Applied and Computational Historical Astronomy

Angewandte und computergestützte historische Astronomie

tredition®

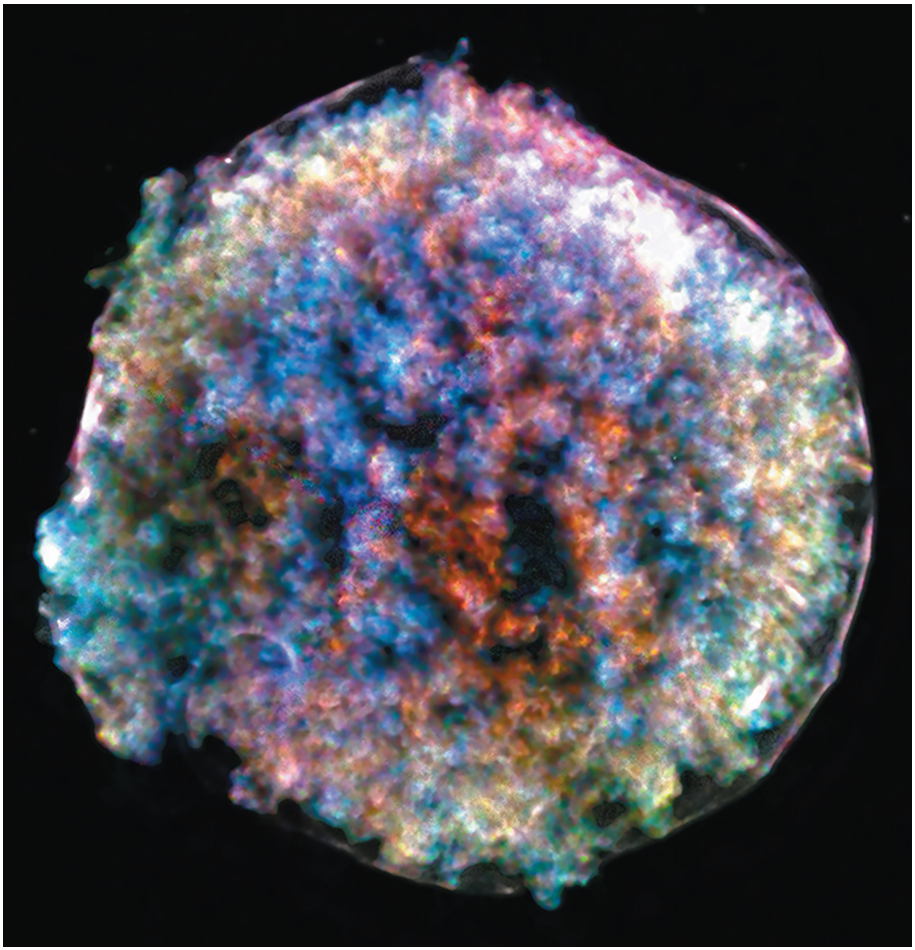

Figure 0.1:
Tycho's Supernove (1572), X-ray image, Chandra X-ray Observatory
(© NASA/CXC/Rutgers/J.Warren & J.Hughes et al.)

Nuncius Hamburgensis
Beiträge zur Geschichte der Naturwissenschaften
Band 55

Wolfschmidt, Gudrun & Susanne M. Hoffmann (ed.)

Applied and Computational Historical Astronomy

Angewandte und computergestützte historische Astronomie

Proceedings of the Splinter Meeting in the *Astronomische Gesellschaft*, Sept. 25, 2020

Hamburg: tredition 2021

Nuncius Hamburgensis
Beiträge zur Geschichte der Naturwissenschaften

Hg. von Gudrun Wolfschmidt, Universität Hamburg,
AG Geschichte der Naturwissenschaft und Technik
(ISSN 1610-6164).

Diese Reihe „Nuncius Hamburgensis“
wird gefördert von der Hans Schimank-Gedächtnisstiftung.
Dieser Titel wurde inspiriert von „Sidereus Nuncius“
und von „Wandsbeker Bote“.

Wolfschmidt, Gudrun & Susanne M. Hoffmann (ed.):
Applied and Computational Historical Astronomy.
Angewandte und computergestützte historische Astronomie.
Proceedings of the Splinter Meeting in the Astronomische Gesellschaft,
Sept. 25, 2020. Hamburg: tredition (Nuncius Hamburgensis –
Beiträge zur Geschichte der Naturwissenschaften; Band 55) 2021.

Figure – Front Cover and Frontispice: Tycho's Supernova (1572), Chandra X-ray Observatory (NASA/CXC/Rutgers/J. Warren & J. Hughes et al.)

