

Hubble-constant and -mass determination of Centaurus A and M83 from tip-of-red-giant-branch distances

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ABSTRACT

An independent determination of the Hubble constant is crucial in light of the persistent tension between early- and late-Universe measurements. In this study, we analysed the dynamics of the Centaurus A (CenA) and M83 galaxies, along with their associated dwarf companions identified via tip-of-the-red-giant-branch (TRGB) distance measurements, to constrain both the group mass and the local value of H_0 . By examining the motions of these galaxies relatively to the system's barycentre, we applied both the minor and major infall models, which provide bounds on the true radial-velocity dispersion. From the overlap of these approaches, we obtain a virial mass estimate of $(7.3 \pm 2.0) \times 10^{12} M_\odot$ and a Hubble-flow-based mass of $(2.6 \pm 1.4) \times 10^{12} M_\odot$. Modeling the cold Hubble flow around the group centre of mass, we derive a corresponding value of the Hubble constant as $(64.0 \pm 4.6) \text{ km s}^{-1} \text{ Mpc}^{-1}$. These results offer an independent, dynamically motivated constraint on the local value of H_0 , explicitly accounting for the impact of peculiar velocities in the nearby Universe. We also discuss the $\sim 2\sigma$ tension between the virial and Hubble-flow-based mass estimates, which likely arises from the fact that M83 is close to the velocity surface and goes against the Hubble-flow-model assumptions. While the Hubble-flow fit emphasises galaxies that follow smooth expansion on the lower branch of the velocity-distance relation, the virial mass estimate is found to be in good agreement with the group mass derived from the K -band luminosity of its brightest members and the projected mass methods.

Key words. galaxies: groups: general – cosmological parameters

1. Introduction

A long-standing discrepancy persists between measurements of the Hubble constant in the early and late Universe: $H_0 = 67 \text{ km s}^{-1} \text{ Mpc}^{-1}$ as inferred from Planck CMB observations (Planck Collaboration VI 2020), versus $H_0 = 73 \text{ km s}^{-1} \text{ Mpc}^{-1}$ derived from local Cepheid-supernova distance ladders (Perlmutter et al. 1999). This so-called Hubble tension has emerged as one of the most significant challenges in modern cosmology, potentially pointing to unknown systematics or a breakdown in the standard Λ CDM model (Di Valentino et al. 2025; Dainotti et al. 2021, 2025; De Simone et al. 2025). Resolving this tension is crucial, as the value of H_0 governs not only the current expansion rate of the Universe, but also its inferred age and ultimate fate. Independent determinations of H_0 based on local dynamics offer a complementary test of this discrepancy, free from many of the assumptions underpinning both early- and late-time probes. However, local measurements are complicated by peculiar velocities that arise from the gravitational interactions with nearby mass concentrations. To disentangle these effects from the cosmic expansion, one must account for both the peculiar velocity field and its cosmological context (Pavlidou & Tomaras 2014; Benisty et al. 2023, 2024).

The CenA (NGC 5128) and M83 (NGC 5236) galaxy complex provides a powerful laboratory for investigating local cosmic expansion dynamics, located at distances of $3.8 \pm 0.1 \text{ Mpc}$ and $\sim 4.7 \text{ Mpc}$, respectively (Karachentsev et al. 2007; Tully

2015a; Müller et al. 2019). Owing to its intermediate position between virialised structures and the onset of the linear Hubble flow, the CenA/M83 system serves as a valuable testbed for probing gravitational perturbations, infall kinematics, and velocity dispersion with minimised contamination from a large-scale structure. Its well-studied constituents – especially the massive and active CenA – enable precise barycentric modeling grounded in robust observational data.

The system is composed of two dynamically distinct sub-groups: a dominant, massive CenA component with a virial mass of $[6.4\text{--}8.1] \times 10^{12} M_\odot$ (Karachentsev et al. 2007), and a less massive M83 sub-group $[1.3\text{--}3] \times 10^{12} M_\odot$ noted for intense star formation and evidence of tidal interactions (Müller et al. 2025). Deep imaging has revealed 16 additional dwarf-galaxy candidates in the M83 sub-group (Müller et al. 2015), whose spatial alignment in a single dominant plane nearly perpendicular to the dust lane of CenA hints at coordinated infall and previous dynamical interactions (Müller et al. 2016), an additional 41 new candidates were found in an expanded survey of 500 sq. deg around the Cen A and M83 sub-groups by Müller et al. (2017).

