DARK MATTER

Light without darkness

A distant galaxy (~ 20 Mpc) appears to have a dark matter component several hundred times less massive than expected, and perhaps even contains no dark matter at all. Pieter van Dokkum et al. (*Nature* **555**, 629–632; 2018) calculated both the stellar mass component and the dynamical mass of the ultra-faint galaxy NGC1052–DF2, finding that the estimates are consistent with each other. If confirmed, this discovery would strengthen the case for the existence of dark matter in general.

NGC1052–DF2 was noticed because it appeared markedly different in images taken with the Dragonfly Telephoto Array and as part of the Sloan Digital Sky Survey (SDSS). In the former, it appears as a 2-arcmin-across, diffuse, low-surface-brightness object with hints of substructure, whereas in the SDSS images it appears to be a collection of point sources that are potentially globular clusters within the galaxy. Follow-up observations with the Hubble Space Telescope produced the image shown here.

Van Dokkum et al. calculated the stellar mass component of the galaxy in two different ways: by fitting the global properties of the galaxy with a stellar population at 20 Mpc; and by assuming a mass-to-luminosity ratio typical of globular clusters. Both methods yielded consistent values for the galaxy's stellar mass content, $2 \times 10^8 M_{\odot}$, some 250 times less massive than the Milky Way. In order to estimate the total mass of the galaxy, the researchers used a dynamical method involving the globular clusters, finding a total mass of $3.4 \times 10^8 M_{\odot}$ within a 7.6 kpc radius of the galaxy's centre. Thus, the bulk of the galaxy's mass is due to the stellar content,

Credit: NASA, ESA, and P. van Dokkum (Yale University)

and the best fit to the kinematic data gives a halo mass of zero. The low dark matter content of this galaxy is extremely unusual for ultra-faint dwarfs, which tend to have high dark matter fractions.

The formation mechanism of NGC1052–DF2 is unknown. The authors suggest three possible scenarios: the galaxy was formed from the gas ejected in a galaxy merger (and indeed, there is a nearby elliptical galaxy, NGC1052, and other supporting evidence for this idea), the galaxy formed in the material swept up by quasar winds, or the galaxy is the result of the fragmentation of gas during inflow to NGC1052. Whatever the galaxy's history,

the implications it has for dark matter could be profound: dark matter does not always coincide with galaxies. This finding causes issues for some modified theories of gravity, which would struggle to explain the velocity dispersion of both NGC1052–DF2 and ultra-faint galaxy Dragonfly 44, which is composed of 99.99% dark matter. Ironically, the lack of dark matter in NGC1052–DF2 is evidence that dark matter exists. □

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