

Contents

1	Introduction	1
1.1	Cool evolved stars in the Hertzsprung-Russell diagram	1
1.1.1	Low- and intermediate-mass stars	1
1.1.2	Massive stars	4
1.2	Importance of studying RSG stars	6
1.3	Properties of RSG stars	8
1.3.1	Stellar parameters	8
1.3.2	Spectra	9
1.3.3	Surface abundances	10
1.3.4	Photometric variability	11
1.3.5	Mass loss	12
1.4	Properties of oxygen-rich AGB stars	14
1.5	Observations of evolved star atmospheres	15
1.5.1	Interferometry	15
1.5.2	Interferometric observations of evolved star atmospheres	17
1.5.3	Spectroscopic observations of RSG star atmospheres	18
1.5.4	Tomography of AGB star atmospheres	20
1.6	Model atmospheres of AGB and RSG stars	22
1.6.1	1D hydrostatic MARCS model atmospheres	23
1.6.2	3D radiative-hydrodynamics CO5BOLD simulations of stellar atmospheres	24
1.7	Outline of the PhD thesis	27
2	The tomographic method	31
2.1	Introduction	32
2.2	The tomographic method	33
2.2.1	The 1D contribution function	33
2.2.2	Mask construction	34
2.2.3	Comparison of "old" and "new" tomographic techniques: the Mira variable V Tau	37
2.2.4	Mean formation depth of spectral lines	38
2.3	Application to 3D atmospheres of red supergiants	39
2.3.1	The CFLD for the 3D simulation: single ray	40
2.3.2	The CFLD for the 3D simulation: stellar disk	44
2.3.3	Tomographic masks	46
2.3.4	Can tomography reliably recover the V_z distribution in a 3D atmosphere?	47
2.4	Conclusions	51

3	Application to the RSG star μ Cep	55
3.1	Introduction	56
3.2	Methodology	57
3.2.1	Tomography	57
3.2.2	Effective temperature determination	59
3.3	The red supergiant star μ Cep	61
3.3.1	Observations	61
3.3.2	Results	61
3.4	3D radiative-hydrodynamics simulations and detailed radiative transfer	69
3.4.1	Results	71
3.4.2	Understanding hysteresis loops from the 3D RHD simulation	76
3.4.3	Surface vs. deep convection	79
3.4.4	Convective and acoustic timescales	80
3.5	Conclusions and future prospects	82
4	Application to the Mira star S Ori	85
4.1	Introduction	86
4.2	Observations and data reduction	88
4.3	Tomographic method	90
4.4	Calibration of the tomographic masks in terms of geometrical depth	93
4.5	Conclusions and perspectives	94
4.5.1	The advantage of using tomography for evolved-star atmosphere studies	96
4.5.2	Derivation of the shock-wave velocity	96
5	RSGs vs Mira stars	97
5.1	Introduction	97
5.2	Application of the tomographic method to the Mira star RY Cep	97
5.3	Comparison between RY Cep and μ Cep	98
5.3.1	Radial velocities	98
5.3.2	Hysteresis loops	99
5.4	Conclusions	101
6	Conclusions and future prospects	105
6.1	Results	105
6.2	Future plans	107
6.2.1	The role of convection in photometric variability of RSG stars	107
6.2.2	The link between surface structures and atmospheric motions in AGB and RSG stars	108
6.2.3	Measuring the shock-wave velocity in Mira star atmospheres	109
A	Numerical resolution of 3D simulations	111
B	Tomographic masks for VLTI/AMBER data	113
C	Reduction of VLT/CRIFRES data of the Mira star S Ori	119

