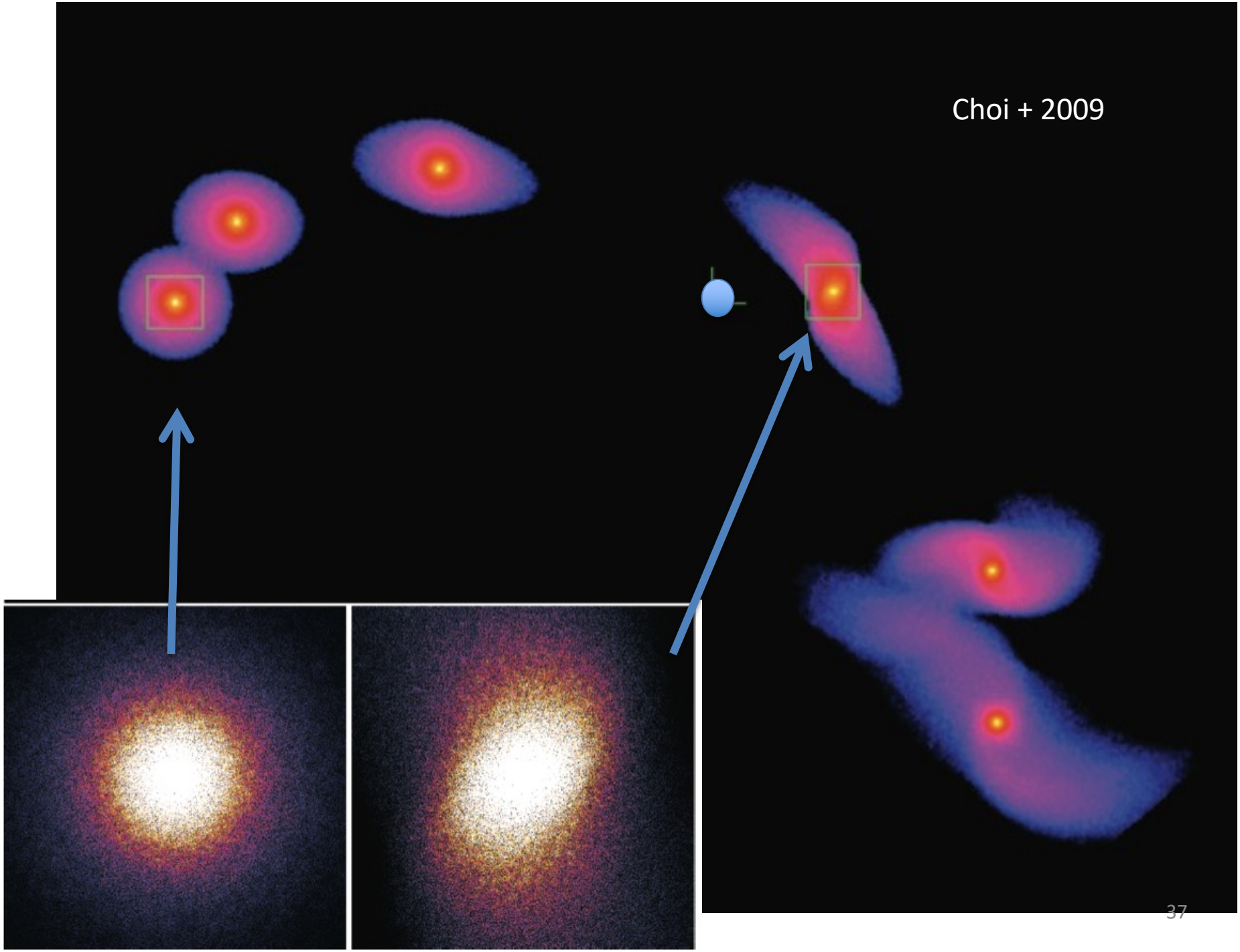
$$r_J = D \left[\frac{m}{2M(<D)} \right]^{1/3}$$

