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The evolution of galaxy scaling relations in clusters at 0.5<z<1.5 ⋆

J. M. Pérez-Martínez[1,2,3], B. Ziegler[1], H. Dannerbauer[2,3], A. Böhm[1], M. Verdugo[1], A. I. Díaz[4], and C. Hoyos[4]

[1] Department of Astrophysics, University of Vienna, A-1180 Vienna, Austria. e-mail: jm.perez@univie.ac.at
[2] Instituto de Astrofísica de Canarias (IAC), E-38205, La Laguna, Tenerife, Spain.
[3] Universidad de La Laguna, Dpto. Astrofísica, E-38206, La Laguna, Tenerife, Spain
[4] Departamento de Física Teórica and CIAFF, Universidad Autónoma de Madrid, E-28049 Madrid, Spain

ABSTRACT

Aims. We present new gas kinematic observations with the OSIRIS instrument at the GTC for galaxies in the Cl1604 cluster system at $z \sim 0.9$. These observations together with a collection of other cluster samples at different epochs analyzed by our group are used to study the evolution of the Tully-Fisher, velocity-size and stellar mass-angular momentum relations in dense environments over cosmic time.
Methods. We use 2D and 3D spectroscopy to analyze the kinematics of our cluster galaxies and extract their maximum rotation velocities (V_{max}), which will be used as the common parameter in all scaling relations under scrutiny. We determine the structural parameters of our objects by fitting surface brightness profiles to the images of our objects, while stellar-mass values are computed via SED fitting by making use of extensive archival optical to NIR photometry. Our methods are consistently applied to all our cluster samples which make them ideal for an evolutionary comparison.
Results. Up to redshift one, our cluster samples show evolutionary trends compatible with previous observational results in the field and in accordance with semianalytical models and hydrodynamical simulations concerning the Tully-Fisher and velocity-size relations. However, we find a factor ~3 drop in disk sizes and an average B-band luminosity enhancement $\langle \Delta M_B \rangle \sim 2$ mag by z~1.5. We discuss the role that different cluster-specific interactions may play in producing this observational result. In addition, we find that our intermediate-to-high redshift cluster galaxies follow parallel sequences with respect to the local specific angular momentum-stellar mass relation, although displaying lower angular momentum values in comparison with field samples at similar redshifts. This can be understood by the stronger interacting nature of dense environments with respect to the field.

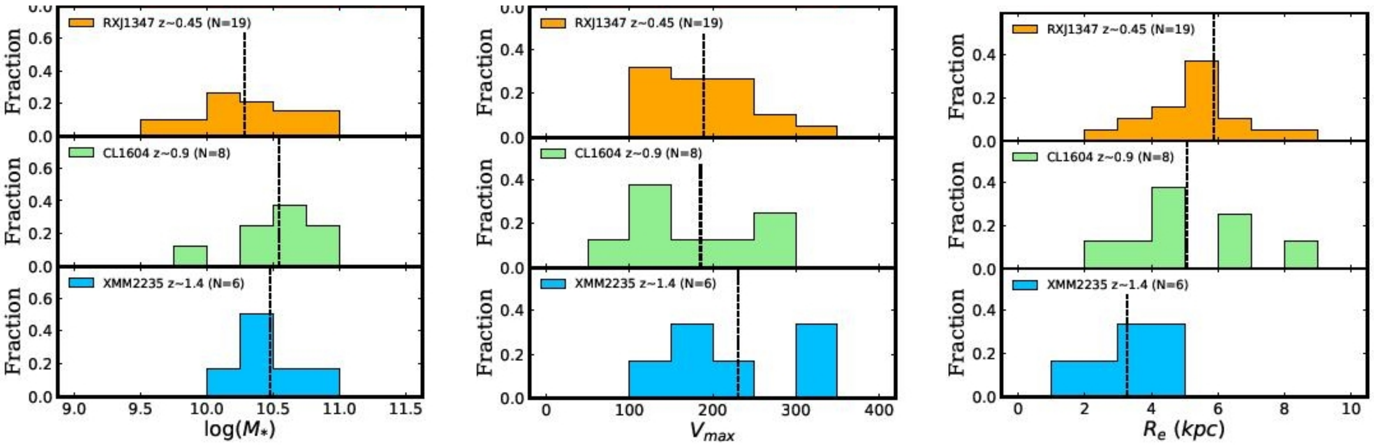
Анализируемые скопления

Table 1: General properties of the clusters investigated in this study: IDs, right ascension, declination, redshift, virial mass (M_{200}) and size (R_{200}), velocity dispersion and references for these measurements.

