

渦状銀河のSPIN Parity分布と 宇宙の構造形成

20190709 家正則(国立天文台)

- (0) TMTについて
- (1) 宇宙スカラー場 \Rightarrow 宇宙ベクトル場
- (2) 銀河回転の宇宙論的起源
 - (a) 原始渦分裂説
 - (b) パンケーキ崩壊時発生説
 - (c1) 潮汐トルク起源 (cluster-galaxy)説
- (3) 渦巻構造はすべてTrailingと確認
- (4) HSC 銀河画像のs/z深層学習分析 $z < 0.8$
- (5) 双極子, 四重極子偏りの探査

(0) TOMOE GOZEN2 on TMT?

- TMT焦点面は2m径
- その隙間にCMOSカメラを配備しては？
- TMTが見ている天域をライブ配信できる！
- 日本の貢献としてメディアと連携しては
- 7.2mas/19um pixelと超オーバーサンプリング
Seeing装置の隙間の場合は500um/pixelでよい
(AO装置の隙間におけるとすごいインパクト)

(1)宇宙の構造形成(スカラー場)

- 理論面

初期揺らぎのスペクトル

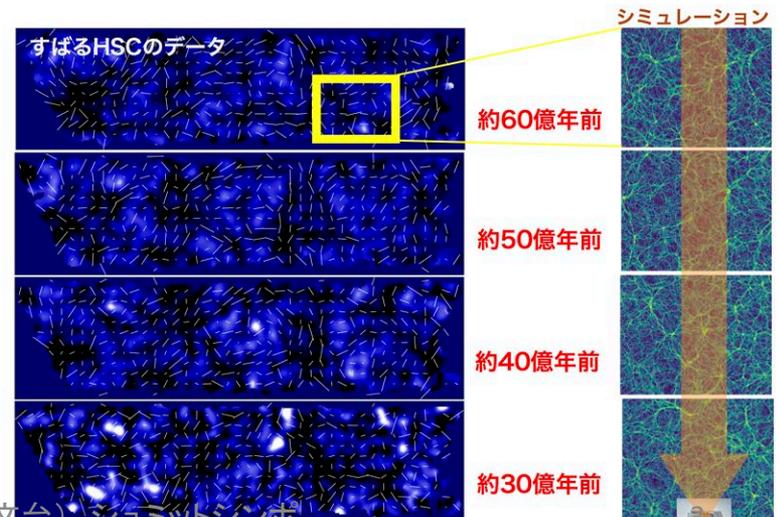
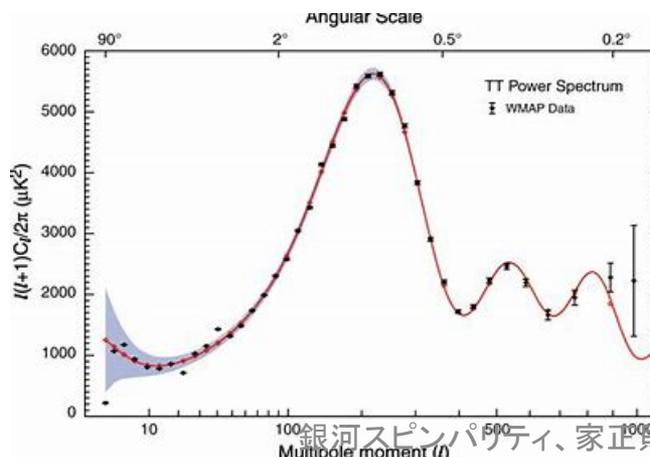
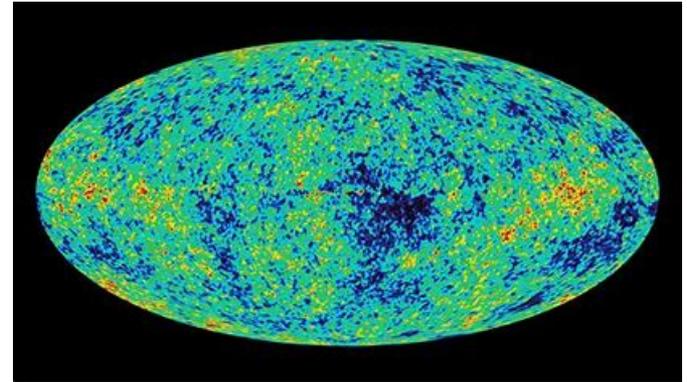
宇宙膨張モデル

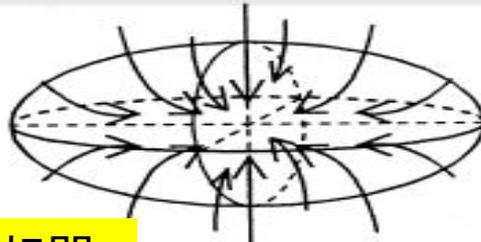
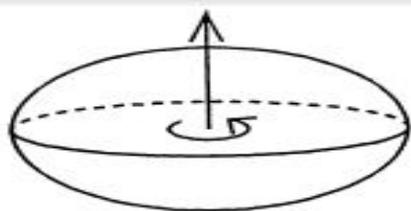
- 観測面

