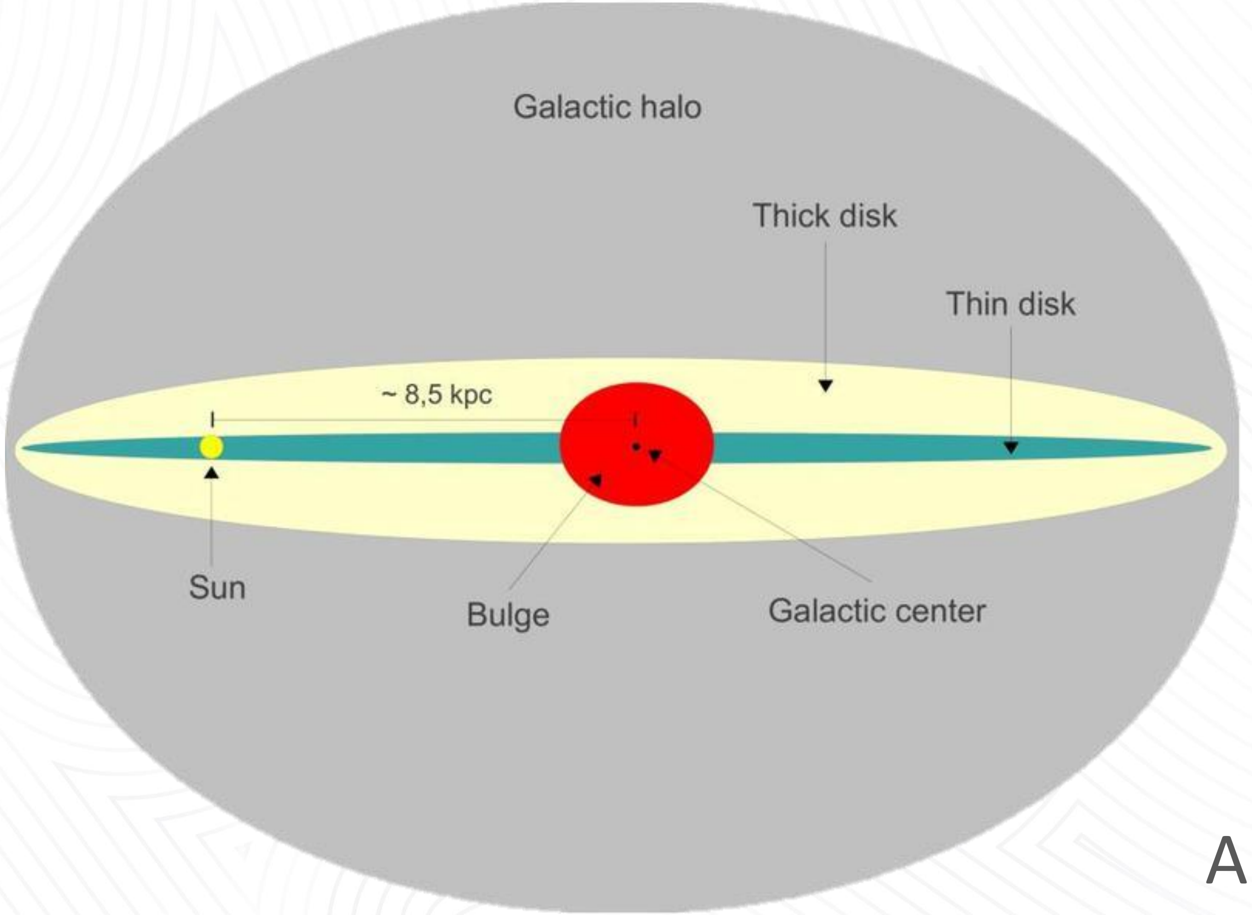
Dinámica de Galaxias

Dylan Castellanos y Juan Felipe Rodríguez

El modelo de galaxia



Bulbo Galáctico

Discos Estelares

Discos de Gas

Aura de Materia Oscura

Los Datos Observacionales

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- Eilers, et al., 2018 - *The Circular Velocity Curve of the Milky Way from 5 to 25 kpc.*

  (5 – 25 kpc)

- Mroz, et al., 2019 - *Microlensing optical depth and event rate toward the Galactic bulge from 8 yr of OGLE-IV observations.*

