MNRAS **000**, 1–?? (2018) Preprint 25 September 2018 Compiled using MNRAS LaTeX style file v3.0

The expected shape of the Milky Way's Dark Matter halo

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Accepted XXX. Received YYY; in original form ZZZ

ABSTRACT
We measure the shape of the dark matter halos of Milky Way type galaxies.

Key words: keyword1 – keyword2 – keyword3

1 INTRODUCTION

A robust prediction of the Cold Dark Matter (CDM) paradigm is that DM halos are ellipsoidal and can be characterized by the principal axes $a > b > c$. This ellipsoidal shape is mostly due to the anisotropical and clumpy accretion of matter influenced by environmental structures. Numerical studies how that the shape has a strong mass dependence (Allgood et al. 2006), halos are also rounder at the outerskirts than at the inner part. Shape also evolves with cosmic time, halos get rounder as they evolve.

In the case of the Milky Way, where we have a three-dimensional view from the inside, the community does not have a clear agreement. Some studies prefer oblate (i.e. a=b>c) configurations at small distances around ≤ 20 kpc (see Law & Majewski 2010; Bovy et al. 2016; Loebman et al. 2012; Olling & Merrifield 2000; Banerjee & Jog 2011) and more triaxial and prolate configurations on the outter distances ≥ 20 kpc (see Vera-Ciro & Helmi 2013; Law et al. 2009; Deg & Widrow 2013; Banerjee & Jog 2011).

However, some studies are inclined towards prolate configurations even at the inner parts of the halo (see Bowden et al. 2016), and although it previously seemed that a triaxial DM halo on the outerskirts would be necessary to fully explain the characterization of the Sagittarius stream (Law et al. 2009), recent studies questioned this claim by reporting inconsistencies with narrow stellar streams Pearson et al. (2015) or finding that the relaxation of other constraints may make this claim unnecessary Ibata et al. (2013).

Although observations predict more symmetric halos than DM-only simulations,

AQUI:Parrafo sobre las predicciones de DM only simulations.

There is strong evidence claiming that the presence of baryons produces axisymmetrical halos. For instance, some studies have shown that the DM halo shape must be axisymmetrical to ensure the stability of a hydrodynamical disk embeded in a static DM halo. Other have studied this rounding effect by simulating the disk as rigid potential inside an N-body triaxial DM halo Debattista et al. (2008); Debattista et al. (2013); Kazantzidis et al. (2010) finding that the halo responds to the disk by becoming less triaxial.

While these studies are elucidating about dynamical aspects that may play an important role in the rounding of the DM halo shape, they do not follow baryons in the whole cosmological context. Other studies overcome this limitation by using resimulations (Abadi et al. 2010; Bryan et al. 2013) finding that the feeback related to star formation in the disk drives the strenght of the round effect.

If one wants to make a numerical study of the DM halo shape for the MW, there is the additinal challenge of making a simulation that resemble the observed properties of the MW disk. Recently Chua et al. (2018) made a study in a cosmological simulation to compare the effect of including baryons. They do find, on average, rounder halo shapes once hydrodynamic effects are included, but it is uncertain the strenght of this statistical effect on galaxies similar to the MW.

All these difficulties (enough numerical resolution, explicit cosmological context, appropriate feedback physics to produce realistic MW disks) have limited the studies that want to study the rounding effect of baryons in MW-like galaxies.

In this work we overcome these three limitation by analyzing the Our objective is to quantify the DM halo shape and investigate the effect of baryons.

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Reference	q_ρ	s_ρ	q_ϕ	s_ϕ	R	θ	comment
Olling & Merrifield (2000)	**1.00**	**0.80**			$\simeq$ 8kpc	0°	Method: Stellar dynamics and HI density.
Law et al. (2009)			**0.83**	**0.67**	$\lesssim$ 60kpc	90°	Mid-axis orientation. Method: Sagittarius stream
Law & Majewski (2010)			**0.99**	**0.72**	[20kpc,60kpc]	90°	Mid-axis orientation, Method: Sagittarius stream
Loebman et al. (2012)	**1.00**	**0.47**			$\sim$ 20kpc	0°	Method: SDSS statistics
Deg & Widrow (2013)	0.72	0.28	0.82	0.40	[20kpc,60kpc]	90°	Mid-axis orientation. Method: Sagittarius stream
Vera-Ciro & Helmi (2013)			**1.00**	**0.90**	$\lesssim$ 10kpc	0°	Method: Sagittarius stream & LMC
			0.90	**0.80**	$\gtrsim$ 10kpc	90°	Mid-axis orientation on the outside.
Bovy et al. (2016)	**0.95**	**0.95**			$\lesssim$ 20kpc	90°	Method: Stellar streams

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