宇宙背景放射の揺らぎ WMAP

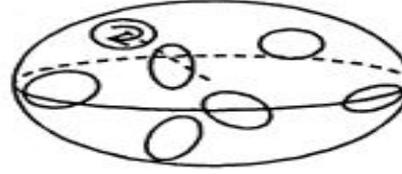
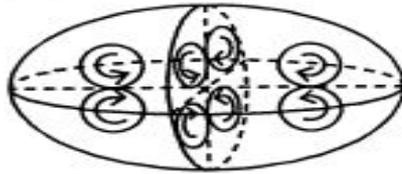
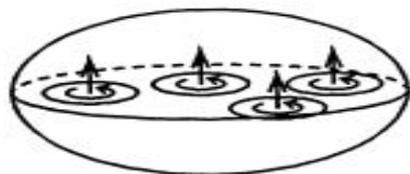
宇宙規模の銀河の3次元分布 SDSS, HSC

重力レンズ効果(ダークマター)

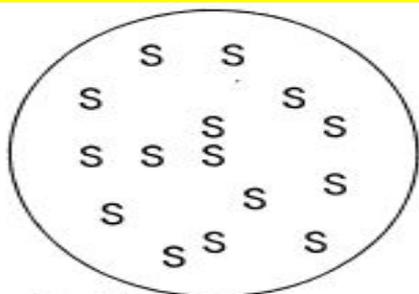




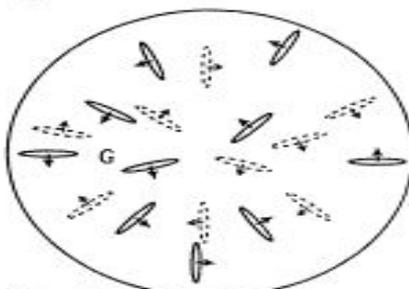
想定される相関
Sugai & Iye 1995



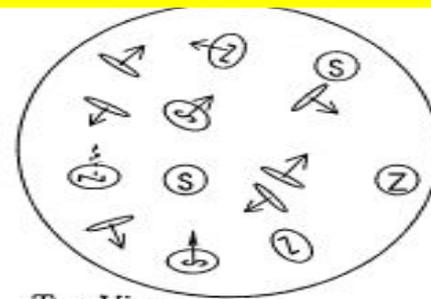
原始渦 (Weizsaecker) パンケーキショック (Zeldovich) 潮汐トルク (Peebles)