Figure – Back Cover: Supernova 1054 – Guest Star, and Crab Nebula (© Susanne M. Hoffmann, NASA 2005, Stellarium)

Center for History of Science and Technology, Hamburg Observatory, University of Hamburg
Bundesstraße 55 – Geomatikum, 20146 Hamburg, Germany
`https://www.physik.uni-hamburg.de/hs/group-wolfschmidt/`

This volume is supported by the *Schimank-Stiftung* and the *Working Group History of Astronomy in the Astronomische Gesellschaft*.

Das Werk, einschließlich aller seiner Teile, ist urheberrechtlich geschützt. Jede Verwertung ist ohne Zustimmung des Verlages und des Autors unzulässig. Dies gilt insbesondere für Vervielfältigungen, Übersetzungen, Mikroverfilmungen und die Einspeicherung und Verarbeitung in elektronischen Systemen.

Publisher: tredition GmbH, Halenreie 40–44, 22359 Hamburg, Germany
ISBN: 978-3-347-27104-3 (Paperback), 978-3-347-27105-0 (Hardcover),
978-3-347-27106-7 (e-Book), © 2021 Gudrun Wolfschmidt.

ISBN 978-3-949060-02-1 (computational Book), © OpenScienceTechnology GmbH.

Table of Contents

INTRODUCTION TO APPLIED AND COMPUTATIONAL HISTORICAL ASTRONOMY 12

1 Introduction to Applied and Computational Historical Astronomy
Susanne M. Hoffmann (Jena) & Gudrun Wolfschmidt (Hamburg) 12
1.1 Introduction to Computational History of Astronomy 14
1.1.1 Digitial History 14
1.1.2 Computational History of Astronomy 17
1.2 Introduction to Applied Historical Astronomy 20
1.2.1 Usage of historical data 21
1.2.2 The aspect of application 22
1.2.3 Exploring stellar evolution: The needs of astrophysics 23
1.2.3.1 New stars – an historical example 23
1.2.3.2 Current research on novae 25
1.2.4 Successful stories 26
1.2.4.1 Supernovae 26
1.2.4.2 Novae 27
1.3 Opening of the conference contributions 27
1.4 Bibliography 28

TECHNICAL ASPECTS 34

2 Exploring Skies Remote in Time and Culture with *Stellarium*
Georg Zotti (Vienna, Austria) 34
2.1 Introduction 35
2.2 Virtual Archaeoastronomy 37
2.2.1 Why simulation is necessary 38
2.3 *Stellarium* 39
2.3.1 *Stellarium* for Virtual Archaeoastronomy 40
2.3.2 Skycultures 41
2.3.3 Calendars 48
2.3.4 Simulation of transient phenomena 50
2.3.5 Interfacing with other programs 51
2.4 Conclusion 51

2.5 Bibliography 52

3 Modeling the Cosmos – Developing a Digital Research Environment for the Computational History of Ancient Astronomy
Ido Yavetz & Luca Beisel (Tel Aviv, Israel) 56
3.1 Background: Ancient Astronomy and the Question of Visualization . 58
3.2 Project Description 59
3.2.1 Overview 59
3.2.2 Technology 60
3.2.3 Stage of Development 60
3.2.4 Functionality 60
3.2.5 User Interface 61
3.2.6 The virtual planetarium as a tool for study and teaching 62
3.2.7 The virtual planetarium as a tool for original research 63
3.2.8 Additional Screenshots 65
3.3 Bibliography 65

4 (Semi-)Manual Data-Mining and -Processing
Karsten Markus-Schnabel (Berlin) 68

GEOMETRY AND ARCHITECTURE 72

5 Alignment of the Temples of Musawwarat es Sufra as exemplification for astronomical orientation of Kushite cult architecture
Tim Karberg (Münster) 72
5.1 Introduction 74
5.2 Alignment of the temples of the Great Enclosure of Musawwarat es Sufra 77
5.3 Alignment of the Apedemak ("Lion") Temple of Musawwarat es Sufra 82
5.4 Religious interpretation of the alignments of the temples of Musawwarat es Sufra 85
5.5 References 86

KEPLER'S *ASTRONOMIA NOVA* – COMPUTATIONALLY 90

6 Kepler's *Astronomia Nova* – A Challenge for Computational History and the Philosophy of Science
Gerd Graßhoff & Mohammad Yeghaneh Abkenar (Berlin) 90
6.1 Kepler's research programme 92
6.2 Observations and data 92
6.2.1 Empirical derivation 92

6.2.2 Brahe's observations 95
6.3 Computational Astronomia Nova 97
6.3.1 A pipeline for text analysis 97
6.3.2 Computational notebooks 99
6.3.2.1 Loading natural language processing models 100
6.3.2.2 Importing Kepler's text corpus 101
6.3.2.3 Data frame of observational paragraphs 101
6.3.3 Reconstruction of the Argument 102
6.4 Summary 104
6.5 Bibliography 106

