Inside-Out Growth of Galaxies

ASTR 511 Final Project

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1. INTRODUCTION

For my project I'm going to investigate the inside-out growth of galaxies, focussing specifically on the Milky Way. This is the concept that star formation in spiral galaxies occurs first in the centre and builds outwards over time.

2. BACKGROUND & EARLY SIMULATIONS

One of the first papers to propose the idea of inside-out growth was Larson (1976). They extended previous simulations of galaxies with the goal of producing both a spheroidal and disc component to the galaxy. Most previous papers on the topic (e.g. Larson 1969; Gott 1973) focussed on reproducing the formation of elliptical galaxies and didn't investigate spiral galaxies with a significant disc component.

Larson (1976) start their simulations with a protogalaxy that is assumed to be a uniform, uniformly rotating sphere with a fixed total mass. Larson addresses the simplicity of these initial conditions by noting that, despite initial uniformity, collapse is always non-homologous and inhomogeneties still emerge.

They explore 9 different models of increasing complexity, including effects such as varying star formation rates, tidally inhibited star formation, different boundary radii. The final model that they find best fits the observations at the time uses a star formation rate that depends on the ratio of the cloud collision time to the free-fall time. This has the effect of producing a more realistic bulge to disc ratio.

3. OBSERVATIONS

3.1. *For*

(van Dokkum et al. 2013)

3.2. *Against*

(Goddard et al. 2017)

4. MODELS

(Frankel et al. 2019)

5. APPLICATIONS

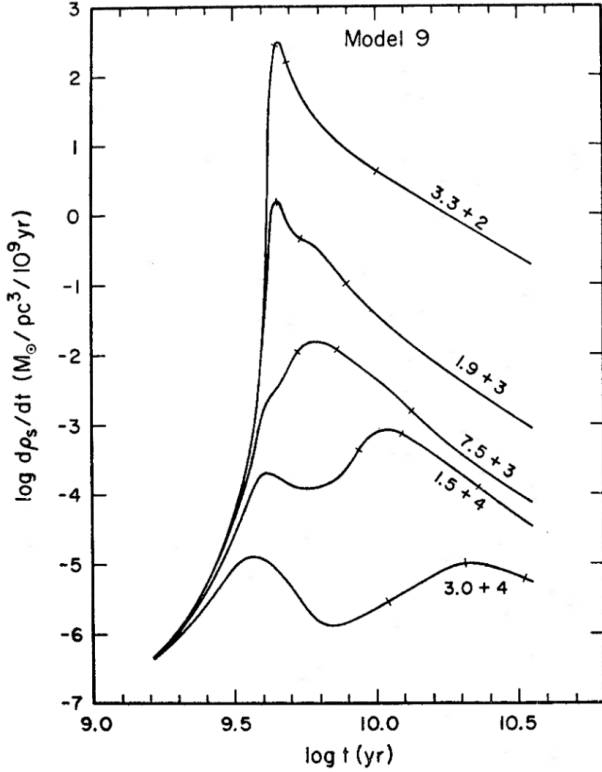(Banerjee et al. 2020)

6. FUTURE WORK

(Hogg et al. 2019)

Figure 1. Figure 13 from Larson (1976). This shows the star formation rate density as a function of time for different radii for Model 9 from the paper. Annotations indicate the radius, where for example $3.3 + 2$ means 3.3×10^2.

REFERENCES

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Larson, R. B. 1969, MNRAS, 145, 271, doi: 10.1093/mnras/145.3.271