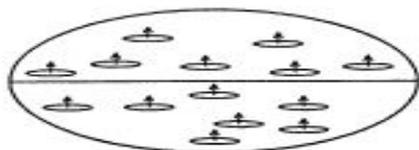
Top View



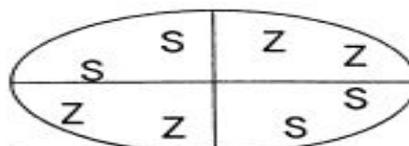
Top View



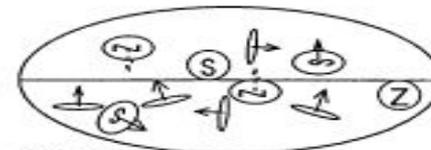
Top View



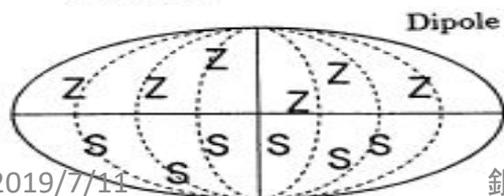
Side View



Side View



Side View



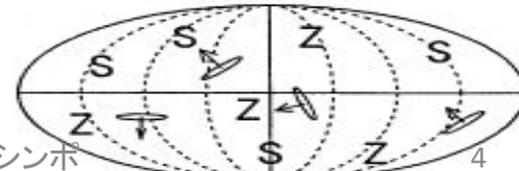
Dipole

View from inside



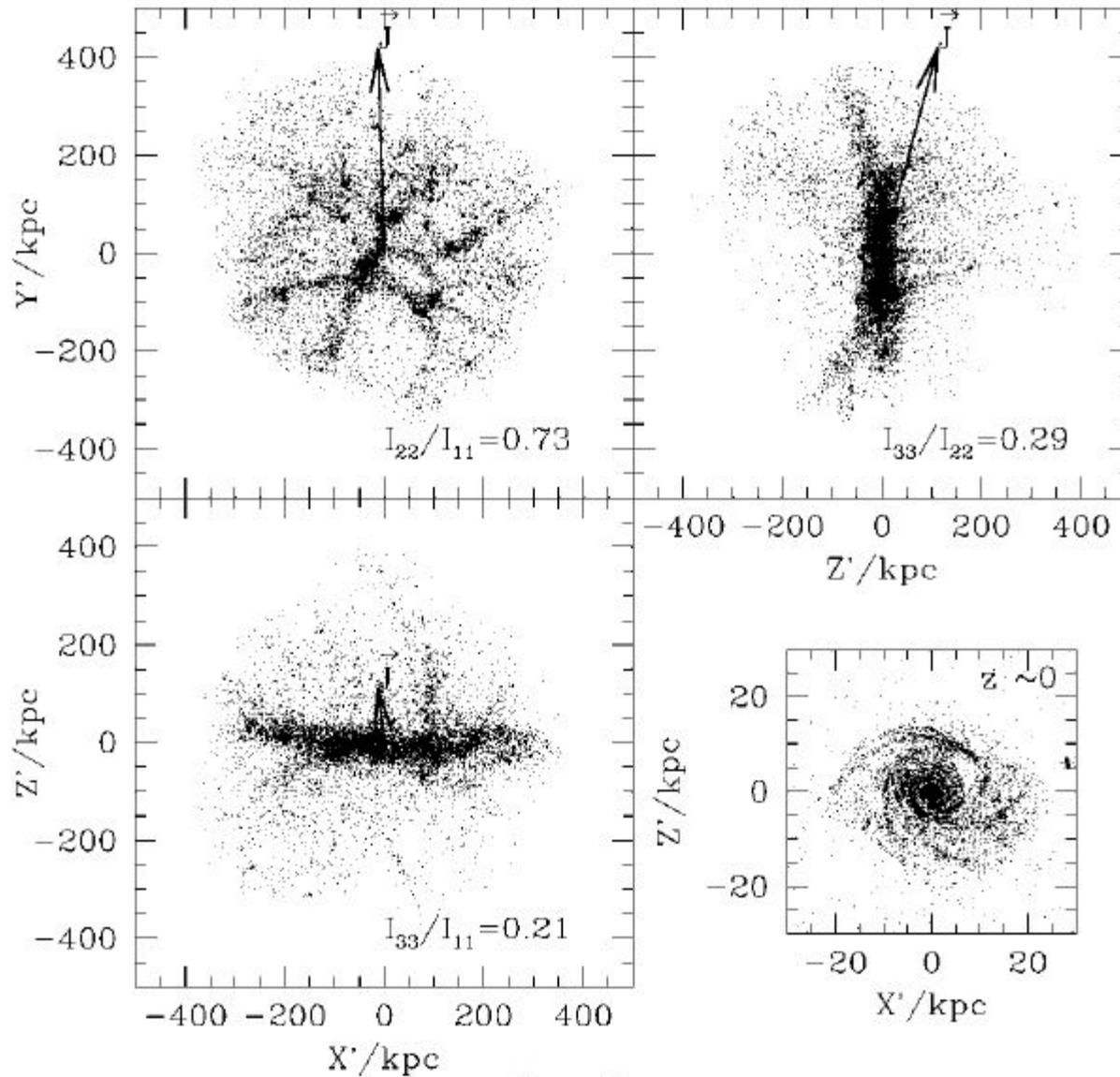
Quadrupole

View from inside



View from inside

Galaxy baryons at turnaround ($z \sim 3$)



Navarro2004
Fig 1b

FIG. 1b

(2) スピンベクトルの観測量

- 銀河の長軸の方位角分布
- 銀河の軸比の分布
=>定量化、校正誤差、
きわどい分布の比較

(MacGillivray et al 1982, Helou 1984,
Trujillo et al 2006, Lee & Erdogdu 2006
....) 右図はLee Erdogduの例

- S/Z判定の分布
=>視線方向成分のみ、
だが紛れの少ない1ビット情報
(Thompson 1973, Borchkhadze&Kogoshvili 1976,
Yamagata et al 1981, Iye & Sugai 1991, Sugai & Iye 1995)

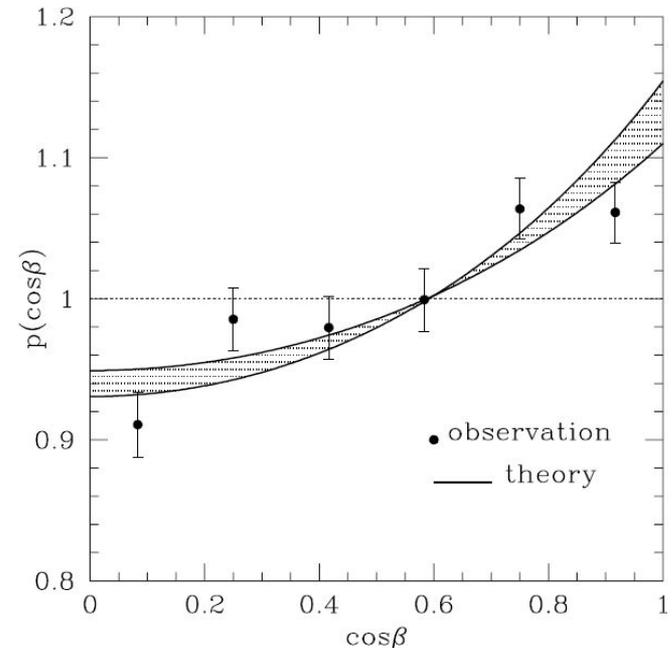


Fig. 3.—Probability density distribution of the cosines of the angles between the spiral galaxy's spin axes and the intermediate principal axes of the local tidal field. A total of 12,347 spiral galaxies with all morphological types are used.

