Observational link between the physics of galaxy rotation and recent anomalies in the large-scale structure

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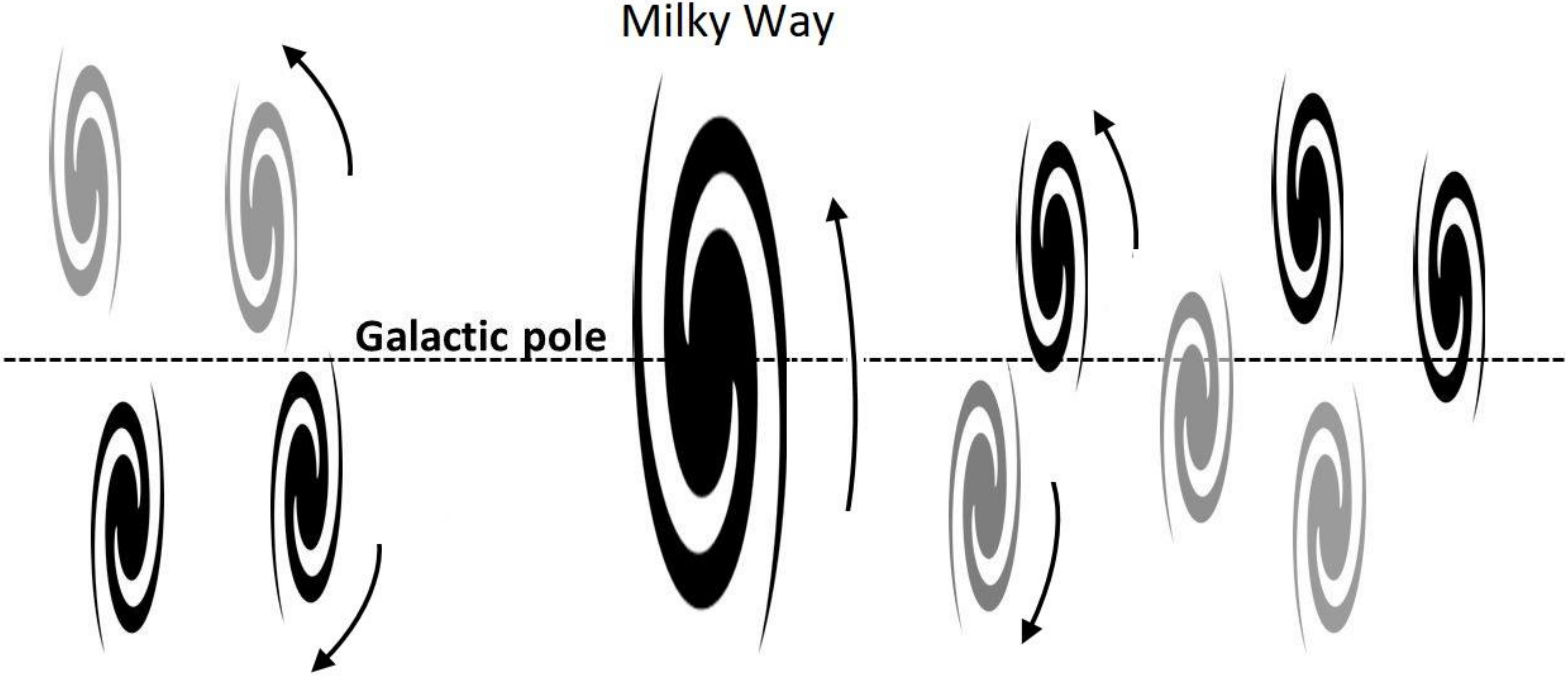

Milky Way
Galactic pole

DESI Legacy Survey

Northern Galactic Pole (60x60 degree window centered at the Northern galactic pole)

Band	# cw galaxies	# ccw galaxies	Mag ccw	Mag cw	ΔMag	t-test P
G	20,918	21,253	20.06525±0.010	20.10073±0.010	-0.03548	0.01
R	20,917	21,251	18.98522±0.008	19.01481±0.008	-0.02958	0.01
Z	20,925	21,261	18.2934±0.007	18.31783±0.007	-0.02443	0.01