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van Dokkum, P. G., Leja, J., Nelson, E. J., et al. 2013, ApJL, 771, L35, doi: 10.1088/2041-8205/771/2/L35
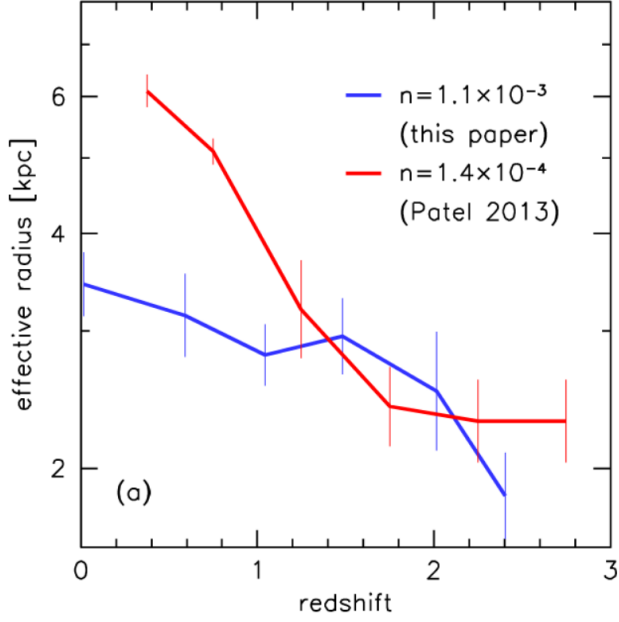
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Figure 2. Figure 5 from van Dokkum et al. (2013). The effective radius of observed galaxies from 3D-HST and CANDELS at different redshifts, compared to another paper.
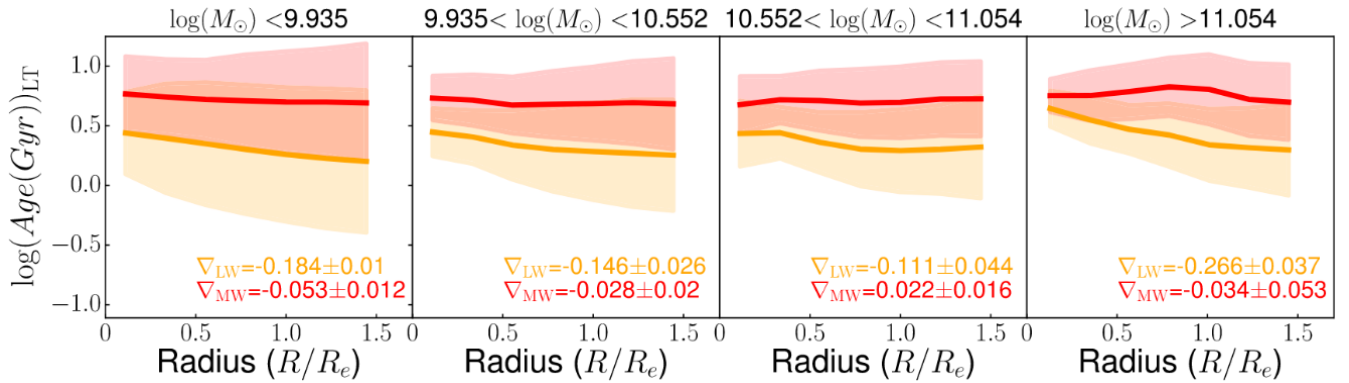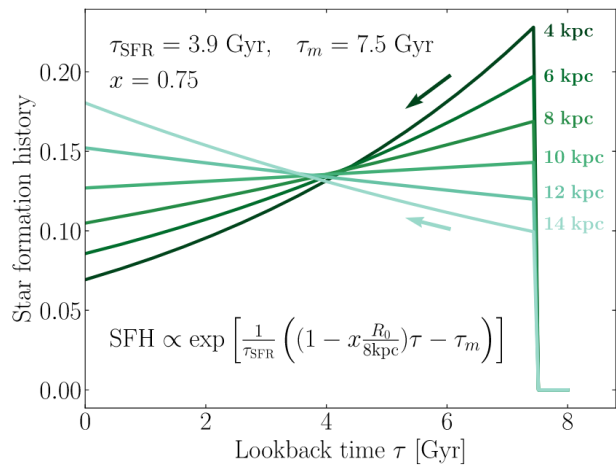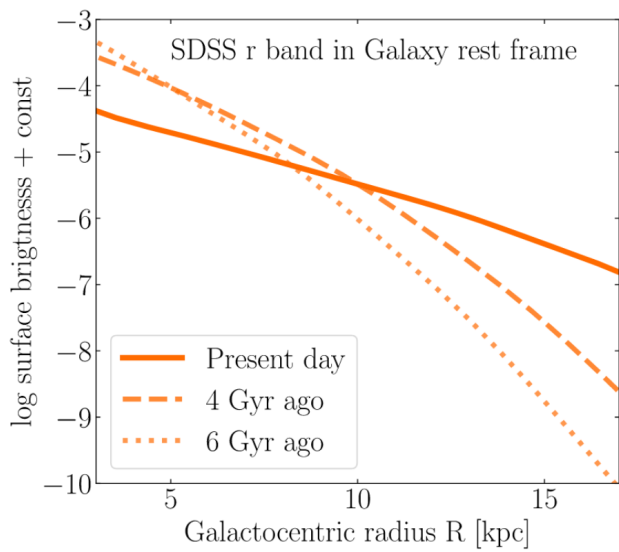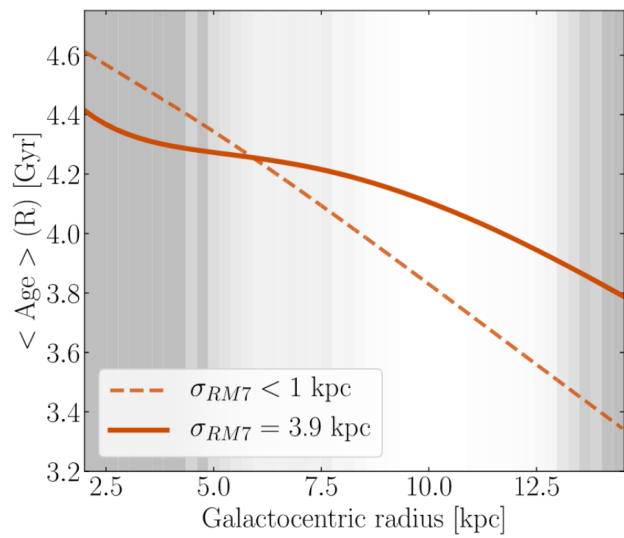

Figure 3. Figure 14 from Goddard et al. (2017). Mass weighted age-radius gradients are given in red for four different mass bins, from observations in SDSS-IV MaNGA.

$\tau_{\mathrm{SFR}} = 3.9$ Gyr, $\quad \tau_m = 7.5$ Gyr

$x = 0.75$

4 kpc
6 kpc
8 kpc
10 kpc
12 kpc
14 kpc

$\mathrm{SFH} \propto \exp\left[\frac{1}{\tau_{\mathrm{SFR}}}\left((1 - x\frac{R_0}{8\mathrm{kpc}})\tau - \tau_m\right)\right]$

Figure 4.

SDSS r band in Galaxy rest frame

Present day
4 Gyr ago
6 Gyr ago

Figure 5.

Figure 6.