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INFALL OF ASSOCIATIONS OF DWARF GALAXIES INTO THE MILKY WAY HALO

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RESUMEN

El origen del disco de satélites de la Véa Léctea (DoS o VPOS) y la M31 (GPoA) continúa siendo uno de los problemas abiertos en la astrofísica actual (Klypin, Kravtsov, Valenzuela, & Prada, 1999; Pawlowski, Kroupa, & Jerjen, 2013). En este trabajo se presenta un estudio sobre la posible formación del disco de satélites de la Vía Láctea a partir de una asociación de galaxias enanas que se precipita hacia su halo de materia oscura, siguiendo órbitas parabólicas. Para esto se realizaron simulaciones numéricas newtonianas de N-cuerpos tomando valores para distancias iniciales de 4, 2 y 1 Mpc. Se analizaron las propiedades morfológicas en las enanas luego de un tiempo de simulación de 10 Gy, propuesto para la interacción con la Vía Láctea, teniendo en cuenta: las distribuciones obtenidas alrededor del plano de la galaxia anfitriona, las distancias a las que se ubica cada una de las enanas, sus perfiles de densidad y su dispersión de velocidades. Se observó que, luego de 10 Gy de caída, las estructuras permanecen compactas manteniendo sus propiedades morfológicas, y con mejores resultados cuando se incluye el halo de materia oscura que las envuelve. Se observa que sólo para asociaciones de galaxias enanas ubicadas a distancias de 1 Mpc éstas logran ingresar al halo de la galaxia. Esto se soporta en el hecho de que las asociaciones más cercanas son las que se hubiesen precipitado hacia el halo de la galaxia, razón por la cual no se observan asociaciones de enanas a estas distancias del Grupo Local, siendo la asociación 14+12 la más cercana, a 1.37 Mpc de la Vía Láctea (Tully, 2006).

ABSTRACT

The origin of the satellite disc of the Milky Way (DoS or VPOS) and M31 (GPoA) remains an open problem in astrophysics (Klypin, Kravtsov, Valenzuela, & Prada, 1999; Pawlowski, Kroupa, & Jerjen, 2013). This paper presents a study on the possible formation of the Milky Way satellite disc from an association of dwarf galaxies that infall into the Milky Way dark matter halo in parabolic orbits. For this, we performed Newtonian numerical simulations of N-bodies taking values for the initial distances of 4, 2 and 1 Mpc. Morphological properties of dwarfs were analyzed after a simulation time of 10 Gy, proposed for the interaction with the Milky Way, taking into account: the distributions obtained around the plane of the host galaxy, the distances at which the dwarfs are located, their density profiles and their velocity dispersion. One result is that, after 10 Gy of fall, the structures remain compact maintaining their morphological properties, with better results when the halo of dark matter that envelops them is included. Only associations of dwarf galaxies located at distances of 1 Mpc manage to enter the halo of the galaxy. This is supported by the fact that these closest associations are those that have fallen in towards the halo of the galaxy, which is why no associations of dwarfs are observed at these distances in the Local Group, the closest association being 14+12, at a distance of 1.37 Mpc from the Milky Way (Tully, 2006).

Key Words: galaxies: dwarf — Galaxy: formation — Galaxy: halo — Local Group

1. INTRODUCTION

In research carried out by Mateo (1998), Metz (2009), and Angus (2011), they consider the possibility that the dwarf galaxies that compose the satellite disc of the Milky Way have been falling into the dark matter halo in associations, and not in an individual way. Therefore the spatial distribution exhibited by this structure should be directly related to the direction of infall of these associations. In this work we consider a model in which the dwarf galaxies grouped in associations and located in regions peripheral to the Local Group were thrown by gravitational interaction towards the dark matter halo of the Milky Way. Our model takes into account: (I) the interaction of the dwarfs with the halo of the host galaxy and the interaction among themselves during the time of fall; (II) the spatial distribution due to their evolution during the infall, starting from the

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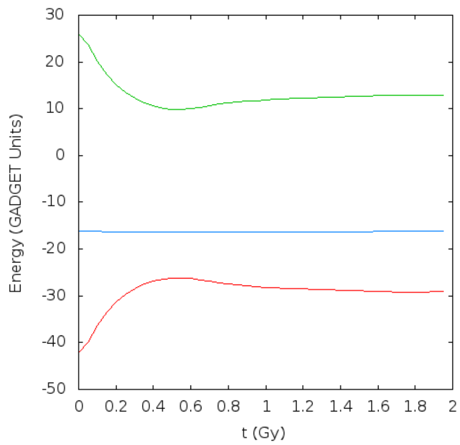

Fig. 1. Generation of dwarf galaxies with ZENO and virialized with GADGET-2. Energy curve: potential (red), kinetic (green) and total (blue). The color figure can be viewed online.

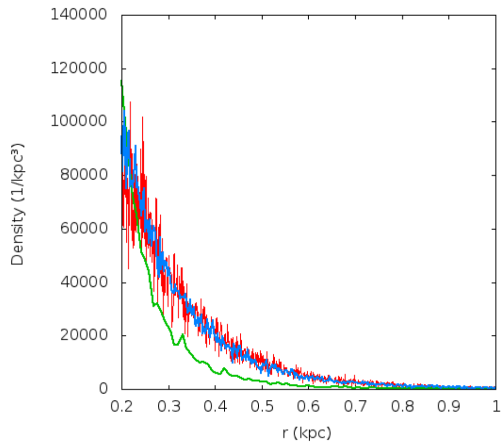

Fig. 2. Density profiles of dwarf galaxies before (red) and after the fallin into the dark matter halo of the Milky Way: without dark matter (blue) and halo of dark matter (green). The color figure can be viewed online.

initial conditions of a parabolic orbit. We perform numerical N-body simulations with ZENO, to generate the objects, and GADGET-2 (Springel, 2005), for the virialization process and interaction environment. Dwarf galaxies were modeled with a Plummer profile, halos of dark matter with a Hernquist profile, and the disc of the Milky Way with an exponential profile.

2. RESULTS AND ANALYSIS

After performing the simulations for the infall of the association of dwarf galaxies onto the halo of the Milky Way for 10 Gy, considering dwarf galaxies with and without dark matter halos (Klenssen & Kroupa 1998 considered a model of dwarf galaxies satellites without dark matter), we noted that their radial distances were approximately 375 kpc without halo of dark matter and 380 kpc when the halo component is included, and the velocity dispersions were 5.12 km/s and 5.97 km/s with and without the dark matter halo, respectively. These values accord with those reported for dwarf galaxies in the Milky Way (Lokas 2011). Furthermore, their density profiles were preserved (important for the stability of the objects) as shown in Figure 2.

3. CONCLUSIONS

Concerning the formation of the disc of satellites of the Milky Way, we discard associations of dwarf galaxies that are at distances equal or greater than 2 Mpc, because their time of infall is larger than a Hubble time. Also, associations of galaxies peripheral to the Local Group located at these distances cannot be considered as objects that in the future could be part of the structure of the disk of satellites following orbits. As for the morphology of dwarf galaxies, after 10 Gy of interaction with the Milky Way, we note that, when they are surrounded by a dark matter halo, they remain more compact despite the effects of tidal forces (the presence of halos of dark matter for dwarf galaxies is therefore relevant). As for the location of dwarf galaxies around the Milky Way, it is best fitted for the model of free dark matter taking into account that most galaxies are at distances between 280 kpc and 500 kpc. Finally, we can say that the disk of satellites of the Milky Way may have formed by this accretion process, with orbits with conditions similar to the ones used in this work.

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