Southern Galactic Pole (60x60 degree window centered at the Southern galactic pole)

Band	# cw galaxies	# ccw galaxies	Mean Mag ccw	Mean Mag cw	ΔMag	t-test P
G	87,640	89,534	20.13622±0.004	20.11937±0.004	0.01685	0.003
R	87,917	89,849	19.08793±0.003	19.07216±0.003	0.01574	0.0002
Z	88,228	90,142	18.38424±0.003	18.37225±0.003	0.01199	0.0047

McAdam & Shamir, Symmetry (special issue on symmetry in gravitation and cosmology), 15(6), 1190, 2023.

https://arxiv.org/abs/2212.04044

Northern galactic pole

SDSS (~1.2*10 ^{5} galaxies)

Band	Mag cw	Mag ccw	ΔMag	P t-test
G	17.7095±0.005	17.6948±0.005	0.0147	0.0376
R	16.9893±0.004	16.9745±0.004	0.0148	0.0089
Z	16.4564±0.004	16.4393±0.004	0.0171	0.0025

HST (COSMOS, ~5*10 ^{4} galaxies)

Band	Mag cw	Mag ccw	ΔMag	P (t-test)
G	23.131±0.019	23.077±0.019	0.054	0.023
R	22.266±0.019	22.218±0.02	0.048	0.045
Z	21.358±0.017	21.323±0.018	0.035	0.087

McAdam & Shamir, Symmetry, 2023
Shamir, L., ApJ, 2016
Shamir, L., PASA, 2017
Shamir, L., Open Ast., 2020

Galaxy Zoo (Northern Galactic Pole)

Band	Mag cw	Mag ccw	ΔMag	P t-test
G	16.9765±0.01	16.9579±0.01	0.0186	0.09
R	16.4129±0.01	16.3723±0.01	0.0406	0.002
Z	15.9817±0.01	15.9539±0.01	0.0278	0.025

McAdam & Shamir, Symmetry (special issue on symmetry in gravitation and cosmology), 15(6), 1190, 2023.

A galaxy rotating in the opposite direction relative to the Milky Way is brighter than a supernovae rotating in the opposite direction

$$F = F_o(1 + 4 \cdot \frac{V_r}{c})$$

Assuming v/c of 0.0007 the brightness difference is expected to be ~0.006.

The observed difference agrees with galaxy rotational velocity of 5-10 times the rotational velocity of the Milky Way.

Magnitude difference should lead to observed dipole axis in galaxy spin directions, and should peak around the Galactic pole

