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Gauging the morphology of the Milky Way's halo through the interaction with the Magellanic clouds.

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Abstract

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Agradecimientos

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1 Introduction

The idea that, during their evolution, galaxies go through many dynamical processes with structures of comparable size, is now commonly accepted. Their history is divided by short periods of collision followed by longer periods of stabilization. The Milky Way (MW hereinafter), the galaxy that planet Earth inhabits, is the most detailed picture of a galaxy we can have access to. Because of this, it has been the prototypical spiral galaxy, but recent evidence suggests that for multiple reasons [2], it's atypical.

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The conscious and constant effort, made by the history of astronomers that precede this attempt to collaborate in humanity's understanding of the universe, have made our models of the galaxies get more precise and sophisticated as time goes on. The technical development occurring thanks to engineering, quantum theories and other physics areas, allow a very fast-paced increase in our computational power and observational capabilities in astronomy.

2 Theoretical Framework

2.1 Potential theory

2.1.1 How DM distributes in the universe

This subsection might be moved to the ***State of the Art*** *later on*

In this section I want to write about how dark matter clumps up into over-densities than can contain other over-densities.

2.2

3 State of the Art

3.1 MW vecinities

3.2 Triaxial distributions

A Multipole analysis of the MW effect on Andromeda

In this section, the contribution of each of the components of the multipolar expansion of the MW (under different models) is analyzed in order to determine if the distribution of dark matter can produce detectable effects at the distance of the Andromeda galaxy (M31).

A.1 Multipole expansion of the gravitational potential

The general expression for the gravitational potential produced by a distribution U on a point $\vec{r}$ (see figure A.1) is given by:

$$\phi(\vec{r}) = -G \int_U \frac{\rho(\vec{r'})}{|\vec{r} - \vec{r'}|} \, \mathrm{d}V' \tag{A.1}$$

The integrand can be expanded using the Legendre polynomials, and considering the addition theorem, the expansion can be brought to the following form [1]:

$$\frac{1}{|\vec{r} - \vec{r'}|} = \sum_{l=0}^{\infty} \frac{{r_<}^{l}}{{r_>}^{l+1}} \sum_{m=-l}^{l} {Y_l}^{m}(\Omega)^* {Y_l}^{m}(\Omega')$$

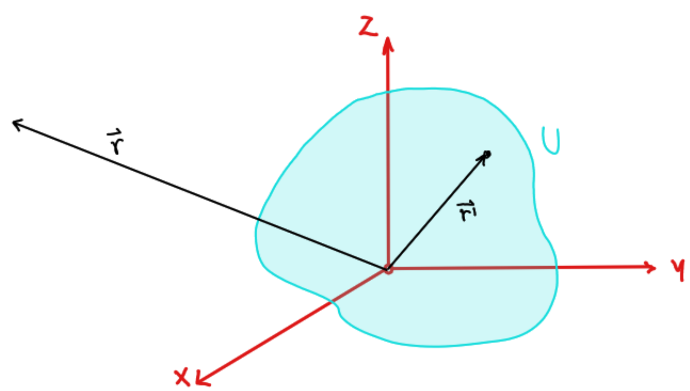

Figure A.1: Scheme of the mass distribution U generating a potential on $\vec{r}$

Where $r_<$ and $r_>$ are, respectively, the smaller and larger of r and r', Y_l^m are the spherical harmonics, and Σ and Σ' are the angular coordinates of r and r'.

In the situations of interest, the potential only needs to be known considerably far away from the mass distribution that produces it. Because of this, is clear that $r > r'$, so the expansion is just:

$$\frac{1}{|\vec{r} - \vec{r'}|} = \sum_{l=0}^{\infty} \frac{r'^l}{r^{l+1}} \sum_{m=-l}^{l} Y_l^m(\Omega)^* Y_l^m(\Omega') \tag{A.2}$$

Considering A.2 in A.1, the multipole expansion of the gravitational potential therefore is:

$$\boxed{\phi = -G \sum_{l=0}^{\infty} \sum_{m=-l}^{l} M_l^m \, \frac{Y_l^m(\Omega)^*}{r^{l+1}}} \tag{A.3}$$

And the multipole moments, M_l^m, are defined as:

$$\boxed{M_l^m = \frac{4\pi}{2l+1} \int_U r'^l \rho(\vec{r'}) Y_l^m(\Omega') \, \mathrm{d}V'} \tag{A.4}$$

A.1.1 Linearity of the multipole moments

When analyzing the mass density distribution of the source, is common to describe the density as a superposition of the density of different components of the system (e.g. $\rho_{disk}(\vec{r})$, $\rho_{bulge}(\vec{r})$, $\rho_{halo}(\vec{r})$). In this case, because of the linearity of the integrals, the multipole moments are also linear in ρ

A.2 Multipole expansion of the gravitational field

A.3 Models for the MW

To measure the contribution of the components and the effect of different types of halos, a set of models will be compared. This models will be:

1. disk + bulge
2. disk + bulge + spherical halo
3. disk + bulge + ellipsoidal halo

A.3.1 disk + bulge

A.3.2 disk + bulge + spherical halo

A.3.3 disk + bulge + ellipsoidal halo

Bibliography

[1] George B. Arfken, Hans J. Weber, and Frank E. Harris. "Chapter 16 - Angular Momentum". In: *Mathematical Methods for Physicists (Seventh Edition)*. Ed. by George B. Arfken, Hans J. Weber, and Frank E. Harris. Seventh Edition. Boston: Academic Press, 2013, pp. 773–814. ISBN: 978-0-12-384654-9. DOI: `https://doi.org/10.1016/B978-0-12-384654-9.00016-5`. URL: `https://www.sciencedirect.com/science/article/pii/B9780123846549000165`.

[2] Marius Cautun et al. "The aftermath of the Great Collision between our Galaxy and the Large Magellanic Cloud". In: *Monthly Notices of the Royal Astronomical Society* 483.2 (Nov. 2018), pp. 2185–2196. ISSN: 0035-8711. DOI: `10.1093/mnras/sty3084`. eprint: `https://academic.oup.com/mnras/article-pdf/483/2/2185/27153859/sty3084.pdf`. URL: `https://doi.org/10.1093/mnras/sty3084`.