ID	RA (hh:mm:ss)	DEC (dd:mm:ss)	z	M_{200} ($10^{14} M_{\odot}$)	R_{200} (Mpc)	σ (km/s)	References
Abell 901/902	-	-	-	-	-	-	-
A901a	09:56:27	-09:57:22	0.16	1.3 ± 0.3	0.8 ± 0.1	880 ± 30	
A901b	09:55:57	-09:59:03	0.16	1.3 ± 0.3	0.8 ± 0.1	940 ± 20	Heymans et al. 2008
A902	09:56:34	-10:10:00	0.17	0.4 ± 0.2	0.6 ± 0.1	810 ± 20	Weinzirl et al. 2017
SW Group	09:55:39	-10:10:19	0.17	0.6 ± 0.2	0.6 ± 0.1	590 ± 40	
RXJ 1347	-	-	-	-	-	-	-
RXJ 1347-1145	13:47:31	-11:45:10	0.45	11.6 ± 3.0	1.9 ± 0.2	1160 ± 100	Lu et al. 2010
RXJ 1347-1145	13:46:27	-11:54:28	0.47	5.6 ± 1.6	1.2 ± 0.2	780 ± 100	
CL1604	-	-	-	-	-	-	-
CL1604+4304	16:04:22	43:04:56	0.90	3.3 ± 1.5	0.9 ± 0.2	720 ± 130	Lemaux et al. 2012,
CL1604+4321	16:04:34	43:21:14	0.92	1.8 ± 1.6	0.8 ± 0.1	690 ± 90	Wu et al. 2014
XMMU J2235.3-2557	22:35:21	25:57:40	1.39	7.3 ± 1.3	1.1 ± 0.1	1180 ± 90	Jee et al. 2009

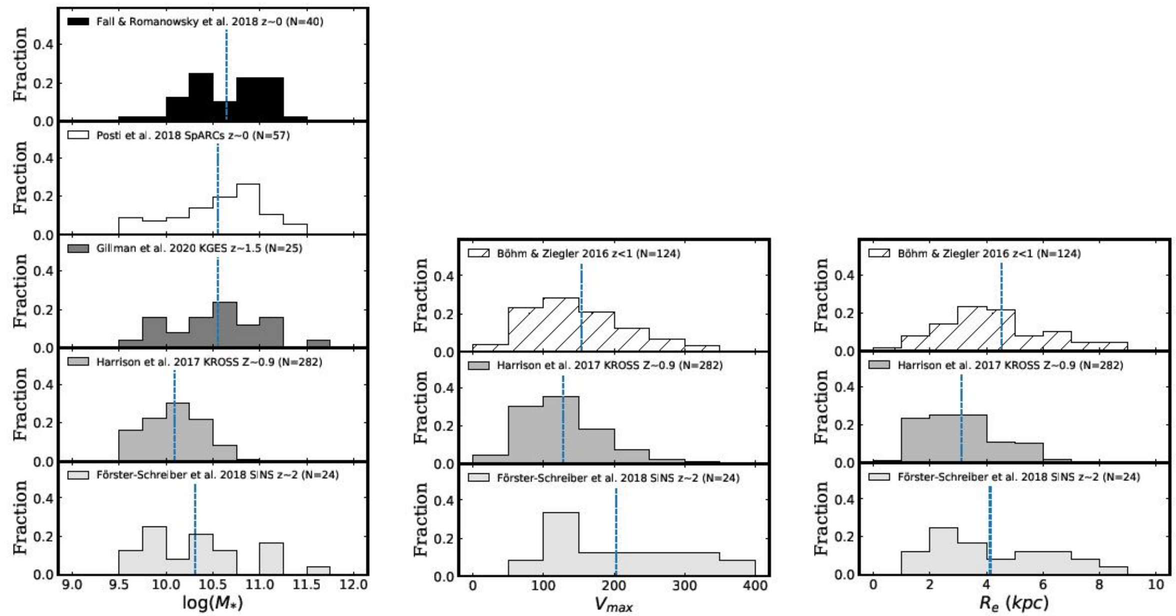
скорости вращения галактик=щель по большой оси

