Spheres

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Abstract

Gravity is the dominant force shaping the spatial distribution of galaxies in the Universe. Under the assumption of homogeneity and isotropy of the Universe beyond a certain physical scale one can usually approximate the local kinematic evolution of galaxy by the matter distribution below that homogeneity scale. In this letter we show that if the matter distribution is composed by a discrete set of points then, due to statistical fluctuations, the influence of matter has a measurable effect at all scales. Our results are based on straightforward analytical considerations, monte-carlo realizations and the analysis of cosmological N-body simulations. We discuss the implications of these results in the interpretation of the peculiar motion of our galaxy. We suggest possible cosmological tests of these ideas for future observational facilities.

1. Of all the fundamental forces gravity plays the dominant role in defining the large scale structure of the Universe. From very homogeneous conditions gravitational instability drives the emergence of a web-like pattern. The influence of matter beyond that scale can be discarded on the grounds that the net gravitational force inside an homogeneous spherical shell is zero. [Inhomogeneity, Kirchoff's theorem] [...]

2. Large galaxy surveys help us to define different physical scales for homogeneity [...]

3. We consider first a simple phenomenological model where matter is homogeneously distributed over the surface of a sphere of radius R. This distribution consists of a set of N point masses with mass m. [...] This shows that the total force, F_{T}, inside that spherical distribution can be expressed as follows in terms of the force $F_{\mathrm{m}}(R)$ produced by each point mass placed at a position R:

$$F_{\mathrm{T}} = N^{1/2} F_{\mathrm{m}}(R), \tag{1}$$

This has been derived before [http://arxiv.org/pdf/0903.1355v1.pdf].

4. Conventional approximations consider that the net gravitational force inside an statistically homogeneous shell matter distribution is zero. However, by extending the result we have just derived, as long the matter distribution is discrete, this result does not hold. We can now extend this result for an statistically homogeneous distribution of points.[...] We run again a simple Monte Carlo simulation to find that the total force produced by the particle

distribution is twice as the of a single mass m located at a distance R_{s} equal to the average interparticle setup, independent of the total number of particles.

$$F_{\mathrm{T}} = 2F_{\mathrm{m}}(R_{\mathrm{s}}). \tag{2}$$

5. In the case of the actual large scale matter distribution in the Universe, galaxies are found to have two distinct characteristics with respect our toy model. First, the galaxies are not randomly distributed, but clustered. Second, the galaxies span a wide range of masses, with less massive galaxies being more common than massive galaxies. In order to test the influence of these two carachteristics we use a large comological N-body simulation.[...]

6. The results of the simulation [...]

7. We also consider the variation in the direction of the net force when the positions of the halos are perturbed within 1 h^{-1} which is the typical lnghtscale that these objects are expected to travel in the age of the Universe.

8. The fact that our simple analytical model describes the result obtained by simulations strenghtens our interpretation on the basis of fundamental point processes. [...]

9. The velocity of our galaxy in the rest-frame of the cosmic micriwave background is 627 km s^{-1}. [http://arxiv.org/pdf/1109.3856v1.pdf]. It has been inferred that the 382 km s^{-1} are induced by the mass distribution within $R = 30$ h^{-1} Mpc, we call this the local component. This gives a net result of 382 km s^{-1} that must be induced by the matter distribution from matter with positions beyond R, this is referred as the tidal component. Both components, local and tidal, are pointing in the same direction (??? SURE ??).[...]

10. The effects of the net force imposed by the matter distribution in the Universe is also in principle detectable in systems isolated from massive structures. The most interesting case would be the kinematic evolution of galaxies located in large scale voids. In these regions the dominant gravitational interaction would be provided by the tidal component and not by nearby structures. [http://adsabs.harvard.edu/abs/2011IJMPS...1...41V]

11. [Implications for local group mass estimates in the timing argument]

12. Possible effects on detailed methods that seek to infer local density modes from redshift measurements.

13. The physics of this effect are very simple to interpret.