銀河自転とフィラメント主軸の相関

(3) 我々の先行研究: 不完全な全天探査

/ How to analyze the sparsely sampled distribution?

Compare with simulated random distributions? Window kernel?

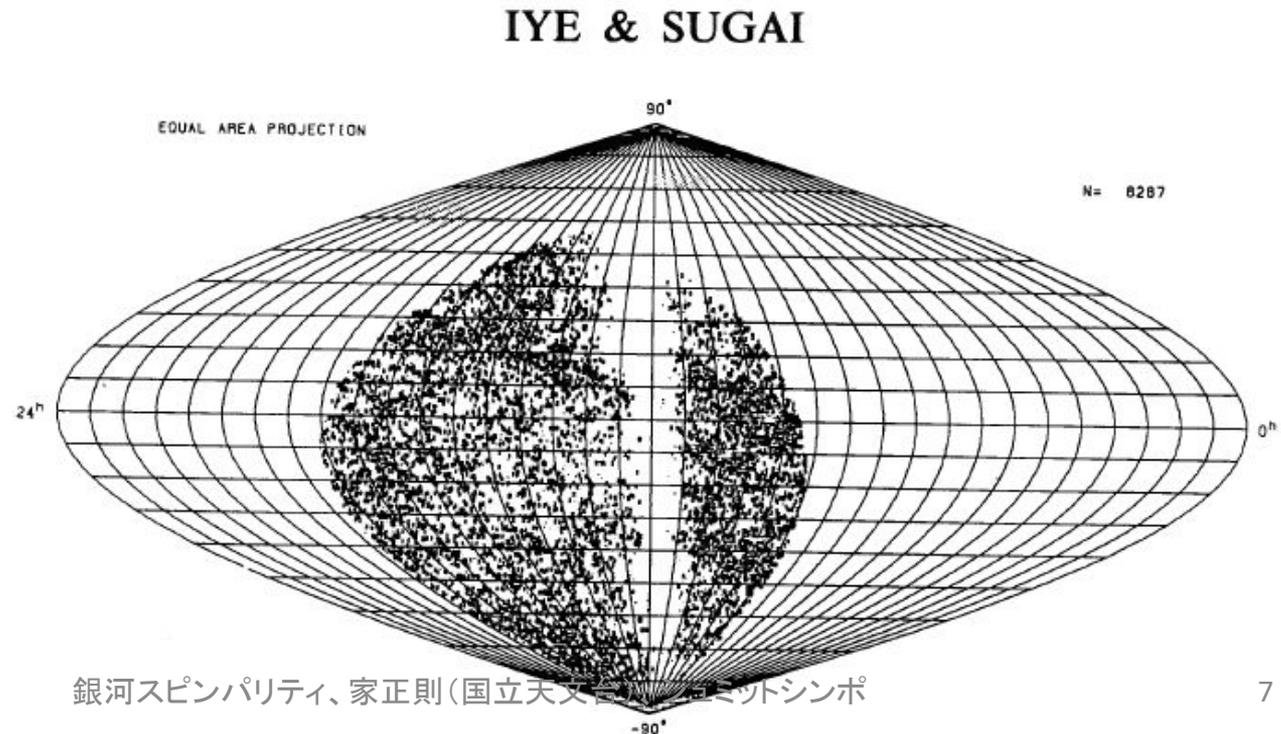
/ So far no significant asymmetry reported.