The system as a whole seems to run away from us with a well-defined zero-velocity surface at $1.40 \pm 0.11 \text{ Mpc}$ (Karachentsev et al. 2007), indicating the gravitational boundary of the complex. HI observations further reveal extended tidal features and velocity bridges between the galaxies (Müller et al. 2021, 2022), confirming ongoing interactions that influence their orbital evolution. Located on the outskirts of the dominant gravitational centres of the local volume, this research focused on the Hubble flow around CenA/M83 by determining the barycentre of

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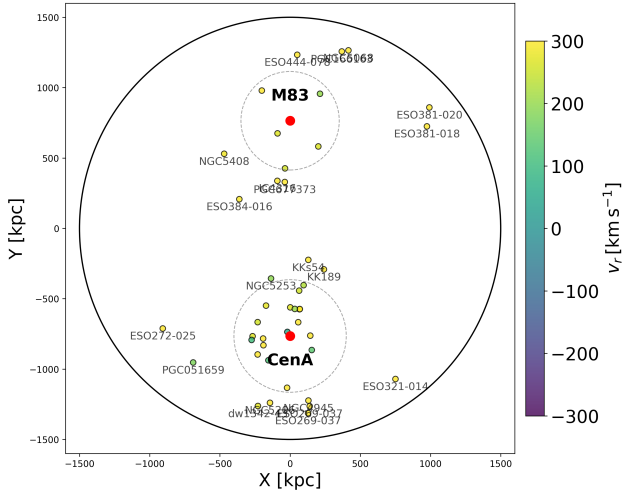


Fig. 1. Spatial distribution of galaxies in CenA – M83 group shown in rotated Cartesian coordinates centred on the midpoint between Cen A and M83. Symbols are colour-coded by heliocentric radial velocity (km s^{-1}). Dashed grey circles indicate the individual virial regions of Cen A and M83, and the black circle marks the 1.5 Mpc zero-velocity surface.

the system and the spread of the galaxies around the local Hubble flow. Recent dynamical models reinforce its transitional nature, showing that flow perturbations decay within this region as the Universe approaches large-scale homogeneity (Müller et al. 2021, 2024, 2025).

An important caveat concerns the kinematics of satellites in the immediate vicinity of Cen A, where most of the dwarf galaxies have been shown to reside in a co-rotating planar structure (Müller et al. 2018, 2021). Since our analysis focuses on galaxies in the surrounding Hubble flow, at distances of approximately [1.5–6] Mpc from the group centre, the co-rotating satellite plane does not directly affect our modelling. This distinction is consistent with previous studies of the LG, where planar satellite distributions around the Milky Way and M31 are acknowledged, but the Hubble-flow analysis relies on the more distant galaxy population (Makarov et al. 2025). As also demonstrated in N-body simulations (Peñarrubia et al. 2014), the large-scale flow at these distances approaches spherical symmetry despite internal anisotropies within virialised regions. We therefore note that while coherent satellite planes are relevant within the virial radius, the present study addresses the dynamics of galaxies at larger scales, where the transition to the local cosmic expansion dominates.

In this paper, we determine the Hubble constant by analysing the peculiar motion of this system. Using tip-of-the-red-giant-branch (TRGB) distances calibrated via the latest distance ladder refinements combined with HI kinematics, we modelled their mutual gravitational interaction and infall trajectory relatively to the Local Group (LG) frame. This approach isolates the peculiar velocity component, enabling direct comparison to the expected Hubble flow at their measured distance and yielding a high-fidelity H_0 estimate with minimised local flow contamination. Section 2 describes the observational data sets and the determination and barycentre modelling that underpin our kinematic analysis. Section 3 reports the derived constraints on H_0 and the total group mass, including a Bayesian treatment of uncertainties. Finally, Section 4 discusses the implications of these results and summarises our conclusions.

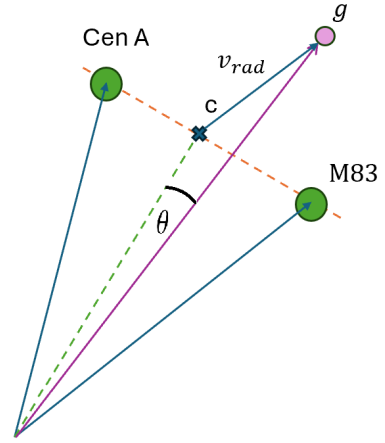


Fig. 2. Schematic illustration of barycentre (c) determination along the line connecting the CenA and M83 galaxies. For a given dwarf galaxy (g), the radial velocity is estimated using either the minor- or major-infall model. The barycentre is identified by minimising the velocity dispersion of the radial velocities towards the barycentre. θ is the angle between galaxy (g) and the centre (c).

2. Phase-space determination

2.1. The data

In this study, we employed data from several extragalactic catalogues to analyse galaxies within the CenA/M83 galaxy group. Distance measurements are primarily adopted from the Cosmicflows 4 (CF4) catalogue (Tully et al. 2023), which provides TRGB distances independently of any assumption on the Hubble constant. Radial velocities were obtained from the LEDA database that Makarov et al. (2014) accessed via the Extragalactic Distance Database (EDD) (Tully et al. 2009). Additionally, we incorporated velocities and TRGB distances from recent studies of dwarf galaxies in the Cen A and M83 groups (Müller et al. 2021, 2025), which also provide TRGB distances. Radial velocities obtained from LEDA are initially in the geocentric frame and are corrected to the LG frame (Karachentsev & Makarov 1996). Distances across all datasets are based on TRGB determinations, ensuring consistency and independence from redshift-based methodologies. Consequently, we were able to accurately reconstruct the spatial and kinematic structure of the CenA/M83 group, free from biases introduced by cosmic-expansion assumptions. Fig. 1 shows the spatial distribution of the galaxies. Our sample selection only includes galaxies that have both distance and radial-velocity measurements with associated uncertainties and that lie close to the inferred barycentre of the CenA/M83 system. As we later assumed that the barycentre lies along the line connecting Cen A and M83, we initially selected all galaxies within 10 Mpc of either Cen A or M83. This yields a final sample of 135 galaxies from the EDD and 22 additional galaxies from recent studies. The selected galaxies span distances from 0.9 Mpc to 14.7 Mpc and have LG frame velocities ranging from -10 km s^{-1} to 1300 km s^{-1} .

