Gibson (2017) commentary on Kroupa (2016) preprint (arXiv:1610.03854)

Collisional (HGD) fluid mechanics requires that the dark matter on <10^22 m (proto-galaxy scales) must be dominated by earth mass planets in clumps of a trillion, with NO COLD DARK MATTER.*

THE OBSERVED SPATIAL DISTRIBUTION OF MATTER ON SCALES RANGING FROM 100 KPC TO 1GPC IS INCONSISTENT WITH THE STANDARD DARK-MATTER- BASED COSMOLOGICAL MODELS

All observations falsify LCDMHC cosmology and support HGD cosmology. CHG

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The fatal flaw of LCDMHC is the neglect of collisional fluid mechanics, Gibson (1997)

Abstract: The spatial arrangement of galaxies (of satellites on a scale of 100 kpc) as well as their three-dimensional distribution in galaxy groups such as the Local Group (on a scale of 1 Mpc), the distribution of galaxies in the nearby volume of galaxies (on a scale of 8 Mpc) and in the nearby Universe (on a scale of 1 Gpc) is considered. There is further evidence that the CMB shows irregularities and for anisotropic cosmic expansion. The overall impression one obtains, given the best data we have, is matter to be arranged as not expected in the dark-matter based standard model of cosmology (SMoC). There appears to be too much structure, regularity and organisation. Dynamical friction on the dark matter halos is a strong direct test for the presence of dark matter particles, but this process does not appear to be operative in the real Universe. This evidence suggests strongly that dynamically relevant dark matter does not exist and therefore cosmology remains largely not understood theoretically. More-accepted awareness of this case would by itself constitute a major advance in research providing fabulous opportunities for bright minds, and the observational data strongly suggest that gravitation must be effectively Milgromian, corresponding to a generalized Poisson equation in the classical limit. Thus, physical cosmology offers a significant historically relevant opportunity for ground-breaking work, at least for those daring to do so.

10^22 m diameter

YES!

Keywords: conference, international, cosmology

PACS: 98.35.-a, 98.52.Wz, 98.56.-p, 98.62.Ai, 98.62.Py, 98.65.At, 98.80.-k

1. Introduction

The direct searches for dark matter particles, which the vast majority of researchers believe dominate the matter density of the Universe, have been coming up

*See journalofcosmology.com volumes 15 to 26. HGD means Hydro-Gravitational-Dynamics.

arXiv:1610.03854v1 [astro-ph.CO] 12 Oct 2016

empty handed despite a huge effort to find these particles with various elaborate, large and expensive experiments on Earth and in space. But the astronomical evidence has already been showing that dark matter particles cannot be there. This seems to be a contradictory statement, because astronomical evidence has been used to argue for the existence of dark matter particles which must be new particles not contained in the standard model of particle physics (SMoPP), which is otherwise a well tested theory.

The argument is as follows: If it is assumed that the Universe is described by Einstein's field equation[1] such that Newtonian gravitation is valid in the classical regime and if all the matter was produced in the Big Bang, then the rate with which structures form as cosmic time progresses, and also the motions of stars and gas in the emerging galaxies when compared to observations, shows conclusively that gravity must be stronger than provided by the matter we know. One hypothesis is that much more gravitating matter, that is dark matter which cannot interact electromagnetically with normal matter and which is not described by the standard model of particle physics (SMoPP), is required to yield, roughly, the observed effects. Given this result, the researcher can now assume this model (Einstein plus dark matter, lets call it the null hypothesis) to be valid and perform detailed calculations of galactic systems to further test the hypothesis. Additional assumptions (inflation and dark energy) are also needed and together comprise the dark-matter-based standard model of cosmology (SMoC). A discussion of the current status of the SMoC can be found in [12] and a critical discussion is also provided by [32].