/ Some debatable observed bias

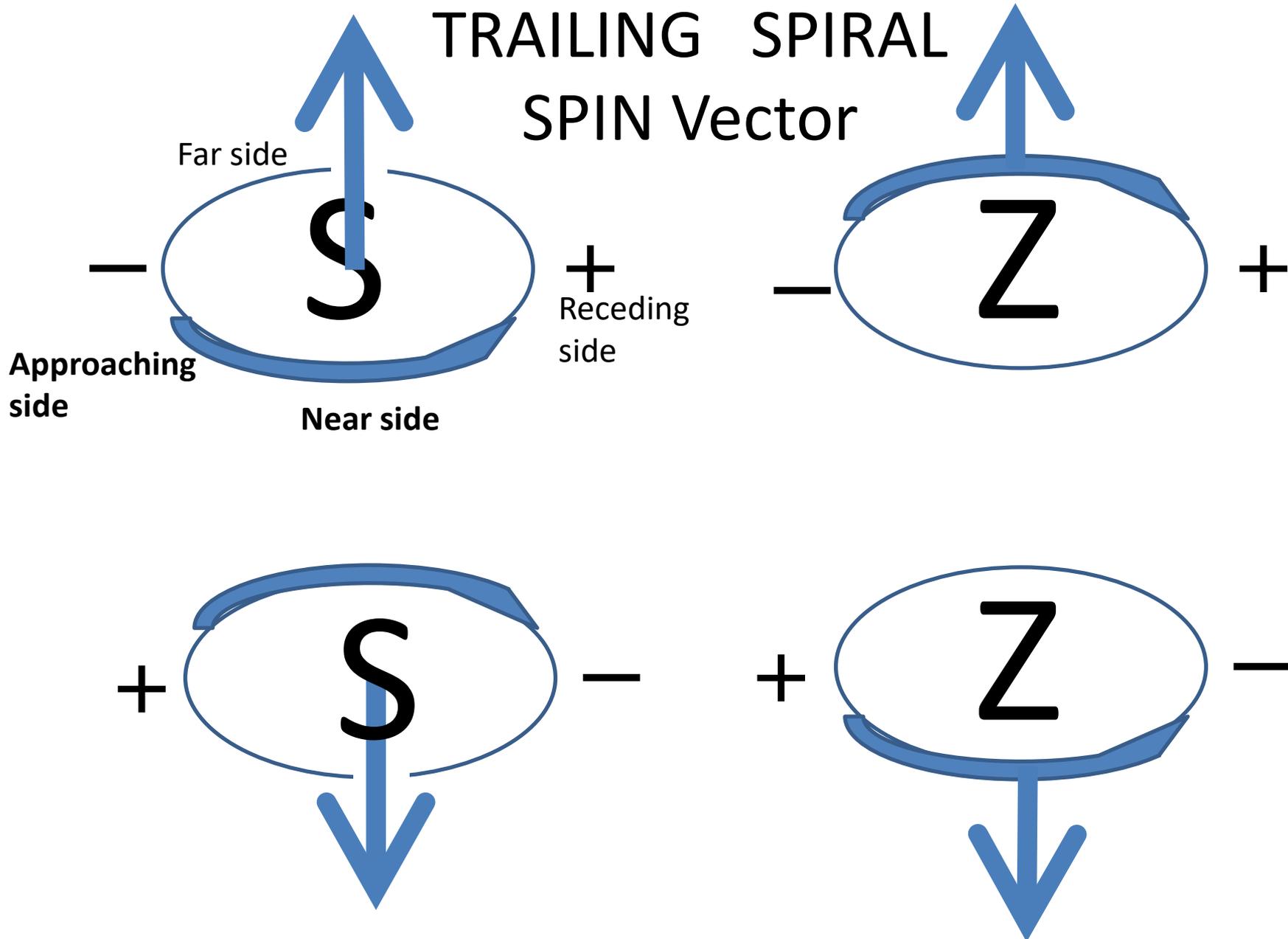
Embarrassing excess of S-spirals over Z-spiral in northern sky (Borchkhadze & Kogoshvilli 1976, Yamagata et al 1981, ...) and reversed excess in the southern sky (Sugai and Iye 1991) for spirals with Sbc-Sc type.

▪ Galaxy Zoo
形態分類のネット投票

▪ 心理学的バイアス?
右利き、左利き



TRAILING SPIRAL SPIN Vector



(3) ダークサイドが近い側 (de Vaucouleurs vs Lindblad)

Limb Darkening 説



FIG. 6.—Schematic vertical section of luminous and dark matter in a nebula of small central mass. Intersections with density surfaces of luminous matter are full drawn, intersections with dark matter are dotted curves. The oblique lines indicate the line of sight.