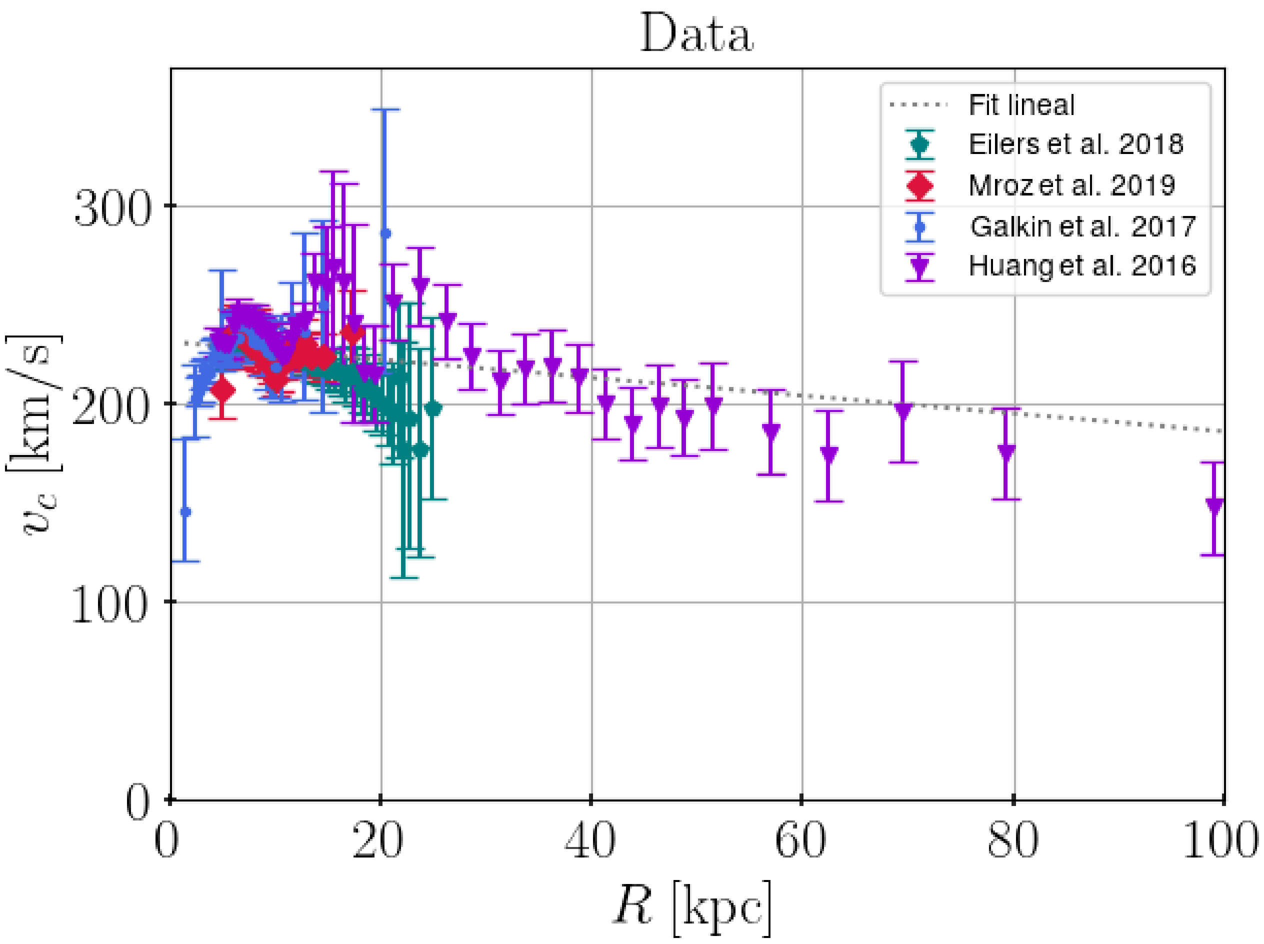
  (5 – 20 kpc)

- Galkin, et al., 2017 - *A new compilation of the Milky Way rotation curve data.*

  (1 – 20 kpc)

- Huang, et al., 2016 - *The Milky Way's rotation curve out to 100 kpc and its constraint on the Galactic mass distribution.*

  (4 – 100 kpc)



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Legado académico y cultural de los santandereanos

Modelo matemático

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Teorema del Virial

$$2K + U = 0$$

$$K = \frac{1}{2} m_s \, v^2 \qquad \mathrm{U} = \frac{-G\, M(r)\, m_s}{r}$$

Se halla *v*:

$$\boldsymbol{v} = \sqrt{\frac{\boldsymbol{G\, M(r)}}{\boldsymbol{r}}}$$

Density profile galactic bulge (McMillan, 2016)

$$\rho_{\mathrm{b}} = \frac{\rho_{0,\mathrm{b}}}{(1 + r'/r_0)^{\alpha}} \exp\left[-(r'/r_{\mathrm{cut}})^2\right]$$

Density profile stellar discs (McMillan, 2016)

$$\rho_{\mathrm{d}}(R,z) = \frac{\Sigma_0}{2z_{\mathrm{d}}} \exp\left(-\frac{|z|}{z_{\mathrm{d}}} - \frac{R}{R_{\mathrm{d}}}\right)$$

Density profile gas discs (McMillan, 2016)