This model can then be tested on various astronomical data, as outlined below. The argument followed here is to proceed testing the SMoC using the relative spatial distribution and, when available, the relative motions of galaxies. The tests then become very robust, that is, do not depend on the details of baryonic physics, since the tests apply largely to the presence of galaxies within their dark matter halos. Thus, if dark matter halos exist, their spatial arrangements relative to each other and their motions relative to each other are being tested, rather than the detailed "sub-grid" properties of individual galaxies. Baryonic processes then only play a role in determining if a dark matter halo hosts a galaxy or not, and arguably, dark matter halos more massive than $10^9 \, M_\odot$ are understood to host galaxies with initial mass $> 10^7 \, M_\odot$. This text is a short summary pointing to the relevant literature, rather than providing the detailed analysis of each problem. More detailed discussions of these issues, which this text is also based on, are available in [34, 35, 36, 37, 38].

The analysis of the distribution of galaxies in the Local Group can be split into two parts: the distribution of satellite galaxies (Sec. 2), the distribution of non-satellite galaxies (Sec. 3). The distribution of galaxies in the Local Volume (Sec. 4) and the variation of the mean matter density in the Local Universe provide further

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[1]As emphasized in [35, 38] this is an extrapolation by many orders of magnitude in scale and gradient of the potential of an empirically derived law, strictly valid *only* on the scale of the Solar-system. See footnote 2 for an analogy.

tests, in particular also of the Cosmological Principle. This question is addressed independently by probing evidence for isotropic cosmic expansion (Sec. 7). A direct test for the presence of dynamically relevant dark matter particles is provided by observable consequences of dynamical friction (Sec. 6).

2. The 100 kpc scale

It is by now well established that the satellite galaxies around the Milky Way are highly significantly distributed anisotropically in a rotational disk-like structure with radius of about 250 kpc and thickness of about 30 kpc [33, 46, 47, 55, 63]. The Andromeda galaxy has a richer population of satellite galaxies with perhaps a number of planar structures [45], but one planar structure which contains 50 per cent of all satellites is even more pronounced and thinner than that of the Milky Way [21]. Both disks-of-satellites are correlated [57]. Other major galaxies show significant evidence that such satellite planes are common [22, 24]. The dwarf spheroidal galaxies in the M81 group, which is the nearest Local-Group analogue (distance about 3.6 Mpc), are in a flattened distribution [15] and the satellite galaxies of Cen A (distance about 3.66 Mpc) are likewise in a plane, wich is perpendicular to the dust lane of Cen A [52]. The observational results are thus rather clear: disks of satellites are common, and in fact they seem to be the rule rather than the exception. This is impossible to be the case in the SMoC.

It has been shown that just to find the one Milky Way satellite system in a dark-matter universe is very unlikely. To have such structures around many hosts, let alone that the Milky Way and Andromeda systems are correlated, essentially leads to a combined probability of zero, assuming the SMoC to be valid and the dwarf galaxies in the Local Group to be in their own dark matter halos [35, 59]. Basically, this single observational result falsifies the SMoC, as has been realized early-on already [33].

Claims that the disks of satellites can be accounted for readily within the SMoC such that they do not constitute a serious problem have been found to be flawed [23, 59, 61, 24]. SMoC simulations show that rotating disks of satellites are as unlikely within pairs of dark matter halos (resembling the pair Milky Way–Andromeda) as in isolated halos [60].

The physical reason for this discrepancy between observation and the SMoC is that the SMoC necessitates *all* Milky-Way-type dark matter halos to form from numerous stochastic mergers of smaller halos such that the result is that the distribution of dark-matter-dominated satellite galaxies is spheroidal. Although the dark matter sub-halos fall-in from cosmic filaments, these have widths larger than the virial radii of the dark matter halos, such that the infall of satellite galaxies, even if being anisotropic to some degree, remains in significant disagreement with the thin disks-of-satellites, since the Rosetta-orbits phase-mix and shrink through dynamical friction [48, 56]. Indeed, the observed positions and velocities of those satellite galaxies for which such data exist show that infall-solutions do not exist, because

dynamical friction on the extended dark matter halos is too efficient [1].

The only known physical process which can lead to such rotating disk of satellites is that the dSph satellite galaxies are ancient tidal dwarf galaxies (TDGs). How such populations can form has been demonstrated [74, 54]. Such low-mass dwarf galaxies cannot capture significant amounts of dark matter and their putative dark matter content would then be explainable by Milgromian gravitation [43, 44, 16].

