Contents

Preface **v**

1. Introduction **1**

1.1. An historical perspective 2
1.2. Characteristics of modern Z-pinch systems 4
1.3. The various types of Z pinches 6
1.4. Pulsed-power drivers 22

2. Equilibria of Z-Pinch Plasmas **31**

2.1. Steady-state equilibria of Z-pinch plasmas 31
2.2. Equilibria of radiating Z pinches 35

3. Dynamics of Z-Pinch Plasmas **44**

3.1. Formation of Z-pinch plasmas: Theoretical modeling 44
3.2. Zero-dimensional models of dynamic Z pinches 45
3.3. Fluid models of Z-pinch plasmas 58
3.4. Self-similar dynamics of an ideal MHD Z pinch 64
3.5. Self-similar solutions for time-dependent Z-pinch equilibria 77

4. Stability of Z-Pinch Plasmas **96**

4.1. The stability of steady-state Z pinches 98
4.2. Effect of ohmic heating and radiative losses: Overheating instability and filamentation 115
4.3. Resistive and viscous effects on Z-pinch stability: Heat conductivity 118
4.4. Effects of finite and large ion Larmor radius: The Hall effect 122
4.5. Kinetic effects 125
4.6. Nonlinear evolution of the $m = 0$ mode 127

5. Rayleigh–Taylor Instability of a Plasma Accelerated by Magnetic Pressure **133**

5.1. Rayleigh–Taylor instabilities of dynamic plasmas 133
5.2. Ideal MHD model: The Rayleigh–Taylor instability modes 135
5.3. Ideal MHD model: Effects of plasma compressibility and magnetic shear 140
5.4. Effect of magnetic shear 145
5.5. Dissipative effects 146
5.6. Large Larmor-radius effects 148
5.7. Nonlinear evolution of the Rayleigh–Taylor instability 153

6. Stability of Dynamic Z-Pinches and Liners **163**

6.1. The thin-shell model 163
6.2. Growth of the RT instabilities in a layer of finite thickness 170
6.3. Rayleigh–Taylor instabilities in an imploding Z pinch: The snowplow model 173
6.4. Imploding wire arrays 178
6.5. Ideal MHD model 197
6.6. Stability of gas-puff Z-pinch implosions 214
6.7. Stabilization of long-wavelength sausage and kink modes of a Z pinch by radial oscillations 226
6.9. Two-dimensional simulation of magnetically driven Rayleigh–Taylor instabilities in cylindrical Z pinches 234

7. Applications of Z Pinches **238**

7.1. Controlled nuclear fusion 238
7.2. Z pinches as sources of x-ray and neutron radiation 241
7.3. X-ray laser 243
7.4. Production of ultrahigh pulsed-magnetic fields 245
7.5. Focusing high-energy particles in an accelerator 246

Conclusions **249**

References **251**

Index **275**