UNIVERSIDAD DE ANTIOQUIA
FACULTAD DE CIENCIAS EXACTAS Y NATURALES
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THE PLACE OF THE MILKY WAY AND ANDROMEDA IN THE COSMIC WEB

Sebastian Bustamante Jaramillo
Facultad de Ciencias Exactas y Naturales
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Author: Sebastian Bustamante
Advisor: Jaime E. Forero-Romero

The next web page contains updated information about this thesis and related topics:
https://github.com/sbustamante/Thesis
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To all my family and friends.

Abstract

Observaciones de la CMBR y algunos surveys muestran que en z=8 aproxidamente, los modos del campo de densidad de materia comienzan a entrar en régimen no lineal. Una de las características más interesantes de este régimen es el clustering debido al colapso gravitacional de las regiones sobredensas y la formación de estructuras jerarquicas a gran escala, en especial la estructura de red que se manifiesta tanto en simulaciones como en surveys (e.g. The Sloan Digital Sky Survey) y que presenta una alta anisotropia a escalas de Mpc pero tiende a ser isotrópica a escalas de Gpc. Ahora, esta alta anisotropía a escalas de Mpc permite definir un entorno para galaxias y clusters, donde según el esquema usado, se puede cuantificar de diferentes maneras; un esquema común constituye cuatro tipo de entornos: voids, filaments, sheets y knots, basados en la geometría local de la distribución de materia (e.g Hoffman Y. Metuki O. et. al., 2012, MNRAS, 425, 2069, Forero-Romero, J. E. Hoffman Y. et. al., 2009, MNRA, 396, 1815, Hahn O. Porciani C. et. al., 2007, MNRAS, 409, 355).

Reciente estudios han mostrado que la influencia del entorno en el cual están embedidos los halos de materia oscura tiene importantes implicaciones en las propiedades de formación de las galaxias. Siguiendo esta línea, se estudia la influencia del entorno en sistemas tipo grupo local (LG), definidos en este caso como sistemas de dos halos tipo Vía Láctea – Andrómeda (Andrómeda es la galaxia más cercana y junto con la Vía Láctea forman un sistema aproxidamente aislado.) que satisfacen propiedades de aislamiento, de distancia relativa, entre otras (ver Forero-Romero, J. E. Hoffman Y. et. al., 2009, MNRA, 396, 1815).

Los sistemas tipo LG son extraidos de catálogos de simulaciones cosmológicas de materia oscura; una de las simulaciones tiene condiciones iniciales completamente aleatorias y es suficientemente grande (250 Mpc/h) para ser usada en la construcción de distribuciones estadísticas necesarias, y tres simulaciones restringidas (Gottloeber et. al., 2010, arXiv:1005.2687) en las cuales las condiciones iniciales son escogidas específicamente para reproducir el universo local a z=0, que aunque con un volumen menor (64 Mpc/h), poseen sistemas tipo LG muy bien definidos. A partir de la muestra de LG de las simulaciones restringidas se propone un método para determinar una muestra análoga en simulaciones no restringidas partiendo de la forma local de la distribución de materia, después de esto se buscan correlaciones respecto al entorno en el que están embedidos los LG y posibles sesgos producidos en las historias de acreción.

Este estudio sugiere que el entorno más favorable para la formación de sistemas tipo LG son regiones dos dimensionales o sheets, para las cuales la distribución local de materia colapsa en una dirección y se expande en otras dos, mientras que no hay un sesgo aparente en las historias de acreción debido al método de construcción de la muestra LG en la simulación no restringida.

Acknowledgements

Estos son los agradecimientos.

Sinceramente,

Sebastian Bustamante

January 2013

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"Equipped with his five senses, man explores the universe around him and calls the adventure Science"

Edwin Hubble

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Introduction

"What is our place in the cosmos?" This is one of the more simple and transcendental question of the human beings, and powered by our innate curiosity has led to a current relatively understandable picture of our Universe. In fact, the astronomy can be only considered as a scientific rigorous discipline after the seventeenth century.

1.1 Prehistory

Almost in every scientific discipline a significant theoretical advance is accompanied of a technical improvement of its own instruments, it is for this reason that at the beginning of the seventeenth century Johannes Kepler could establish his three well-known empirical laws of the planetary movements based on the very precise data of astronomical bodies computed for Tycho Brahe. This event was very remarkable in the astronomy history due to was the first of many strikes against the well established anthropomorphic notion of the cosmos. Although the Kepler laws constituted the most crucial test to the Nicolaus Copernicus heliocentric model, it was only until 1685 when Isaac Newton formulated the law of universal gravitation (from which can be derived all the Kepler laws) when the astronomers could have a enough powerful tools to begin a depth and serious discussion about the real nature of our universe on scales bigger than the solar system, and thus inaugurating the *sciences of gravity* [2].

After the establishment of the universal gravitation, the next significative theoretical achievement in this area came in the centuries eighteenth and nineteenth with the development of classical mechanics, as the Hamiltonian and Lagrangian formalism, and powerful numerical tools. All this achievements impulse the study of key topics as the many body problem, allowing a depth understanding of the dynamic of complex gravitational system, as planetary system, star clusters, etc.

