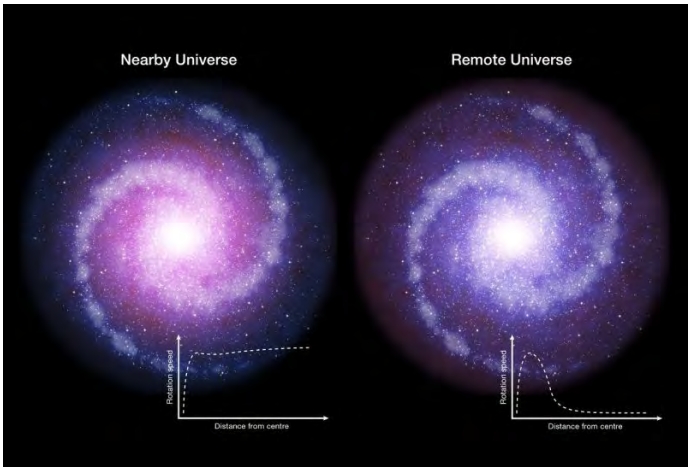
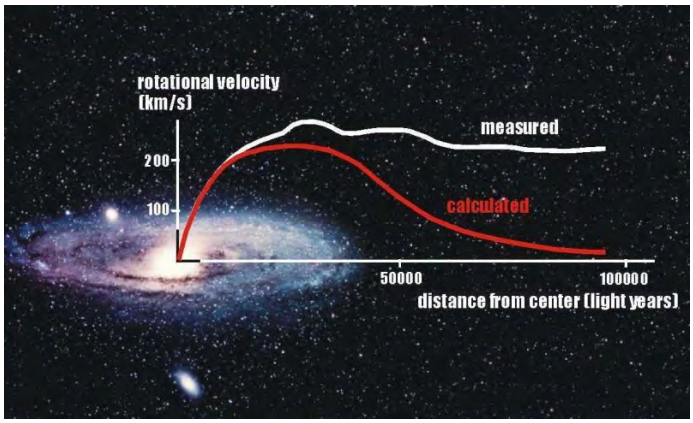
Where was Dark Matter In the early Universe?
Based on new observations of distant galaxies, Dark Matter was less influential in forming the early galaxies of the Universe than it is today. **The first direct evidence of Dark Matter appeared in the late 1970s, when Vera Rubin and Kent Ford of the Carnegie Institution of Washington observed the Andromeda Galaxy to be rotating all wrong**. The principle itself was already hinted at by the Swiss-born astronomer **Fritz Zwicky** in 1933, who used "Dunkle Materie" to explain the rotation of galaxies within Super-clusters. Zwicky was the first to use the Virial Theorem (defined by **Rudolf Clausius** in 1870) to infer the existence of an unseen substance in astronomy. **The Virial Theorem provides a general equation that relates the total kinetic energy of a system to the average over time,** $2\langle T\rangle = n\langle V_{\mathrm{TOT}}\rangle$.



According to new observations Dark Matter – shown in red – may have been less concentrated in the early Universe (right) than in the present-day Universe (left),

Galaxies, stars and gases at the edges of systems around us today are moving just too fast to be held captive by the visible matter of the system alone. This is contrary to established laws of motion, which say that planets closer to the Sun – or stars closer to the centre of a galaxy – should move faster in orbit than the ones at the edge. It seems to suggest that what we see as a galaxy's edge is not the edge, after all. And so astronomers began speaking of vast halos of unseen matter – or Dark Matter – surrounding galaxies. **They've been talking about Dark Matter ever since**.

Modern cosmology has embraced the idea of Dark Matter wholeheartedly. For example, astronomers believe that galaxies were made in a process whereby Dark Matter actually initiates matter to clump together as gravitationally bound systems. **That's why it is so surprising that new observations with the European Southern Observatory Very Large Telescope in Chile indicate that disk galaxies in the early Universe seem to be less controlled by dark matter than the galaxies of today**. In other words, the new observations have led astronomers to suggest that Dark Matter might have been less prominent or concentrated in the early universe. The research is presented in four papers, one of which was just published March 15, 2017 in the peer-reviewed journal Nature.



The orbital speeds of a galaxy's visible stars or gas versus the star or gas distance from that galaxy's centre, as the galaxy rotates

The international team of astronomers conducting this new research was led by **Reinhard Genzel** at the Max Planck Institute for Extraterrestrial Physics in Garching, Germany. The team used the Telescope in Chile to measure the rotation of six massive, star-forming galaxies in the distant Universe 10 billion years ago. **The outer regions of these distant galaxies do seem to be rotating more slowly than regions closer to the core**. Genzel said in an ESO statement that there could be two causes for this:

1. Most of these early massive galaxies are strongly dominated by normal matter, with Dark Matter playing a much smaller role than in the Local Universe.
2. Early disks were much more turbulent than the spiral galaxies we see in our cosmic neighbourhood.

Both effects seem to become more marked as astronomers look further and further back in time, into the early Universe. **Apparently it took billions of years longer for Dark Matter to form or condense, so its dominating effect is only seen on the rotation velocities of galaxy disks today**. This new result does not call into question the need for Dark Matter as a fundamental component of the Universe, or the total amount. Rather it suggests that Dark Matter was differently created or distributed in and around disk galaxies at earlier times, compared to the present day.

AK, with EarthSky and Wikipedia Notes