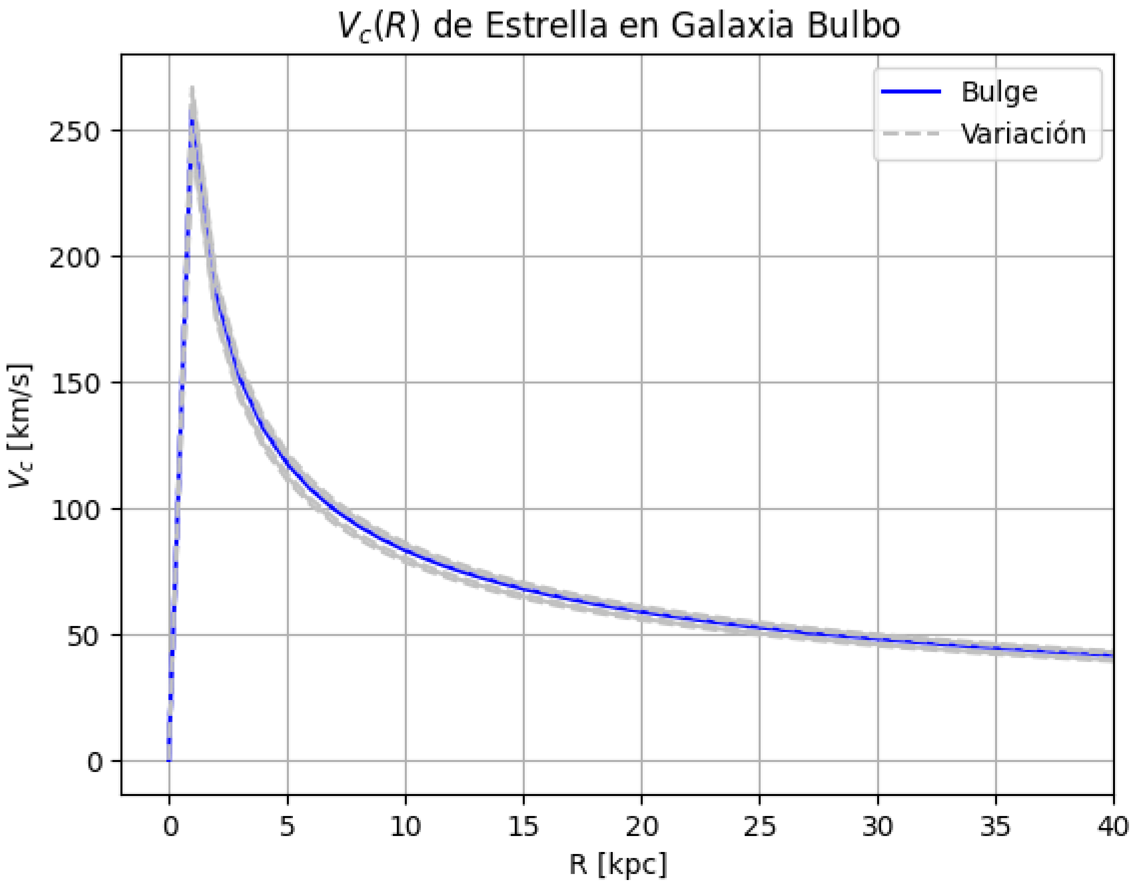
$$\rho_{\mathrm{d}}(R,z) = \frac{\Sigma_0}{4z_{\mathrm{d}}} \exp\left(-\frac{R_{\mathrm{m}}}{R} - \frac{R}{R_{\mathrm{d}}}\right) \mathrm{sech}^2(z/2z_{\mathrm{d}})$$

Density profile dark matter halo

$$\rho(r) = \frac{\rho_{crit}\,\delta_c}{\left(\frac{r}{r_s}\right)\left(1 + \frac{r}{r_s}\right)^2}$$

(Navarro, Frenk, White, 1996)

Bulbo Galáctico



$$\rho_b = \frac{\rho_{0,b}}{(1 + r'/r_0)^{\alpha}} \exp\left[-(r'/r_{cut})^2\right]$$

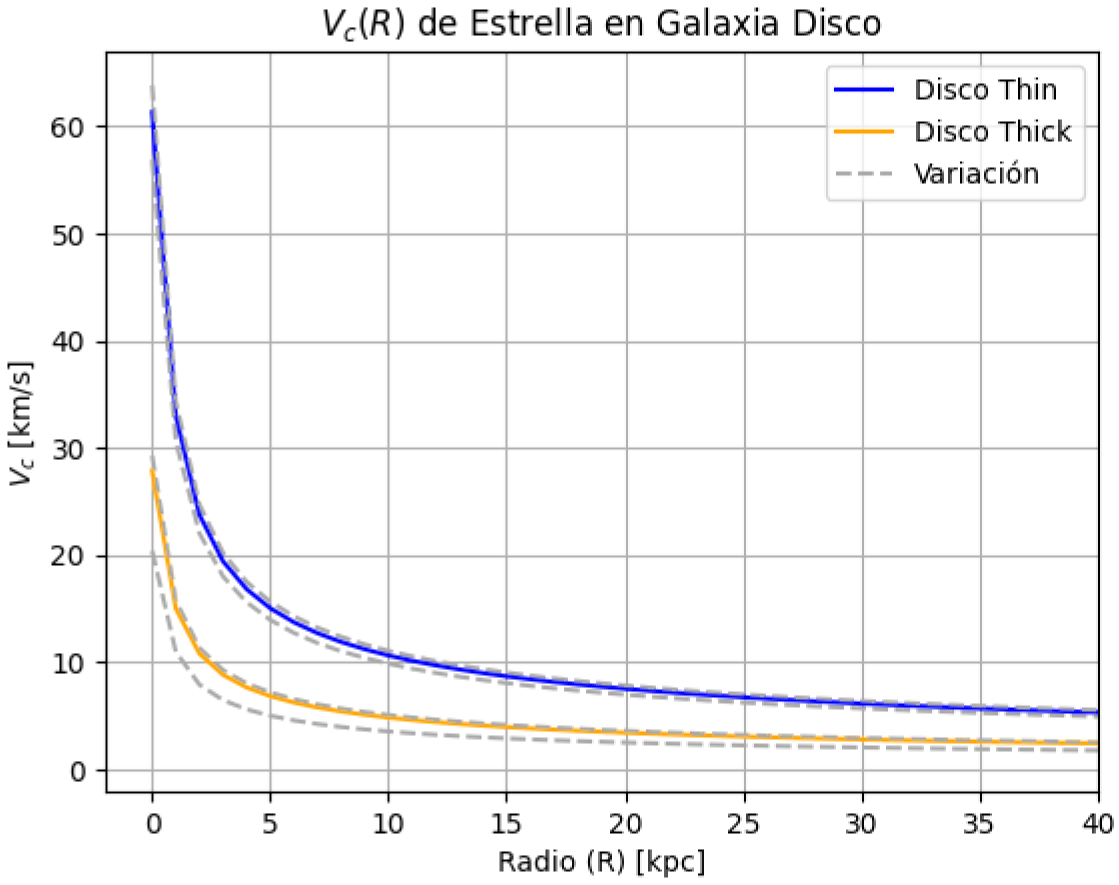
Best Fitting Model:

$$\rho_{0,b} = 9.84e10 \left[\frac{M_{sun}}{kpc^2}\right]$$
$$r_0 = 0.075\ [kpc]\ (\text{fijo})$$
$$r_{cut} = 2.1\ [kpc]\ (\text{fijo})$$
$$\alpha = 1.8\ (\text{fijo})$$