Dark Laneは渦巻きの内側説

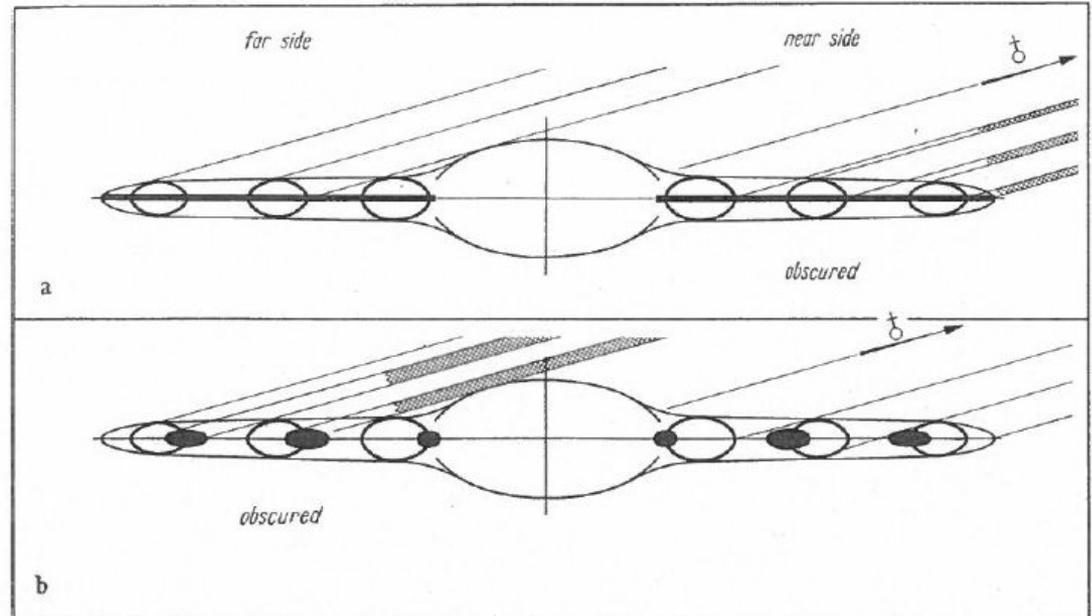


Fig. 26 a and b. Alternative hypotheses on the distribution of dark matter in spirals. (a) Usual interpretation: if the dark matter is more or less uniformly spread in the equatorial plane of the system the obscured side is the near side. (b) LINDBLAD'S interpretation: if the dark matter is localized in the concavity of the bright arms the obscured side is the far side.

(2b) M31 Near Side from GC reddening

Iye & Richter 1985

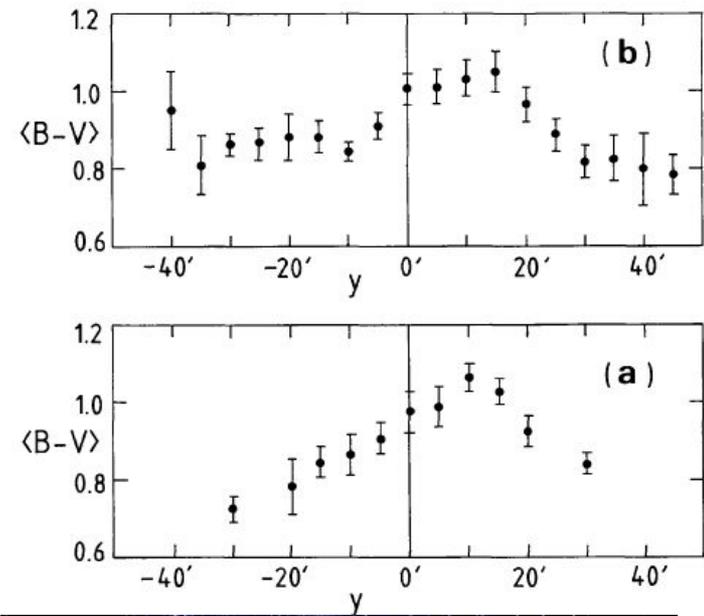
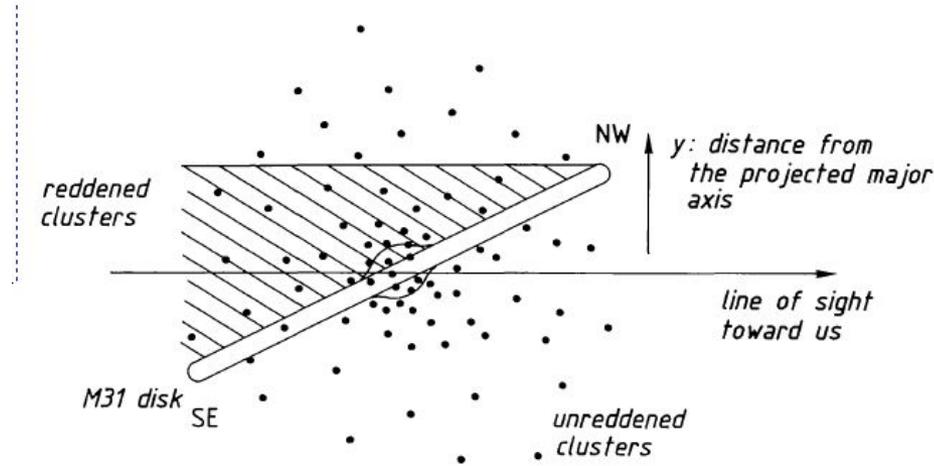
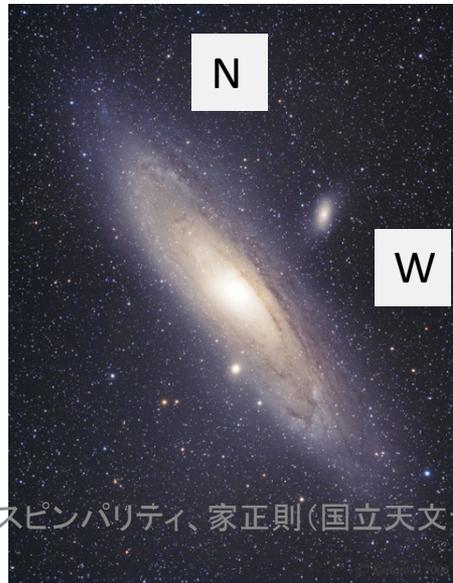


Fig. 1. Sketch of the distribution of reddened and unreddened globular clusters in M31