HISTORICAL STAR CATALOGUES 108

7 Pre-telescopic star catalogues – Accuracy in magnitudes and positions
Philipp Protte (Jena) & Susanne M. Hoffmann (Jena) 108
7.1 Introduction 110
7.1.1 Dependencies and open questions 111
7.1.2 Previous works on historical magnitudes 112
7.2 On the original catalogues 113
7.3 Analysis of the magnitudes 115
7.3.1 Conversion of the magnitude scales 115
7.3.2 Analysis of the magnitude errors 118
7.3.2.1 Variance and covariance 118
7.3.2.2 Dependence on the colour index 120
7.3.2.3 Extinction features 122
7.3.2.4 Star maps and background brightness 124
7.4 Conclusions from the magnitude analysis 129
7.4.1 Statistical significance 129
7.4.2 Final Remarks on the accuracy of pre-telescopic magnitudes . 130
7.5 Appendix: Optical Illusion for regression 132
7.6 Modern attempts of magnitude estimation 134
7.6.1 Neutral density filters 134
7.6.2 A Citizen Science App 137
7.7 Reconstruction of Ptolemy's Armillary sphere 137
7.8 Bibliography 141

8 Measurements of stellar magnitudes in Ptolemy's *Almagest*
Gerd Graßhoff (Berlin) 146
8.1 Bibliography 150

9 How visible are celestial objects?
Victor Reijs (Lochem, The Netherlands) 152
9.1 Introduction . . . 154
9.2 Definitions used to define the visibility of celestial objects . . . 154
9.2.1 Some angle definitions . . . 154
9.2.2 Visibility during full darkness . . . 156
9.2.3 Heliacal events . . . 156
9.2.3.1 Stars and outer planets . . . 156
9.2.3.1.1 Star types . . . 157
9.2.3.2 Inner planets . . . 157
9.2.3.3 The Moon . . . 158
9.2.3.4 A summary of apparent heliacal events . . . 158
9.3 Visibility models . . . 160
9.3.1 Different types of visibility models . . . 160
9.3.1.1 Observational models . . . 160
9.3.1.2 Mathematical models . . . 160
9.3.1.3 Combined models . . . 160
9.3.2 Schaefer's model . . . 161
9.3.2.1 Parameters in Schaefer's model . . . 161
9.3.2.2 Sensitivity analysis using Schaefer's model . . . 162
9.3.3 Sensitivity of observational models . . . 164
9.4 Comparing with observations and other models . . . 165
9.4.1 Schaefer's combined model and Kolev's observations . . . 165
9.4.2 Schaefer's combined model and Schoch's observational model 165
9.4.3 Schaefer's and de Jong's combined model . . . 165
9.5 Analysing more visibility aspects using a combined model . . . 167
9.5.1 Day and night vision . . . 167
9.5.2 Star type determination . . . 167
9.5.3 Visibility of First Crescent . . . 168
9.5.4 Visibility of Venus during a year . . . 168
9.5.5 Date distribution of Venus' heliacal rise . . . 168
9.5.6 Are observations actual observations? . . . 169
9.6 Concluding remarks . . . 171
9.7 Bibliography . . . 173

10 The Star Catalogue of Wilhelm IV, Landgraf von Hessen-Kassel
Andreas Schrimpf (Marburg) & Frank Verbunt (Nijmegen, The Netherlands) 176
10.1 Introduction . . . 178
10.2 Astronomy at Kassel . . . 180
10.3 The Star Catalogue of Wilhelm IV . . . 184

10.4 Accuracy of the Measurements 186
10.5 Accuracy of the Computations 188
10.6 Accuracy of the Star Catalogue 190
10.7 Conclusions and Outlook 192
10.8 Appendix 193
10.9 Bibliography 193

INDIVIDUAL STARS 196

11 Studies of Historical Solar Observations: Recent Advances and Future Prospects
José M. Vaquero (Mérida, Badajoz, Spain) 196
11.1 Introduction 198
11.2 Sunspot counting and solar activity 199
11.3 Sunspot distribution and characteristics 203
11.4 The Maunder Minimum 204
11.5 Some final comments 206
11.6 Bibliography 208

12 What can photographic plate archives contribute to modern astrophysics?
Rene Hudec (Prague, Czech Republic) 214
12.1 Introduction 216
12.2 Astronomical plates as cultural heritage 216
12.3 The non-astronomical photographic collections 218
12.4 Photographic plate scanning methods 218
12.4.1 Transportable digitizing device 219
12.4.2 The inventory of astronomical plate collections 220
12.4.3 Selected plate and/or negative collections 223
12.5 The value of astronomical photographic archives for modern astrophysics 226
12.5.1 Variable Stars 226
12.6 Conclusions 231
12.7 References 231