Variación de parámetros:

$$\rho_{0,b} = 9.73e10 \pm 9.7 \left[\frac{M_{sun}}{kpc^2}\right]$$

Disco Galáctico



$$\rho_d(R,z) = \frac{\Sigma_0}{2z_d} \exp\left(-\frac{|z|}{z_d} - \frac{R}{R_d}\right)$$

Best Fitting Model:

$$\Sigma_{0,thin} = 896e6 \left[\frac{M_{sun}}{kpc^2}\right]$$
$$z_{d,thin} = 0.3\ [kpc]\ \text{(fijo)}$$
$$R_{d,thin} = 2.5\ [kpc]$$

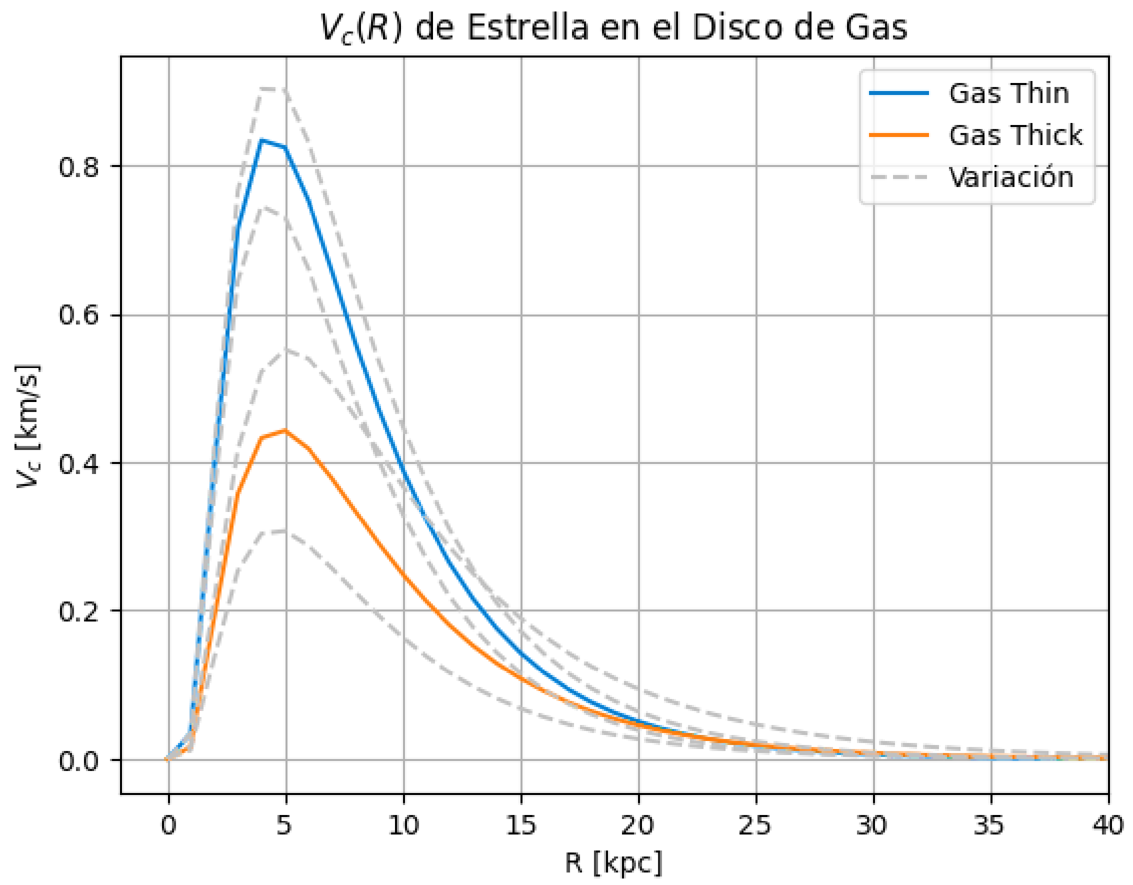
$$\Sigma_{0,thick} = 183e6 \left[\frac{M_{sun}}{kpc^2}\right]$$
$$z_{d,thick} = 0.9\ [kpc]\ \text{(fijo)}$$
$$R_{d,thick} = 3.02\ [kpc]$$

Variación de parámetros:

$$\Sigma_{0,thin} = 886.7e6 \pm 116.2e6 \left[\frac{M_{sun}}{kpc^2}\right]$$
$$R_{d,thin} = 2.53 \pm 0.14\ [kpc]$$

$$\Sigma_{0,thick} = 156.7e6 \pm 58.9e6 \left[\frac{M_{sun}}{kpc^2}\right]$$
$$R_{d,thick} = 3.38 \pm 0.54\ [kpc]$$

Disco de Gas



$$\rho_d(R,z) = \frac{\Sigma_0}{4z_d}\exp\left(-\frac{R_m}{R} - \frac{R}{R_d}\right)\mathrm{sech}^2(z/2z_d).$$