For future tests, [58, 62] predict the proper motions of the Milky Way satellite galaxies based on the argument that they need to orbit within the disk-of satellites as otherwise the chance of having such a vast polar structure for randomly moving satellites would be negligibly small. And, if dSph satellites are ancient TDGs, then their number is expected to correlate with other indicators for past galaxy–galaxy encounters, such as the bulge mass [34, 42]. This opens a possibility for further testing this notion (i.e. that dSph satellite galaxies are mostly if not exclusively old TDGs) through observational campaigns using small (also amateur) telescopes [26].

3. The 1 Mpc scale ~ 3.1x10^22 m

The dwarf galaxies in the Local Group which are not satellites are distributed in a very organized manner, namely in two $\approx 50\,\text{kpc}$ thin planes of about $1.5\,\text{Mpc}$ extension, whereby each is nearly equidistant from the line joining the Milky Way and Andromeda [57]. These structures suggest the Milky Way and Andromeda to be causally connected, and this poses an important constraint on models of the formation of the Local Group. The physically best-motivated cause for this entire structure, including the correlated disks of satellite systems around the Milky Way and Andromeda, is for the two major galaxies to have had an encounter about $9-11\,\text{Gyr}$ ago [78, 2]. This is only possible if they do not have dark matter halos, as they would otherwise have merged by now (e.g. [3] for similar cases). The structure of the Local Group is indeed not explainable within the dark matter framework.

The next group of galaxies beyond the Local Group is the M81 system at a distance of about $3.6\,\text{Mpc}$. Here we already do not have such good three-dimensional coordinate information, but the system of dwarf galaxies in it is known to be highly anisotropic [15] as noted in Sec. 2. The highly significant anisotropy in the Cen A group [52] at a distance of approximately $3.66\,\text{Mpc}$ has been noted above.

Furthermore, the major galaxies in the M81 group have been encountering each other at least once, because the system is filled with tidal HI gas. This provides crucial information on the existence of dark matter halos because solutions do not seem to exist which explain the matter distribution as well as the present-day positions and line-of-sight velocities [71, 77]. Essentially, if dark matter halos exist, then this system ought to have already merged. The probability that all three major inner galaxies of the M81 system have just met in the very recent (less than 1 Gyr) past after forming independently is remotely small [53].

The same argument applies to compact groups of galaxies [69]. Too many compact groups are observed with a constancy in number density with redshift such

that they appear to be largely non-merging in contradiction to the expectation in the SMoC. That the compact groups have just assembled in the past 1 Gyr of their observation with the member galaxies having formed independently of each other constitutes a negligible physical possibility, especially given the large number of such systems. The only viable physical explanation for the existence of so many compact groups is that the galaxies in them interact for many Gyr without merging. This is not possible in a dark-matter-based cosmological model.

4. The 8Mpc scale

Cosmological structure is evident in the galaxy distribution within the Local Volume which is a sphere with a radius of about 8 Mpc around the Local Group. This volume contains galaxies within the local sheet and also the local void. At least two fundamental problems with the observed distribution of galaxies have been emphasized [64]: (i) the local void is too empty and (ii) massive galaxies are too far from the sheet within the outer regions of the void. Each problem individually they describe as being about 1 per cent or less probable within the SMoC, such that the combined probability that the observed distribution can arise in the SMoC approaches zero. Consequently, structure formation appears to have proceeded differently to the SMoC.

5. The 1Gpc scale

The Local Universe on a scale of about 1 Gpc around the Local Group should have small fluctuations in the density of galaxy counts, but within about 300 Mpc of us the density decreases significantly with decreasing distance to about 50 per cent its global cosmological value posing serious tension with the SMoC [28, 29, 10, 75]. The under-density on a sale of 300 Mpc and less is significantly more pronounced than allowed by the SMoC (fig. 1 in [38]). This has bearing on the deduced acceleration of cosmic expansion because photons arriving from larger distances are redshifted more than in a homogenous universe. This may be partially or entirely responsible for the dark-energy effect [76, 11], and this needs to be studied further.