13 Mira, Eta Carinae and Algol – Variable Stars as Milestones in the History of Astronomy and Astrophysics
Björn Kunzmann (Hamburg) 234

14 Discovery of an emission nebula in the Galactic globular cluster M 22
Fabian Göttgens (Göttingen), Peter M. Weilbacher (Potsdam), Martin M. Roth (Potsdam), Stefan Dreizler (Göttingen) et al. 236

15 Review on the search for historical novae and several byproducts
Susanne M. Hoffmann (Jena) & Nikolaus Vogt (Valparaíso, Chile) 238
15.1 Long-term studies in astrophysics . . . 240
15.2 Suggestions of historical novae and supernovae . . . 241
15.2.1 Supernovae . . . 241
15.2.2 Several questions occurring . . . 243
15.2.3 Novae . . . 243
15.3 How many novae do we expect? . . . 245
15.4 How can we judge the likelihood that a record matches a particular star? 247
15.5 A new computational method . . . 251
15.5.1 Test data . . . 252
15.5.2 Expected Results and Uncertainties . . . 252
15.5.3 Yearly change in the dataset . . . 254
15.6 Results from applying our method . . . 254
15.6.1 Successful findings . . . 254
15.6.2 Are there possibly recurrent novae on the timescale of centuries? 255
15.6.3 Does Shara's CV+shell pair in Sco really match the event 1437? 256
15.6.4 There are novae candidates among the three suggested supernovae in the 4th century! . . . 257
15.6.5 The event 483 CE east of Shen . . . 257
15.6.6 The single event in Niandao: 1404 or 1408 . . . 260
15.6.7 The single event 1181 in Huagai, LM Kui . . . 261
15.6.8 Doubtful records analysed . . . 264
15.6.8.1 Three potential novae after comet 837 CE . . . 264
15.6.8.1.1 Event 837(c). . . . 264
15.6.8.1.2 Event 837(b). . . . 265
15.6.8.1.3 Event 837(a). . . . 266
15.6.8.1.4 Results on 837 CE. . . . 266
15.6.8.2 Eratosthenes' additional star . . . 267
15.6.8.3 The record from 396 CE . . . 269
15.6.8.4 The record from 437 CE . . . 269
15.6.8.5 The records from 667 and 668 CE . . . 272
15.6.8.6 The record from 891 CE . . . 273
15.6.8.7 The records from 1592 CE . . . 274
15.6.9 Open questions . . . 275
15.6.9.1 The single event −76 in Zigong . . . 275
15.6.9.2 The single event −46 east of Juanshe, LM Mao . . . 276
15.6.9.3 The single event +107 in Hu, LM Dongjing . . . 276
15.6.9.4 The event 1073 or '74 south of Dongbi . . . 277
15.6.9.5 The single event 1113 in Yingshi . . . 278

15.7 Summary . . . 279
15.7.1 An addition to the historical catalogue . . . 279
15.7.2 News for the interpretation of text . . . 283
15.7.3 News for astrophysics . . . 284
15.8 Bibliography . . . 288

16 Frequently Asked Questions on our Method
Susanne M. Hoffmann (Jena) 296
16.1 Can we exclude comets by selection criteria? . . . 298
16.2 Why do we consider 'fuzzy stars' and 'broom stars'? . . . 298
16.3 Why we neglect terminology . . . 300
16.3.1 The noun . . . 300
16.3.2 The verb . . . 303
16.3.3 Two examples of misleading text . . . 303
16.3.4 Conclusion on terminology. . . . 304
16.4 On which identification can we rely for the search fields? . . . 305
16.5 What counterparts do we search for novae? . . . 306
16.6 Why do we not consider the distances? . . . 306
16.7 What types of objects do we search for the thesis and antithesis? . . . 307
16.8 Why is the resulting table of targets not the solution? . . . 308
16.8.1 Uncertainty 1: Position and Computing . . . 308
16.8.2 Uncertainty 2: Corrupted text . . . 309
16.8.3 Uncertainty 3: Further possibilities for counterparts . . . 310
16.8.4 Why the research should go on: Uncertainty principle . . . 310
16.9 What are the error bars of the position? . . . 310
16.10 What is the outcome of all this? . . . 311
16.11 Why the *Star of Bethlehem* is irrelevant here . . . 311
16.12 Why 'red Sirius' is irrelevant here . . . 312
16.13 Seven(?) Pleiades . . . 314
16.14 What were the filter criteria for modern counterparts? . . . 318
16.15 Bibliography . . . 318

Authors 321

Nuncius Hamburgensis 328

Index 339