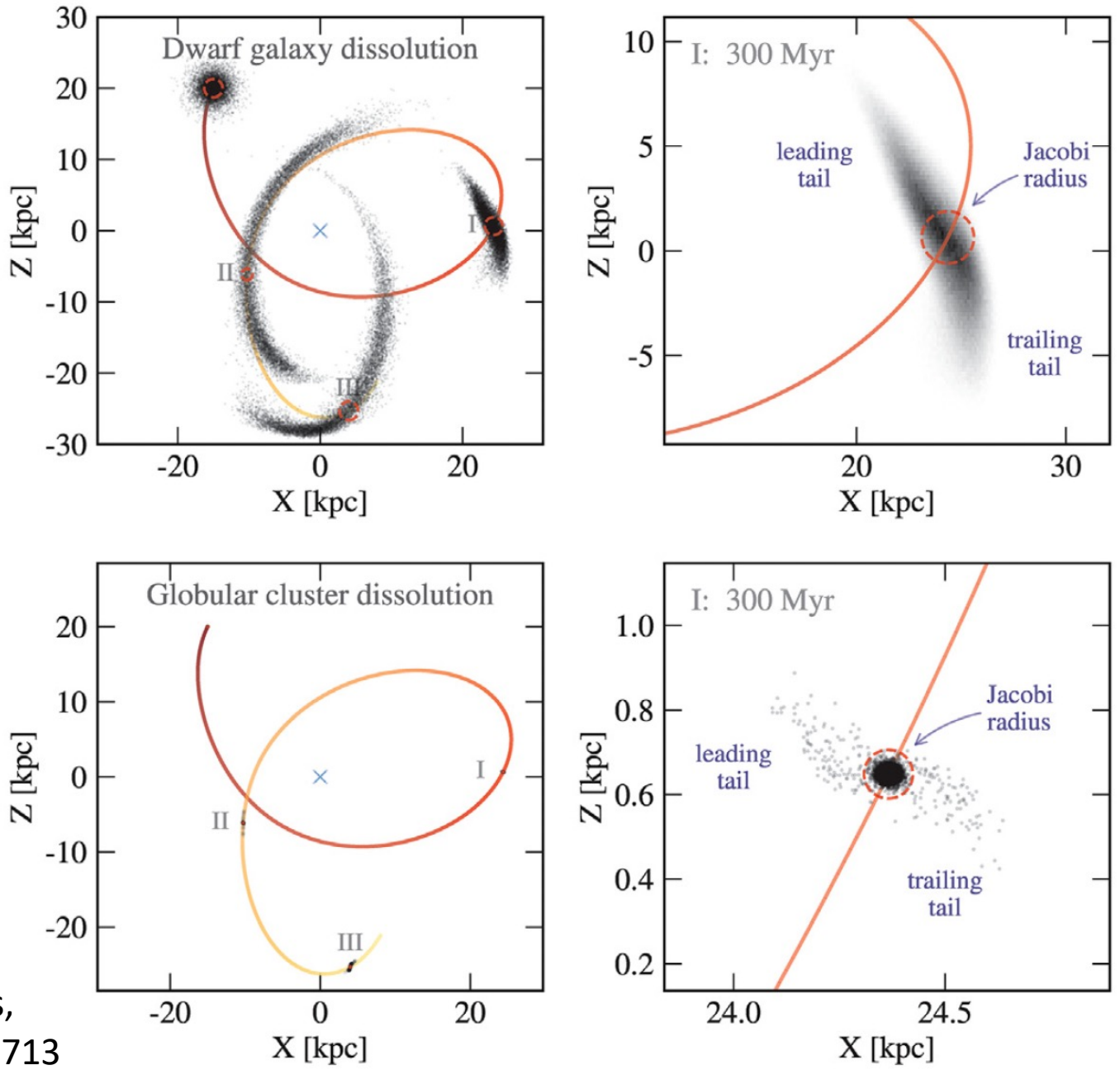
For an extended host (in general):

Chapter 4 of Sparke & Gallagher

$$r_J = \left(\frac{GM_{sat}}{\Omega^2 - d^2\Phi/d^2r} \right)^{1/3}$$


L4
L3
L1
L2
L5


Choi + 2009



Bonaca & Price-Whelan 2025 New Astronomy Reviews, Volume 100, id.101713