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Description of Fornax A (NGC 1316)

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ABSTRACT

This article presents a short overview and description of the astronomical object Fornax A, otherwise classified as NGC 1316. Delving into the history, formation, and evolution of galaxy and aiming to provide the key statistics of the object. As well as an exploration of its surroundings and potential future events.

Key words: galaxies: elliptical and lenticular – galaxies: individual: NGC1316 – galaxies: structures

1 INTRODUCTION

Fornax A was first believed to have been catalogued in Astronomical literature by Dunlop (1828) in which it was recorded as the 548th entry from his findings and observations in the southern hemisphere, within the Fornax constellation. It was succinctly described at the time as,

"A rather bright round nebula, about $1\frac{1}{2}'$ diameter, gradually condensed to the centre."

A more notable catalogue in which Fornax A has been recorded is the New General Catalogue (NGC) by Dreyer (1888). From this we get given another common and widespread name for this galaxy, NGC 1316. This, alongside Fornax A, will be used interchangeably when appropriate. It should be noted that there are in fact 71 documented names for Fornax A[1] which, as riveting as they are to learn, none have quite caught on to the aforementioned powerhouse duo.

2 KEY INFORMATION ON FORNAX A

Research by Schweizer (1980, 1981) provides much of the substantial groundwork in regards to our understanding of the galaxy. Before this, there was scarce information in comparison to other, closer radio galaxies; namely Centaurus A and Messier 87. Investigations by Richtler et al. (2012, 2017, 2020) also yields much more knowledge on the galaxy.

A summary of this key information can be seen in Table 1.

Table 1. (Table of Information) A selection of key statistics and information about Fornax A used in text. Citations for the information can be found in this table and within the text, alongside more explanatory language.

		Reference
Other Name(s)	NGC 1316	-
Right Ascension	$03^h22^m41.5^s$	Dreyer (1888)
Galaxy Type(s)	Elliptical, Lenticular, Early-type	Schweizer (1980)
Brightness	1.4 GHz	Ekers et al. (1983)
Redshift	$1760 \pm 10 kms^{-1}$	Longhetti et al. (1998)
Distance Estimate[1]	17.5 Mpc	Tully et al. (2013)

[1] Taken from the statistical approach which is an average of measurements using different methods. See Section 2.2.

2.1 Formation, Structure and Contents

It is thought that the galaxy is a merger remnant which occurred roughly 3 gigalight-year's ago (Goudfrooij et al. 2001). Analysis by Vagshette et al. (2021) found that Fornax A had a star formation rate of $0.15 \pm 0.05 M_\odot y^{-1}$ if based on far-ultraviolet imaging, or $0.36 \pm 0.07 M_\odot y^{-1}$ if measured by near-ultraviolet imaging. This is a rather low Star formation rate and indicates that it is an early-type galaxy (Duah Asabere et al. 2016). Research suggests the star formation rate was at its highest $\sim 2Gyr$ ago (Richtler et al. 2012) and most of the current star formation stems from a H II region known as SH2. With the appearance of a H II region noted by Schweizer (1980) and researched further by Richtler et al. (2017).

It was originally designated as S0 (=Lenticular galaxy) or Sa (=spiral without bars) type galaxy by Baade & Minkowski (1954); albeit a footnote added in October 1953 clarified it may have not been right to define it as such at the time. Later, Schweizer (1980) classified Fornax A as an elliptical galaxy, which is a member of the 'early-type' galaxies. Whilst, with a brightness of 1.4 GHz as using the Fleurs Synthesis Telescope (Ekers et al. 1983), it is the 4th brightest radio-source visible from earth (Schweizer 1980). The preferred Redshift value stands at $1760 \pm 10 kms^{-1}$ (Longhetti et al. 1998).

With regards to its contents, NGC 1316 is a rather dusty galaxy, believed to contain a dust mass of around $9.35 \times 10^6 M_\odot$ (where $M_\odot$ denotes solar mass) (Rémy-Ruyer et al. 2014). The origin of said dust is the subject of work by Richtler et al. (2020) which suggests that Nuclear outflows may be producing much of it.

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[1] According to NASA/IPAC Extragalactic Database which has been appropriately acknowledged and can be accessed in the Data Availability section.

2.2 Estimates of the Redshift-Independent Distance

With use of the NED as a basis point (see Section 4), we can see how our understanding and measuring of distances to Fornax A has changed over time. While different sources use different methods to measure, we shall stay consistent and all distances shall be in megaparsecs (Mpc). For example, if we have a distance modulus $(m - M)$, we can convert to megaparsecs, denoted r_{mpc}, as follows:

$$r_{\mathrm{mpc}} = 1.585^{(m-M)} \cdot 10^{-5} \quad (1)$$

If we look at Table 2 we can see that surface brightness fluctuation (SBF) and planetary nebula luminosity function (PNLF) are popular methods used to find the distance to NGC 1316. We also see that a distance measurement will not always yield the same results. Highlighting the difficult nature of predicting distances light years away. Error is also a problem with distances, with some studies having particular difficulties in finding accurate measurements (see Faber-Jackon method used by de Vaucouleurs & Olson (1984)). However, we could also perhaps compile these estimates and create an average to better inform a guess. Tully et al. (2013) tried this and used a 'statistical' approach by taking a mean of different method estimates (SBF, SNIa and FP) to come up with an distance estimate of 17.50 Mpc.

Table 2. (Table of observations) A selection of metric distance estimates in Astronomical Literature using a variety of measurement techniques, sorted by publication date. This table is not exhaustive but a weighted selection of a variety of estimates over time.

