John Schuster

Descartes-Agonistes

Physico-mathematics, Method & Corpuscular-Mechanism 1618-33

Springer
# Contents

1 Introduction: Problems of Descartes and the Scientific Revolution

1.1 Prologue: The 'Young' and the 'Mature' Descartes, Natural Philosopher ................................................................. 1

1.2 Descartes and the Historians of Science .............................................. 3

1.3 Key Pitfalls (and Opportunities) Facing Descartes’ Biographers (Even Authors of Quite Truncated Biographies) ............................................. 8

1.3.1 The Problem of Method and Its Texts: Regulae and Discours .............. 8

1.3.2 The Problem of Descartes the Natural Philosopher, and of Natural Philosophy as a Wide and Dynamic Field of Discourse and Contention .................................................. 10

1.3.3 Scientific Biography and the Historiography of Science ..................... 13

1.4 Overview of the Argument ............................................................... 19

References ......................................................................................... 26

2 Conceptual and Historiographical Foundations—Natural Philosophy, Mixed Mathematics, Physico-Mathematics, Method ........................................................................ 31

2.1 Jesuit neo-Scholasticism for the noblesse de robe ..................................... 31

2.2 In Search of Proper Categories and Angle of Attack ................................. 35

2.3 Constructing the Category of Natural Philosophy, Part 1—Natural Philosophizing as Culture and Process ........................................... 37

2.4 Some Heuristic Help: Modeling Modern Sciences as Unique, Agonal Traditions in Process ................................................................. 44

2.5 Constructing the Category of Natural Philosophy, Part 2: The Dynamics and Rules of Contestation of Natural Philosophizing ............................. 49
2.5.1 Articulation on Subordinate Disciplines: Grammar and Specific Utterance ........................................ 50
2.5.2 Find or Steal Discoveries, Novelties or Facts, Including Experimental Ones ........................................ 53
2.5.3 Bend or Brake Aristotle's Rules About Mathematics and Natural Philosophy: The Gambit of 'Physico-Mathematics' .................................................... 56
2.5.4 “Hot Spots” of Articulation Contest: Additional Causes and Effects of Heightened Turbulence in the Field of Natural Philosophizing .................................................... 59
2.5.5 Modeling System Construction and Contestation—The ‘Core’, ‘Vertical’ and ‘Horizontal’ Dimensions of a Natural Philosophical System .................................................... 62
2.5.6 The Mechanics of Responding to ‘Outside’ Challenges and Opportunities .................................................... 65
2.6 The Special Status of the Problem of Method ........................................ 70
2.7 Phases and Stages in the ‘Scientific Revolution’ Seen as an Unfolding Process in the Field of Natural Philosophizing, with Its Attendant Articulations to Other Domains .................................................... 77
2.8 Looking Forward—What Kind of Natural Philosopher/Physico-Mathematician Was René Descartes? ................. 88
References ......................................................................................................................... 93

3 ‘Recalled to Study’—Descartes, *Physico-Mathematicus* ........................................ 99
3.1 Introduction .................................................................................................................... 99
3.2 Beeckman: Mentor and Colleague in Physico-Mathematics and Natural Philosophy ........................................ 104
3.2.1 Corpuscular-Mechanical Natural Philosophy and the Values of the Practical Arts ........................................ 104
3.2.2 Beeckman’s Causal Register, Principles of Mechanics and Version of Physico-Mathematics ........................................ 108
3.3 Exemplary Physico-Mathematics: The Hydrostatics Manuscript of 1619 ........................................ 112
3.3.1 Stevin, Archimedes and the Hydrostatic Paradox ........................................ 113
3.3.2 The Hydrostatics Manuscript [1] The Micro-Corpuscular Reduction ........................................ 114
3.3.3 The Hydrostatics Manuscript [2] The Force of Motion ........................................ 121
3.4 What’s the Agenda: Descartes’ Radical Form of Physico-Mathematics ........................................ 124
3.5 The Physico-Mathematics of Natural Fall ........................................ 128
3.5.1 Introduction—The Study of Fall as [Abortive] Physico-Mathematics ........................................ 128
3.5.2 Beeckman’s Problem, and His Version of Descartes’ Solution ........................................ 130
### 3.5.3 Descartes’ Solution—Triumphs and Pitfalls
of a Physico-Mathematics of Fall ........................................ 134