MacGillivray & Dodd, 1985, A&A

Longo, 2011, PLB

Shamir, 2012, PLB

Shamir, 2020, ApSS

Shamir, 2021, PASA

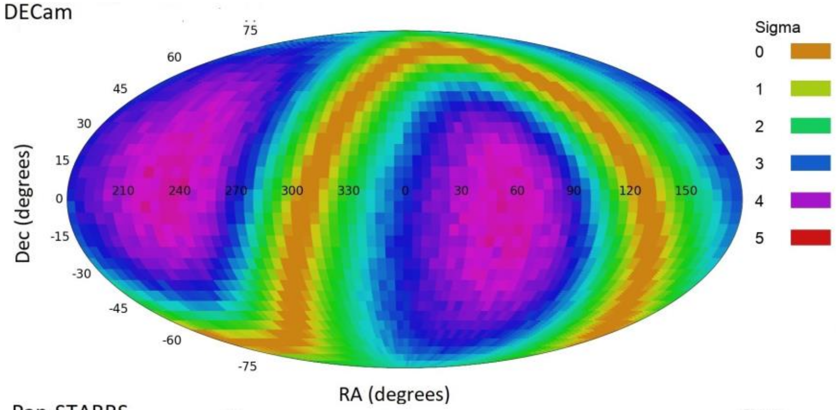
Shamir, 2022, AN

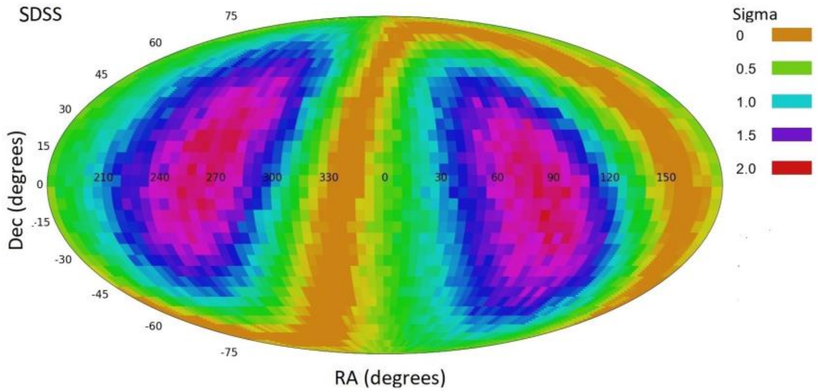