Характеристики выборок галактик

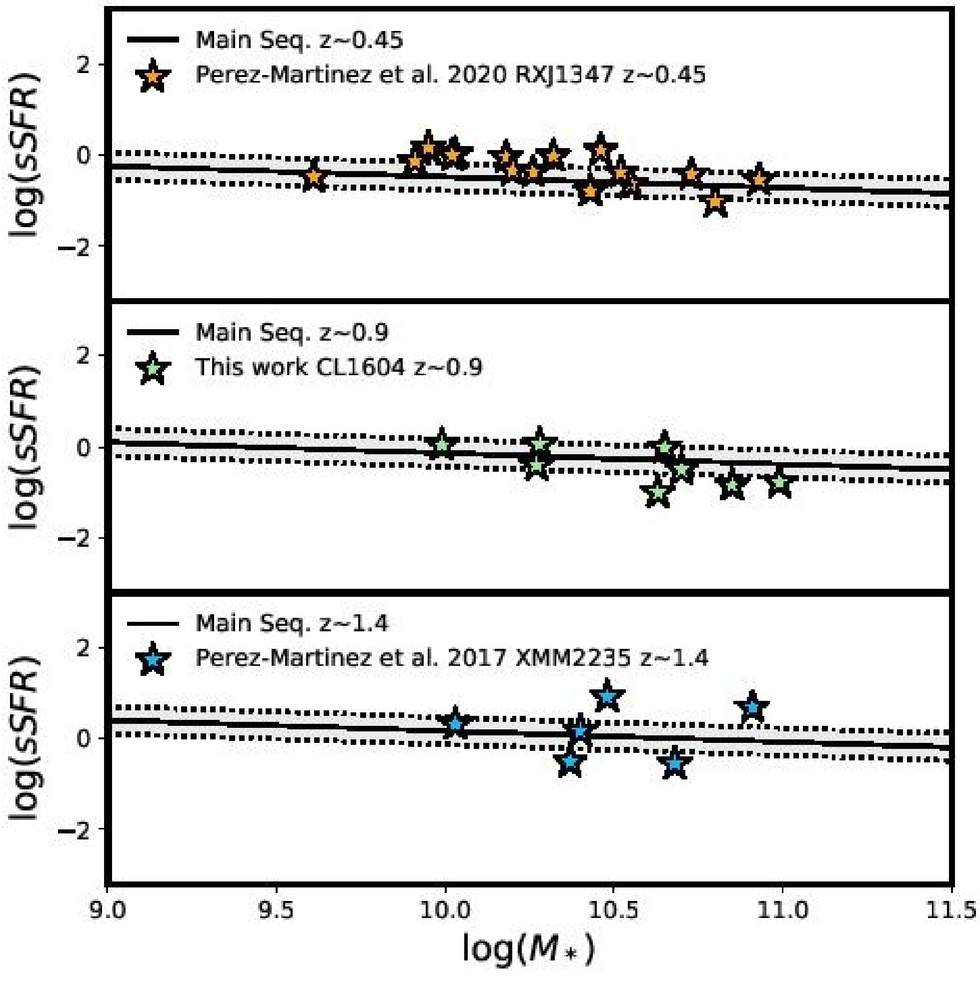


скопления

поле



Все галактики скоплений – на главной последовательности SF



Эволюция Tully-Fisher

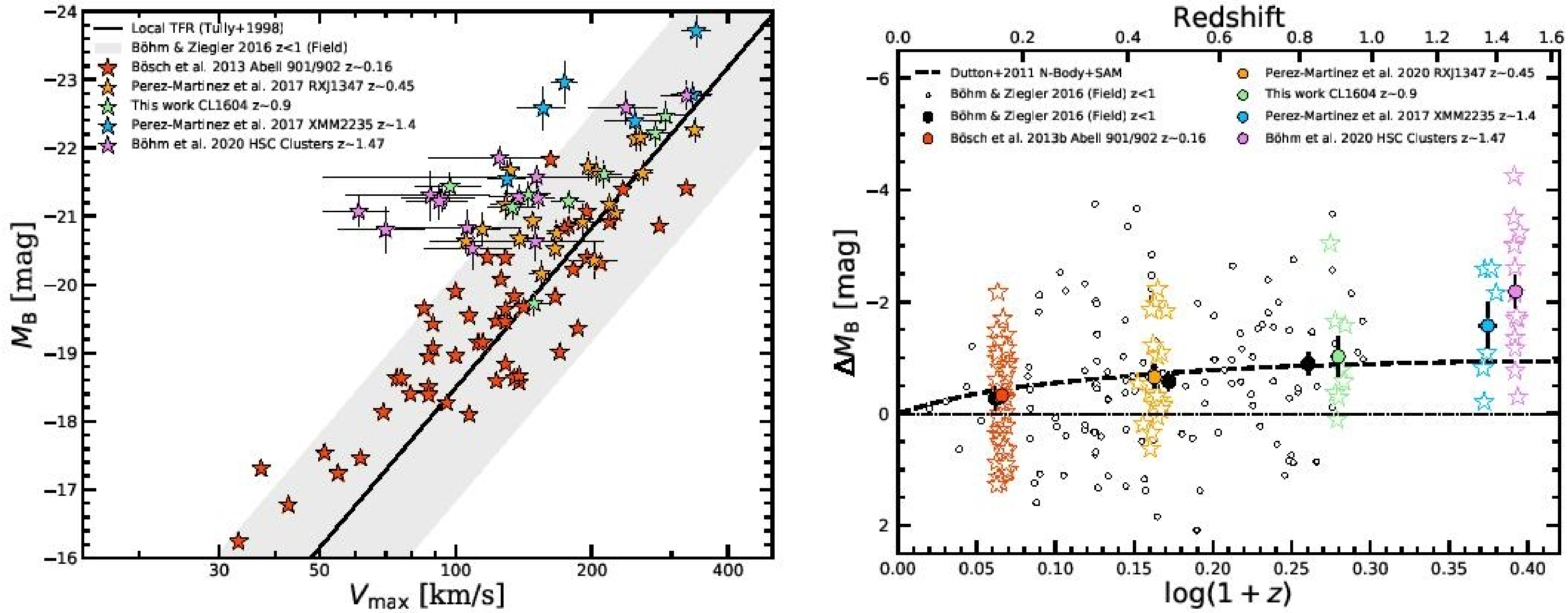
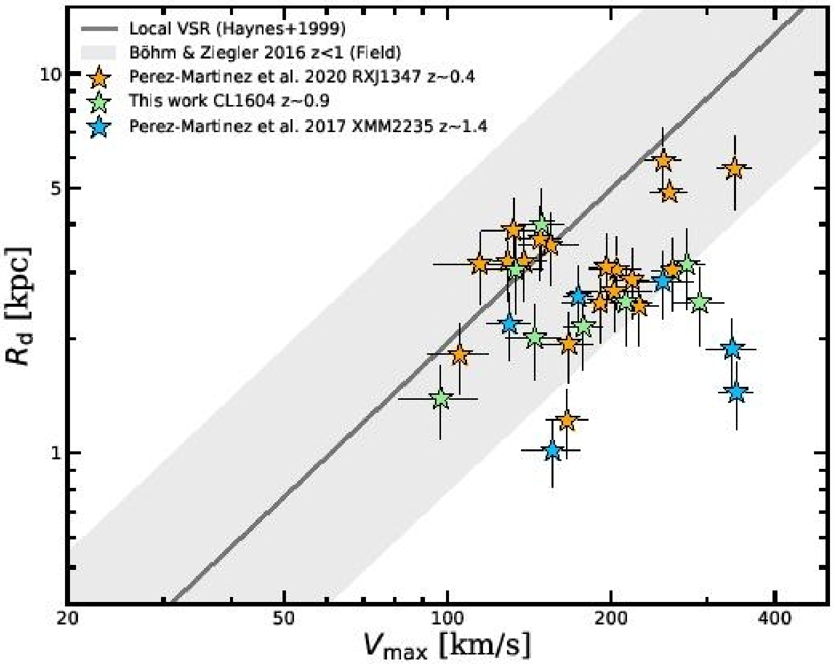


