Contents

1 Introduction **1**

2 Basics of Tokamaks and Edge Stability Control **5**

2.1 Basics of Tokamaks 5

2.1.1 Tokamak Principle 5

2.1.2 Particle and Energy Exhaust: Limiter vs. Divertor concept 8

2.1.3 High Confinement Mode and Edge Instabilities (ELMs) 9

2.2 ELM Control in High Confinement Plasmas by Resonant Magnetic Perturbations 10

3 Experimental Setup **13**

3.1 TEXTOR Tokamak 13

3.2 Resonant Magnetic Perturbations at TEXTOR: the Dynamic Ergodic Divertor 14

4 Plasma Edge Diagnostics **17**

4.1 High Resolution Gas-Puff Imaging (GPI) 18

4.1.1 Setup of GPI at TEXTOR 18

4.1.2 Electron Density Dependence of H_α Emission 20

4.2 Electron Density and Temperature Measured with a Supersonic Helium Beam 21

4.2.1 Stationary Collisional Radiative Model and Application to Dynamic Processes 22

4.2.2 Application of Supersonic Gas Injections 25
4.2.3 Experimental Setup of the SHE 26
4.2.4 Spatial and Temporal Resolution of the SHE Diagnostic 30
4.2.5 Highly Resolved SHE Measurements and Comparison to Standard Diagnostic at TEXTOR 32
4.3 Particle Flux Measurements with Langmuir Probes in Front of the DED coils 34
4.4 Data Evaluation Methods: Conditional Averaging and Cross-Correlation . 36

5 Perturbed Magnetic Topology at TEXTOR and Plasma Response 39

5.1 Field Line Tracing in Vacuum Approximation in High Resistivity Plasmas 40
5.2 Visualization Methods of the Magnetic Topology 41
5.3 Modeling of the Plasma Parameters in a Perturbed Magnetic Topology in Vacuum Approximation 45
5.4 Experimental Findings with static RMP fields in High and Low Resistivity Plasmas 46
5.5 Plasma Response in Resistive Plasmas 49

6 Results 55

6.1 Three-dimensional Imaging of a Rotating Edge Plasma Structure 55
6.1.1 Experimental Scenario 56
6.1.2 Visualization of a Rotating Plasma Structure 58
6.1.3 Summary and Conclusion 61
6.2 Formation of a Three-Dimensional Scrape-Off Layer with Fast Rotating Resonant Magnetic Perturbation Fields 62
6.2.1 Experimental Scenario 63
6.2.2 Formation of a Rotating Three-Dimensional Scrape-Off Layer . . . 64
6.2.3 Summary and Conclusion 68
6.3 Rotation Dependence of Electron Density and Temperature Fields in the Plasma Edge 70
6.3.1 Experimental Scenario 70

6.3.2 Rotation Dependent Shift of the Edge Plasma Structure Relative to the Magnetic Topology in Vacuum Approximation 71

6.3.3 Comparison of Electron Density and Temperature Modulations to the Magnetic Topology in Vacuum Approximation 75

6.3.4 Identification of the Local Magnetic Topology by Density, Temperature and Pressure Profile Reactions 80

6.3.5 Summary and Conclusion 84

6.4 Rotation Dependence of Ion Fluxes in Front of Resonant Magnetic Perturbation Coils 87

6.4.1 Experimental Scenario 88

6.4.2 Rotation Dependence of a Target Plasma Structure 89

6.4.3 Summary and Conclusion 93

7 Summary **95**

List of Figures **106**