Best Fitting Model:

$\Sigma_{0,thin} = 896e6 \left[\frac{M_{sun}}{kpc^2}\right]$

$R_{d,thin} = 2.5\ [kpc]$

$\Sigma_{0,thick} = 183e6 \left[\frac{M_{sun}}{kpc^2}\right]$

$R_{d,thick} = 3.02\ [kpc]$

$R_m = 12.0\ [kpc]$ (fijo)

$z_{d,gas} = 0.045\ [kpc]$ (fijo)

Variación de parámetros:

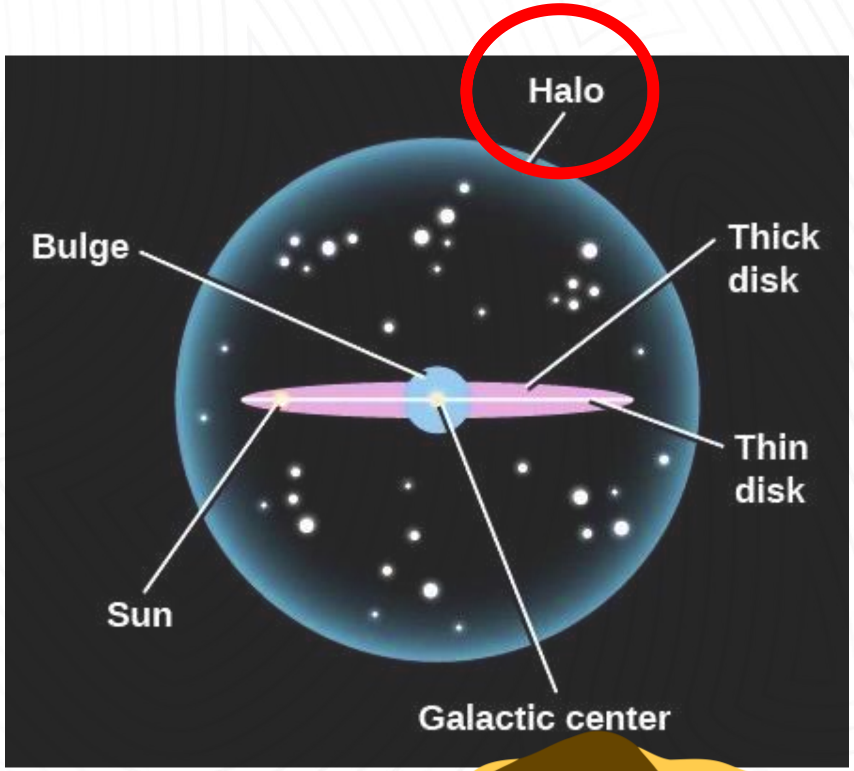
$\Sigma_{0,thin} = 886.7e6 \pm 116.2e6 \left[\frac{M_{sun}}{kpc^2}\right]$

