Обзор ArXiv/astro-ph, 16-21 февраля 2024

От Сильченко О.К.

ArXiv: 2402.12016

A Distinct Radial Acceleration Relation across Brightest Cluster Galaxies and Galaxy Clusters

Yong Tian[1], Chung-Ming Ko[1,2,⋆], Pengfei Li[3,⋆⋆], Stacy McGaugh[4], and Shemile L. Poblete[1]

[1] Institute of Astronomy, National Central University, Taoyuan 320317, Taiwan
[2] Department of Physics and Center for Complex Systems, National Central University, Taoyuan 320317, Taiwan
e-mail: cmko@astro.ncu.edu.tw
[3] Leibniz-Institute for Astrophysics, An der Sternwarte 16, 14482 Potsdam, Germany
[4] Department of Astronomy, Case Western Reserve University, 10900 Euclid Avenue, Cleveland, OH 44106, USA
e-mail: stacy.mcgaugh@case.edu

Received xxx; accepted xxx

ABSTRACT

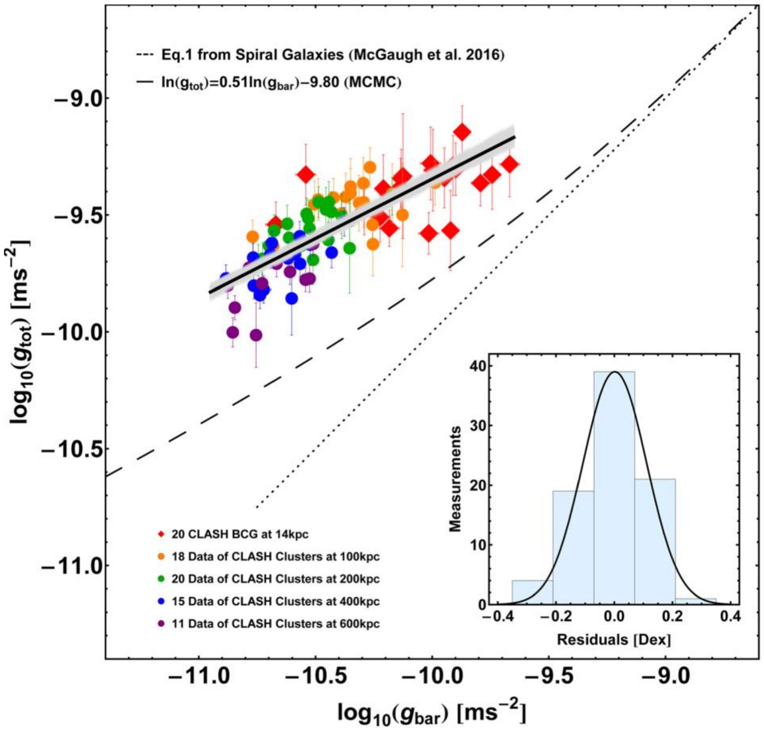
Recent studies reveal a radial acceleration relation (RAR) in galaxies, which illustrates a tight empirical correlation connecting the observational acceleration and the baryonic acceleration with a characteristic acceleration scale. However, a distinct RAR has been revealed on BCG-cluster scales with a seventeen times larger acceleration scale by the gravitational lensing effect. In this work, we systematically explored the acceleration and mass correlations between dynamical and baryonic components in 50 Brightest Cluster Galaxies (BCGs). To investigate the dynamical RAR in BCGs, we derived their dynamical accelerations from the stellar kinematics using the Jeans equation through Abel inversion and adopted the baryonic mass from the SDSS photometry. We explored the spatially resolved kinematic profiles with the largest integral field spectroscopy (IFS) data mounted by the Mapping Nearby Galaxies at Apache Point Observatory (MaNGA) survey. Our results demonstrate that the dynamical RAR in BCGs is consistent with the lensing RAR on BCG-cluster scales as well as a larger acceleration scale. This finding may imply that BCGs and galaxy clusters have fundamental differences from field galaxies. We also find a mass correlation, but it is less tight than the acceleration correlation.