2.2. Barycentre determination

To analyse the dynamics of galaxy pairs within the CenA/M83 system, we transformed observed velocities into the barycentre frame. Observational constraints limited velocity measurements to the line-of-sight (LoS) components. Consequently, we required dynamical models to estimate radial infall velocities

relatively to the CenA/M83 barycentre. We adopted the following two limiting cases (Karachentsev & Kashibadze 2006; Wagner & Benisty 2025).

- The minor-infall model assumes negligible transverse velocities ($v_{\perp,c} = v_{\perp,j} = 0$). The radial infall velocity for galaxy j relative to the centre of mass (CoM) (c) is

$$v_{\text{rad,min}} = \frac{v_c r_c + v_j r_j - \cos \theta_{c,j}(v_j r_c + v_c r_j)}{r_{gc}}. \quad (1)$$

This symmetric treatment minimises peculiar velocity contributions, representing the most probable scenario when transverse motions are sub-dominant.

- The major-infall model assumes zero transverse Center of Mass (CoM) velocity and negligible galaxy tangential velocity ($v_{\perp,c} = v_{\text{tan}} = 0$). The infall velocity becomes

$$v_{\text{rad,maj}} = \frac{v_j - v_c \cos \theta_{c,j}}{r_j - r_c \cos \theta_{c,j}} r_{gc}. \quad (2)$$

Note that for this model, galaxies located very close to the CoM can make the denominator arbitrarily small, resulting in non-physical velocity values. In all subsequent analyses, these galaxies are excluded.

As shown in Wagner & Benisty (2025), Benisty & Mota (2025), the minor infall statistically underestimates the true radial velocity, and the major infall overestimates the radial velocity.

Understanding the motion of galaxies within the group requires careful modelling of their velocity field. The analysis begins by transforming the observed heliocentric velocities into a reference frame of LG (Karachentsev & Makarov 1996). We assume that the dynamical centre lies along the axis connecting the CenA and M83 halos, with its exact position determined by their mass ratio (see Fig. 2). Similarly to Ref. Karachentsev et al. (2009), we parameterised the barycentre velocity, v_c , using the mass ratio \bar{m}_{CenA} :

$$v_c = \bar{m}_{\text{CenA}} v_{\text{CenA}} + (1 - \bar{m}_{\text{CenA}}) v_{\text{M83}}, \quad (3)$$

where \bar{m}_{CenA} represents the fractional mass contribution of CenA relative to the total mass of the system; we then projected this velocity on the barycentre LoS vector to obtain the LoS velocity. This formulation allowed us to explore the kinematic structure across possible mass ratios: $\bar{m}_{\text{CenA}} = 1$ corresponds to a CenA-centred frame, while $\bar{m}_{\text{CenA}} = 0$ gives an M83-centred frame.

The determination of the barycentre position requires a fixed set of galaxies with a position and velocities that are always usable. So, the galaxies used for this analysis are those that are closer than 3 Mpc from the barycentre and have $|\Delta v_r| < 500 \text{ km s}^{-1}$ for all possible barycentres (the second restriction excludes galaxies with non-physical velocities).

For each trial mass ratio, we computed minor and major infall velocities relatively to the CoM and evaluated the velocity dispersion $\sqrt{\langle v^2 \rangle}$ for selected galaxies. The optimal \bar{m}_1 minimises this dispersion, identifying the most stable dynamical frame. Fig. 3 shows $\sqrt{\langle v^2 \rangle}$ as a function of \bar{m}_1 , revealing distinct minima for both infall models: the major infall model curve gives the minimum at $\bar{m}_{\text{CenA}} \approx 0.70$, which gives a distance from us of $r_c = 3.95 \text{ Mpc}$ and a velocity from the LG CoM of $v_c = 302 \text{ km s}^{-1}$, and the minor-infall-model curve gives the minimum at $\bar{m}_{\text{CenA}} \approx 0.83$, which gives a distance from us of $r_c = 3.80 \text{ Mpc}$ and a velocity from the LG CoM of $v_c = 304 \text{ km s}^{-1}$. This kinematic minimisation provides a model-dependent mass-ratio estimate independent of luminosity-based methods. The difference between models reflects systematic uncertainties in the assumptions of transverse velocity, which we propagate into our H_0 constraints.