Distance (Mpc)[1]	Error (± Mpc)[1]	Technique [2]	Citation
17.50	8.02	Faber-Jackson	de Vaucouleurs & Olson (1984)
16.03 17.33	0.91 0.57	SBF PNLF	Ciardullo et al. (1993)
21.50 17.50	1.78 1.95	SBF	Ajhar et al. (2001)
20.00	1.62	I-SBF	Jensen et al. (2003)
20.00 17.90	- 1.02	SBF PNLF	Feldmeier et al. (2007)

[1] Taken from literature or converted to Megaparsecs using (eq 1).
[2] Further information on what these techniques are can be found in the NED/IPAC Library.

2.3 The Fornax Cluster and relation to Fornax B

NGC 1316 lies on the edge of the Fornax cluster, with a right ascension of $03^{\mathrm{h}}\ 22^{\mathrm{m}}\ 41.5^{\mathrm{s}}$ (Dreyer 1888), and is its brightest galaxy (Jordán et al. 2007). A rather peculiar oddity as, from analysis by Lin & Mohr (2004) shows, most brightest cluster galaxies lie nearer the centre. The central galaxy in this case is NGC 1399, which contains a supermassive black hole at its core.

Another galaxy, Fornax B (=NGC 1317), lies in the NGC 1316 subgroup and is its closest galaxy. A spiral galaxy, little is known in regards to its distance from us. With the NED database providing a single noted estimate of 16.9 Mpc (Tully & Fisher 1988).

We can see in Figure 1 the closeness between the two galaxies, Fornax B also appears relatively unperturbed in comparison to its neighbour. With a relatively structured spiral, this is in stark comparison to the large disarray of dust and light emitted from Fornax A; caused by the probable mergers mentioned in the previous section. This leads to a brief conclusion by Duah Asabere et al. (2016), and a short analysis by Schweizer (1980) in which both state there is little to suggest NGC 1316 and 1317 have interacted or been a cause to the merger in NGC 1316.

Figure 1. An image taken with the MPG/ESO 2.2-metre telescope of Fornax A (centre) and the smaller spiral galaxy Fornax B (right). You can see Fornax B as having a much more uniformed spiral structure in comparison to its larger neighbour. Credit: ESO

3 CONCLUSION

In this article we have investigated and collated information on the astronomical object Fornax A. The galaxy yields much intrigue and is being readily studied and explored to this day. As seen in recent literature by Vagshette et al. (2021); Richtler et al. (2020, 2017); Duah Asabere et al. (2016). Hopefully, by providing key information, importance, and developments, this article acts as an introduction and a platform to expand and further explore the literature surrounding NGC 1316.

In regards to the future, it has been actively suggested that Fornax A could develop from its current merger state to a bulge galaxy (McNeil-Moylan et al. 2012); akin to what is seen in a galaxy such as M104 (commonly known as the Sombrero galaxy).

4 DATA AVAILABILITY

This article has made use of the NASA/IPAC Extragalactic Database (NED), which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration. And can be accessed from ned.ipac.caltech.edu

REFERENCES

Ajhar E. A., Tonry J. L., Blakeslee J. P., Riess A. G., Schmidt B. P., 2001, ApJ, 559, 584
Baade W., Minkowski R., 1954, ApJ, 119, 215
Ciardullo R., Jacoby G. H., Tonry J. L., 1993, ApJ, 419, 479
Dreyer J. L. E., 1888, Mem. RAS, 49, 1
Duah Asabere B., Horellou C., Jarrett T. H., Winkler H., 2016, A&A, 592, A20
Dunlop J., 1828, Philosophical Transactions of the Royal Society of London Series I, 118, 113
Ekers R. D., Goss W. M., Wellington K. J., Bosma A., Smith R. M., Schweizer F., 1983, A&A, 127, 361
Feldmeier J. J., Jacoby G. H., Phillips M. M., 2007, ApJ, 657, 76
Goudfrooij P., Alonso M. V., Maraston C., Minniti D., 2001, MNRAS, 328, 237
Jensen J. B., Tonry J. L., Barris B. J., Thompson R. I., Liu M. C., Rieke M. J., Ajhar E. A., Blakeslee J. P., 2003, ApJ, 583, 712
Jordán A., et al., 2007, ApJS, 169, 213
Lin Y.-T., Mohr J. J., 2004, ApJ, 617, 879
Longhetti M., Rampazzo R., Bressan A., Chiosi C., 1998, A&AS, 130, 267
McNeil-Moylan E. K., Freeman K. C., Arnaboldi M., Gerhard O. E., 2012, A&A, 539, A11
Rémy-Ruyer A., et al., 2014, A&A, 563, A31
Richtler T., Bassino L. P., Dirsch B., Kumar B., 2012, A&A, 543, A131
Richtler T., Husemann B., Hilker M., Puzia T. H., Bresolin F., Gómez M., 2017, A&A, 601, A28
Richtler T., Hilker M., Iodice E., 2020, A&A, 643, A120
Schweizer F., 1980, ApJ, 237, 303
Schweizer F., 1981, ApJ, 246, 722
Tully R. B., Fisher J. R., 1988, Catalog of Nearby Galaxies
Tully R. B., et al., 2013, AJ, 146, 86
Vagshette N. D., Naik S., Kumari N., Patil M. K., 2021, arXiv e-prints, p. arXiv:2101.05190
de Vaucouleurs G., Olson D. W., 1984, ApJS, 56, 91

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