

Contents

1	Introduction to dark matter	5
1.1.	Evidence for dark matter in the universe	5
1.1.1.	Galaxy clusters	5
1.1.2.	Lensing	6
1.1.3.	Halos of galaxies	6
1.1.4.	Cosmological implications and the baryon fraction	7
1.2.	The nature of dark matter	8
1.2.1.	Baryonic dark matter	8
1.2.2.	Non-baryonic dark matter	9
1.2.3.	MOND – A universe without dark matter	10
2	Luminous and Dark Matter in Spiral Galaxies: A new Test	13
2.1.	Maximal disks or not?	13
2.2.	The concept	14
2.3.	The spiral structure of galaxies	16
3	The Observed Stellar Mass Distribution and Gas Velocity Fields	19
3.1.	The galaxy sample	19
3.2.	The data	20
3.2.1.	NIR photometry observations	21
3.2.2.	H α spectroscopy observations	23
3.3.	Data reduction	29
3.3.1.	NIR photometry	29
3.3.2.	H α kinematics	31
3.4.	Derived quantities	32
3.4.1.	Remarks to individual galaxies	35
4	The modelling	37
4.1.	Deriving the potential from NIR observations	37
4.1.1.	<i>K</i> -band Light as Tracer of the Stellar Mass	37
4.1.2.	Color correction	38
4.1.2.1.	Performing the color correction	38
4.1.2.2.	Results from the color correction	39
4.1.3.	Deprojection	42
4.1.4.	Cleaning the image	42
4.1.5.	Calculating the stellar potential	43

CONTENTS

4.1.6.	Determining the halo parameters	44
4.1.7.	Assembling the final potential	45
4.2.	Hydrodynamic gas simulations	46
4.2.1.	The BGK scheme	46
4.2.2.	The code	47
4.2.2.1.	The collision time τ and its approximations	47
4.2.2.2.	Application to galactic gas simulations	48
4.2.3.	Boundary conditions	49
4.2.4.	Performing the simulations	50
4.3.	Comparing observations and simulations	51
4.3.1.	The gas density	51
4.3.2.	The gas velocity	52
4.3.2.1.	Evaluation of the comparison	53
5	NGC 4254 – a case study	55
5.1.	Hydrodynamic simulations for NGC 4254	56
5.2.	Results for NGC 4254	58
5.2.1.	Simulated Gas Density	58
5.2.2.	Simulated Gas Velocity Fields	60
5.2.2.1.	The observed kinematics	60
5.2.2.2.	Overall Fit Quality	60
5.2.2.3.	Varying the Stellar to Dark Matter Ratio	62
5.2.2.4.	Varying the Gas Temperature	64
5.2.2.5.	Varying the Grid Resolution	66
5.3.	Discussion of possible caveats	66
5.3.1.	Is the Concept Reasonable?	67
5.3.2.	Are there Systematic Errors in the Modelling?	68
5.3.3.	Is the Galaxy Suited for this Analysis?	70
5.4.	Conclusions	70
6	Analysis of more galaxies	73
6.1.	NGC 3810	73
6.1.1.	Performing the hydrodynamical gas simulations	75
6.1.2.	Premature termination of simulations	76
6.1.3.	Results from the hydrodynamical gas simulations	77
6.1.3.1.	The gas density	77
6.1.3.2.	The gas velocity field	79
6.2.	NGC 3893	81
6.2.1.	Performing the hydrodynamical gas simulations	83
6.2.2.	Results from the hydrodynamical gas simulations	83
6.2.2.1.	The gas density	83
6.2.2.2.	The gas velocity field	84
6.3.	NGC 5676	87
6.3.1.	Performing the hydrodynamical gas simulations	88
6.3.2.	Preliminary results from the hydrodynamic gas simulations	90
6.3.2.1.	The gas density	90

CONTENTS

6.3.2.2. The gas velocity field	91
6.4. NGC 6643	94
6.4.1. Performing the hydrodynamical gas simulations	95
6.4.2. Results from the hydrodynamical gas simulations	96
6.4.2.1. The gas density	96
6.4.2.2. The gas velocity field	97
7 Synthesis of the Results and Conclusions	99
7.1. Results from the analysis	99
7.1.1. The color correction	99
7.1.2. Disk dynamics	101
7.1.2.1. Location of the corotation resonance	101
7.1.2.2. The disk kinematics	104
7.1.3. The dark matter content in the analyzed galaxies	105
7.1.3.1. Discussion	107
7.2. Lessons learned and outlook	109
7.2.1. Outlook	110
Appendix	111
A NGC 3810	112
B NGC 3893	117
C NGC 4254	123
D NGC 5676	124
E NGC 6643	130
Bibliography	135
Acknowledgements	143