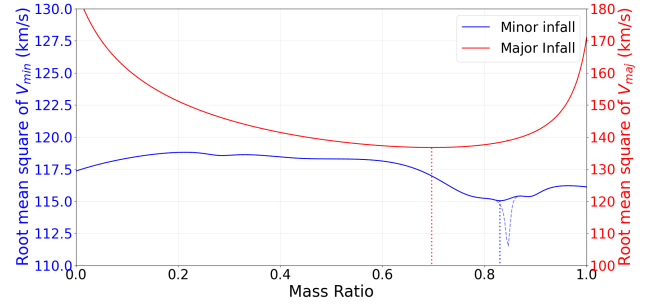


Fig. 3. Root mean square of the relative velocity dispersion, $\sqrt{\langle v^2 \rangle}$, with respect to the CenA/M83 system’s barycentre, shown as a function of the mass ratio $\bar{m}_{\text{CenA}} = m_{\text{CenA}}/m_{\text{Tot}}$. Velocities are measured in the Local Group frame under the minor-infall (blue) and major-infall (red) models. Dotted lines: Raw results of $\sqrt{\langle v^2 \rangle}$ as a function of \bar{m}_{CenA} , mostly lying slightly below the smoothed (solid) curves, except for a local spike near $\bar{m}_{\text{CenA}} \approx 0.85$ in the minor infall case. This spike is interpreted as a numerical bias arising from the clustering of galaxies near the CenA/M83 barycentre position (Müller et al. 2021, 2025). The vertical dashed lines show positions of the minima in $\sqrt{\langle v^2 \rangle}$ for each model, indicating the best-fitting mass ratio. To avoid confusion, these vertical lines are plotted with a distinct dashed style, different from the dotted raw data lines.

3. Parameter determination

3.1. Hubble-flow fit

A fundamental tool for analysing these systems is the velocity-distance relationship. Sandage (1986) introduced a method to estimate the mass of galaxy systems using this relationship, which encapsulates the kinematic state of the system. By measuring velocities and distances of member galaxies, one can estimate both the total mass of the system and the Hubble constant through non-linear fitting techniques (Teerikorpi & Chernin 2010). This method has been applied to groups and clusters (Peirani & de Freitas Pacheco 2006; Peirani & Pacheco 2008; Del Popolo & Chan 2022; Kim et al. 2020; Peñarrubia et al. 2014; Nasonova et al. 2011; Benisty et al. 2025; Benisty 2025; Wagner et al. 2025). The concept of turnaround, where gravitational attraction balances cosmic expansion, has been proposed as a stringent test of the Λ CDM cosmological model (Pavlidou & Tomaras 2014; Tanoglidis et al. 2015; Pavlidou et al. 2014, 2020; Paraskevas & Perivolaropoulos 2024). The Hubble flow around the LG has been particularly informative to studies of the dynamics of dwarf galaxies relative to cosmic expansion (Karachentsev et al. 2009). We modelled the interplay between gravitational collapse and cosmic expansion through a non-linear fit to CenA/M83 kinematics via the relation from Peñarrubia et al. (2014):

$$v = (1.2 + 0.31\Omega_\Lambda)H_0 r - 1.1 \sqrt{\frac{GM}{r}}, \quad (4)$$

with $\Omega_\Lambda = 0.67$. Our framework incorporates the zero-gravity radius demarcating bound and unbound regions (Teerikorpi & Chernin 2010), dark-energy effects via the cosmological constant (Peirani & Pacheco 2008; Del Popolo & Chan 2022), and turnaround radius tests of Λ CDM cosmology as Pavlidou & Tomaras (2014), Tanoglidis et al. (2015) claimed.

We selected fitted galaxies as those lying between [1.40, 6] Mpc from the CoM, within the Hubble-flow velocity range. The inner limit of 1.40 Mpc corresponds to the zero-velocity radius from (Karachentsev et al. 2007); galaxies inside

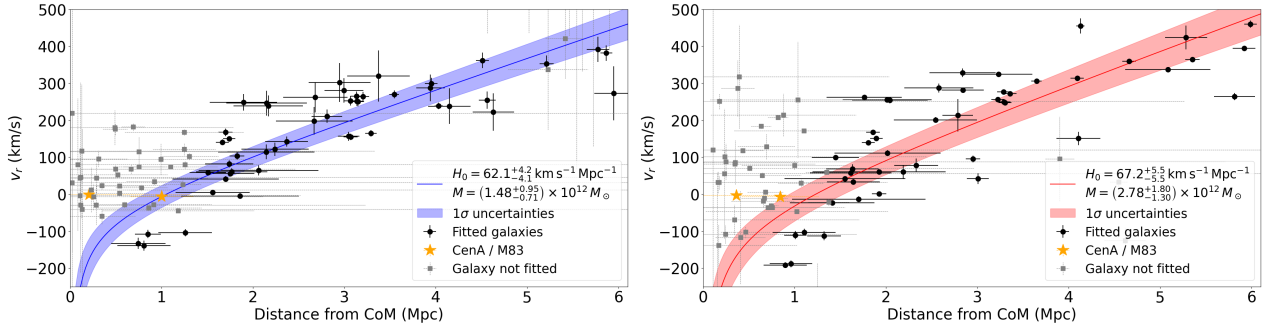


Fig. 4. Radial-velocity versus 3D distance from the group barycentre for the minor (left) and the major (right) infall models. The Muse galaxies are shown in green, and the galaxies used for the fit are shown in black. The Hubble-flow-fit model is presented with a 3σ error.