### 3.5.4 How and Why Descartes Hit a Pitfall ................................ 139

### 3.5.5 The Physico-Mathematics of Fall Stalls—Too
Many Laws, Too Many Causes, No Measurements .......... 145

### 3.6 A Physico-Mathematical Foray into Optics (1620) .......... 153

### 3.7 Conclusion: Options, Pitfalls and Trajectories ........ 163

### References .................................................................... 165

### 4 Descartes Opticien: The Optical Triumph of the 1620s .......... 167

#### 4.1 Genealogical Detective Work—Hints, Clues
and the Problematical Text of the Dioptrique .......... 167

#### 4.2 Cartesian Dynamics in Le Monde .................................. 169

#### 4.3 Making Sense of the Proofs of the Laws of Reflection
and Refraction in the Dioptrique ......................... 173

#### 4.4 Descartes’ Dynamical Premises: Demonstrative Efficacy
and Empirical Weakness ........................................ 178

#### 4.5 Descartes’ Route to the Law of Refraction 1619–1627 .......... 184

##### 4.5.1 The Mydorge Letter of 1626/1627 ......................... 184

##### 4.5.2 Lens Theory and the Date of the Material
in Mydorge’s Letter .................................................. 186

##### 4.5.3 Traditional Geometrical Optics and the Discovery
of the Cosecant Form of the Law .......................... 188

#### 4.6 The Dynamical Premises for the Deduction of the Sine Law
of Refraction: Their Pre-History and History 1618–1629 .......... 190

#### 4.7 The Mechanical Theory of Light 1620–1628 ........ 194

##### 4.7.1 Expository Strategy and Working Distinctions .......... 194

##### 4.7.2 Reprise—The Optical Fragment of 1620 ................. 195

##### 4.7.3 Light as an Instantaneously Transmitted
Mechanical Impulse 1626–1628 ............................ 197

##### 4.7.4 Light as Mechanical Impulse and the Explanation
of the Law of Refraction 1626–1628—The Balance
Beam Model .................................................. 199

#### 4.8 Full Circle: Cartesian Dynamics, Optics
and the Tennis Ball Model 1628–1633 .................. 204

##### 4.8.1 The Exemplar for Descartes’ Laws of Dynamics
in His Physico-Mathematical Optics .................... 204

##### 4.8.2 In a Spin Over Tennis Balls and Boules
of Second Element: Cartesian Dynamics,
Optics and the Problem of Color .................... 209

#### 4.9 Grist for the Method Mill: Method and Optics
in Rule 8 of the Regulae ad directionem ingenii .......... 215

#### 4.10 Conclusion: Looking Forward—Mathematics
and Method: 1618–1629 ........................................ 220

### References ........................................................... 221
5 Analytical Mathematics, Universal Mathematics and Method: Descartes' Identity and Agenda Entering the 1620s