Fig. 5: *Left*: B-band Tully-Fisher relation. Colored stars represent the different cluster samples that compose our study. The black solid line shows the local B-band TFR (Tully et al. 1998) with a 3σ scatter area around reported by Böhm & Ziegler (2016) for galaxies at $0 < z < 1$ (grey area). *Right*: B-band Tully-Fisher offsets evolution. Stars with colored edges represent the distribution of our cluster samples with their respective mean values being shown as bigger circles of the same color. Error bars represent the error of the mean for every sample. Open
circles display the Böhm & Ziegler (2016) field sample at $0.1 < z < 1$. We binned the field sample in three redshift intervals ($0 < z < 0.33$, $0.33 < z < 0.66$, $0.66 < z < 1$). Black circles depict the mean value and its error for the field sample in every redshift window. The dashed line represents the predicted B-band luminosity evolution by Dutton et al. (2011) in the TFR, while the dashed-dotted line at $\Delta M_B = 0$ means no size evolution.

Эволюция размера



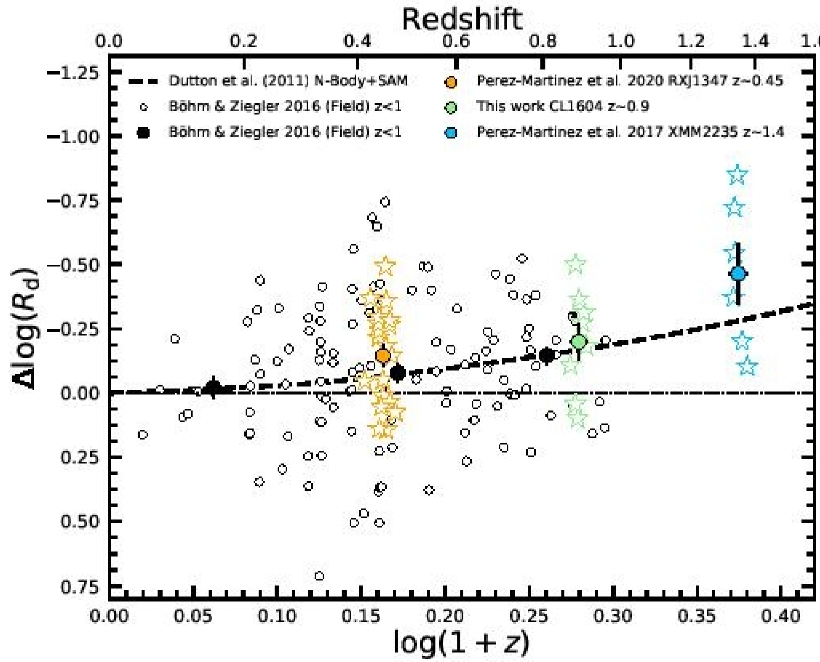


Fig. 6: The symbols and color schemes are the same as in Fig. 5.
Left: Velocity-Size diagram. The solid black line shows the local VSR from Haynes et al. (1999a), with a 3σ scatter gray area around it. *Right*: Velocity-size offset evolution.