this radius are not expected to follow the Hubble law. The outer limit of 6 Mpc is imposed, because beyond this scale other large-scale structures may significantly influence galaxy kinematics. For a better M_{group} estimate, we also added a few galaxies with $r < 1.40$ Mpc, which fall towards the CoM ($r < 1.40$ Mpc and $v_r < -100$ km s $^{-1}$). Galaxies with uncertainty estimates under 10% for velocity and 100% for distance were not used. We fitted the velocity-distance relation using a Bayesian approach. The likelihood of observing galaxies at given distances, r_i , from the CenA-M83 group CoM, with radial velocities of r_i , the parameters H_0 and M , and the intrinsic velocity dispersion δ_I is

$$p(v|r, H_0, M, \delta_I) = - \sum_i \frac{(f(r_i) - v_i)^2}{2\sigma_I^2} + \ln 2\pi\sigma_I^2; \quad (5)$$

here, $\sigma_I = \text{err}(v_i)^2 + \text{err}(r_i)^2 \times (\frac{\partial f}{\partial r})^2 + \delta_I^2$. Additionally, $\text{err}(v_i)$ and $\text{err}(r_i)$ are measurement errors, and δ_I is the intrinsic velocity dispersion interpreted as scatter from peculiar motion.

We employed the *emcee* sampler (Foreman-Mackey et al. 2013) to explore the posterior distributions of key model parameters, as illustrated in Fig. 5. These include the Hubble constant H_0 , the group mass M_{group} , and the intrinsic velocity dispersion δ_I . For the minor-infall model, the analysis yields $H_0 = 62.1^{+4.2}_{-4.1}$ km s $^{-1}$ Mpc $^{-1}$, $M_{\text{group}} = 1.48^{+0.95}_{-0.71} \times 10^{12} M_{\odot}$, and $\delta_I = 67.7^{+8.8}_{-7.8}$ km s $^{-1}$. In contrast, the major-infall model gives a slightly higher Hubble constant of $H_0 = 67.2^{+5.5}_{-5.5}$ km s $^{-1}$ Mpc $^{-1}$, a larger group mass of $M_{\text{group}} = 2.78^{+1.80}_{-1.30} \times 10^{12} M_{\odot}$, and a higher intrinsic velocity dispersion of $\delta_I = 98.2^{+11.5}_{-9.7}$ km s $^{-1}$.

These results highlight subtle but important differences between the two models. The minor-infall model tends to underestimate H_0 , while the major-infall model tends to overestimate it. Moreover, radial trends shown in Fig. 4 reveal three key features: H_0 estimates stabilise beyond ~ 1.5 Mpc, where the Hubble flow dominates; mass estimates converge within $r < 0.8$ Mpc, where virial equilibrium is expected to hold; the systematic offset in H_0 between models reflects differing assumptions about the nature of galaxy infall. The 2σ overlapping the models gives

$$H_0 = 64.0 \pm 4.6 \text{ km s}^{-1} \text{ Mpc}^{-1}$$

and

$$M_{\text{Group}} = (2.6 \pm 1.4) \times 10^{12} M_{\odot},$$

which we adopted as the best combined values accounting for the bias introduced by different infall assumptions. However, the approach used to fit H_0 and M_{group} is not exact; this is due to the

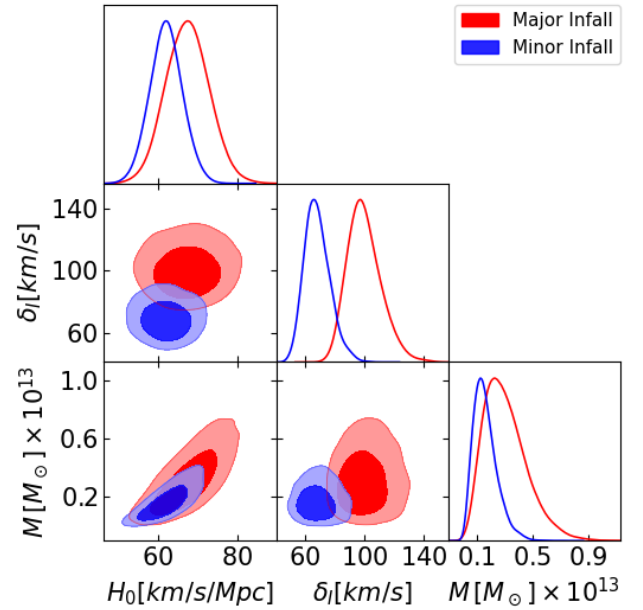


Fig. 5. Posterior distributions for Hubble constant, H_0 ; the group mass, M [$10^{12} \odot$]; and intrinsic velocity dispersion, δ_I [km/s]. The blue contour shows the minor-infall model, while the red one shows major-infall posterior.

fact that the independent variable, r , is itself subject to measurement error – a phenomenon known as regression dilution bias. A more accurate formulation of the likelihood function is given by

$$p(v|r, H_0, M, \delta_I) = - \sum_i \left[\frac{(y_i - v_i)^2}{2(\delta_I^2 + \text{err}(v_i)^2)} + \frac{(x_i - r_i)^2}{2 \text{err}(r_i)^2} \right] + \ln(2\pi\sigma_I^2), \quad (6)$$

where (x_i, y_i) is the orthogonal projection of the observed data point (r_i, v_i) onto the model curve $y = f_{H_0, M}(x)$. Although the previous likelihood expression was similar to the standard form, χ^2 , used in least-squares regression, the above formulation corresponds to the Deming regression method, which accounts for uncertainties in both variables.