M31はNW側が手前
M31はSW側が近づく
M31の渦巻はS型
=> Trailing



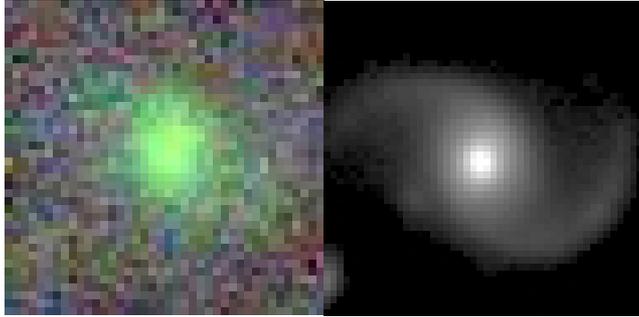
Confirmed Spin Parity of 146 Spiral Galaxies

(Iye, Tadaki, Fukumoto 2019: submitted to ApJ)

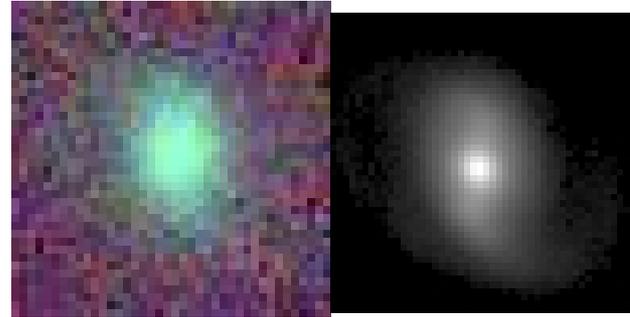
Table 1. Observationally confirmed spin parity of spiral galaxies

ID	S/Z Side	Dark Side	Appr.	T/L	Image1	Image2	Image3	Image4
Circinus Galaxy	S	SE	NE	T				
IC1683	Z	W	N	T				
IC1755	S	SW	SE	T				
IC2101	S	NE	NW	T				
IC5376	Z	W	N	T				
MCG-02-02-030	Z	SW	NW	T				
MCG-02-51-004	Z	NE	SE	T				
NGC24	Z	NW	NE	T				
NGC157	S	SE	NE	T				
NGC169	Z	N	E	T				
NGC224	S	NW	SW	T				
NGC247	S	E	N	T				

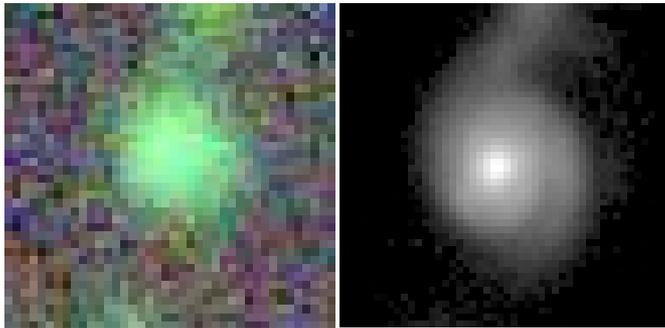
第2論文: 深層学習によるS/Z判定 PS1 vs HSC(z<0.8)



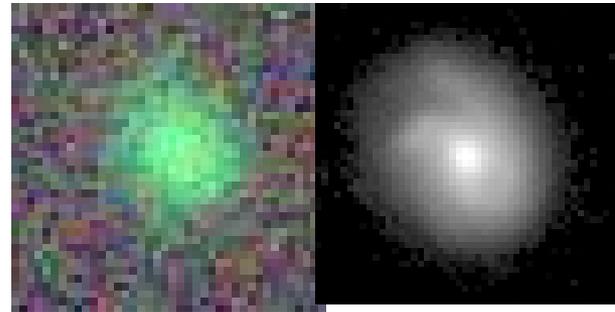
(1) 41135358515108699 (z=0.37)



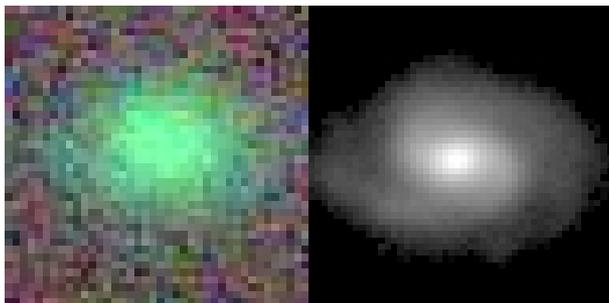
(2) 43122987775319272 (z=0.27)



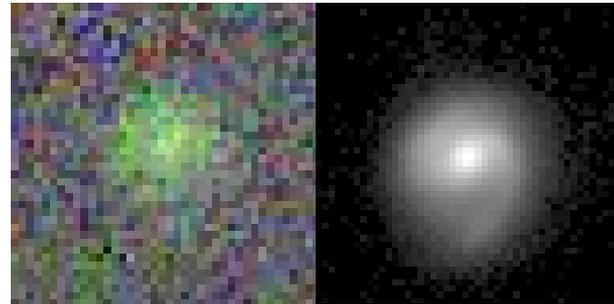
(3) 42187049977014045



4)40959015747868366 (z=0.18)



(5) 40959574093612032 (z=0.07)