Parallel to previous theoretical advances, in the observational side was beginning to arise the idea of *island universe*, from which will evolve the concept of galaxy. This was powered by the development of the telescope, allowing besides to understand that the galaxy is only a large collection of stars like our sun. It was very remarkable the pioneer work of William Herschel, who tried to make a map of our galaxy determining distances with the assumption that stars have the same intrinsic luminosity and the inverse square law for the intensity decay (see figure 1.1). Although his results were very imprecise due to the incorrect assumption on which were based, the importance of his work lies in the recognition of a structure (disk-like) for our galaxy.

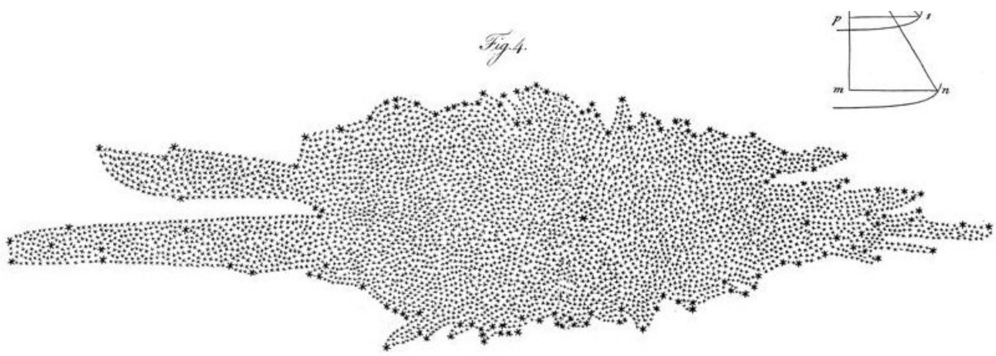

Figure 1.1: William Herschel's model of our galaxy based upon star counts and the equal luminosity assumption.[1]

Another important observational question that was emerging in that epoch is the existence of *island universes* like ours. It was already well-known the existence of extended objects that do not fit to definition of stars or planets, as nebulae, planetary disks and galaxies. Even William Herschel and his son John Herschel contributed with the realization of an large (for the epoch) catalogue of extended bodies known as *Catalogue of Nebulae and Clusters of Stars* and an expanded version finished by John Dreyer in 1888, *New General Catalogue of Nebulae and Clusters of Stars*, which together with *Index Catalogues* of 1895 and 1908 constitute a large collections of bodies widely used in current astronomy, referred with the abbreviations *NGC* and *IC* respectively [2]. Despite of this observational advances, the real nature of this objects was a complete mystery, especially if they lie within our own galaxy or are completely independent systems.

This question remained until twentieth century and together with the real size of the universe were the two big issues treated in the well-known *Great Debate*, also called the *Shapley-Curtis Debate*, an important event in the history of astronomy where the astronomers Harlow Shapley and Herber Curtis gave respectively different arguments in favour of and against the belonging of these objects to our galaxy and the Milky Way as our whole universe. Despite of this, their arguments were not very conclusive and the solution to these issues had to wait until 1924 when Edwin Hubble measured the distance to Andromeda Galaxy (M31 or NGC 224) and demonstrated unquestionably the real extragalactic nature of this object, and in the following years for other ones. This achievement together to the observational verification of expanding universe (also due to Hubble) were the beginning of modern observational cosmology.

It also happened in the twentieth century a key event for the modern sciences of gravity, Albert Einstein formulated his theory of General Relativity, changing completely the previous conception of space and time and laying the foundation of current cosmology picture.

1.2 The Current Cosmology Picture

The conceptions of space and time were misunderstanding before 1900 century and their connection with the gravitational interaction was completely neglected, both key issues for the adequate understanding of our universe, it is for these reason that the formulation of the General Relativity opened the door to a complete set of theoretical tools

1.3 Cosmological Observations

1.4 Numerical Simulations

The cosmos is all that is or ever was or ever will be. Our feeblest contemplations of the Cosmos stir us, there is a tingling in the spine, a catch in the voice, a faint sensation, as if a distant memory, or falling from a height. We know we are approaching the greatest of mysteries.

Carl Sagan

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Historical methodology, as I see it, is a product of common sense applied to circumstances.

Samuel E. Morison

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A brief introduction to N-body simulations bla

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Historical methodology, as I see it, is a product of common sense applied to circumstances.

Samuel E. Morison

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Nomenclature

IC Index Catalogues

LG Local Group

NGC New General Catalogue of Nebulae and Clusters of Stars

Declaration

I herewith declare that I have produced this work without the prohibited assistance of third parties and without making use of aids other than those specified; notions taken over directly or indirectly from other sources have been identified as such. This work has not previously been presented in identical or similar form to any examination board.

The dissertation work was conducted from 20XX to 2013 under the supervision of Name Surname and Name Surname at the University of Deusto.

Bilbao,

This dissertation was finished writing in Medellín, Colombia on Monday 28 January, 2013

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