6. The lack-of-dynamical friction and lack-of-merging problems

It has been noted by [68] that the observed galaxy population does not support the profusion of mergers that are expected in the SMoC such that these authors argue that dynamical friction must be less efficient. This is consistent with the deficit of galaxies with bulges compared to SMoC predictions and the survival of pure disk galaxies since 8 Gyr [73, 31, 19, 67] and with the absence of the evolution of the ratio of the co-moving number density of the most massive galaxies relative to less-massive galaxies [14]. The absence of an evolution of the number density of elliptical galaxies [17] and the lack of recoiled super-massive black holes [39] are furthermore also consistent with this general lack of evidence for mergers being an

important process in the evolution of galaxies, in contrast to the expectations from the SMoC.

But this is only possible if the dynamical influence of dark matter is much below that in the SMoC (which would by itself be a violation of the SMoC), or if dark matter does not exist, as otherwise the massive and expansive dark matter halos around each galaxy are dictated by the theory. That is, it is not possible to arbitrarily reduce the process of dynamical friction to fit the data but keeping the dark matter halos as obtained from the SMoC. Consistent with this problem is the lack of merging already observed in the M81 group of galaxies and in the compact galaxy groups (Sec. 3).

7. Discussion

Given the statements in the Introduction, it is apparent that in order to save the model we have two possibilities:

1. We can shrug the problems away by arguing that we *simply know the model to be right anyway.* Such a statement is rather popular and is based on the main-stream understanding that the CMB is extremely well represented by the SMoC as evident with the Planck results. Any irregularities in the non-linear structure-formation regime (galaxy clusters, galaxies) are then not to be taken too seriously. But there are tensions between the CMB and the SMoC (see sec. 17.3.1 in [35] and also [25] and e.g. [20]). For example, there is tentative evidence for an unexpected alignment of various independent measures of anisotropy in the CMB, SN1a-based cosmological expansion and galaxy morphology possibly raising questions concerning the Cosmological Principle [25, 27]. There is also tension between the locally-measured Hubble constant and the Hubble constant as derived from the CMB [66, 4]. Ignoring such tensions and claiming excellent fits of the SMoC to the CMB as proving the dark-matter models to be correct may serve the short-term aims of a famous-few but undermines the very principle of natural scientific research, as such claims are based on belief rather than comprehensive evidence, remembering that no theory can ever be proven, but merely tested and if necessary discarded.

   Thus, this avenue of thinking is not convincing. Lambda =0: NO DARK ENERGY!

2. It may be speculated that baryonic physics, which is described by perhaps the best model of physics we have (the SMoPP), conspires on every studied scale to annul the discrepancies in the sense that what we observed does not seem to match, but what we cannot see is an excellent account of reality.

   Such an argument rests on speculation of unverifiable processes and needs to be discarded. SMoPP is corrected by monopolium in JofC vol. 26.

3. The more scientific approach is to accept the failures and to seek an entirely different model. Such a model would need to be dark-matter free in order to test if baryonic structures alone, which are described by the best model

of physics we currently have (the SMoPP), may be able to account for the observations, but in a different gravitational framework. Gravitation remains the least well understood force, if it is a force at all, and thus this ansatz appears to be the most promising avenue. Our work in Bonn and Strasbourg, using the Phantom of Ramses (PoR) computer code ([41], see also [13]), developed with sparse funding from Bonn, is now allowing us to perform exactly this work in the Milgromian-gravitational framework [49, 51, 18]. The results so far appear highly promising [65, 70].

8. Conclusion

> HGD agrees with LCDMHC that the non-baryonic dark matter exceeds the BDM by a large factor > 30.