Эволюция удельного момента

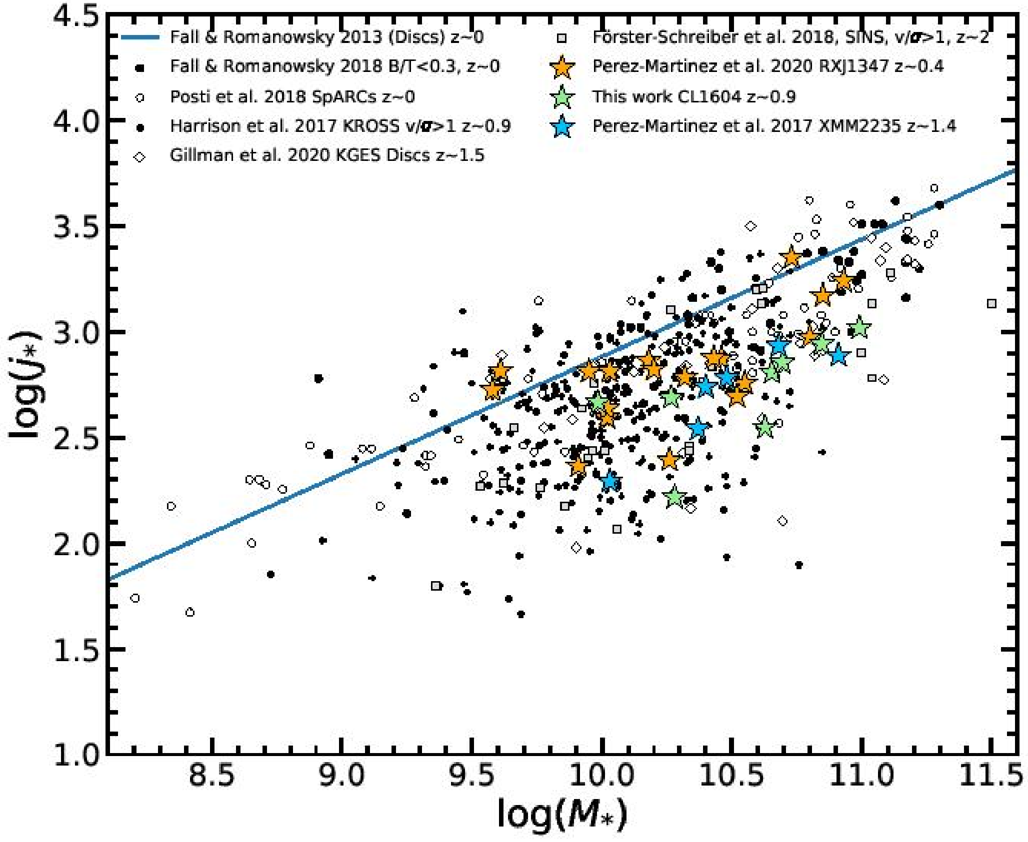
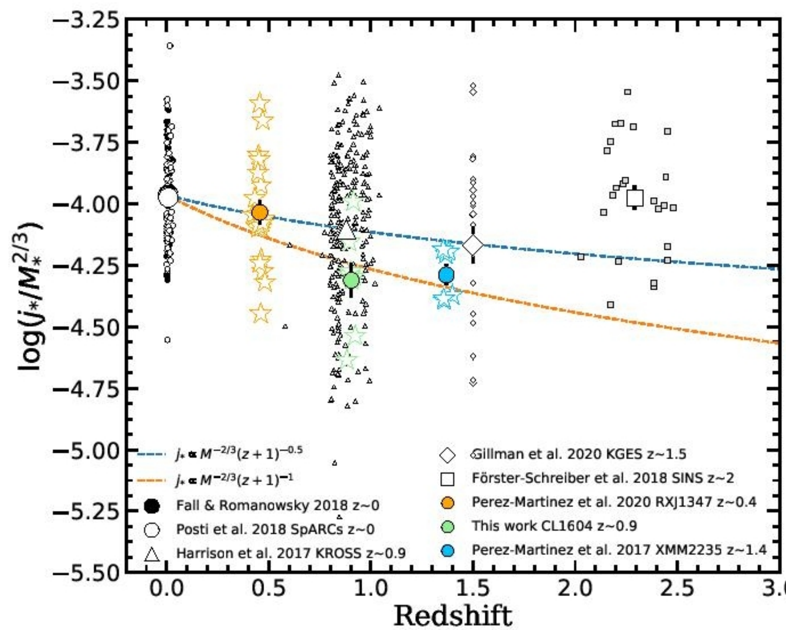


Fig. 7: Specific angular momentum diagram. Orange, green and blue stars respectively represent the RXJ1347, CL1604 and XMM2235 cluster galaxies studied by our group. Black and empty circles show the local universe disc-like samples from Fall & Romanowsky (2018) and Posti et al. (2018) respectively. The small black crosses show the field objects from KROSS sample at z~0.9 (Harrison et al. 2017), empty diamonds display the KGES sample at z~ 1.5 (Gillman et al. 2020), while the grey squares depict SINS/zC-SINF galaxies at z~2 (Förster Schreiber et al. 2018). The blue solid line display the local "Fall relation" for disc galaxies from Fall & Romanowsky (2013).

