

Contents

Part I Taylor–Couette flow

Pitchfork bifurcations in small aspect ratio

Taylor–Couette flow

<i>Tom Mullin, Doug Satchwell, Yorinobu Toya</i>	3
1 Introduction	3
2 A numerical bifurcation method	7
2.1 Governing equations	7
2.2 The finite element technique	9
2.3 Spatial discretisation and symmetry	11
2.4 Stability	13
2.5 Bifurcation points and extended systems	15
3 Results	16
3.1 Experimental apparatus	16
3.2 Numerical and experimental bifurcation set	17
4 Discussion	18
References	19

Taylor–Couette system with asymmetric boundary conditions

<i>Oliver Meincke, Christoph Egbers, Nicoleta Scurtu, Eberhard Bänsch</i>	22
1 Introduction	22
2 Experimental setup	23
3 Measurement techniques	23
3.1 PIV	23
3.2 LDV	25
4 Numerical method	26
5 Results	27
5.1 Symmetric system	27
5.2 Asymmetric system	30
6 Conclusions	34
References	35

Bifurcation and structure of flow between counter-rotating cylinders

<i>Arne Schulz, Gerd Pfister</i>	37
1 Introduction	37

2	Experimental setup	37
3	Stability diagram	39
4	Primary instabilities	40
4.1	Transition to Taylor vortex flow (TVF)	40
4.2	Transition to time-dependent flow states	42
5	Transition from Spirals to TVF	45
6	Wavy-vortex flow	46
7	Observation of propagating Taylor vortices	50
8	Comparison to theoretical investigations	51
9	Conclusion	53
	References	53

**Spiral vortices and Taylor vortices in the annulus
between counter-rotating cylinders**

	<i>Christian Hoffmann, Manfred Lücke</i>	55
1	Introduction	55
2	System	56
3	Linear stability analysis of CCF	57
4	Bifurcation properties of Taylor vortex and spiral flow	58
5	Structure of Taylor vortex and spiral flow	64
6	Summary	64
	References	66

Stability of time-periodic flows in a Taylor–Couette geometry

	<i>Christiane Normand</i>	67
1	Introduction	67
2	Modulated base flow	71
2.1	Narrow gap approximation	73
3	Stability problem	74
3.1	Perturbative analysis	76
4	Nonlinear models	77
4.1	Amplitude equations	77
4.2	Lorenz model	79
5	Conclusions	81
	References	82

**Low-dimensional dynamics of axisymmetric modes
in wavy Taylor vortex flow**

	<i>Jan Abshagen, Gerd Pfister</i>	84
1	Introduction	84
2	Experimental setup	86
3	An intermittency route to chaos	86
3.1	Onset of ‘symmetric’ chaos	87
3.2	Type of intermittency	90
3.3	Observation of Shil’nikov attractor	92
3.4	Transition to Hopf regime	94

4 A T^3 -torus in spatial inhomogeneous flow 96
 4.1 Axially localised Large-jet mode 96
 4.2 Onset of VLF mode and transition to chaos 98
 5 Discussion 100
 References 100

**Spatiotemporal intermittency
 in Taylor–Dean and Couette–Taylor systems**

Innocent Mutabazi, Afshin Goharzadeh and Patrice Laure 102
 1 Introduction 102
 2 Pomeau model of spatiotemporal intermittency 103
 2.1 Analogy with the directed percolation 104
 2.2 Ginzburg–Landau amplitude equation 106
 3 STI in the Taylor–Dean system 107
 3.1 Main results on critical properties 107
 3.2 STI in other extended systems 108
 4 STI in the Couette–Taylor system 109
 4.1 Experimental setup 109
 4.2 Results 111
 4.3 Physical origin of turbulent bursts 112
 4.4 Kinematics of turbulent spiral 113
 4.5 Hayot–Pomeau model for spiral turbulence 115
 5 Conclusion 116
 6 Acknowledgments 116
 References 116

