On the CenA/M83 Local Hubble Flow

Faucher Adrian,[1,*] David Benisty,[2,†] and David F. Mota[3,‡]

[1] *École polytechnique, Route de Saclay, 91128 Palaiseau, France*
[2] *Leibniz-Institut fur Astrophysik Potsdam, An der Sternwarte 16, D-14482 Potsdam, Germany*
[3] *Institute of Theoretical Astrophysics, University of Oslo, 0315 Oslo, Norway*

The dynamics

I. INTRODUCTION

II. THEORY

A. Relative Motion and Infall Models

Angle between galaxy 1 and galaxy 2:

$$\cos\theta = \sin\mathrm{dec}_1 \sin\mathrm{dec}_2 + \cos\mathrm{dec}_1 \cos\mathrm{dec}_2 \cos\left(\mathrm{ra}_1 - \mathrm{ra}_2\right) \tag{1}$$

To analyze the dynamics of galaxy pairs within the LG, we transform observed velocities into the CoM frame. The physical separation $r_{\rm gc}$ between two galaxies is determined from their angular separation θ on the sky and their distances $r_{\rm g}$ and $r_{\rm c}$ from the observer:

$$r_{\rm gc}^2 = r_{\rm g}^2 + r_{\rm c}^2 - 2 r_{\rm g} r_{\rm c} \cos\theta, \tag{2}$$

where $r_{\rm g}$ and $r_{\rm c}$ correspond to the distances of the galaxies from the observer. Observational limitations restrict velocity measurements to the line-of-sight ($v_{\rm LoS}$) components, as the other components $v_\perp$ are challenging to constrain. Consequently, assumptions about the unobserved velocity components are required to estimate radial infall velocities relative to the LG's CoM. Below, we outline two limiting models for these infall velocities, following [**?**] and recent clarifications in [**?**].

Minor Infall Model: The minor infall model approximates the radial velocity $v_{\rm r,min}$ of a galaxy j toward the CoM by symmetrically treating the velocities and positions of the galaxy and the CoM. Assuming vanishing perpendicular velocity components $v_{\perp,\rm c} = v_{\perp,j} = 0$, the infall velocity is:

$$v_{\rm r,min} = \frac{v_{\rm c} r_{\rm c} + v_j r_j - \cos\theta_{{\rm c},j}\left(v_j r_{\rm c} + v_{\rm c} r_j\right)}{r_{gc}}, \tag{3}$$

where $v_{\rm c}$ and v_j denote the line-of-sight velocities of the CoM and galaxy j, $\bar{r}_{\rm c}$ and $\bar{r}_j$ are unit vectors along their respective lines of sight, and $\theta_{{\rm c},j}$ is the angular separation between them. This model implicitly assumes that any non-radial motion is negligible, though a fine-tuned scenario with non-zero perpendicular components is theoretically possible but statistically unlikely [**?**].

Major Infall Model: In contrast, the major infall model adopts an asymmetric approach by projecting the velocity difference between the galaxy and the CoM onto the line of sight. Assuming zero tangential velocity $v_{\rm t} = 0$, the radial infall velocity becomes:

$$v_{\rm r,maj} = \frac{v_j - v_{\rm c}\cos\theta_{{\rm c},j}}{r_j - r_{\rm c}\cos\theta_{{\rm c},j}} r_{gc}. \tag{4}$$

This model prioritizes the relative velocity component along the line connecting the galaxy and the CoM, effectively ignoring transverse motions. As with the minor model, an alternative fine-tuned scenario exists but is considered improbable [**?**].

III. DISCUSSION

ACKNOWLEDGMENTS

DB is supported by a Minerva Fellowship of the Minerva Stiftung Gesellschaft für die Forschung mbH. DFM thanks the Research Council of Norway for their support and the resources provided by UNINETT Sigma2 – the National Infrastructure for High-Performance Computing and Data Storage in Norway.

* adrian.faucher@polytechnique.edu

† dbenisty@aip.de

‡ d.f.mota@astro.uio.no