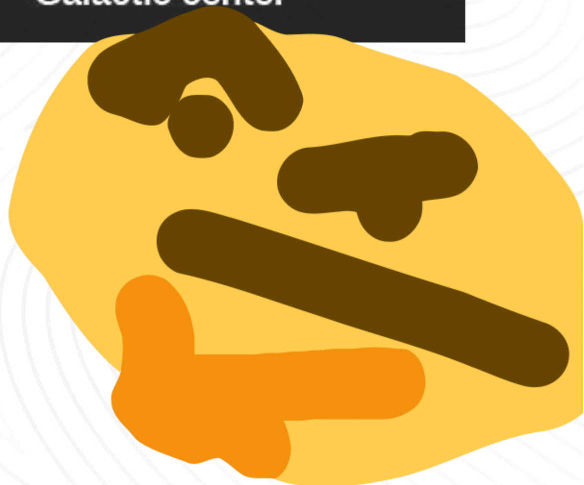
$R_{d,thin} = 2.53 \pm 0.14\ [kpc]$

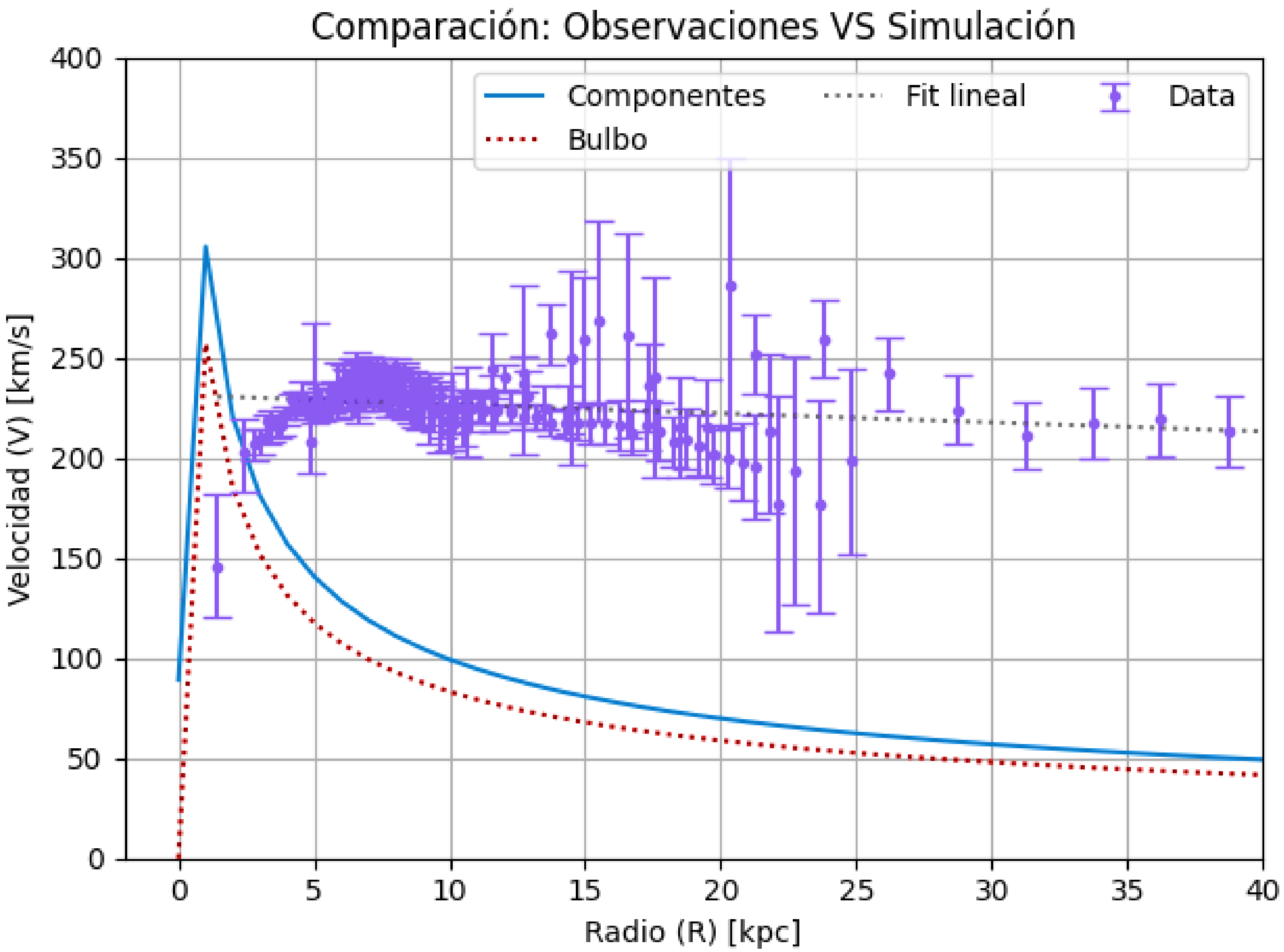
$\Sigma_{0,thick} = 156.7e6 \pm 58.9e6 \left[\frac{M_{sun}}{kpc^2}\right]$

$R_{d,thick} = 3.38 \pm 0.54\ [kpc]$

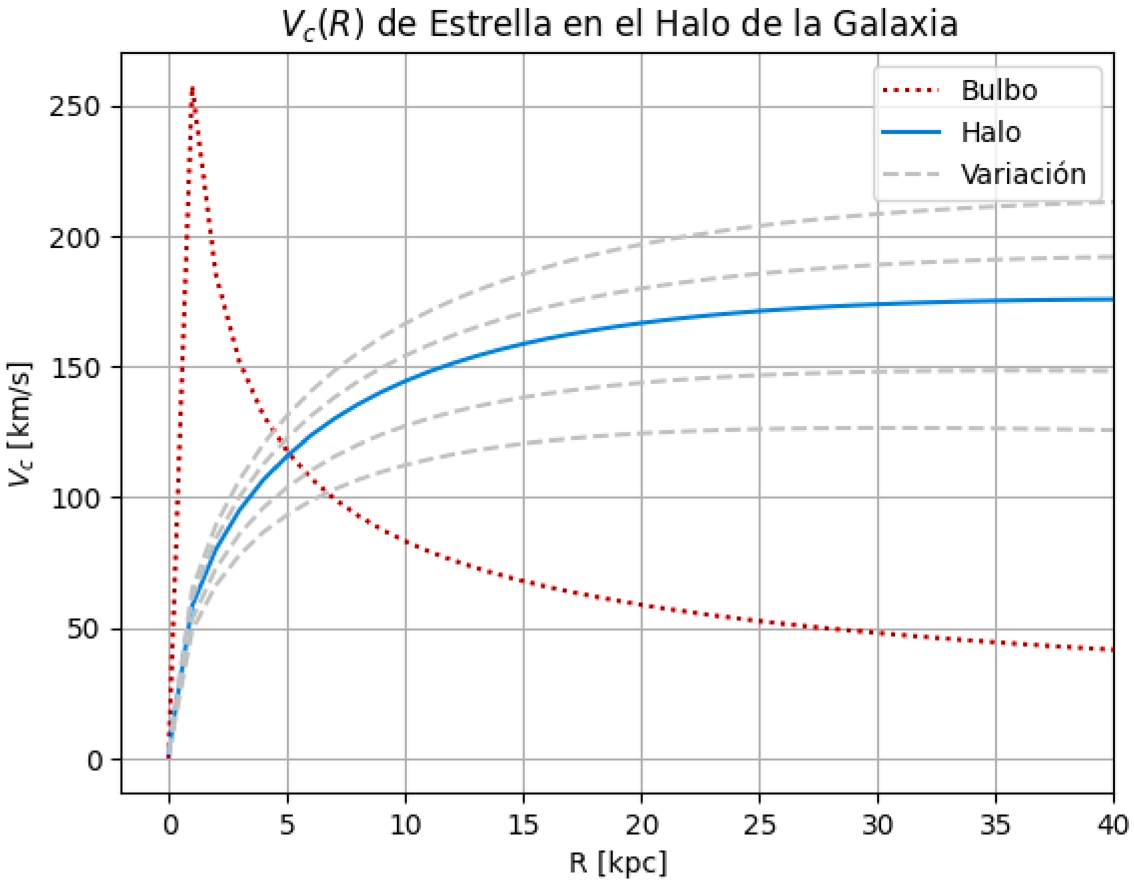
Aún falta masa...