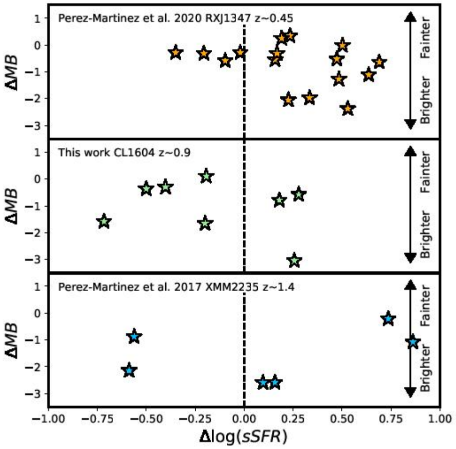
До z=0.8 все, как в поле; на больших z в скоплениях момент меньше, чем в поле!

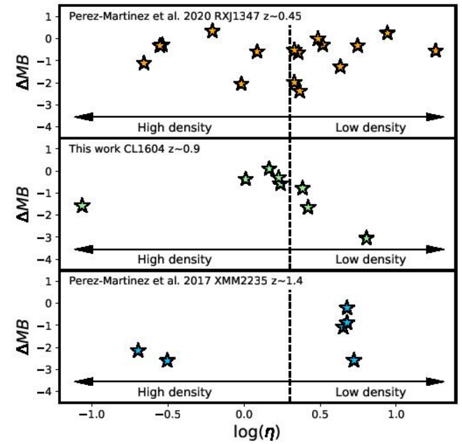
Table 5: Summary of the angular momentum properties of the cluster and field samples studied in this work. Columns: Sample IDs, redshift, mean $\Delta \log j_*$ followed by its standard error and standard deviation values, mean $\log(j_*/M_*^{2/3})$ followed by its standard error and standard deviation values.

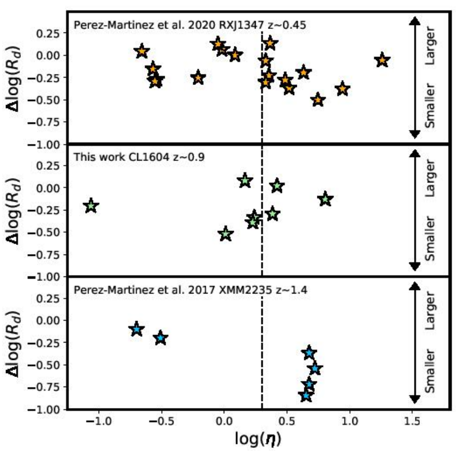
Sample ID	z	$\overline{\Delta \log j_*}$	$\sigma_{\overline{\Delta \log j_*}}$	$\sigma_{\Delta \log j_*}$	$\overline{\log(j_*/M_*^{2/3})}$	$\sigma_{\overline{\log(j_*/M_*^{2/3})}}$	$\sigma_{\log(j_*/M_*^{2/3})}$
RXJ1347	0.45	-0.24	0.04	0.19	-4.04	0.05	0.22
CL1604	0.91	-0.41	0.07	0.19	-4.31	0.07	0.20
XMM2235	1.39	-0.42	0.05	0.12	-4.29	0.04	0.10
Fall & Romanowsky (2018)	0	-	-	-	-3.96	0.03	0.18
SpARCs	0	-	-	-	-3.97	0.03	0.21
KROSS	0.9	-	-	-	-4.10	0.02	0.30
KGES	1.5	-	-	-	-4.17	0.08	0.38
SINS	2.0	-	-	-	-3.98	0.05	0.24

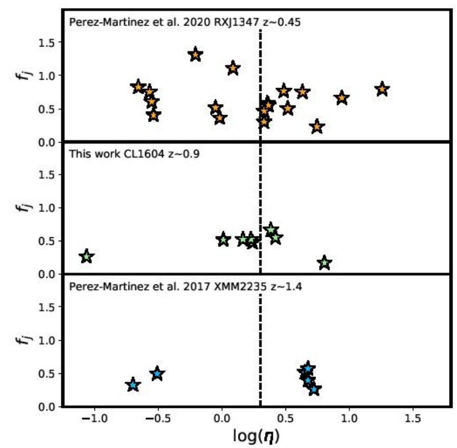


И нет корреляции ни с SF, ни с плотностью окружения!









ArXiv: 2007.14577

The tidal remnant of an unusually metal-poor globular cluster

Zhen Wan[1], Geraint F. Lewis[1], Ting S. Li[2,3,4,5,6], Jeffrey D. Simpson[7], Sarah L. Martell[7,8], Daniel B. Zucker[9,10], Jeremy R. Mould[11], Denis Erkal[12], Andrew B. Pace[13], Dougal Mackey[14], Alexander P. Ji[2,15], Sergey E. Koposov[13,16], Kyler Kuehn[17,18], Nora Shipp[19,5,4], Eduardo Balbinot[20], Joss Bland-Hawthorn[1,8], Andrew R. Casey[21], Gary S. Da Costa[14], Prajwal Kafle[22], Sanjib Sharma[1,8] & Gayandhi M. De Silva[18,8] (S^5 Collaboration)