Shamir, 2022, New Astronomy

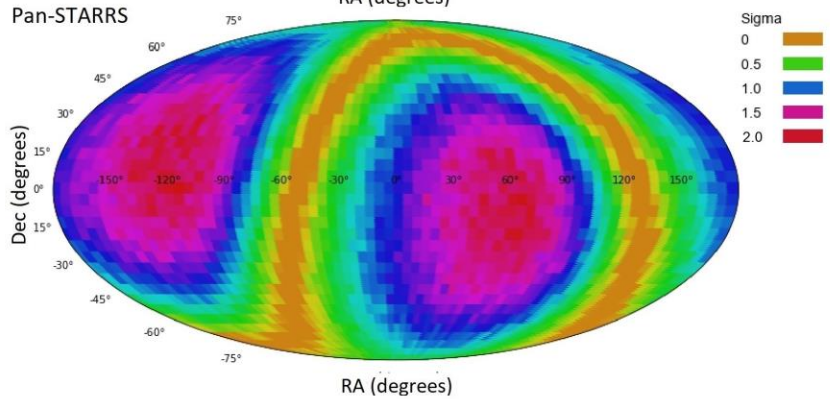
Shamir, 2022, AA

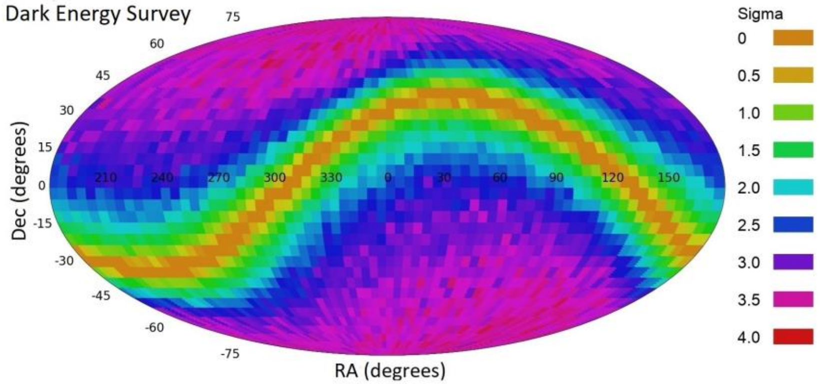
Shamir, 2022, Universe

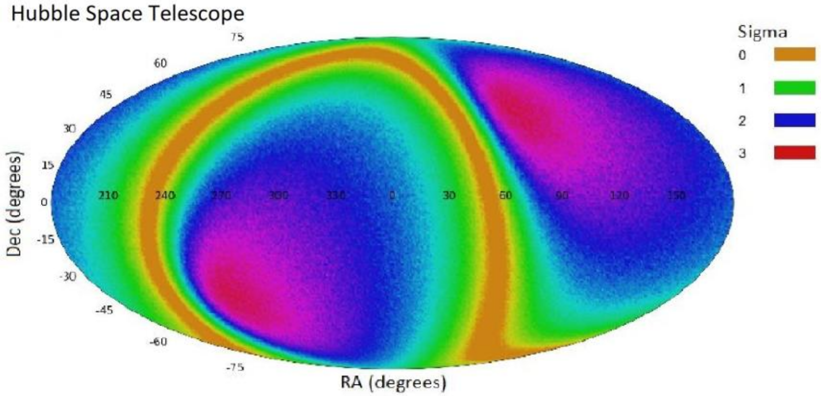
Shamir, 2022, MNRAS