Halo de Materia Oscura



$$\rho(r) = \frac{\rho_{crit}\,\delta_c}{\left(\frac{r}{r_s}\right)\left(1+\frac{r}{r_s}\right)^2}$$ (NFW profile)

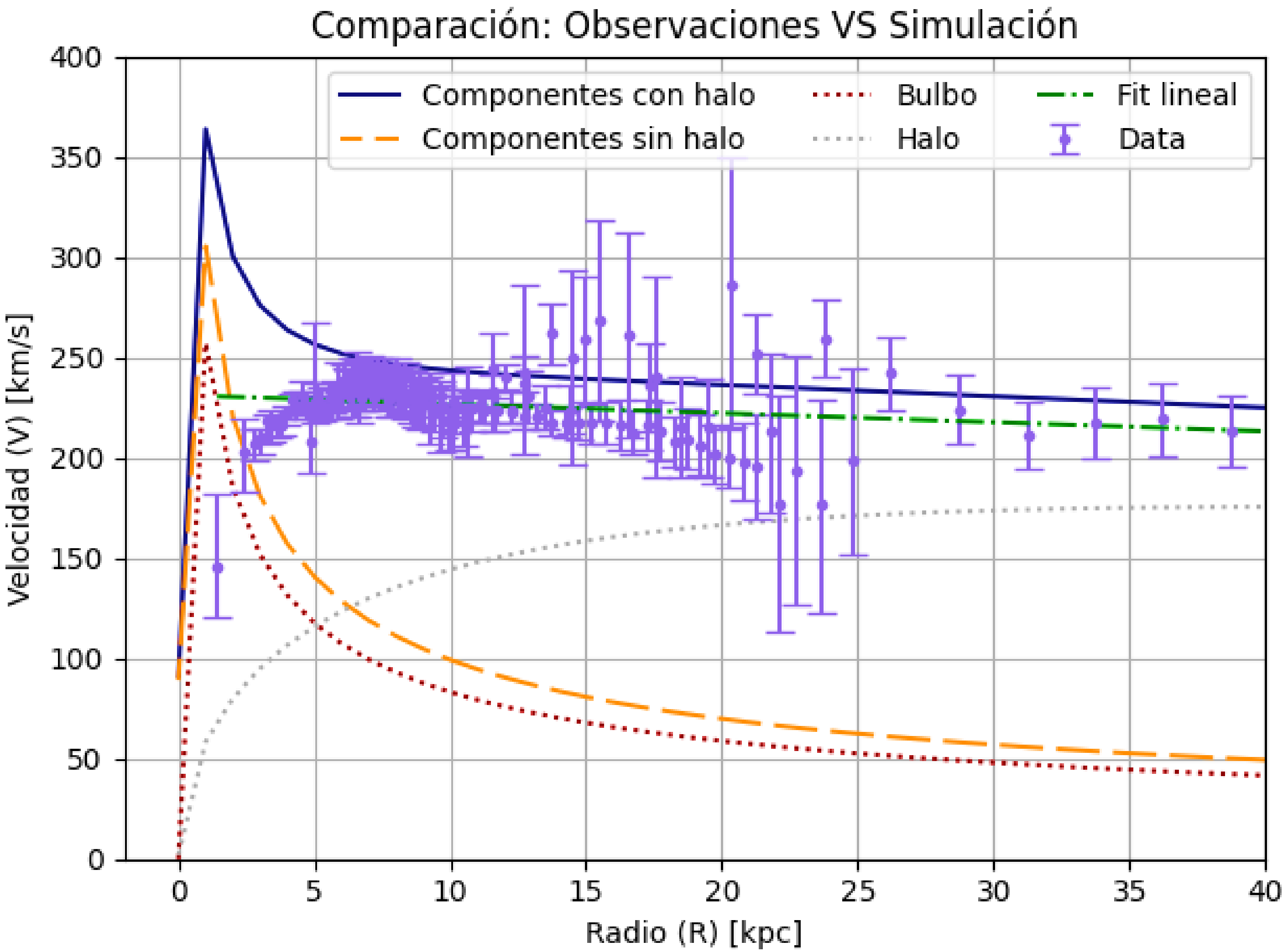
Best Fitting Model:

$$\rho_{crit} = \frac{(3H^2)}{8\pi G}\left[\frac{M_{sun}}{kpc^2}\right] \approx 8.86e6\left[\frac{M_{sun}}{kpc^2}\right] \text{ (fijo)}$$
$$r_s = 19.6[kpc]$$
$$\delta_c = 5.0 \text{ (fijo)}$$