Абстракт в Nature

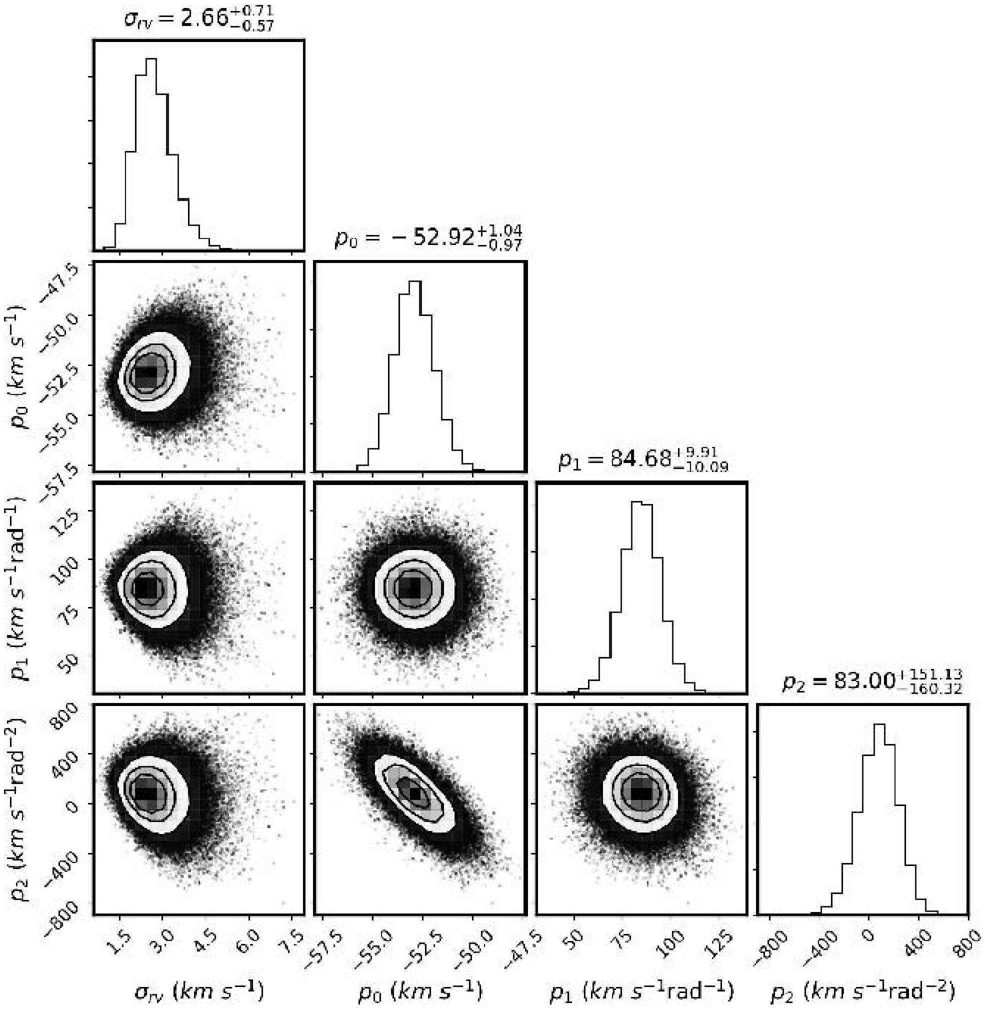
and the hierarchical build-up of structure[2,3]. Observations of globular clusters in the Milky Way, and a wide variety of other galaxies, have found evidence for a 'metallicity floor', whereby no globular clusters are found with chemical ('metal') abundances below approximately 0.3 to 0.4 per cent of that of the Sun[4–6]. The existence of this metallicity floor may reflect a minimum mass and a maximum redshift for *surviving* globular clusters to form, both critical components for understanding the build-up of mass in the universe[7]. Here we report measurements from the Southern Stellar Streams Spectroscopic Survey of the spatially thin, dynamically cold Phoenix stellar stream in the halo of the Milky Way. The properties of the Phoenix stream are consistent with it being the tidally disrupted remains of a globular cluster. However, its metal abundance ($[\mathrm{Fe/H}] = -2.7$) is substantially below that of the empirical metallicity floor. The Phoenix stream thus represents the debris of the most metal-poor globular cluster discovered so far, and its progenitor is distinct from the present-day globular