5.1 Introduction: The Struggle Over Mathematics, Universal Mathematics and Method

5.2 The Universal Mathematics of 1619: Rule 4 of the Regulae

5.3 Reading Rule 4: Method and Universal Mathematics

5.4 Straining at the Classical Bit: Descartes' Early Work in Analytical Mathematics

5.5 Genesis and Dating of Universal Mathematics

5.6 The Core of Descartes' Method Discourse in the Early Regulae

5.7 The Making of Cartesian Method-Talk, Winter 1619–1620

5.8 Conclusion: Descartes' Unfolding Agendas and Identities 1618–1620

References

6 Method and the Problem of the Historical Descartes

6.1 The Way Forward: Between Naive Belief and Pure Debunking

6.2 The Cult of Method in Descartes Studies

6.3 Descartes' Method as Mythic Speech: Where 'Myth' Is Not a Colloquial Term of Abuse

6.4 The Failure of Adequate Redescription: An Example of Descartes Attempting to 'Methodologize' a Field of Inquiry

6.5 The Structural Levels and Underlying Metaphors in Descartes' [or Anybody's] Method Discourse

6.6 The First Two Structural 'Effects': Adequate Redescription' and 'Application'

6.7 The Third and Fourth 'Effects': The 'Unity' and 'Progress' of a Method Discourse

6.8 The Rhetorical Functions of Cartesian (and Other) Method Discourses

6.9 Rethinking Method and the Career of Descartes

6.9.1 The Original Inscription of Descartes' Method: Bricolage, Self-Deception and Self-Definition

6.9.2 The Failure of the Regulae, the Birth of the System and the Problem of the Cynical Discours de la méthode

References

7 Universal Mathematics Interruptus: The Program of the Later Regulae and Its Collapse 1626–1628

7.1 Introduction—Toward the Renewed Project of Mathesis Universalis in the Later Regulae

7.2 Rule 8: The Emergence of the Project of the Later Regulae
7.3 Rule 12: From ‘Most Splendid Example’ to the Articulation of the Machinery of Universal Mathematics .......................... 314
7.4 Rules 14–18: The Machinery of Universal Mathematics .......... 320
7.5 The Structure of Universal Mathematics in the Later *Rules* and Its Legitimatory Functions ........................................... 328
7.6 The Instability of the Later *Regulae* and the Beginnings of the Origins of Cartesianism .................................................. 334
    7.6.1 Discursive Corpuscular–Mechanism in Tension with Genuine Mathematization and the Aims of the O-P-P Nexus ................. 334
    7.6.2 Ambushed by the Unexpected Manifestation of the Problematic of Modern (Cartesian) Epistemology ................................. 339
    7.6.3 Analytical Mathematics Works and Is Useful, But Resists Mapping onto the Legitimatory O-P-P Nexus .................................. 343
7.7 Conclusion—The Project of the Later *Regulae* and the Inflection of Descartes’ Agenda and Identity Toward Systematic Natural Philosophy and Metaphysical Grounding .............................. 345

References................................................................................. 347

8 Reinventing the Identity and Agenda: Descartes, Physico-Mathematical Philosopher of Nature 1629–1633 ........................................ 349
8.1 The Problem of Descartes’ Career ‘Inflection Point’ and How to Approach It ................................................................. 349
8.2 Fundamental Intellectual Agendas and Projects 1629–1633 .......... 352
    8.2.1 The Emergence of Cartesian Metaphysical Dualism ................ 353
    8.2.2 Some Voluntarist Theology and Its Strategic Uses ............... 360
    8.2.3 Plenist or Holistic Realism .................................................. 373
8.3 Events and Interactions Partially Shaping the Motives for and Content of *Le Monde* ................................................................. 384
    8.3.1 Abandonment of the Later *Regulae* Actually the Most Important ‘Event’ of All .......................................................... 384
    8.3.2 The Chandoux Episode and Relations with Cardinal Bérrulle: Method and/or Metaphysics and the Defeat of Scepticism ................ 385
    8.3.3 Challenge of Renewed Interaction with Beeckman ............... 390
    8.3.4 The Galileo Affair and Its Perceived Meanings ....................... 394
8.4 The Chronology of *Le Monde* .................................................. 399
    8.4.1 Introduction: Sliding and Tinkering Toward a System of Natural Philosophy ............................................................... 399
    8.4.2 Optics—Physico-Mathematical, Mixed and Practical ............. 400
    8.4.3 ‘Tous les Phainomenes Sublunaires’—The Parhelia: Grasping Opportunities and Pregnant Problems ................................. 404
8.4.4 ‘Tous les Phaenomenes de la Nature’—Le Monde Begins to Crystallize ................................................................. 405
8.4.5 Reprise: In a Spin Over Light and Color ........................................... 407
8.4.6 Descartes at Work, November 1629 to April 1630........ 408
8.4.7 Spring to Autumn 1630—Writer’s Melancholy, Visioning, Spinning and Dealing with Beeckman ........... 410
8.4.8 Organizing the System and Himself—Investigations, Decisions, Hesitations ........................................................ 413
8.5 An Exercise in Counter-Factual History:
If the Regulae Had Not Failed ........................................... ........... 416
8.6 Aspiration, Identity and Strategy at the Birth of Le Monde:
Between Natural History and A Priori ‘Science’ ......................... 418
References............................................................................................... 421

