

# Gas rich galaxies confirm prediction of modified gravity theory

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The star dominated spiral galaxy UGC 2885. Image by Zagursky & McGaugh

(PhysOrg.com) -- Recent data for gas rich galaxies precisely match predictions of a modified theory of gravity know as MOND according to a new analysis by University of Maryland Astronomy Professor Stacy McGaugh. This -- the latest of several successful MOND predictions -- raises new questions about accuracy of the reigning cosmological model of the universe, writes McGaugh in a paper to be published in March in *Physical Review Letters*.

Modern cosmology says that for the universe to behave as it does, the mass-energy of the universe must be dominated by [dark matter](#) and [dark energy](#). However, direct evidence for the existence of these invisible

components remains lacking. An alternate, though unpopular, possibility is that the current [theory of gravity](#) does not suffice to describe the dynamics of cosmic systems.

A few theories that would modify our understanding of gravity have been proposed. One of these is Modified Newtonian Dynamics (MOND), which was hypothesized in 1983 by Moti Milgrom a physicist at the Weizmann Institute of Science in Rehovot, Israel. One of MOND's predictions specifies the relative relationship between the mass of any galaxy and its flat rotation velocity. However, uncertainties in the estimates of masses of stars in star-dominated spiral galaxies (such as our own Milky Way) previously had precluded a definitive test.

To avoid this problem, McGaugh examined gas rich galaxies, which have relatively fewer stars and a preponderance of mass in the form of [interstellar gas](#). "We understand the physics of the absorption and release of energy by atoms in the interstellar gas, such that counting photons is LIKE counting atoms. This gives us an accurate estimate of the mass of such galaxies," McGaugh said.

Using recently published work that he and other scientists had done to determine both the mass and flat rotation velocity of many gas rich galaxies, McGaugh compiled a sample of 47 of these and compared each galaxy's mass AND rotation velocity with the relationship expected by MOND. All 47 galaxies fell on or very close to the MOND prediction. No dark matter model performed as well.

"I find it remarkable that the prediction made by Milgrom over a quarter century ago performs so well in matching these findings for gas rich galaxies," McGaugh said. "

## **MOND vs. Dark Matter - Dark Energy**

Almost everyone agrees that on scales of large galaxy clusters and up, the Universe is well described by dark matter - dark energy theory. However, according to McGaugh this cosmology does not account well for what happens at the scales of galaxies and smaller.

"MOND is just the opposite," he said. "It accounts well for the 'small' scale of individual galaxies, but MOND doesn't tell you much about the larger universe.

Of course, McGaugh said, one can start from the assumption of dark matter and adjust its models for smaller scales until it fits the current finding. "This is not as impressive as making a prediction ahead of [new findings], especially since we can't see dark matter. We can make any adjustment we need." This is rather like fitting planetary orbits with epicycles," he said. Epicycles were erroneously used by the ancient Greek scientist Ptolemy to explain observed planetary motions within the context of a theory for the universe that placed the earth in its center.

"If we're right about dark matter, why does MOND work at all?" asks McGaugh. "Ultimately, the correct theory - be it dark matter or a modification of gravity - needs to explain this."

**More information:** Preprint of original paper on [arXiv.org](https://arxiv.org)

Read more about dark energy and dark matter on this [NASA Web page](#)

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