In a recent paper, McGaugh describes a local relation between galactic mass discrepancies (dynamic mass/baryonic mass) and gravitational acceleration behavior as a direct consequence of MOdified Newtonian Dynamics - MOND (McGaugh 2014). This letter challenges this view, with observed mass discrepancies being a natural property and a physical requirement for rotationally supported disk/spiral galaxies as a consequence of an early-era relativistic formation process (La Fortune 2015).

**DISCUSSION**

McGaugh derived an empirical relationship describing a “singular effective force law” and defined the term mass discrepancy as the square of the ratio between observed dynamic rotation velocity to velocity as determined from the stellar and/or gas constituents, $D = \left( \frac{V_{\text{Dyn}}}{V_{\text{bar}}} \right)^2$. To support his contention, McGaugh proposes three properties for rotationally supported galaxies:

1.) Flat rotation curves to indefinite radii
2.) Adherence to the baryonic Tully-Fisher relationship
3.) Close correspondence between radial forces and baryonic matter distribution

McGaugh asserts that these three properties are directly attributable to MOND and is supported by observational results as interpreted in Figure 5 from his paper, “The Third Law of Galactic Rotation.”
His Figure 5 is reproduced with caption and includes the RC-SP mass discrepancy, \( (D) \) expectations for the Milky Way (MW) and M31 denoted as open circles. The radii of their stellar and HI disks are determined from recently published new Grand Rotation Curves. We associate McGaugh’s mass discrepancy to RC-SP (Rotation Curve-Spin Parameter) dynamics via the functional relationship, 

\[
D = \left( \frac{V}{V_b} \right)^2 \approx \frac{M_{RC-SP}}{M_{Stellar}}.
\]

Since the RC-SP stellar mass discrepancy is based off the characteristics of a typical, quiescent disk galaxy the MW, \( D = 10 \) may be considered a representative value for galaxies sharing similar morphologies and kinematics. Using \( \Lambda CDM \) terminology, \( 1/D \) is related to the baryonic fraction, \( f_b = 0.1 \).

As a result of this early-era formation process, spiral galaxies obey the Spin Parameter equation given below. This equation provides the governing relationship between mass, angular momentum and energy content that uniquely characterize the very broad class of fully self-gravitating galactic disks exhibiting exponentially declining surface densities:

\[
\lambda = \frac{J^2}{G^2 M^{b/2}}.
\]

Where \( J = \) Angular Momentum, \( E = \) Total Energy, \( M = \) Dynamic mass, and Total \( E = K + PE \).

In the upper panel of Figure 5, only the stellar disk mass, \( (Vb) \) is considered. We see that RC-SP dynamics is in agreement with the observed mass discrepancies for the large number of galactic data provided. In the lower panel, disk gas is included with the stellar component. For the RC-SP data, ‘total’ gas is estimated by the rule-of-thumb equation of proportionality \( M_{gas} = 4/3 \times 0.15M_{HI}/M^{*RC-SP} \times M^{*RC-SP} \). RStellar and RHI designate edges of MW and M31 stellar and atomic hydrogen disks, respectively as obtained directly from a visual fit of their Grand Rotation Curves.
By including MW and M31 in Figure 5, we see there is no mass discrepancy data beyond their baryonic disks. This data cannot make the case for MOND, as it does not provide any evidence for flat rotation (increasing $D$ with radius) at indefinite radii. The data must be extended another order of magnitude to capture the true nature of the rotation velocity profile in order to substantiate the central tenet of MONDian theory. The RC-SP expectation is that mass discrepancy will level off at or slightly below $D = 10$ at extended radii, outside the galactic gas disk proper.

**CONCLUSION**

Near the end of McGaugh’s paper, he summarizes, “At present, one can imagine three broad categories of possibilities that lead to an effective radial force law in galaxies:

1. MOND represents a true modification of dynamical laws.
2. The laws of galactic rotation are a consequence of some process during galaxy formation.
3. The properties of dark matter particles impose the observed phenomena.”

Of McGaugh’s three possibilities, the first and third categories can be discounted. According to MOND, galaxies such as the MW and M31 should experience Keplerian dynamics in the inner disk transitioning to an effective $(1/r)$ radial force law supporting flat rotation to indefinite radii. As it pertains to dark matter, it is evident that both the MW and M31 are convincing counterexamples to the existence of extended flat rotation associated with massive halos.

By process of elimination, we find McGaugh’s second possibility is most correct - that current galactic properties and phenomenology are consequences of the formation process. The larger implication is that we inhabit a truly WYSIWYG universe. Future work must include a thorough appreciation and understanding of relativistic physics driving early-era galactic formation in order to expose galactic properties and phenomena for what they are – expected outcomes. As always, I would like to thank The Winnower for open access to publish and have this work reviewed online.

Bibliography