Implementing this likelihood in a Markov chain Monte Carlo (MCMC) sampler cannot directly fit for δ_I . To approximate its effect, we artificially inflated the velocity uncertainties by adding the intrinsic dispersions obtained from the MCMC fit: $\delta_I^{\text{min}} = 68.1$ km s $^{-1}$ for the minor-infall model and $\delta_I^{\text{maj}} = 98.4$ km s $^{-1}$ for the major-infall model. Using this approximation, we obtain

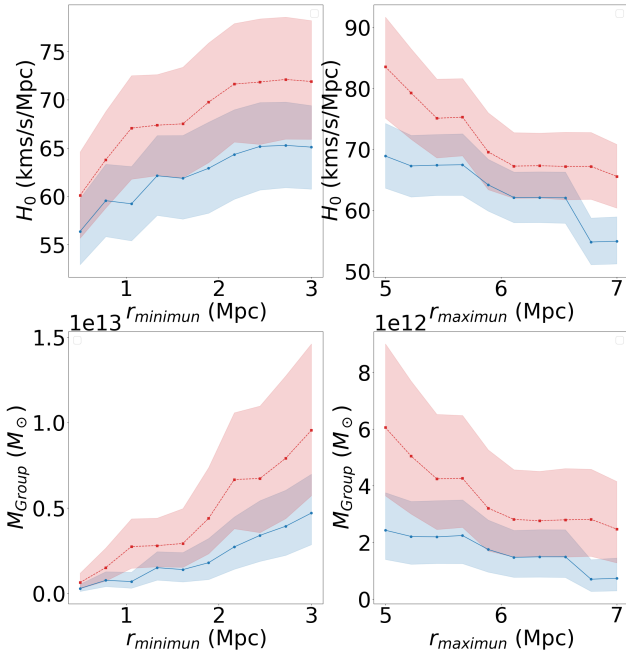


Fig. 6. Dependence of fitted Hubble constant (H_0) and group mass (M_{group}) on the choice of minimum and maximum selection radii. The blue curves correspond to the minor-infall model, and the red curves correspond to the major-infall model. The coloured area corresponds to the 1σ uncertainty on the results. Top panels: Fitted values of H_0 . Bottom panels: Fitted values of M_{group} . Left: Variation of H_0 and M_{group} as function of minimum radius, r_{minimum} , used on selected galaxies for the fit. In these cases, the maximum radius was fixed at 6 Mpc, and galaxies close to the CoM and apparently infalling towards it were kept. Right: Variation of H_0 and M_{group} as function of maximum radius, r_{maximum} . Here, the minimum radius was fixed at 1.4 Mpc, and nearby galaxies infalling towards the CoM were kept.

$H_0 = 63.8 \pm 3.9 \text{ km s}^{-1} \text{ Mpc}^{-1}$ and $M_{\text{group}} = 1.81 \pm 0.84 \times 10^{12} M_{\odot}$ for the minor infall case, and $H_0 = 68.1 \pm 5.2 \text{ km s}^{-1} \text{ Mpc}^{-1}$ with $M_{\text{group}} = 3.05 \pm 1.55 \times 10^{12} M_{\odot}$ for the major-infall case.

These results are consistent with those obtained from the complete posterior MCMC procedure, confirming that the inclusion of δ_l dominates the uncertainty budget and effectively justifies the use of a least-squares approximation as a proxy for orthogonal distance regression (ODR). A key advantage of the Bayesian framework is its capacity to incorporate observational uncertainties and prior information in a coherent, principled manner. However, assumptions regarding the functional form of intrinsic velocity dispersion and the symmetric treatment of distance and velocity errors may introduce subtle biases. Future work could explore hierarchical Bayesian models or Gaussian process regression to more flexibly account for these effects and better characterise the local velocity field.

We also tested different values of the selection radii, with $r_{\text{min}} \in [0.5 \text{ Mpc}, 3 \text{ Mpc}]$ and $r_{\text{max}} \in [5 \text{ Mpc}, 7 \text{ Mpc}]$, which define the radial range of galaxies used for the Hubble-law fitting. This allowed us to assess the impact of galaxy selection on the fitted parameters H_0 and M_{group} . The results are shown in Fig. 6. When the minimum radius decreases below the zero-velocity surface, an increasing number of galaxies that do not follow the Hubble flow –because of the internal dynamics within the bound region –are included in the fit. Similarly, when the maximum radius exceeds 6 Mpc, more galaxies deviate from the Hubble law due to motions induced by other large-scale structures.

