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# Dark Matter And Planes Of Corotating Satellite Galaxies

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## Abstract

We propose a new model to explain the reported excess of corotating satellite pairs located near diametric opposition with respect to their host (i.e. at opening angles of  $\alpha < 8^\circ$ ) detected in the Sloan Digital Sky Survey (SDSS) data. This model also allow explaining the precipitous drop in the corotating fraction over  $8^\circ < \alpha < 28^\circ$  and the no overabundance of corotating satellite pairs for greater angles. Furthermore, this model predicts two other unexpected features that could be tested now in the SDSS data, the correlation between the distance of hosts' galaxies and the angle of the planes of corotating satellites and the spatial extent of this correlation. This new model has been proposed to explain dark matter without modifying the gravitation's laws, without introducing new matter and in the frame of general relativity. The verification of these two new predictions would be a very strong validation of this model of "dark matter" and would put very strong constraints on the other models.

**Key words:** galaxies: dwarf – galaxies: evolution – galaxies: formation – Local Group – galaxies: star formation – cosmology: dark matter.

## 1 Introduction

A recent published paper (Phillips et al. 2015) tested the hypothesis that a large fraction of satellites corotate in coherent planes. This hypothesis comes from the planar distribution exhibited by M31 and from recent observational data that has been interpreted in some papers as a possible ubiquitous corotating planes of satellites. In this recent paper, the authors analyze several models and compare them with the observational data. It leads to the following results.

## 2 Data analysis

In term of observational data, they confirm the previously reported excess of corotating satellite pairs located near diametric opposition with respect to their host (i.e. at opening angles of  $\alpha < 8^\circ$ ). They also noticed a precipitous drop in the corotating fraction over  $8^\circ < \alpha < 28^\circ$  and no overabundance of corotating satellite pairs for greater angles.

In term of models, they demonstrate that no viable alternative models can explain this distribution. The best fit is obtained with « dumbbell model ». But this model is not physically acceptable and it can't explain the M31 distribution. The more physical model seems to be an isotropic velocity distribution. But this model can't explain the precipitous drop in the corotating fraction over  $8^\circ < \alpha < 28^\circ$ .

Without other better models, they conclude that the corotation signal for  $\alpha < 8^\circ$  is likely the product of random chance.

## 3 A new model which predicts these unexpected observational data

Caution must be taken with this conclusion. This conclusion is one possible "explanation" (by interpreting the tendency of corotating satellite pairs for small angle  $\alpha$  as a random noise), but one cannot exclude the possibility of a new model that could explain this distribution. One can also note that if the distribution is the product of random chance, it can't explain the distribution for M31. Furthermore, and it is certainly the main weak point of this explanation, it is very astonishing (and very unlikely) that M31 and these new observational data provide by chance the same tendency of corotating satellite pairs for the same small angle  $\alpha$ . One can also cite the authors who write "repeatedly resampling 400 satellite pairs placed randomly in phase space (as in our 'isotropic' model) will frequently produce satellite samples with excess corotating fractions at random opening angles". The important words are "at random opening angles", to compare with the observation data that produce by two times (M31 and SDSS data) the same small angle around  $0^\circ$ . So another conclusion (also in agreement with their study) cannot be rejected, to find a new model that can explain M31 and the current observational data.

In fact, a recent paper published in ArXiv (Le Corre 2015) had predicted this distribution. This paper emits an assumption to explain the dark matter without modifying the gravitation laws and without new matter. This model implies very strong constraints. These constraints allow making several sine qua none predictions. In particular the two following ones (with  $\vec{k}_0$  a gravitomagnetic vector approximatively uniform on large areas):

« The movement of satellite dwarf galaxies should

be in a plane perpendicular to a vector  $\vec{k}_0 \gg$

« Statistically, inside a cluster, the satellite dwarf galaxies' planes should be close to the supergalactic plane »

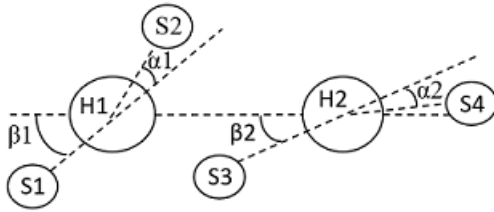
These two predictions translated with the words of the paper (Phillips et al. 2015) means that the movement of satellite galaxies should be in planes with small angle  $\alpha$  (because close to their supergalactic plane). These planes should lead to a precipitous drop in the corotating fraction for slightly greater angle (because the planes are perpendicular to one vector  $\vec{k}_0$ ). And finally one should have no overabundance of corotating satellite pairs for greater angles (because the vector  $\vec{k}_0$  is uniform on large areas). These predictions match very well with the three previous observational data characteristics.

## 4 New unexpected predictions of the new model on observational data

This explanation of the dark matter also implies two others predictions that could be tested with these observational data:

« Statistically, smaller is the distance between two galaxies; smaller is the difference of orientation of their satellite dwarf galaxies' planes. »

In the terms of previous paper, it means that in the sample of corotating satellite pairs (i.e. for small angles), more the distance between two hosts galaxies is small, more the difference of the angle between the corotating satellite galaxies' plane of these two hosts should be small. In other words, the planes of the corotating satellites pairs between two hosts tend to be more and more parallel with the proximity of the two hosts but it doesn't mean that the angle  $\alpha$  becomes smaller (Fig. 1).



**Figure 1.** Smaller is the distance between the H1 and H2 hosts, smaller should be the difference of angles between the corotating pairs  $|\beta_2 - \beta_1|$  of each host.

The other prediction can be translated in terms of a spatial extension of this correlation:

« Only the clusters [...] seem to be able to generate the expected vector  $\vec{k}_0$  on large areas. »

It means that this unexpected correlation on the angle of the planes of corotating satellites of close hosts' galaxies should be detectable on hosts' distances of the order of magnitude of the cluster's size (i.e. at least until around 5Mpc).

## 5 Conclusion

In this work, we propose a new model (Le Corre 2015) which explains the main features of the observational data about the planes of corotating satellite galaxies (Phillips et al. 2015).

1. An excess of corotating satellite pairs located near diametric opposition with respect to their host (i.e. at opening angles of  $\alpha < 8^\circ$ ).
2. A precipitous drop in the corotating fraction over  $8^\circ < \alpha < 28^\circ$ .
3. No overabundance of corotating satellite pairs for greater angles.

This new model predicts two others features:

1. A correlation between the distance of hosts' galaxies and the angle of their planes of corotating satellites.
2. This correlation should be maintain on very large areas (at least until 5Mpc).

One can recall that the main goal of this new model is to explain the dark matter without modifying the gravitation's laws and without new matter. Furthermore, with another unexpected assumption (soon tested at CERN), this new model could also explain the dark energy. The verification of these two new predictions would be a very strong validation of this model of "dark matter" and would put very strong constraints on the other models. This could be a major flaw in the  $\Lambda$ CDM model.

## REFERENCES

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