The Milky Way is just an average spiral

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\section{INTRODUCTION}

It is part of astronomical lore that we inhabit an overly large spiral galaxy. This belief has little grounding but remains as a hang-over from early large estimates of the value of the Hubble parameter ($H_0 > 100 \text{ km s}^{-1} \text{ Mpc}^{-1}$) which implied that the Milky Way was perhaps the largest spiral galaxy in the observable Universe (Hubble 1936). There is still considerable uncertainty about the value of $H_0$, and values as high as 80 km s$^{-1}$ Mpc$^{-1}$ and as low as 50 km s$^{-1}$ Mpc$^{-1}$ have recently appeared in the literature (Freedman 1994; Sandage 1996). When the linear diameters of distant galaxies are measured from their angular diameters and distances obtained solely from their redshifts, high values of $H_0$ make galaxies closer and therefore smaller. Such a situation goes against the cosmological prejudice that applies the principle of terrestrial mediocrity: that there is nothing special about where or when we live and observe from (Vilenkin 1995). We seem to live on an ordinary planet orbiting an ordinary star, and it is natural to infer that the Solar System resides in an ordinary galaxy.

The diameter of a galaxy is problematic to define and here we take it to be the face-on diameter of the 25 B-mag arcsec$^{-2}$ isophote, allowing direct comparison between external galaxies and the Milky Way. We present calculations of the true 25 B-mag arcsec$^{-2}$ isophotal diameters of 15 spiral galaxies with independent distance estimates derived from Cepheid variable observations, mostly carried out in the past few years with the Hubble Space Telescope, and compare these with the inferred diameter of the Milky Way at this same surface brightness.

\section{THE DIAMETERS OF OTHER GALAXIES}

Until recently, it has not been possible to compare the size of the Milky Way with the sizes of a statistically meaningful sample of other nearby spirals because very few independent distance estimates had been obtained to such galaxies. This situation has now changed dramatically with the advent of the Hubble Space Telescope. The external galaxies in our sample were chosen because they have distances that have been determined via the application of the Cepheid period-luminosity relation, which has long been recognised as the most reliable primary extragalactic distance indicator. The availability of an accurate independent distance estimate removes any requirement to assume a Hubble parameter or correct for any peculiar motion. 17 calibrating galaxies were chosen, mainly from the targets of the HST ‘Key Project’ survey (Kennicutt, Freedman & Mould 1995) whose distances have recently been collated in the literature (Giovanelli 1996; Freedman 1996).

All of these galaxies are included in the RC3 bright galaxy catalogue from which their Hubble type ($T$) and isophotal diameters ($D_{25(\text{ang})}$) were taken (de Vaucouleurs et al. 1991). These isophotal diameters have been corrected for Galactic extinction but not for inclination as the RC3 catalogue assumes that the discs are optically thick and hence the major axis diameter is used directly.

Table 1 presents the angular diameters, distances and inferred linear diameters of 17 spiral galaxies.

\section{THE SIZE OF THE MILKY WAY}

The 25 B-mag arcsec$^{-2}$ isophotal diameter of the Milky Way has been calculated by assuming that the Galactic disc is
Table 1. The Hubble type $T$, face-on angular 25 B-mag arcsec$^{-2}$ isophotal diameters $D_{25\text{(ang)}}$, Cepheid distances $d$ and actual 25 B-mag arcsec$^{-2}$ isophotal diameters $D_{25\text{(true)}}$ for 17 spiral galaxies.

| NGC | M | T | $D_{25\text{(ang)}}$ | $d$ | $D_{25\text{(true)}}$ |
|-----|---|---|----------------------|-----|------------------|
| 224 | 31| 3 | 204                  | 0.77| 45.7             |
| 300 | 7 | 22.4 | 2.15               | 14.0|
| 598 | 33| 6 | 74.1                | 0.85| 18.4             |
| 925 | 7 | 11.0 | 9.38               | 30.0|
| 1365| 3 | 11.2 | 18.2               | 59.3|
| 2366| 10| 8.32 | 3.44               | 8.32|
| 2403| 6 | 22.9 | 3.18               | 21.2|
| 3031| 81| 2 | 27.5                | 3.63| 29.0             |
| 3109| 9 | 20.0 | 1.23               | 7.16|
| 3351| 3 | 7.59 | 10.1               | 22.3|
| 3368| 96| 2 | 7.59                | 11.6| 25.6             |
| 3621| 7 | 13.5 | 6.80               | 26.7|
| 4321| 100| 4 | 7.59               | 16.1| 36.2             |
| 4496| 9 | 3.98 | 16.8               | 19.5|
| 4536| 4 | 7.59 | 16.7               | 36.8|
| 4639| 4 | 2.82 | 25.1               | 20.6|
| 5457| 101| 6 | 28.8               | 7.38| 61.8             |

4 CONCLUSION

Figure 1 shows a histogram of the distribution of spiral galaxy sizes for all of the 18 galaxies in our sample, with the positions of the Milky Way and M31 indicated. The Milky Way lies almost exactly on the mean of the galaxy sizes (actually, just below the average as $<D_{25\text{true}}>$ = 28.3 kpc).

It is even more interesting to compare the Milky Way with galaxies of a similar Hubble type. Figure 2 shows the histogram obtained for the 12 galaxies of Hubble types 2 through 6. In this case the Milky Way lies further below the average linear diameter of 33.6 kpc; one should not read too much into this, however, since the Milky Way still lies well within one standard deviation of the sample mean. A more quantitative statistical analysis would clearly require a larger calibrating sample and also a more realistic model for the distribution of linear diameters (Sodre & Lahav 1993).

There seems no doubt, however, that the Milky Way is not one of the largest spiral galaxies. NGC 1365 and NGC 5457 (M101), in particular, are the local giants, more than twice as large as the Milky Way. This confirms Eddington’s (1933) prescient comment, made more than 60 years ago that the ‘relation of the Milky Way to the other galaxies is a subject upon which more light will be thrown by further observational research, and that ultimately we shall find that there are many galaxies of a size equal to and surpassing our own.’

The implications of this conclusion for estimates of the Hubble Parameter are clear - specifically, if the Milky Way is an average spiral this may favour estimates of $H_0$ at the lower end of the range of accepted values. We are carrying out a detailed analysis of the implications for $H_0$ which will be published shortly.

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Figure 1. A histogram of the true diameters of all 18 spiral galaxies in the sample. The diameters of the Milky Way (MW) and M31 have been marked.

Figure 2. A histogram of the true diameters of 12 galaxies in the sample with Hubble types 2 to 6 (the range of possible Milky Way values), again the diameters of the Milky Way (MW) and M31 have been marked.