3.2. Virial mass

Assuming that the core of the CenA-M83 system encompasses galaxies within the velocity surface around the barycentre, we calculated the virial mass (Limber & Mathews 1960; Bahcall & Tremaine 1981; Heisler et al. 1985; An & Evans 2011; Tully 2015a; Benisty et al. 2024):

$$M_{\text{vir}} = \alpha \frac{\sigma_v^2 r_G}{G}, \quad \text{where } r_{G0} = N / \sum 1/r_{i0}, \quad (7)$$

where r_G runs over all of the dwarf galaxies towards the main halo. In the case of two main halos (CenA and M83), the harmonic radius is modified to be $\frac{1}{r_G} = \frac{m_1}{r_{G,\text{CenA}}} + \frac{1-m_1}{r_{G,\text{M83}}}$. σ_v represents the velocity dispersion of galaxies in the core, r_G denotes the harmonic mean of 3D pairwise distances between the N galaxies (weighted by their inverse separations r_{ij}), and α is a dimensionless geometrical factor that depends on the dark-matter distribution and velocity anisotropy.

For reference, $\alpha = 3$ corresponds to isotropic orbits in an isothermal sphere, $\alpha = 2.6$ to isotropic velocities in an Navarro–Frenk–White (NFW) profile, and $\alpha = 2.4$ to specific anisotropy models (Limber & Mathews 1960; Bahcall & Tremaine 1981). To encompass uncertainties in the dark-matter distribution, we adopted a broad uniform prior of $\alpha \in [2, 4]$. We adapted the area up to the velocity surface. We used a Gaussian prior on the velocities and our distances. The velocity dispersion for galaxies in the virial core is $103 \pm 3 \text{ km/s}$. Substituting these results into Eq. (7), we give the overall mass as

$$M_{\text{vir}} = (7.3 \pm 2.0) \times 10^{12} M_{\odot}. \quad (8)$$

3.3. K-band luminosity mass

We can use the luminosity of the main galaxies to infer the total mass of the group. Following Tully (2015b), we estimated group masses using the empirical K -band luminosity-to-mass relation calibrated against the virial masses of groups, which provides a robust total mass estimate independent of the stellar initial-mass function assumptions. The relation reads

$$M_{\text{group}} = 43 h \left(\frac{L_K}{10^{10} L_{\odot}} \right)^{1.15} \times 10^{10} M_{\odot}, \quad (9)$$

where L_K is the luminosity of 2MASS K_s . This relation implies a mass-to-light ratio

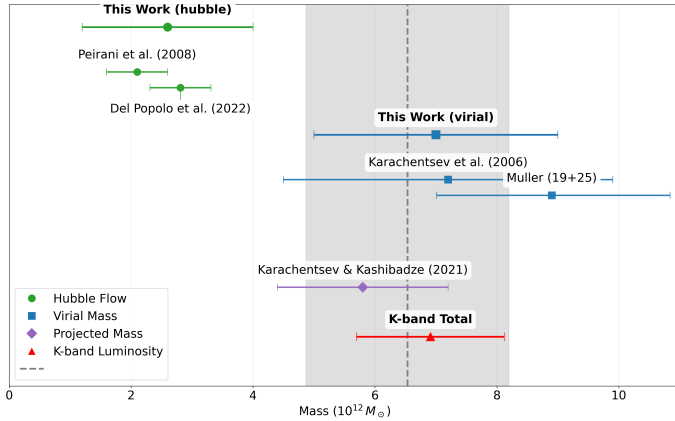
$$\frac{M}{L_K} = 43 \left(\frac{L_K}{10^{10} L_{\odot}} \right)^{0.15} M_{\odot}/L_{\odot}, \quad (10)$$

which is fixed at $M/L_K = 43 M_{\odot}/L_{\odot}$ for $L_K \leq 10^{10} L_{\odot}$ and at $M/L_K = 121 M_{\odot}/L_{\odot}$ for $L_K \geq 10^{13} L_{\odot}$. Between these luminosity limits, the power-law captures the trend observed in nearby groups from numerical-action modelling and other studies. Systems dominated by elliptical galaxies carry roughly 25% more mass per unit, K_s , of light than spiral-dominated systems, and the overall uncertainty in the luminosity-to-mass conversion is about 20% (Tully 2015b). Adopting $h = 0.7 \pm 0.1$ and the 2MASS luminosities – $L_{K,\text{CenA}} = 7.8 \times 10^{10} L_{\odot}$ and $L_{K,\text{M83}} = 7.2 \times 10^{10} L_{\odot}$ – from Karachentsev & Kashibadze (2021) (summarised in Table 1), we find $M_{\text{CenA}} = (3.97 \pm 0.98) \times 10^{12} M_{\odot}$ and $M_{\text{M83}} = (2.93 \pm 0.72) \times 10^{12} M_{\odot}$, where the CenA mass includes the 25% elliptical correction. The total mass of the combined system is

$$M_{K\text{-band}} = (6.91 \pm 1.21) \times 10^{12} M_{\odot}. \quad (11)$$

Table 1. K-band luminosity data from Karachentsev & Kashibadze (2021).

Group	$\log(L_K/L_\odot)$	$L_K (L_\odot)$
CenA	10.89	7.76×10^{10}
M83	10.86	7.24×10^{10}


Fig. 7. Comparison of CenA/M83 galaxy-group mass estimates obtained in this work with other recent estimates taken from Peirani & Pacheco (2008), Karachentsev et al. (2007), Müller et al. (2019, 2025), Karachentsev & Kashibadze (2021), Del Popolo et al. (2021). An overall estimate with $(6.53 \pm 1.66) \times 10^{12} M_\odot$ is added as a grey zone.

