The Distance to NGC 1042 in the Context of its Proposed Association with the Dark Matter-Deficient Galaxies NGC1052-DF2 and NGC1052-DF4

Pieter van Dokkum,¹ Shany Danieli,¹ Aaron Romanowsky,² ³ Roberto Abraham,⁴ and Charlie Conroy⁵

¹Yale University
²San José State University
³University of California Observatories
⁴University of Toronto
⁵Harvard-Smithsonian Center for Astrophysics

Keywords: galaxies, kinematics and dynamics — dark matter

A “SHORT DISTANCE” SOLUTION TO NGC1052-DF2 AND NGC1052-DF4

The galaxies NGC1052-DF2 (van Dokkum et al. 2018a) and NGC1052-DF4 (van Dokkum et al. 2019) have received considerable attention, as their kinematics indicate that they have little or no dark matter. Both galaxies are also unusually large for their mass, and both host a population of unusually luminous globular clusters.

Most of the properties of the galaxies are distance-dependent. The distances were measured to be 19−20 Mpc (Cohen et al. 2018), consistent with that of the nearby elliptical galaxy NGC 1052 and with their radial velocities ($cz = 1804$ km s$^{-1}$ for NGC1052-DF2 and $cz = 1445$ km s$^{-1}$ for NGC1052-DF4). However, Trujillo et al. (2019) suggest a shorter distance of $≈13$ Mpc: for that distance the globular clusters and velocity dispersions are still highly unusual, but less extreme than for 19–20 Mpc.

In van Dokkum et al. (2018b) we analyzed this suggestion,¹ showing that the CMD of NGC1052-DF2 is inconsistent with a distance of 13 Mpc and that its surface brightness fluctuation signal implies $D = 18.7 ± 1.7$ Mpc independent of absolute calibrations. Here we focus on a different aspect of the Trujillo et al. (2019) argument. NGC1052-DF2 and NGC1052-DF4 are likely at the same distance, but their velocity difference of 360 km s$^{-1}$ rules out the possibility that they are an isolated bound pair. Therefore, the short distance solution only “works” if they are satellites of a massive galaxy in the foreground of the NGC 1052 group. The only plausible candidate is the spiral galaxy NGC 1042; in projection it is near NGC1052-DF2 and NGC1052-DF4, and Trujillo et al. suggest its distance is “within a range of 8–13 Mpc”.

Neutral Hydrogen in NGC 1042 and NGC 1052

In this Research Note we show that NGC 1042 is probably not in the foreground of the NGC 1052 group but a member of it. In projection it is near NGC 1052 itself, its radial velocity of $cz = 1371$ km s$^{-1}$ is close to the central group velocity ($cz ≈ 1450$ km s$^{-1}$), and in group catalogs such as that of Kourkchi & Tully (2017) it is listed as a bona fide member. An additional argument comes from the H I distribution in NGC 1042 and NGC 1052, as shown in van Gorkom et al. (1986). NGC 1052 has H I emission in two spatially- and dynamically-distinct components, to the NE and SW of the galaxy. The velocity range of the NE component (1297 km s$^{-1}$–1442 km s$^{-1}$) overlaps precisely with that of NGC 1042 (see Figs. 1 and 15 of van Gorkom et al. 1986). Furthermore, the H I in both galaxies has a disturbed morphology. We show the total H I emission in Fig. 1, as well as channel maps at 1297 km s$^{-1}$ and 1442 km s$^{-1}$. The blue- and redshifted velocities of NGC 1042 show ordered rotation but the total emission exhibits an asymmetry along the NE-SW axis, in the direction of NGC 1052. As noted in van Gorkom et al. (1986) NGC 1042 is the only galaxy in the group with a large gas reservoir, and a likely interpretation of Fig. 1 is that NGC 1052 stripped gas from NGC 1042 in a past interaction.

Corresponding author: Pieter van Dokkum
pieter.vandokkum@yale.edu

¹ The Trujillo et al. study is still under review, but appeared on the arXiv in June 2018.
Figure 1. Main panel: H\textsc{i} distribution adapted from van Gorkom et al. (1986). Lower left: HST/WFPC2 image of the central regions of NGC 1042. Lower right: Large scale distribution of star formation (blue) and stars (grey).
THE TULLY-FISHER DISTANCE TO NGC 1042

The distance of NGC 1042 quoted in Trujillo et al. (“8–13 Mpc”) is based on the Tully-Fisher relation. The NASA/IPAC Extragalactic Database lists 17 Tully-Fisher distances for NGC 1042, ranging from 4.2 Mpc to 16.7 Mpc. The main reason for this large range is the uncertain inclination of the galaxy. With a velocity width of \( W_{\text{mx}} = V_{\text{max}} - V_{\text{min}} \approx 145(\sin i)^{-1} \text{km s}^{-1} \) (van Gorkom et al. 1986; Luo et al. 2016), an observed magnitude of \( m_T^I = 10.19 \), and the RC3 inclination of \( i = 40^\circ \), the Tully & Courtois (2012) calibration gives \( D_{\text{TF}} \approx 11.5 \text{Mpc} \). The RC3 inclination is derived from the axis ratio, but as shown in the bottom panels of Fig. 1 the axis ratio and position angle of NGC 1042 are strongly dependent on radius. In the inner regions the axis ratio is strongly influenced by the bar. At larger radii the galaxy first becomes nearly round and then flattens again but now in the opposite direction, such that it is elongated along the rotation axis in the Dragonfly data. These results reinforce the notion that the galaxy is disturbed, and also suggest that it is viewed close to face-on. For inclinations \( i < 30^\circ \) the Tully-Fisher distance to NGC 1042 is \( D_{\text{TF}} \gtrsim 18 \text{Mpc} \).

CONCLUSION

We infer that NGC 1042 is almost certainly a member of the NGC 1052 group, consistent with previous determinations that were based on its radial velocity and location in the sky (Kourkchi & Tully 2017).

We thank Jacqueline van Gorkom for comments on the manuscript.
Cohen, Y., et al. 2018, ApJ, 868, 96
Kourkchi, E., & Tully, R. B. 2017, ApJ, 843, 16
Luo, R., et al. 2016, ApJ, 823, 85
Trujillo, I., et al. 2019, MNRAS, submitted
(arXiv:1806.10141)
Tully, R. B., & Courtois, H. M. 2012, ApJ, 749, 78

van Dokkum, P., et al. 2018a, Nature, 555, 629
van Dokkum, P., et al. 2018b, ApJL, 856, L30
van Dokkum, P., et al. 2019, ApJ Letters, submitted
(arXiv:1901.05973)
van Driel, W., et al. 2016, à, 595, 118
van Gorkom, J. H., et al. 1986, ApJ, 91, 791