Presence of a fundamental acceleration scale in galaxies

To the Editor — We performed a Bayesian analysis[1] on galaxy rotation curves from the SPARC database[2] and found strong evidence for a characteristic acceleration scale a_0. We considered fits to individual galaxies where a_0 is either held fixed or allowed to vary. Results are not meaningfully improved with variable a_0, so there is no added value with such freedom. The data are consistent with a single value of a_0.

A recent paper[3] performs a subset of the same analysis using the same data, reaching the opposite conclusion. These authors neglect errors on galaxy inclination and assume flat priors with hard boundaries on stellar mass-to-light ratio and galaxy distance. Distance and inclination are measured quantities with associated errors, so the only sensible choice is a Gaussian prior with standard deviation given by the error[1]. A Gaussian prior on mass-to-light ratios is motivated by stellar population models and is superior to the flat prior in breaking parameter degeneracies[1]. The priors adopted in ref. [3] are prone to give unphysical results, with many mass-to-light ratios pinned to the extremes of the imposed boundaries.

Despite these important technical aspects, the difference between the conclusions of ref. [1] and ref. [3] is mostly driven by the interpretation of outliers. Figure 1 shows the baryonic Tully–Fisher relation from both analyses and a histogram of the scatter around the line of constant acceleration. The data tell a consistent story: the vast majority of the data cluster around a characteristic acceleration scale. The claim in ref. [3] that the width of this distribution cannot be ascribed to observational errors is driven by degeneracies in Bayesian fits and neglecting uncertainties in inclination. We performed error budget calculations many times[4–6] and consistently found that they are enough to explain outliers.

The claim that modified Newtonian dynamics (MOND)[7] is ruled out at high significance is not supported by the SPARC data. Rather, MOND predicts rotation curves with an average accuracy of 13% (ref. [1]). ❐

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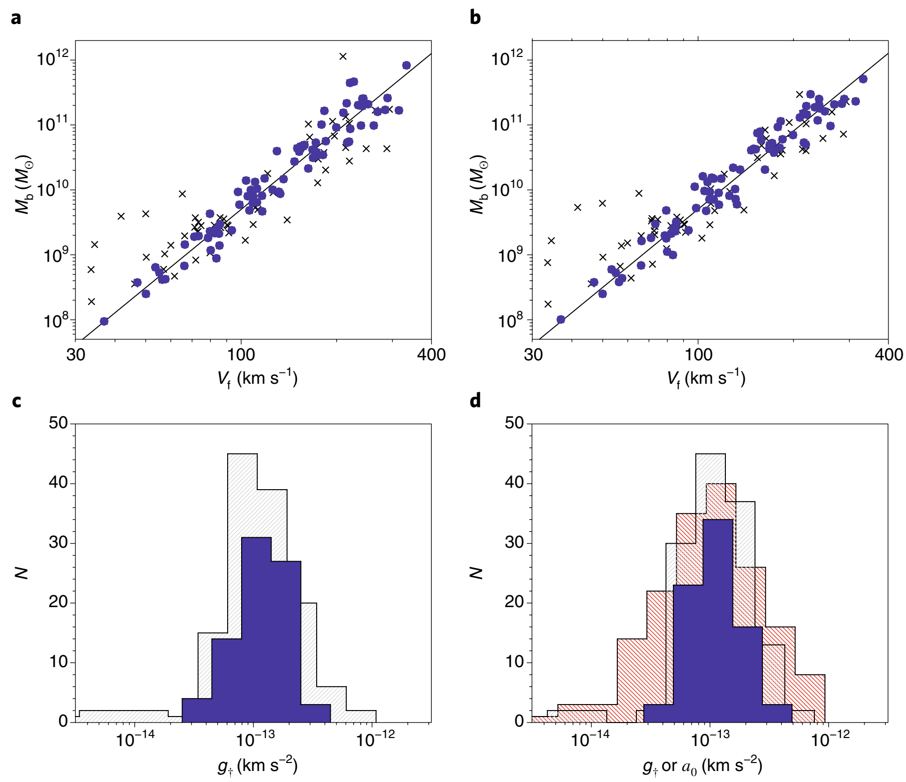

Fig. 1 | The fundamental acceleration scale in galaxy data. a–d, The baryonic Tully–Fisher relation between the observed mass in stars and gas, M_b, and the flat rotation velocity V_f from our analysis[1] (**a**) and that of ref. [3] (**b**). Blue points show high-quality data with distance uncertainties less than 20% and excluding the worst rotation curves ($Q = 3$ in SPARC[2]). Crosses show the remaining data. The data follow a line of constant $a_0 = 1.2 \times 10^{-13}$ km s^{-2} (ref. [6]). Each galaxy has $g_\dagger = xV_f^4/(GM_b)$ (ref. [8]), where G is Newton's constant and $x = 0.8$ accounts for the disk geometry of rotating galaxies[9]. The line is not a fit; it simply shows $g_\dagger = a_0$. Scatter around this line is shown in **c** and **d**. Grey histograms include all available data; blue histograms are restricted to higher-quality data as defined above. The red histogram in **d** shows the fitted a_0 of ref. [3].

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Competing interests

The authors declare no competing interests.