Variación de parámetros:

$$r_s = 19.0 \pm 4.9\ [kpc]$$

Modelo Completo

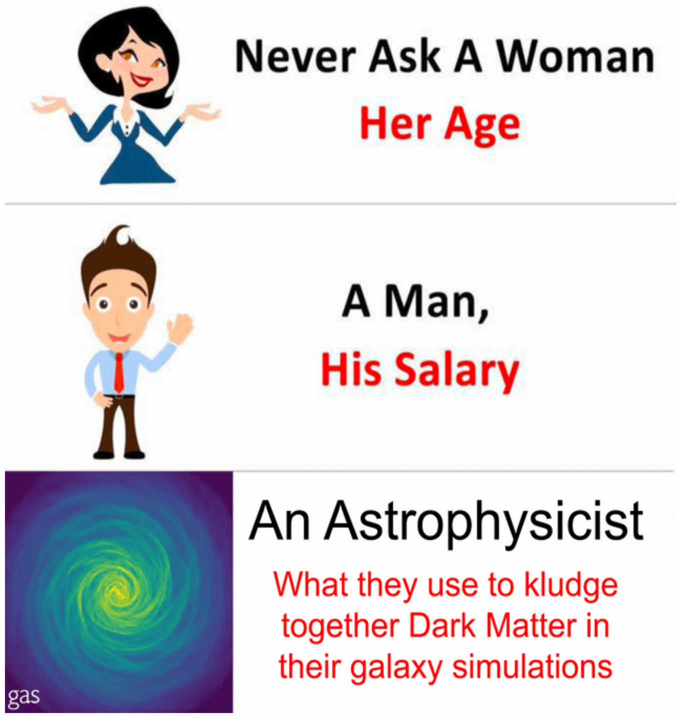


Conclusiones

- Se logró modelar las distintos componentes de una galaxia y obtener la velocidad de una estrella en función de su radio.
- Se comprobó que este modelo es consistente con los datos observacionales.
- En futuros estudios se recomienda la variación individual de los parámetros en los modelos de disco, así como el uso de datos de otras galaxias.

¡Gracias!

When someone uses light years instead of parsecs



Modelo de Concentración

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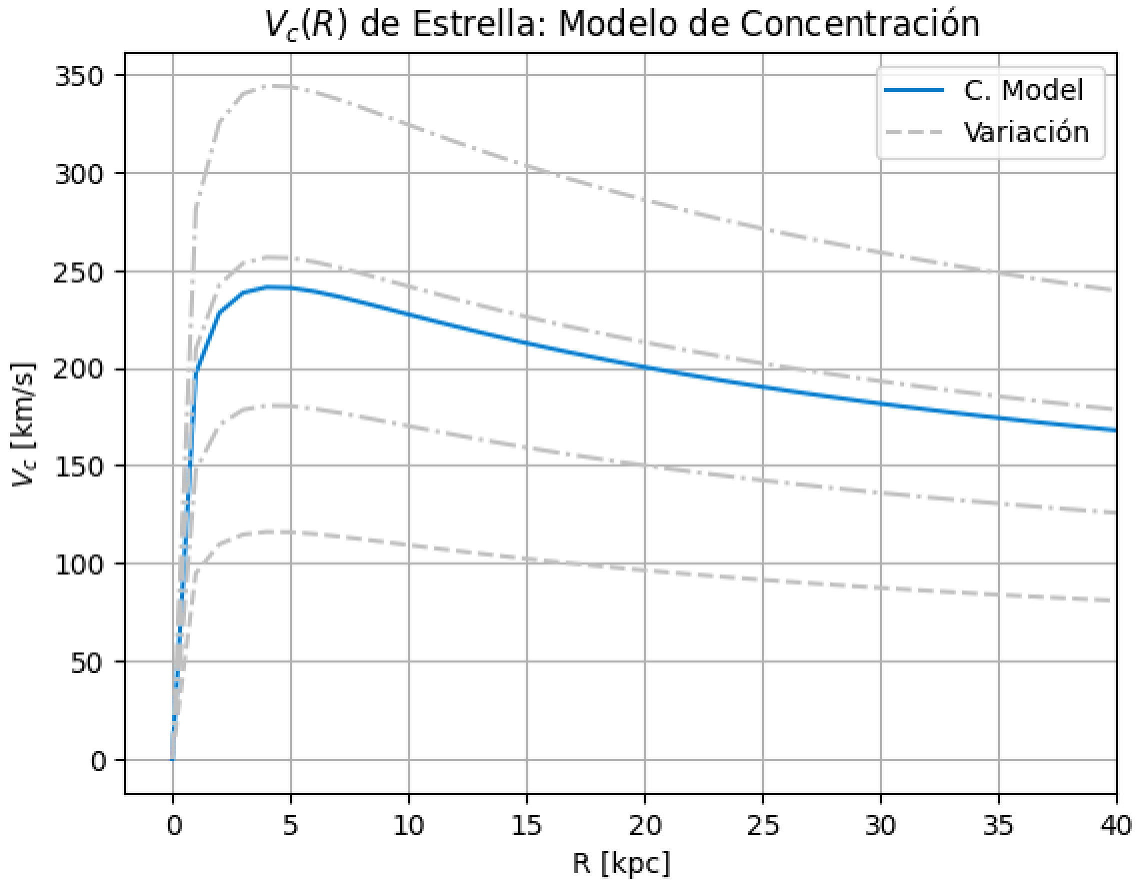

$$M = \int_0^{R_{\rm vir}} 4\pi r^2 \rho(r)\, dr = 4\pi \rho_0 R_s^3 \left[\ln(1+c) - \frac{c}{1+c} \right]$$

$$\rho_0 \equiv \rho_{crit}$$
$$R_s \equiv r$$

$$r = c r_s$$
$$\rightarrow c = \frac{r}{r_s}$$

$$c \in (0, \infty)$$

Best Fitting Model:

$$\rho_{crit} \approx 8.86e6 \left[\frac{M_{sun}}{kpc^2}\right] \text{ (fijo)}$$
$$r_s = 19.6[kpc]$$

Variación de parámetros:

$$r_s = 19.0 \pm 4.9\ [kpc]$$

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Modelo de Concentración Completo