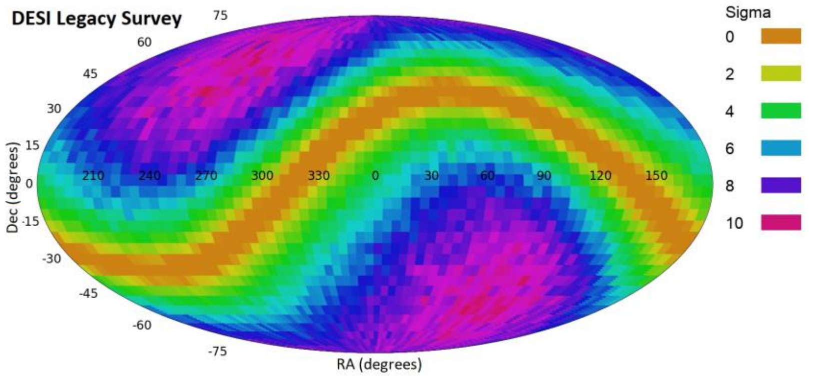


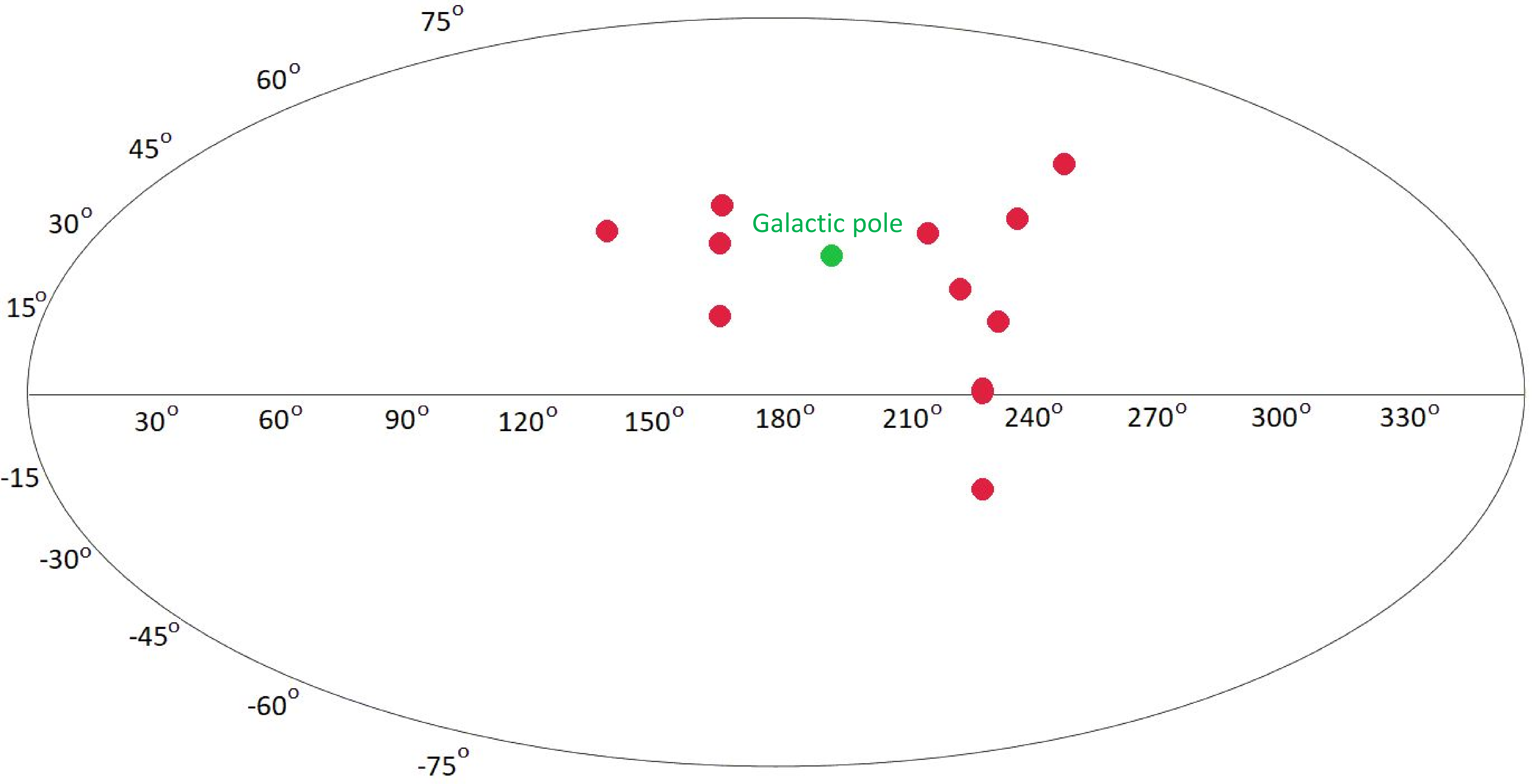






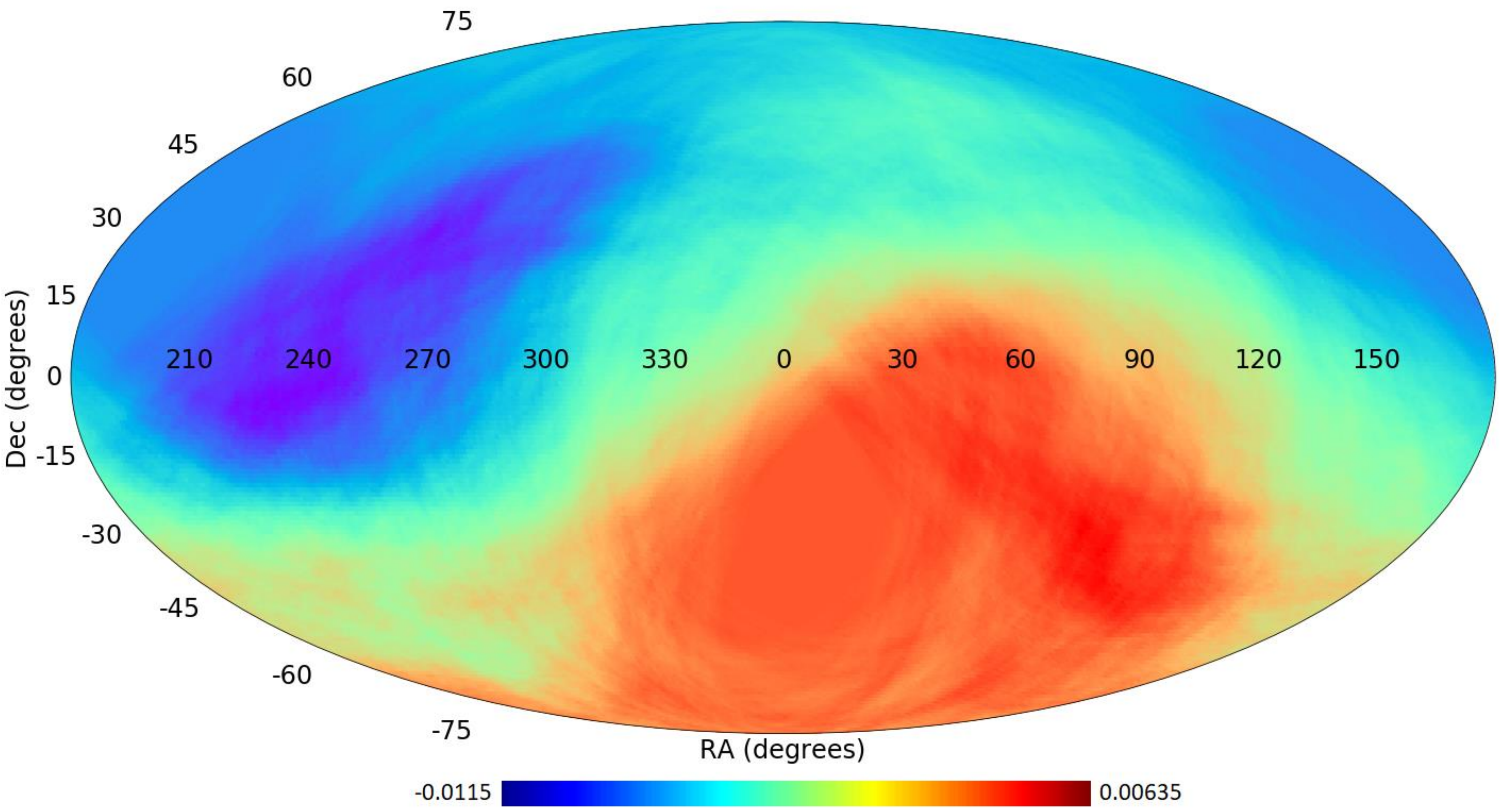






https://arxiv.org/abs/2212.04044

DESI Legacy Survey (1.3M galaxies)