Предыстория: RAR…

Recent discoveries have unveiled a tight empirical radial acceleration relation (RAR; McGaugh et al. 2016; Lelli et al. 2017) in spiral galaxies, providing a fresh perspective on the dark matter problem. The correlation can be parameterized between g_{obs} and g_{bar} as

$$g_{obs} = \frac{g_{bar}}{1 - e^{-\sqrt{g_{bar}/g_{\dagger}}}}, \qquad (1)$$

which exhibits a characteristic acceleration scale $g_{\dagger} = (1.20 \pm 0.02) \times 10^{-10} \mathrm{m\,s^{-2}}$ (McGaugh et al. 2016; Lelli et al. 2017; Li



в галактиках поздних типов

и в скоплениях (Tian+2020)

Модели 50 BCG– примитивные:

the projected velocity dispersion $\sigma_I(R)$ in the form of an Abel integral equation with its inverse (Binney & Mamon 1982; Mamon & Łokas 2005; Binney & Tremaine 2008):

$$\rho\sigma_r^2 = \frac{-\Upsilon}{\pi}\int_r^\infty \frac{dI(R)\sigma_I^2(R)}{dR}\frac{dR}{\sqrt{R^2-r^2}}, \quad (5)$$

where $I(R)$ represents the surface density and Υ denotes the mass-to-light ratio, depending on R in general.. Then, we can conduct $g_{\rm obs}$ through Abel inversion, deducing from Eq. (4) and Eq. (5) expressed as (Binney & Mamon 1982; Mamon & Łokas 2005; Binney & Tremaine 2008)

$$g_{\rm obs}(r) = \frac{-\sigma_r^2}{\Upsilon}\frac{d\Upsilon}{dr} + \frac{r\Upsilon}{\pi\rho}\int_r^\infty \frac{d}{dR}\left(\frac{dI(R)\sigma_I^2(R)}{RdR}\right)\frac{dR}{\sqrt{R^2-r^2}}. \quad (6)$$

In this study, we model $\sigma_I(R)$ using a linear relation in the velocity dispersion profile due to mostly flat velocity dispersion profiles in our MaNGA BCG samples, see Fig. 1. Consequently, the total mass in Newtonian dynamics is defined as $M_{\rm tot}(< r) = r^2 g_{\rm obs}(r)/G$. Additionally, we estimate the deviation for the anisotropic models in Appendix B, resulting in at most 6% (or a scatter of 0.02 dex) for $g_{\rm obs}$.

- Круглые (сферы?)
- Изотропные
- С плоским профилем дисперсии скоростей звезд (MaNGA)
- Профиль яркости – единый Серсик, чаще всего с n=6 (SDSS)

Тем не менее:

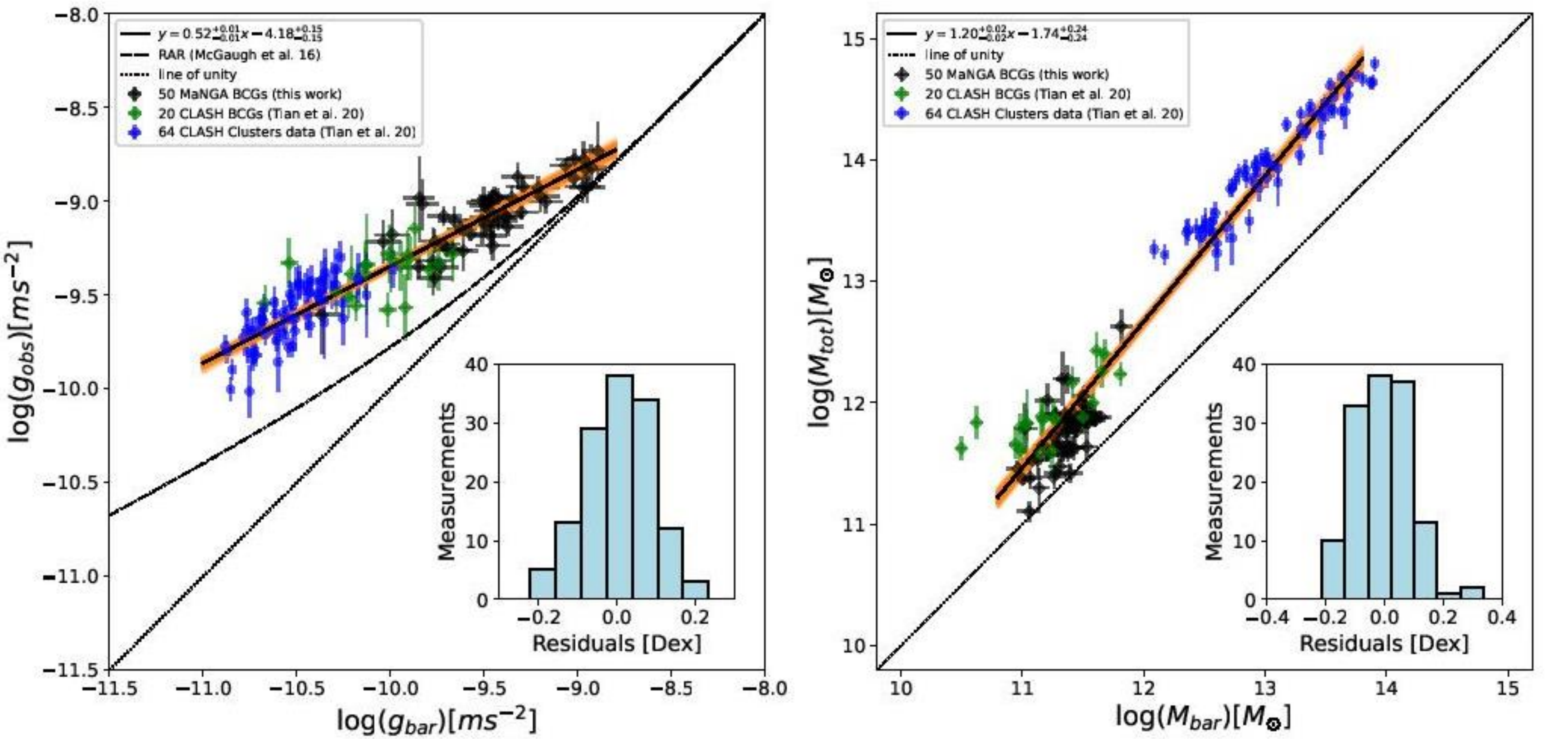


Fig. 2 The RAR and mass correlation of both BCGs and clusters are presented. *Left panel*: Black and green diamonds represent 50 MaNGA and 20 CLASH BCGs, while blue circles indicate 64 CLASH galaxy cluster data. The black solid line illustrates the resulting RAR of all samples: $\log(g_{obs}/ms^{-2}) = 0.52^{+0.01}_{-0.01} \log(g_{bar}/ms^{-2}) - 4.18^{+0.15}_{-0.15}$. The orange shaded area illustrates the 1σ error of the best fit with the ODR MCMC method. The inset panel demonstrates the histograms of the orthogonal residuals of a whole sample (blue). For comparison, the galactic RAR is depicted by the dot-dashed line, while the dotted line represents the line of unity. *Right panel*: The black solid line represents the mass correlation of all samples: $\log(M_{tot}/M_\odot) = 1.20^{+0.02}_{-0.02} \log(M_{bar}/M_\odot) - 1.74^{+0.24}_{-0.24}$. All symbols are the same as those in the left panel.

Если RAR=MOND, то избыток скрытой массы в скоплениях

To explore the possibility of compensating for the distinct RAR with missing mass, we connect the RAR as fitted in McGaugh et al. (2016) to the same observed acceleration g_{obs} by

$$\sqrt{g_{bar} g_{\ddagger}} \approx \frac{g_M}{1 - e^{-\sqrt{g_M / g_{\dagger}}}} . \tag{9}$$

Using Eq. (9), we can compute the factor Q for a given g_{bar}. For example, with a median logarithm of baryonic acceleration in 50 BCGs at $\log(g_{bar}) = -9.5$, we find $Q = 2.2$. However, the value of Q exhibits significant variability with g_{bar}: for the highest acceleration in our MaNGA BCG samples, $\log(g_{bar}) = -8.9$, Q decreases to 1.2, while for the lowest acceleration, $\log(g_{bar}) = -10.4$, Q increases to 4.9. This variability indicates that a systematic constant offset in the mass-to-light ratio is insufficient to address the discrepancy. Consequently, it appears that the residual missing mass is correlated with the baryonic acceleration g_{bar}.