On MOND's Missing-Mass Problem in Galaxy Clusters

by Paul R. Gerber

Gerber Molecular Design, Forten 649, CH-8873 Amden

Email: Paul.Gerber@moloc.ch

95.30.Sf Relativity and gravitation

04.80.Cc Experimental tests of gravitational theories

Abstract

We suggest that the missing (dark) mass in galaxy clusters can be explained by a picture of a cosmos consisting of matter and negative-mass antimatter, the latter residing in voids. It is proposed that the modification of Newtons law of Gravitation in the form of Modified Newtonian Dynamics (MOND) can be explained by the quantum nature of Gravity.

Introduction

MOND (Modified Newtonian Dynamics) is a empirical modification of Newtons law of gravitation by M. Milgrom [1], designed to reproduce the rotation curves of galaxies [2]. For distances, r, where the acceleration, a(r), provided by the baryonic mass, M_b, of a galaxy falls below a critical value value, a_0, the centripetal force crosses over from Newton's r^{-2}-law to a r^{-1}-law, such that the velocity of masses on a circular orbit, reaches a constant value V_c, proportional to the 4th root of M_b. This is in satisfactory agreement with experimental observations, as is nicely recapitulated by McGaugh [3] in his Fig. 4. This representation shows that for a wide variety of disk galaxies, varying in M_b by more then 6 decades the $M_b \propto V_c^4$ law holds true. However, it also shows that groups of galaxies and galaxy-clusters do not fully fit into this picture. Even though the V_c^4 law is still well obeyed, their values of M_b are too small by a factor of two to three to fit on the same curve with single galaxies. This missing mass problem is particularly annoying because MOND set out to make the concept of dark matter obsolete.

Remark

The following Figure reproduces McGaugh's Fig. 4, including legend, together with a representation in which the masses of galaxy-groups and galaxy-clusters are multiplied by a factor $f = 2.88$ such that all points are perfectly fitted by MOND's $M_b \propto V_c^4$ law. Of course the same type of agreement is reached if masses of groups and clusters of galaxies are up-scaled by a smaller factor f_{cl} and masses of single galaxies are down-scaled by a factor of f_g, provided we keep $f_{cl} f_g = f$.

Of course, such an amendment can only be legitimized by proper argumentation. Here we advance again an idea that has been around in the past and which we keep advertising, namely the concept that negative gravitational masses can exist [4]. This concept postulates that the so-called voids, which seem to occupy roughly half the volume of the cosmos, are actually filled by antimatter with negative gravitational mass, which repels matter. We have produced a simple model to illustrate the development of the cosmos as a process of demixing of mass and anti-mass [5,6].

In such a picture we would expect that larger assemblies (groups and clusters of galaxies) would predominantly be surrounded by voids, and thus, antimatter. Correspondingly, they would experience a gravitational pressure which one may reasonably describe by a effectively increased mass $M^{eff} = M_b f_{cl}$. By the conventional hole picture this increase is expected to be on the order of a factor of two, $f_{cl} \approx 2$.