Shamir, L., 2022, MNRAS, 516, 2281

Studies showing no dipole in galaxy spin directions

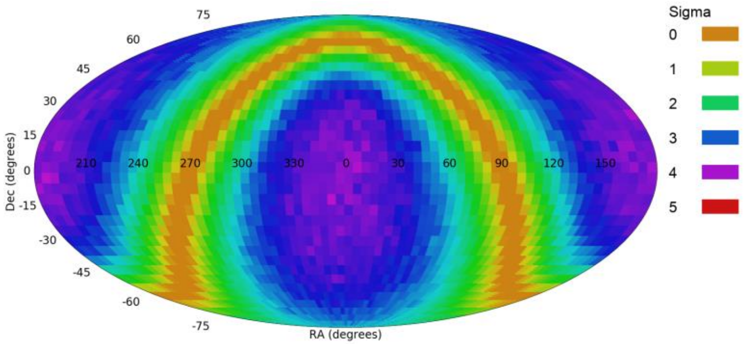
Study | **Reproduction** | **Explanation**

(Land et al., 2008)

Statistical analysis shows P=~0.038.

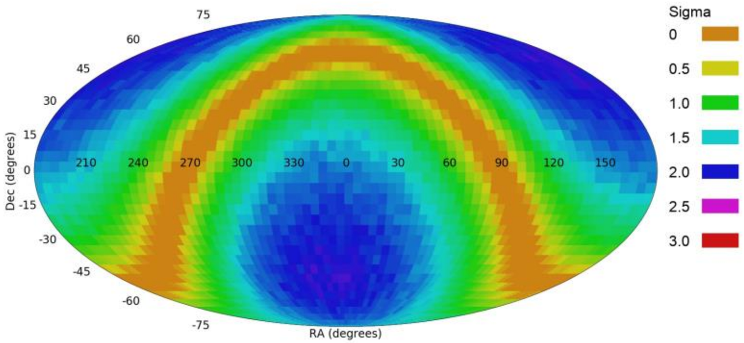
1) Very small dataset. 2) No statistical analysis.
(Shamir, PASJ, 2022)

(Hayes et al., 2017)



Machine learning was used, but all features that correlate with galaxy spin directions were manually removed before the algorithm was applied.
(McAdam & Shamir, *Advances in Astronomy*, 2023)

(Iye et al., 2021)



Confirmation bias?