**Axial effects in the Taylor–Couette problem:
 Spiral–Couette and Spiral–Poiseuille flows**

Álvaro Mesequer, Francesc Marquès 118
 1 Introduction 118
 2 Spiral–Couette flow 119
 2.1 Linear stability of the SCF 121
 2.2 Computation of the neutral stability curves 122
 2.3 Stability analysis for $\eta = 0.5$ 122
 2.4 Comparison with experimental results ($\eta = 0.8$) 127
 3 Spiral–Poiseuille flow 130
 3.1 Linear stability results ($\eta = 0.5$) 131
 4 Conclusions 133
 References 135

**Stability and experimental velocity field
 in Taylor–Couette flow with an axial and radial flow**

Richard M. Lueptow 137
 1 Introduction 137
 2 Cylindrical Couette flow with an imposed axial flow 139
 2.1 Stability 139

2.2	Velocity field	143
3	Cylindrical Couette flow with an imposed radial flow	148
4	Combined radial and axial flow	150
5	Summary	153
	References	154

Transport phenomena in magnetic fluids in cylindrical geometry

	<i>Stefan Odenbach</i>	156
1	Introduction	156
	1.1 Magnetic fluids	157
	1.2 Magnetic properties of ferrofluids	158
	1.3 Viscous properties of ferrofluids	160
2	Taylor vortex flow in magnetic fluids	163
	2.1 Taylor vortex flow as a tool for magnetic fluid characterization	163
	2.2 Changes of the flow profile in magnetic fields	167
3	Taylor vortex flow in magnetic fluids with radial heat gradient	169
4	Conclusion and outlook	169
	References	170

Secondary bifurcations of stationary flows

	<i>Rita Meyer-Spasche, John H. Bolstad, Frank Pohl</i>	171
1	Stationary Taylor-vortex flows	171
2	Convection rolls with stress-free boundaries	172
	2.1 Critical curves of the primary solution	174
	2.2 Pure-mode solutions	175
3	Secondary bifurcations on pure mode solutions	177
	3.1 The 2-roll,4-roll interaction in a model problem	177
	3.2 The perturbation approach	179
	3.3 A Hopf curve	180
	3.4 The 2-roll, 6-roll interaction in a model problem	181
	3.5 Other interactions	183
4	Numerical investigations	184
	4.1 The Rayleigh–Bénard code used	184
	4.2 Convection rolls with rigid boundaries on top and bottom	187
	4.3 Secondary bifurcations in the Taylor problem revisited	191
	References	193

Taylor vortices at different geometries

	<i>Manfred Wimmer</i>	194
1	Introduction	194
2	Flow between cones with a constant width of the gap	195
	2.1 Experimental set-up	195
	2.2 Flow field and Taylor vortices	195
	2.3 Influence of initial and boundary conditions	198
3	Combinations of circular and conical cylinders	200

3.1	Rotating cylinder in a cone	201
3.2	Rotating cone in a cylinder	201
4	Flow between cones with different apex angles	203
5	Flow between rotating ellipsoids	206
5.1	Oblate rotating ellipsoids	209
5.2	Prolate rotating ellipsoids	210
6	Conclusions	211
	References	212

Part II Spherical Couette flow

Isothermal spherical Couette flow

	<i>Markus Junk, Christoph Egbers</i>	215
1	Introduction	215
2	Summary of previous investigations	218
3	Experimental methods	220
3.1	Spherical Couette flow apparatus	220
3.2	LDV measuring system and visualisation methods	222
4	Transitions	224
4.1	Small and medium gap instabilities	224
4.2	Bifurcation behaviour	227
4.3	Wide gap instabilities	228
5	Conclusion	231

Vortical structures and velocity fluctuations of spiral and wavy vortices in the spherical Couette Flow

	<i>Koichi Nakabayashi, Weiming Sha</i>	234
1	Introduction	234
2	Onset Reynolds numbers of various disturbances	235
3	Structure and formation of the spiral TG vortices	236
4	Motion of the azimuthally travelling waves	241
5	Spectral analysis of velocity fluctuations	244
6	Relaminarization	247
7	Concluding remarks	254
	References	254