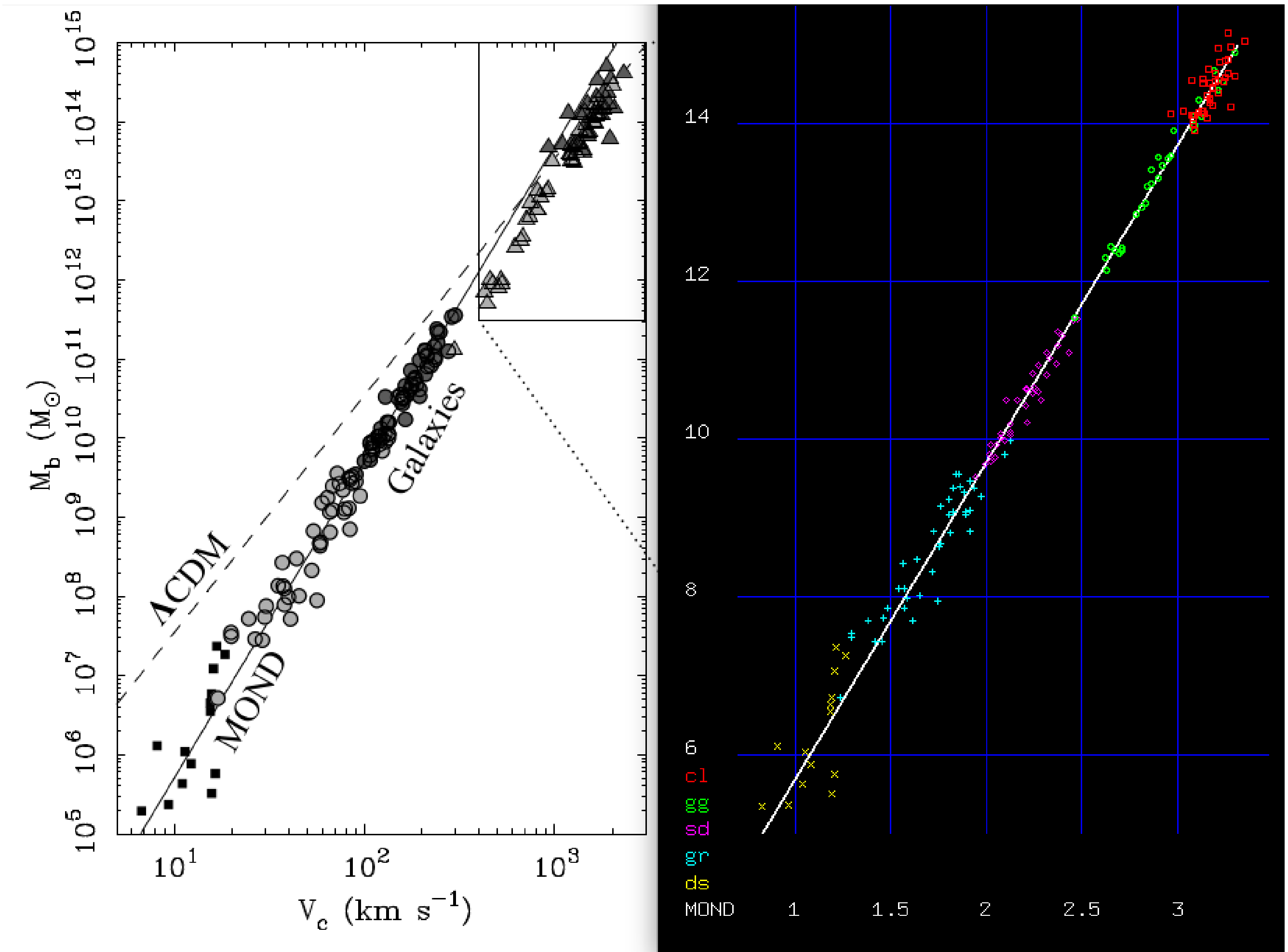

Fig. 4. Baryonic mass as a function of circular velocity for systems ranging from dwarf spheroidals (66, squares) through gas rich (67, light gray circles) and star dominated (68, dark gray circles) spiral galaxies to groups (69, light gray triangles) and clusters (70, dark gray triangles) of galaxies. The prediction of MOND is shown as a solid line and the nominal expectation of ΛCDM is shown as a dashed line. MOND describes the data well over six decades in mass. The inset is expanded at right to illustrate that ΛCDM provides a better description of the richest clusters of galaxies. Neither theory provides an entirely satisfactory description of groups. The data more closely follow the line of constant acceleration ($M \propto V_c^4$) expected in MOND at all scales — nearly ten decades in baryonic mass. The discrepancy with the slope predicted by ΛCDM for objects smaller than clusters of galaxies leads to the inference of missing baryons (in addition to non-baryonic CDM) in each and every dark matter halo (71).

Furthermore, single galaxies are most often found in a context with other galaxies such that a treatment by external field effects [7] seems more appropriate here. However, a mixed but predominantly positive-mass environment would lead to the expectation that their effective mass is slightly below the baryonic mass $M^{eff} = M_b / f_g$, i.e. $f_g > 1$. Thus, in this negative-mass picture a value $f = f_{cl} f_g \approx 2.88$ is quite plausible.

Discussion

The concept of negative mass is in disagreement with the theory of General Relativity (GR), the nowadays highly favored theory of Gravitation. However, we have repeatedly argued against GR on the ground that it's very basic principle, Einstein's equivalence principle, does not allow for the generation of gravitational waves [8]. GR's corresponding amendment, added afterwards, leads to "waves" that cannot exist [9,10], even though this has not properly been recognized! Therefore, we think that there is nothing wrong with the concept of masses of either sign.

Consequently, in this picture a MOND-type gravitational-force law would not lead to missing (dark) matter. However, the big remaining question is why Newtons law should break down for large distances, or more correctly for small acceleration values. We think [11], that the reason lies in the quantum nature of the gravitational force, namely that the galactic gravitons taking part in the scattering processes, which provide the Gravitational force, start to receive concurrence by gravitons of the cosmic gravitational wave background (GWB). This would also explain why MOND's modification is in the acceleration rather than in the distance.

References

1. Milgrom M., (1983), "MOND", Astrophysical J., 270, p. 365

2. Wikipedia, Galaxy_rotation_curve

3. Stacy s. McGaugh, (2014), "ΛCDM and MOND", arXiv:1404.7525

4. Gerber P. R., (2013), "Physics with Negative Masses", viXra:1303.0100

5. Gerber P. R., (2020), "Lattice Model of a MAR-Cosmos", viXra:2008.0160

6. Gerber P.R., Youtube: Bipolar Cosmos

7. Beckenstein J., Milgrom m>, (1984), Astrophysical J., 286, p. 7

8. Gerber P.R., "What's Wrong with General Relativity?", viXra:1502.0067, viXra:1506.0038

9. Gerber P.R., (2020), "On the Polarization of Gravitational Waves", viXra:2001.0398

10. Gerber P.R., Youtube: Curious Graviational Waves

11. Gerber P. R., (2019), "On Quantum Field Theory and Gravitation", viXra:1911.0010, and work in progress