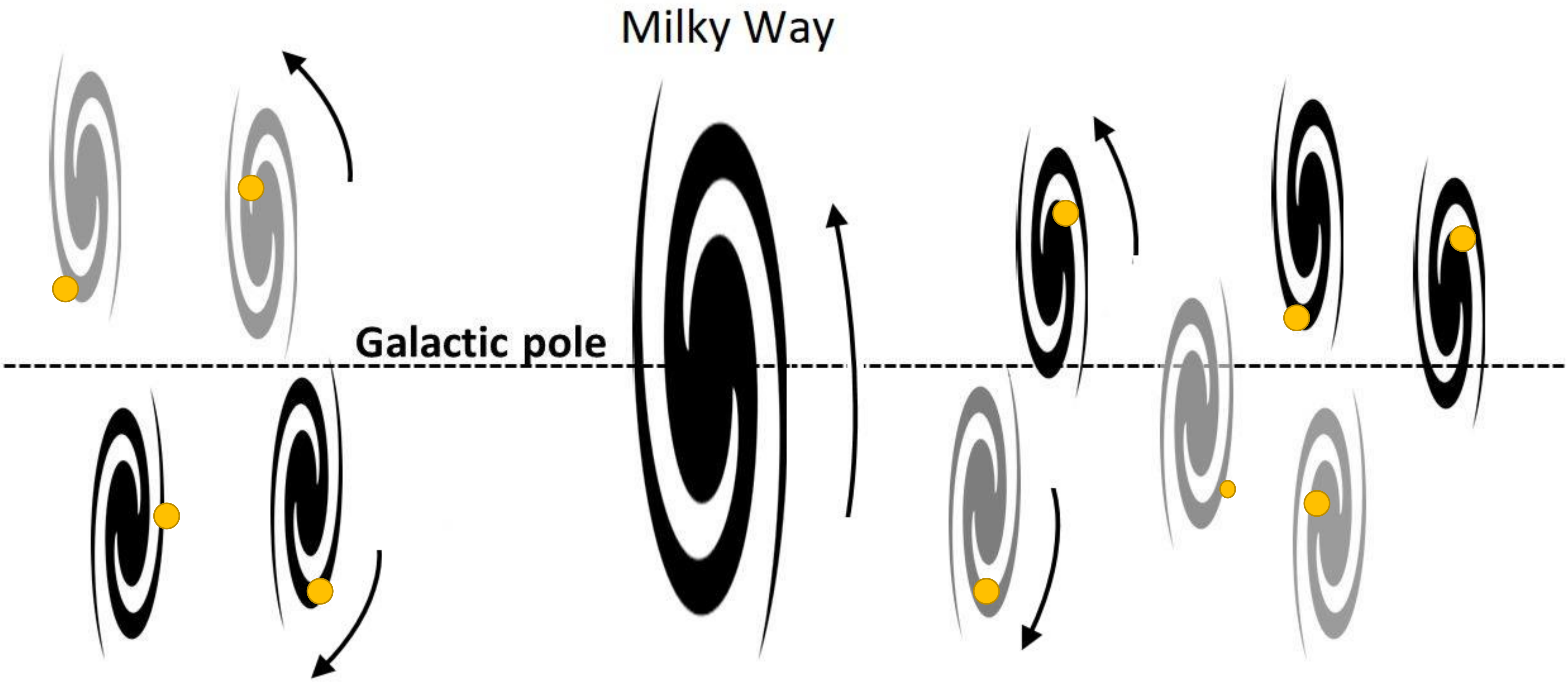
1) 3D analysis with the photometric redshift.
2) SDSS galaxies are assumed to be uniformly distributed in the hemisphere.

(Shamir, PASJ, 2022)
https://people.cs.ksu.edu/~lshamir/data/iye_et_al

Ho tension
(oversimplified)

Something unknown about the Universe

Something unknown about the measurements


Milky Way
Galactic pole

A&A 647, A72 (2021)

A new measurement of the Hubble constant using Type Ia supernovae calibrated with surface brightness fluctuations

Nandita Khetan[1,2], Luca Izzo[3], Marica Branchesi[1,2,4], Radosław Wojtak[3], Michele Cantiello[4], Chandrashekar Murugeshan[5], Adriano Agnello[3], Enrico Cappellaro[6], Massimo Della Valle[7], Christa Gall[3], Jens Hjorth[3], Stefano Benetti[6], Enzo Brocato[4,8], Jamison Burke[9,10], Daichi Hiramatsu[9,10], D. Andrew Howell[9,10], Lina Tomasella[6] and Stefano Valenti[11]

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https://pbrown801.github.io/SOUSA/

Results (SH0ES)

Rotation direction	#	Ho	3% error range	SD
All	96	73.758	70.193-77.404	1.943
Same direction	22	69.049	62.955-76.005	3.42
Opposite direction	36	74.182	68.758-79.915	3.2

Z<0.02 excluded

When limiting to Ia supernovae that rotate in the same direction relative to the Milky Way, Ho drops.

Rotation direction	#	Ho	3% error range	SD
All	140	71.069	67.739-74.321	1.758
Same direction	34	69.060	62.998-75.082	3.122
Opposite direction	48	73.824	68.484-79.976	3.158

Z<0.02 not excluded

McAdam & Shamir, Symmetry (special issue on symmetry in gravitation and cosmology), 15(6), 1190, 2023.
https://doi.org/10.20944/preprints202301.0390.v1

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