The above discussion suggests that the real Universe appears to produce more structure, which is at least partially more ordered and organized than the SMoC, and that the observed galaxy population neither matches nor does it evolve as expected by the SMoC. The explicit tests for the presence of dark matter via dynamical friction suggest this process not to be acting. All of this is consistent with the null results in the searches for dark matter particles. Here I would wish to emphasize the incredible *consistency* of the tests amongst each other: none of the tests performed yield positive results concerning the SMoC, and all appear to suggest more structure and organisation. This is important to note because we do not have the situation where a test yields excellent agreement while another one does not. They are all consistently problematical for the SMoC. In [35, 37, 38] the *theory confidence graph* lists the many individual tests performed such that, if each failed test decreases the confidence by 50 per cent then the remaining confidence in the SMoC remains today at less than 10^{-5} per cent.

We are left with inferring that the important hypothesis that dark matter particles exist needs to be rejected by astronomical data. Gravitation must therefore be effectively[2] stronger on scales relevant for galaxies. Mordehai Milgrom [49] has conceptualized a generalized gravity known as MOND, or as Milgromian gravitation. This finding can be seen as constituting the greatest advance in gravitational physics since Newton and Einstein and it is based on a generalized Poisson equation and a Lagrangian [8] and can also be embedded in a general-relativistic theory, as discovered by Jacob Bekenstein [5] with notable reviews [6, 7] with alternatives [9, 72, 30]. The observed deviations from Newtonian gravitation at the very weak accelerations, which are described by Milgromian gravity, may be a result of vacuum processes, perhaps as discussed for Minkowski space by Milgrom [50]. Milgromian dynamics has proven to be extraordinarily successful [18] and is now being used in numerical experiments to study galaxy formation and evolution [41, 70, 65]. These numerical

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[2]*Effectively*, because it may still be Einsteinian but with additional but non-exotic physics possibly playing a role in Minkowski space [50]. This is nicely visualized by an analogy by Indranil Banik: consider a trampoline. One can measure its depth-extension $s = s(w)$ as a function of weight w. These measurements can be fitted by an empirical law for macroscopic weights (e.g. $w > 1$ kg). We would then not expect this same law $s = s(w)$ to hold in an extrapolation to $w < 10^{-5}$ g, for instance, because molecular forces will begin to play a role for very small w.

experiments appear to be showing an incredible amount of success in reproducing all major issues in the astrophysics of galaxies, as our work at the Universities of Strasbourg and Bonn is demonstrating. Further work will be published in due course, subject to the availability of funding.

As to the issue of a more structured universe which may also be more organized [40], it appears that a Milgromian universe may provide the former, and self-regulatory growth processes may provide the latter which may be related to the fundamental assumption of conservation of matter.

Closing this critical discussion, one of the currently most fundamental problems in theoretical physics is the origin of Milgromian dynamics rather the nature of (non-existing) dark matter particles. This is likely to be an immense opportunity for talented young researchers. Concerning the theory of galactic astrophysics, understanding the formation and evolution of galaxies in Milgromian gravity provides a great opportunity for talented young researchers interested in performing numerical astrophysics experiments.

> MOdified Newtonian Dynamics (MOND, aka Milgromian gravity) is very likely not the answer: try HGD. CHG

Acknowledgements

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The standard model of cosmology fails because it starts with the utterly false assumption of collisionless fluid mechanics used by Einstein. This claim of LCDMHC cosmology permits the idea that the hot big bang at Planck conditions was not turbulent. In fact, the big bang was powered by a turbulent gas of Planck particles and anti-particles with sufficient negative pressure to extract mass-energy from the vacuum (p< -10^113 Pa as shown by Fortov) before the appearance of quarks and gluons that vastly increase the viscosity and Reynolds number of the turbulence. Proton-antiproton plasma is extracted by spinning magnetic monopole pairs (monopolium) that explain inflation by fluid mechanics and the Schild et al. concept of MECO. MECOs replace the failed "black hole" idea. Turbulence MUST be understood in terms of inertial vortex forces and Kolmogorov universal similarity laws. These predict phase transitions at 10^12 seconds, when proto-galaxies fragment, and 10^13 seconds, when dark matter planets in proto-globular-star-cluster clumps of a trillion fragment and begin forming the first stars. See journalofcosmology.com vol. 26. Commentary by Carl H. Gibson (Feb. 2017).