9 Reading Le Monde as Pedagogy and Fable........................................... 425
9.1 Introduction .................................................................................... 425
9.2 The Ground Plan of Le Monde.................................................. 426
9.3 The Common Sense of Corpuscular-Mechanism pour
les honnêtes hommes—The Opening Chapters of Le Monde ........ 428
9.4 Why the Fable of the Mechanistic World?................................. 440
9.5 Working Out the Fable: Chapters 6–8 of Le Monde ............ 442
  9.5.1 Cosmogony, Matter–Extension and the Introduction of Motion and Its Laws .................................................. 442
  9.5.2 The Laws of Nature .................................................................. 444
  9.5.3 Vortex Formation, Stability Principle and [Re-]Introduction of the Elements .............................................. 446
References .................................................................................................. 450

10 ‘Waterworld’: Descartes’ Vortical Celestial Mechanics
and Cosmological Optics in Le Monde ........................................... 453
10.1 Introduction: Uncommon Vortices ................................................. 453
10.2 Descartes’ Vortical Celestial Mechanics in Le Monde........... 455
  10.2.1 Charitable Hermeneutics—Principles and Aims .................. 455
  10.2.2 Size and Speed Distributions of Vortex Corpuscles and the Role of Central Stars ............................................. 458
  10.2.3 Locking and Extruding—Unpacking the Technical Core of the Vortex Celestial Mechanics ............................................. 464
  10.2.4 Genealogical and Systematic Dimensions of the Vortex Celestial Mechanics .................................................. 469
10.3 Beeckman’s Cosmic Balancing Acts—The Last Genealogical Step to the Vortex Mechanics .................................................. 471
10.4 Descartes’ Celestial Vortex Mechanics as a ‘Science of Equilibrium’ in ‘Trinitate’ ...................................................... 475
10.5 Applying the Vortex Mechanics to Local Fall,
the Moon and the Tides: An Exercise in Charitable Interpretation ................................................................. 478
10.5.1 Aims of This Section and the Strategy of Reading .............. 478
10.5.2 Local Fall as Downward Extrusion (In Ultimate Search for an Orbit—Like the Moon's) ........................................ 479
10.5.3 Vortex, Earth, Sea and Moon: Descartes' Theory of the Tides ............................................................. 484
10.5.4 Summing Up the Vortex Mechanics and Its Consequences on Charitable[1] Reading ........................................... 486
10.6 Some Intricacies of the Theories of Local Fall and the Moon—Bearing the Imprint of the Genealogy of Physico-Mathematics ......................................................... 486
10.6.1 The Intricacies of the Theory of Local Fall and Weight ................................................................. 487
10.6.2 Some Intricacies of Descartes' Moon Theory ................. 495
10.7 Cosmological Theory of Light in Relation to Celestial Mechanics and the Style of Cartesian Physico-Mathematics in Corpuscular-Mechanical Model .......... 499
10.7.1 Reprising the Dynamics and Laws of Nature .................. 499
10.7.2 The Cosmological Theory of Light as Tendency to Motion Transmitted Instantaneously Through the Boules of the Vortex ........................................ 501
10.7.3 The Physico-Mathematical Style and Protocols and the Celestial Optics ......................................................... 507
10.7.4 The Physico-Mathematical Hydrostatics of 1619 as Precise Exemplar for the Celestial Optics .......... 509
10.8 Matching of Evidence: The Appearance of Comets in Relation to the Celestial Mechanics, the Cosmological Optics and the Style of Cartesian Physico-Mathematics in Corpuscular-Mechanical Mode ................................................................. 515
10.9 Looking Forward: Le Monde as Natural Philosophical System and Gambit .............................................................. 521
References ........................................................................... 522

11 Le Monde as a System of Natural Philosophy and Gambit in the Field ........................................................................ 525
11.1 Le Monde as Competitive Gambit in the Natural Philosophical Field ................................................................. 525
11.2 Le Monde as a System: 'Core', 'Horizontal' and 'Vertical' Dimensions and 'System-Binding' Moves .......................... 527
11.2.1 Horizontal Analysis of the System in Le Monde ............. 527
11.2.2 'System-Binding' Moves on the Horizontal Plane ........... 532
11.2.3 The Vertical Dimension of Systematicity ...................... 533
11.3 Remediating Problems and Taking the Best Steps Forward in the Principia .............................................................. 538
References ........................................................................... 540
### 12 Cosmography, Realist Copernicanism and Systematising Strategy in the Principia Philosophiae