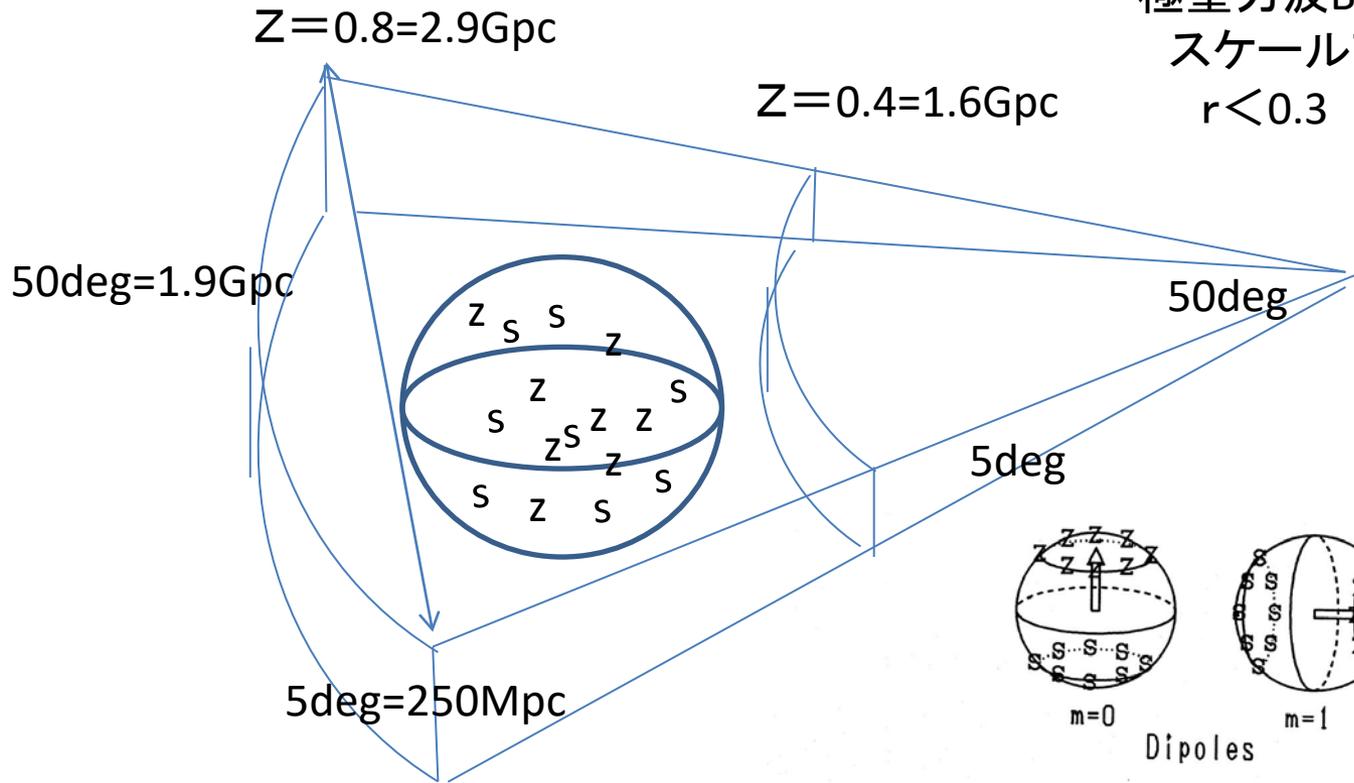


(6) 40959294920743177 (z=0.35)

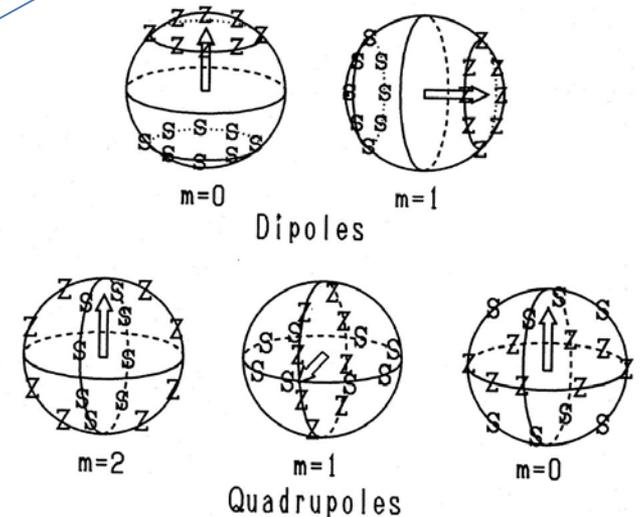
但木他
2019

HSC銀河分布 (但木氏より7月末納入予定?)

インフレーションの4重極重力波Bモード成分
スケールフリー
 $r < 0.3$



初の1Gpcスケールの銀河のS/Z 3次元分布
バリオン振動 100Mpcスケール
=> 何か見つかったら大発見!



Dipole Peak Detection

双極子分布+ランダム分布のデータから双極子方向を正しく判別できるか？

Simulated data からランダム率 95%でも判別できることを確認(福本)

投稿準備中