Поток в Фениксе: фотометрия DES+кинематика Gaia

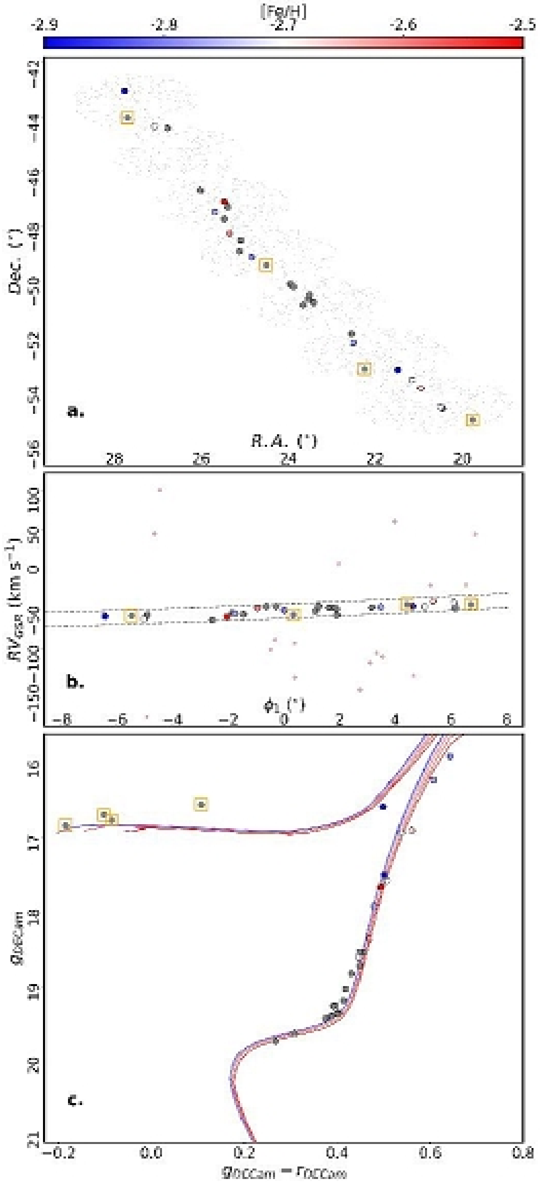
The Phoenix stellar stream is a thin over-density of stars in the Milky Way halo. It spans approximately 8° lengthwise on the sky and was originally identified in the Dark Energy Survey (DES)[8]. Comparison of the DES photometry with theoretical isochrones shows that the stream to be located at a heliocentric distance of about 19 kpc, and that its constituent stars are old and

- Ширина потока 50 пк → масса разорванной системы $3x10^4$ масс Солнца

Подтверждено восстановленной внутренней дисперсией скоростей

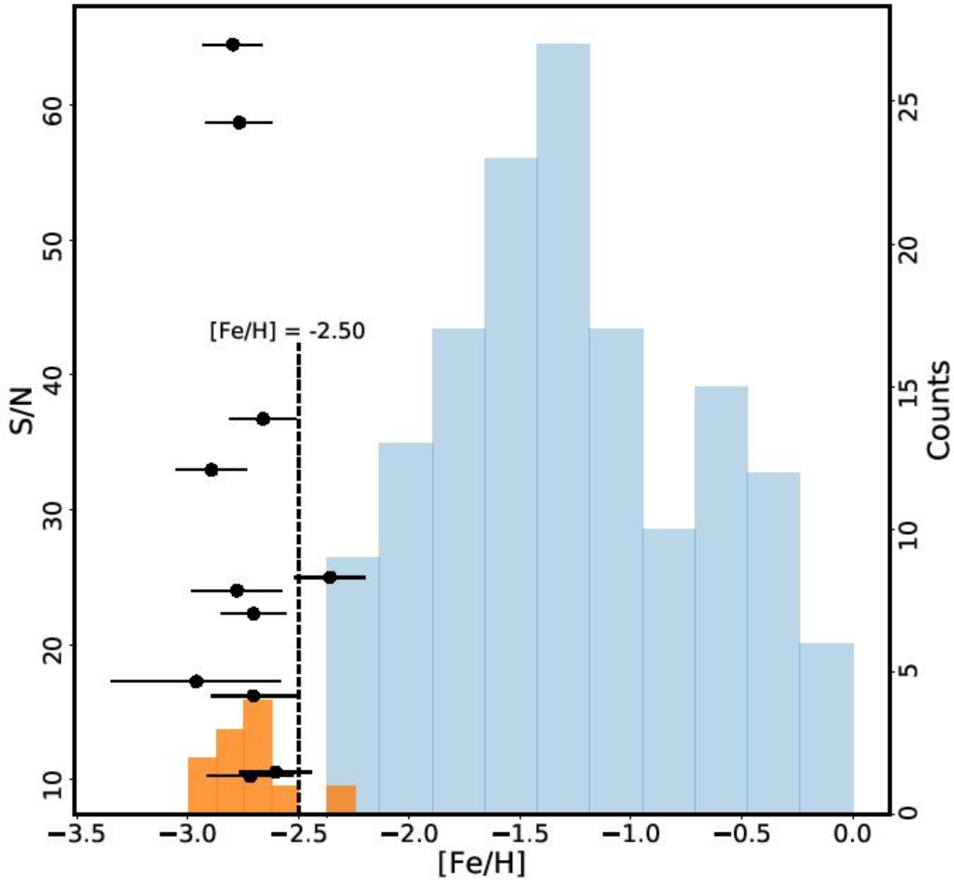


Происхождение? Хотят шаровое скопление, разорванное совсем



- Восстановили орбиту на 3 млрд лет назад: эксцентриситет 0.2, перигалактий 13 кпк, апогалактий 18 кпк

Сняли спектры звезд: чемпион по металлобедности среди шаровых



AAT: Southern Stellar Streams Spectroscopic Survey (S 5)