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.1 More than Remediation: the Principia as a Triumph of Novel and Daring System-Binding</td>
<td>543</td>
</tr>
<tr>
<td>12.2 Cosmogony, Cosmology and Cosmography: Key Categories and Insights</td>
<td>544</td>
</tr>
<tr>
<td>12.3 Matter and Element Theory in Le Monde and the Principia philosophiae</td>
<td>549</td>
</tr>
<tr>
<td>12.4 Inter-Vortical Phenomena</td>
<td>557</td>
</tr>
<tr>
<td>12.5 Co-opting and Re-framing Gilbert’s ‘Cosmic’ Magnetism</td>
<td>558</td>
</tr>
<tr>
<td>12.6 Claims About Sunspots from Galileo and Scheiner to Descartes</td>
<td>561</td>
</tr>
<tr>
<td>12.7 Gaining Strategic Leverage: Sunspots as Explananda and Explanans in the Principia Philosophiae</td>
<td>566</td>
</tr>
<tr>
<td>12.8 Claimed Matters of Fact About Novae and Variable Stars Before Descartes</td>
<td>568</td>
</tr>
<tr>
<td>12.9 Extending the Strategy: Seizing upon Novae and Variable Stars in the Principia Philosophiae</td>
<td>571</td>
</tr>
<tr>
<td>12.10 Raising the Cosmographical Stakes: Genealogy of the Earth and All Other Planets in All Other Systems</td>
<td>574</td>
</tr>
<tr>
<td>12.11 Radical Realist Copernicanism and the Grand Cosmographical Gambit</td>
<td>576</td>
</tr>
<tr>
<td>12.12 Conclusion: Cosmographical System and Strategy in the Principia, the Culmination of Descartes’ Natural philosophical Trajectory</td>
<td>582</td>
</tr>
</tbody>
</table>

References                                                                 | 586  |

### 13 Conclusion: The Young and the Mature Descartes Agonistes

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.1 Coda: Descartes’ ‘Youthful’ Struggles Reconsidered</td>
<td>589</td>
</tr>
<tr>
<td>13.2 Epilogue: The Mature, Public and Published Descartes Agonistes</td>
<td>593</td>
</tr>
</tbody>
</table>

References                                                                 | 600  |

### Appendix 1: Descartes, Mydorge and Beeckman: The Evolution of Cartesian Lens Theory 1627–1637

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.1 Introduction</td>
<td>603</td>
</tr>
<tr>
<td>A.2 Mydorge’s Refractive Instrument: Cosecants, Not Sines</td>
<td>604</td>
</tr>
<tr>
<td>A.3 Mydorge’s Synthetic Propositions 3 and 4 on Anaclastic Surfaces: An ‘Antique’ Version of the Sine Law</td>
<td>605</td>
</tr>
<tr>
<td>A.4 Relating Mydorge’s Propositions 3 and 4 to Descartes’ Analogues in the Dioptrique: From ‘Antique’ to ‘Natural’ Representation of the Sines, Thanks to Isaac Beeckman in October 1628</td>
<td>607</td>
</tr>
<tr>
<td>A.5 Decoding Mydorge’s Proposition 5: The Cosecant Form Leads to the ‘Discovery’ of the ‘Antique’ Sine Form Then Used Synthetically in Propositions 3 and 4</td>
<td>610</td>
</tr>
</tbody>
</table>
A.6  A Reconstruction of Descartes and Mydorge’s
First Analysis of the Anaclastic Problem,
with Cosecant Law of Refraction to Hand.............................. 613
A.7  The Kramer-Milhaud Thesis: Discovering the Law
of Refraction by Analysis of the Anaclastic Problem............... 615
A.8  Conclusions................................................................. 617
References............................................................................. 619

Appendix 2: Decoding Descartes’ Vortex Celestial Mechanics
in the Text of *Le Monde* .................................................. 621