THE TUCANA DWARF GALAXY

An Unusually Dense Dwarf in the Local Group

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The Tucana Dwarf

Located 880 kpc from the Milky Way and 1350 kpc from M31, Tucana is one of the most isolated galaxies of the Local Group. It has experienced no recent star formation, possibly due to an interaction with the Milky Way some 10 Gyr ago which may have stripped the gas. This makes it a clean test for probing the nature of dark matter, since it is less likely to have had its dark matter `heated up' by stellar feedback.

Using FLAMES+GIRAFFE we have taken high resolution spectra of 36 member stars in Tucana. We measure a heliocentric velocity of v=216.7 ± 2.9 kms^{-1} and a velocity gradient of 7.6 ± 4.3 kms^{-1} kpc^{-1}, consistent with a dwarf spheroidal receding from the Milky Way.

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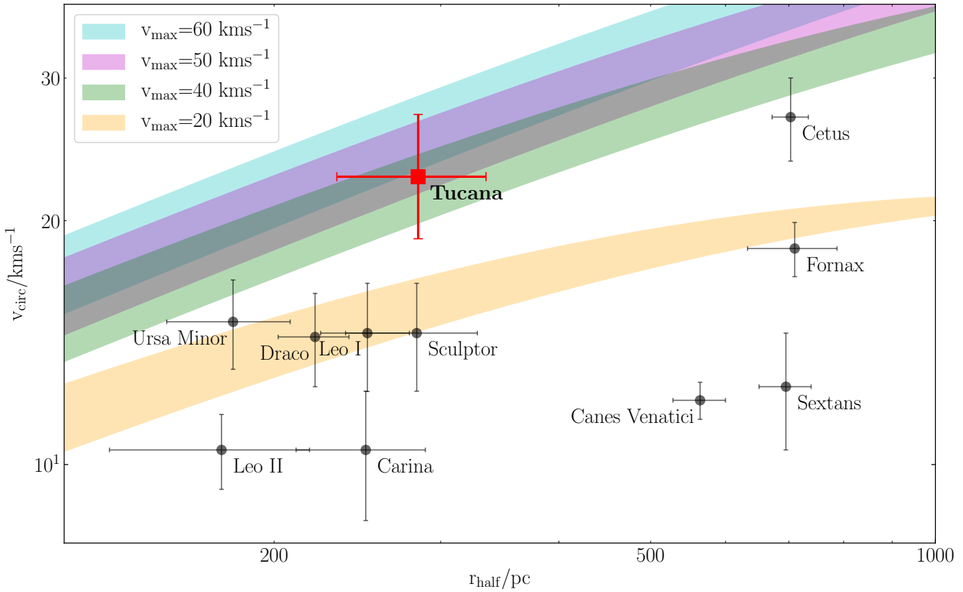
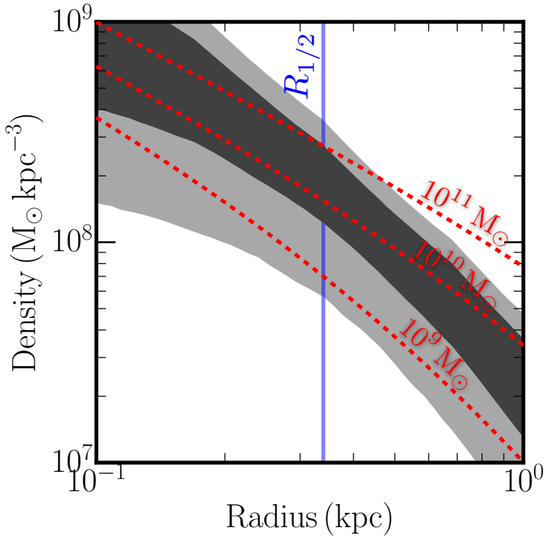
A Massive Failure?

Our velocity dispersion of σ_v= 14.4 ± 2.8 kms^{-1} is consistent with Tucana residing within a supposed `massive failure' halo. This would make Tucana the first known exception to the too-big-to-fail problem, where simulated ΔCDM subhaloes are too centrally dense to host the observed dwarfs. The circular velocity of Tucana (v=22.7 kms^{-1}) suggests that Tucana is much more centrally dense than the typical dSph. Tucana appears to reside in a halo with v_{max}>40 kms^{-1} i.e. a `massive failure' subhalo.

This shows that there are conditions under which galaxies can retain their central mass and reside in ΔCDM predicted haloes. Tucana's isolation from tidal effects and quenched star formation history mean it has been unaffected by the baryonic feedback effects usually invoked to resolve too-big-to-fail.





A Pristine Cusp in Tucana

We use Jeans modelling with GravSphere to estimate the dark matter density profile of Tucana, favouring a high central density consistent with a pristine cusp. Dark matter `heating' suggests that extended bursty star formation reduces the central density and transforms cusps to cores. In such models, the quiescent Tucana is expected to retain a higher central density than other isolated dwarfs. The errors on the inner density are very large, but we can be confident that Tucana is more dense at 150 pc than the isolated dIrrs at better than 95% confidence. Spectroscopic follow-up in the central regions with MUSE will further constrain the central density to confirm the presence of a cusp.

Consistent with the expectations of dark matter heating, galaxies whose star formation shut down long ago appear to host a central cusp, while those with extended star formation are consistent with a core. Using abundance matching we estimate a halo mass for Tucana of M_{200}= 9.4 ± 3.6 × 10^9 M$_\odot$. The high central density places Tucana above other dwarf galaxies in the M_{200}-ρ_{DM} space, and is consistent with the expectations of a cusped profile within 1σ.