These estimates assume the group mass prescription is valid in the luminosity interval considered. The quoted uncertainties reflect contributions from both the adopted value of h and the intrinsic 20% scatter in the luminosity-to-mass relation, but they do not include other potential sources of error such as distance uncertainties, internal extinction corrections, dynamical disturbances, or variations in the stellar initial-mass function.

4. Discussion

Our analysis provides an independent, dynamical estimate of the Hubble constant and total group mass of the CenA/M83 system, using both the minor- and major-infall models to bracket the impact of unknown transverse motions. The values we derive for the Hubble constant range from $H_0 = 62.1^{+4.2}_{-4.1} \text{ km s}^{-1} \text{ Mpc}^{-1}$ (minor infall) to $H_0 = 67.2^{+5.5}_{-5.5} \text{ km s}^{-1} \text{ Mpc}^{-1}$ (major infall), with a total value of $H_0 = 64.0 \pm 4.6 \text{ km s}^{-1} \text{ Mpc}^{-1}$. These values are consistent with, but systematically lower than, recent late-Universe measurements based on Cepheid-calibrated supernovae (e.g. $H_0 \approx 73 \text{ km s}^{-1} \text{ Mpc}^{-1}$), and they are closer to early-Universe determinations from the CMB (e.g. $H_0 \approx 67.4 \text{ km s}^{-1} \text{ Mpc}^{-1}$ from Planck Collaboration VI 2020). These findings highlight the importance of local dynamical effects in reconciling discrepancies in H_0 measurements. The significant peculiar velocities observed in the Local Volume complicate direct extrapolation of redshifts to infer the Hubble flow, especially within $\sim 5 \text{ Mpc}$.

The spread between the two infall models illustrates the systematic uncertainty arising from the unknown tangential velocities. The minor-infall model assumes purely radial motion and likely underestimates the total infall velocity, thus producing a lower Hubble constant and smaller group mass. In contrast, the

major infall model assumes more concentrated motion along the line of sight and provides an upper bound. Our results suggest that the true values likely lie between these extremes. The posterior distributions show consistent correlations between Hubble constant, group mass, and intrinsic dispersion, underscoring how LG dynamics imprint on the observed Hubble flow.

A recent analysis based on the CF4 catalog (Tully et al. 2023; Duangchan et al. 2025) infers $H_0 = 74.6 \pm 0.8 \text{ km s}^{-1} \text{ Mpc}^{-1}$, a value higher than ours. This offset can be traced to several factors. First, the CF4 distance scale ties together multiple indicators (Tully-Fisher, Fundamental Plane, surface-brightness fluctuations, and others) and is calibrated assuming a particular adopted value of the Hubble constant, whereas our distance ladder uses TRGB distances that are independent of H_0 . Second, the treatment of peculiar velocities and bulk flows differs: CF4 analyses and ours weight nearby objects differently, and because peculiar motions constitute a larger fraction of the observed redshift at small distances, the inferred expansion rate is especially sensitive to flow modeling and sky coverage. Third, selection and sample-correction procedures differ between the studies. Because peculiar-velocity corrections directly affect the measured dispersion and thus the derived expansion rate, analyses that rely more heavily on the very Local Volume are particularly vulnerable to under- or over-estimates arising from flow modelling.

In addition to the Hubble constant, we derive two independent estimates of the total mass of the CenA/M83 system. From the Hubble-flow model, we obtain $M_{\text{Hubble}} = (2.6 \pm 1.4) \times 10^{12} M_\odot$. This value agrees with earlier CenA estimates, but it is notably lower than our virial result of $M_{\text{vir}} = (7 \pm 2) \times 10^{12} M_\odot$, which includes the full velocity dispersion of galaxies within the turnaround radius. Therefore, there is a tension between the virial and the K-band masses and Hubble-flow determinations. Fig. 7 compares our virial estimate with previous virial results (Müller et al. 2019, 2025), Hubble-flow fits (Del Popolo et al. 2021; Del Popolo & Chan 2022), K-band luminosity estimates (Tully 2015b), and projected mass (Karachentsev & Kashibadze 2021). An overall estimate of the mass without the lower Hubble flow gives $(6.53 \pm 1.66) \times 10^{12} M_\odot$.

The lower Hubble-flow mass is expected, because the Hubble-flow-mass method assumes a single concentrated mass and treats each satellite as a test particle that has moved outward with zero peculiar velocity since the Big Bang. Such an approximation is valid only when satellites lie far enough from the main halo to feel its gravity as if it were a point mass. For example, in the Milky Way-M31 system, the satellites are sufficiently distant that a clean, cold Hubble flow is observed, and the method performs well (Karachentsev et al. 2009; Makarov et al. 2025).

In contrast, for CenA/M83 the situation is different: as Fig. 4 shows, M83 lies close to the system's velocity surface, so the assumption of a single isolated point mass is violated. The proximity of M83 and its interaction with CenA introduce internal dynamics that the simple Hubble-flow model cannot capture, which naturally results in a lower total mass. Therefore, we place greater weight on the virial estimate, which more fully reflects the true dynamical state of the system.

Data availability

The data are available at the CDS via <https://cdsarc.cds.unistra.fr/viz-bin/cat/J/A+A/705/A112>

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