On the lack of stellar bars in Coma dwarf galaxies

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Abstract. We present a study of the bar fraction in the Coma cluster galaxies based on a sample of ~190 galaxies selected from the SDSS-DR6 and observed with the Hubble Space Telescope (HST) Advanced Camera for Survey (ACS). The unprecedented resolution of the HST-ACS images allows us to explore the presence of bars, detected by visual classification, throughout a luminosity range of 9 mag (−23 ≤ M_r ≤ −14), permitting us to study the poor known region of dwarf galaxies. We find that bars are hosted by galaxies in a tight range of both luminosities (−22 ≤ M_r ≤ −17) and masses (10^9 ≤ M_*/M_⊙ ≤ 10^11). In addition, we find that the bar fraction does not vary significantly when going from the center to the cluster outskirts, implying that cluster environment plays a second-order role in barformation/evolution. The shape of the bar fraction distribution with respect to both luminosity and mass is well matched by the luminosity distribution of disk galaxies in Coma, indicating that bars are good tracers of cold stellar disks.

1 Introduction

Stellar bars are observed in optical images of roughly half of all the nearby disk galaxies [21]. This fraction rises to about 59-62% when near-infrared images are analysed [57]. It is established that they appear naturally in most simulations of galaxy formation once a dynamically cold and rotationally-supported disk is at place. However, even if bars are ubiquitous in the universe, it is not clear yet why one galaxy can exhibit a bar structure while another apparently similar does not. With the recent advent of large galaxy surveys statistical studies of bar frequencies have been possible. However, bar studies have been usually restricted to luminous galaxies due to either the lack of spatial resolution or because images were not deep enough. In [6] we attempt to put observational constraints on the internal (mass) and external (environment) parameters that influence bar formation by carrying out a comprehensive study of the bar fraction in the Coma cluster galaxies throughout a wide range of 9 magnitudes, covering from giant ellipticals (M_r ∼ −23) to dwarf galaxies (M_r ∼ −14). This research will also provide us the luminosity/mass interval where cold stellar disks are present in galaxies.

2 Data and cluster membership selection

The HST-ACS Coma Cluster Treasury Survey [3] covers ~230 arcmin² with 21 ACS pointings (~3 × 3 arcmin²). At the distance of the Coma cluster (∼ 100 Mpc), the resolution of HST-ACS (0.1 arcsec) corresponds to ~50 pc. This gives essentially the same physical resolution as ground-based observations have in Virgo and it will allow us to resolve bars down to sizes of ~150 pc. In addition, the Coma cluster is also covered by the SDSS, providing galaxy magnitudes in five bands (u, g, r, i, z).

We create our catalog of sources using the SDSS-DR6. The steps followed to obtain our final sample of Coma cluster members were: i) download a catalogue of extended sources (m_r < 21, b/a > 0.5) from the SDSS-DR6 within a 5 arcmin radius from the position of every ACS pointing. This resulted in a sample of 477 galaxies, 104 of them having recession velocities available from the NED. ii) Select galaxies with velocities ±3000 km/s (3σ) with respect to the Coma redshift as cluster members. All 104 galaxies satisfy this condition. iii) Visually inspect every galaxy to determine its possible cluster membership based on its morphology (see [3]). From the remaining 373 galaxies without redshift, 127 galaxies are cluster members following the morphological criteria. iv) A color cut condition was imposed. Members should have a g − r color less than 0.2 mag above the value of the red sequence fit.

Our final sample of Coma secure members consists of 188 galaxies with magnitudes in the range ~23 < M_r < −14.

3 Method and results

We visually classified all galaxies into strong barred, weakly barred, and unbarred using the redder available filter (F814W) of the HST-ACS images. Since our goal is to understand where bars form, we have used all galaxies, independently of their Hubble type, when calculating the bar fraction. Using this definition, our bar fraction turns to be ~9% and
Aguerri et al. (2009) show that the optical bar fraction of strong (solid black line) and weak + strong (dashed blue line) as a function of the galaxy absolute magnitude in the Coma cluster. Independently of the bar strength, bars are hosted by galaxies in a tight range of luminosities or masses. There are no strong bars in the Coma cluster out of the luminosity range between $-21 \leq M_r \leq -18$. These limits become $-22 \leq M_r \leq -17$ if we also include weak bars. We find the same behavior in the bar fraction when using the galaxy mass: bars exist only in a range of masses between either $10^{9.5} \leq M_* / M_\odot \leq 10^{11}$ or $10^9 \leq M_* / M_\odot \leq 10^{11}$ depending on whether only strong or strong + weak bars are considered, respectively.

4 Discussion and Conclusions

If bars are tracers of cold stellar disks, the presence of bars could be useful to identify galaxies with disks in clusters, and therefore, the distribution of bar fraction with the galaxy magnitude should trace the shape of the disk galaxies’ luminosity distribution. We have computed the luminosity distribution of morphologically selected disk galaxies (from S0 to Sc) using the classification by Michard & Andreon (2008). The resulting luminosity distribution (Fig. 1) matches well the shape of the bar fraction distribution in both luminosity and mass, confirming that bars are good tracers of disks.

Since our sample galaxies cover both the center and infall regions of the Coma cluster, we have studied the influence on environment by dividing our sample into internal and external galaxies and calculating the bar fraction for every subsample. We have repeated this procedure for three values of the separation distance (0.5, 1, and 1.5 Mpc) from the cluster center. For the smaller separation distance, we found 14% and 15% of bars for the internal and external subsamples, respectively. The bar fractions of both subsamples are 14% and 17% when using 1 Mpc, and 14% and 17% if we use 1.5 Mpc. Therefore, we did not find differences in the bar fraction between the subsamples for any separation distance, implying that the cluster environment plays a second-order role in bar formation/evolution.

Few works have investigated the dwarf realm in order to look for the presence of bars. Lisker et al. (2006), studying a sample of dwarf galaxies in the Virgo cluster, claim that dwarf ellipticals with and without disks represent two distinct types of galaxies, and show how the fraction of dwarfs with disks decreases dramatically for galaxies below $M_B \sim -16$. Therefore, even if the non-presence of bars in our low-luminosity galaxies could be due to the heating of the disk component or due to its absence, our result support that of Lisker et al. (2006), and we suggest that no disks are present in Coma dwarf galaxies below $M_r \sim -17$. This result is also supported by the recent work of Sánchez-Janssen et al. (2010) where they found, for a large sample of galaxies in the field, that disks becomes thicker for galaxies with $M_* / M_\odot \leq 2 \times 10^9$.

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