Spherical Couette flow with superimposed throughflow

	<i>Karl Bühler</i>	256
1	Introduction	256
2	Numerical simulations	260
3	Experiments	260
4	Conclusion	267
	References	267

Three-dimensional natural convection in a narrow spherical shell
Ming Liu, Christoph Egbers 269

1 Introduction 269

2 Mathematical formulation 270

3 Results and discussion 273

 3.1 Axisymmetric basic flow 273

 3.2 Three-dimensional convective motions 274

 3.3 Transient evolution 287

4 Concluding remarks 291

References 292

Magnetohydrodynamic flows in spherical shells
Rainer Hollerbach 295

1 Introduction 295

2 The induction equation 296

3 Kinematic dynamo action 301

4 The Lorentz force 304

5 Magnetic Couette flow 306

References 314

Intermittency at onset of convection in a slowly rotating, self-gravitating spherical shell
Pascal Chossat 317

1 Introduction 317

2 Heteroclinic cycles in systems with $O(3)$ symmetry and the spherical Bénard problem 318

3 Perturbation induced by a slow rotation of the domain 322

References 324

Part III Goertler vortices and curved surfaces

Control of secondary instability of the crossflow and Görtler-like vortices (Success and problems)
Viktor V. Kozlov, Genrich R. Grek 327

Part I. Active control over secondary instability in a swept wing boundary layer 327

Part II. Transition and control experiments in a boundary layer with Görtler-like vortices 336

PART III. Influence of riblets on a boundary layer with Görtler-like vortices 346

References 349

Part IV Rotating annulus

Higher order dynamics of baroclinic waves

<i>Bernd Sitte, Christoph Egbers</i>	355
1 Introduction	355
2 The rotating annulus experiment	357
3 Stability	359
4 Nonlinear dynamics	362
4.1 Measurement technique	362
4.2 Flow characterization	364
4.3 Bifurcation scenario	371
4.4 Comparison to Taylor–Couette flow	374
5 Conclusions	374
References	375

Part V Plane Couette flow

Superfluid Couette flow

<i>Carlo F. Barenghi</i>	379
1 Liquid helium	379
2 Helium II and Landau’s two-fluid model	379
3 Vortex lines and the breakdown of Landau’s model	381
4 The generalized Landau equations	383
5 The basic state	386
6 Rotations of the inner cylinder: absolute zero	389
7 Rotations of the inner cylinder: finite temperatures	390
8 Rotations of the inner cylinder: nonlinear effects	394
9 Rotations of the outer cylinder	394
10 Co-rotations and counter-rotations of the cylinders	396
11 Finite aspect ratios and end effects	396
12 Discussion and outlook	397
References	398

Tertiary and quaternary solutions for plane Couette flow with thermal stratification

<i>R.M. Clever, Friedrich H. Busse</i>	399
1 Introduction	399
2 Mathematical formulation of the problem	401
3 Steady three-dimensional wavy roll solutions in an air layer	404
4 Wavy roll solutions in dependence on the Grashof number	408
5 Transition to quaternary states of fluid flow	413
6 Concluding remarks	414
References	416

**On the rotationally symmetric laminar flow
of Newtonian fluids induced by rotating disks**

Antonio Delgado 417

1 Introduction 417

2 Isotherm, steady flow of a Newtonian fluid 419

 2.1 Governing equations 419

 2.2 Von Kármán's solution for a single rotating disk 420

 2.3 Flow between co-rotating disks 422

3 Conclusions and future investigations 437

References 438



<http://www.springer.com/978-3-540-67514-3>

Physics of Rotating Fluids

Selected Topics of the 11th International

Couette-Taylor Workshop Held at Bremen, Germany,

20-23 July 1999

Egbers, C.; Pfister, G. (Eds.)

2000, XVIII, 442 p., Hardcover

ISBN: 978-3-540-67514-3