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Nicholas Copernicus in focus of interdisciplinary research: An outline of main results**

(1) Introduction

To be able to comprehend the genesis, essence and reception of Copernicus's scientific works we must apply an interdisciplinary approach in our research of these issues. A good familiarity with the history of Copernican studies should be chosen as the foundation of such inquiries. Furthermore, we should be critically open to all possible aspects of Copernican studies. We must precisely analyse the issues belonging to the areas of astronomy, physics, mathematics, methodology, philosophy of science, logic, rhetoric, theology, general philosophy, arts (with literature, painting, ...), linguistic, politics (including the question of German-Polish quarrel about Copernicus), ... as well as the question of patronage. We must consider all these matters through their historically changing contexts.

I applied this type of broad strategy in my own Copernican studies over the last twelve years. This approach — at least by the author's conviction and by that of some of his careful readers — appeared to be fruitful or even very fruitful.[1] In this paper I would like to elaborate on the key concepts of my earlier works. For details of this approach, see my works mentioned in *Bibliography*.

(2) Methodology and the history of science

It is an obvious truth that methodological analyses of historical texts cannot be distorted by presentism (Whig's interpretations). That is why in such analyses we should attempt to clearly determine two groups of problems, those which depend and those which do not depend on the epoch. This general observation is valid also in the case of research pertaining to the history of the methodology of all mathematico-physical sciences, that is, all sciences which consist of (1) making observations and measurements of phenomena (by help of various measurement tools) and (2) creating mathematical models of phenomena. Let us notice that these branches were referred to different ways throughout History: the quadrivium (with astronomy and optics), mathematics, Aristotelian physics (in special cases!), mathematico-physics, exact sciences, mathematico-physical sciences, and modern physics. [*Notice, in this point we do not decide about ontological, hypothetical or instrumental character of postulated models! It always depends on historical context.*][2]

What does the general method of these disciplines consist of? My answer is this: the Hypothetico-Deductive Method of *Korespondenzdenken* (Correspondence-oriented Thinking) [later called the HDMCT]. This method is composed of two complementary parts: the Hypothetico-Deductive Method (HDM) and the Method of *Korespondenzdenken* (Correspondence-oriented Thinking) [MCT], that is *HDMCT = HDM + MCT*.[3]

The HDM is a general method of mathematico-physical sciences. It gives a researcher clear answers to some fundamental methodological issues, such as *hypothesis*, *deduction*, *the issue of the economy of Nature*, *the issue of theory ladeness of facts* (that is all facts are always explained in the terms of a

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[1] Cf. Schröder (2000), Barker (2005), Zycinski (2005), Evans (2006) and Moesgaard (2006). W. Applebaum (2006), in his review of my monograph Kokowski (2004) expressed an opposite view. However, in my opinion, it is a mistaken review of this book. On this matter, see Kokowski (2007a).

[2] Cf. Kokowski (2004) p. 102–3 fn. 35.

[3] For more details, see Kokowski (1996) p. 10–25.

theory) and *the principle of undetermination of theory by facts* (that is facts do not determine the structure of theory entirely).[4]

However, the HDM — as a characterisation of a scientific method — still passes over the very important methodological subject-matter of: (a) correspondence between theoretical and observational magnitudes, (b) correspondence principles linking subsequent theories (such as *Quantum Mechanics* and *Classical Mechanics*, or *Relativistic Mechanics* and *Classical Mechanics*), and (c) the correspondence postulate of a new theory (that we are searching for) and old theories (already accepted). The problems mentioned here are analysed by the Method of *Korespondenzdenken* (MCT).

In the context of my considerations on the scientific method I assume that one of the best indicators of the maturity of a branch of science and of a scientific revolution having occurred, is the following criterion. The formulation of a certain new (scientific) theory / law is linked to an old theory / law by means of a certain generalized correspondence principle. ... The global or local character of this type of revolution depends on the profoundness of the newly formulated theory and its relationship to other theories of the exact sciences. The classical examples of theories linked by a generalized correspondence principle are quantum mechanics and classical mechanics as well as relativistic mechanics and classical mechanics.

Furthermore, in analyses of the development of mathematico-physical sciences it is worth remembering that many important features of new and old theories are linked by a certain generalized correspondence principle.

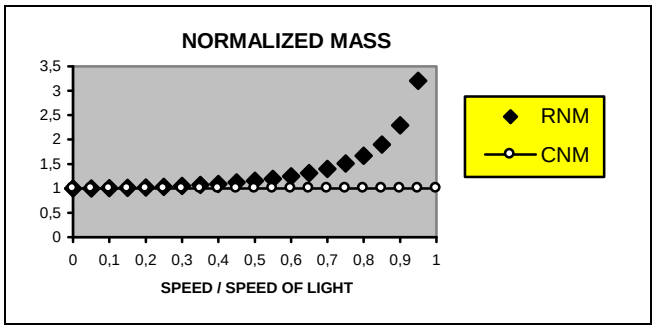
- The new theory is (in a mathematical sense) more general than the old theory.
- Within the mentioned limit space, the new and the old theories are observationally equivalent, whereas outside it they are observationally non-equivalent. It should be noted, however, that in the case of the generalized correspondence principle of theories not every type or range of modeled phenomena must exhibit such observational equivalence.
- Corresponding theories (that is theories which are linked by a certain generalized correspondence principle) are ontologically and notionally incommensurable, and thus they are mutually irreducible (as Kuhn and Feyerabend assumed), but this does not mean that they are incomparable (as Kuhn and Feyerabend thought).
- The graphs of corresponding laws (functions) coincide or merge in a certain limit space and within a certain range of variables. That is to say that the corresponding laws (functions) are observationally equivalent within this range, and beyond this range the graphs visibly differ, i.e. they are observationally non-equivalent beyond this range. In a special case, the limit case may comprise a whole domain of independent variables of compared functions; we then speak of observational equivalency of the new and old laws throughout the entire range of variables.[5]

Let us ilustrate above considerations by the following graphs of the dependence of normalized inertial mass (that is the quotient of inertial mass and inertial mass for a speed equal to zero) from velocity according to relativistic mechanics (RNM) and classical mechanics (CNM).[6]

[4] *It is maybe worth adding one clarification here*: It is a historical observation that in a general case a scientific reasoning is a mix of inductive, deductive and abductive reasoning. For this reason the term "deduction", in general, is understood here as a conglomerate of "deduction" in the narrow sense *(which is the process of deriving the consequences of what is known*), "induction" (which *is the process of reasoning in which the premises of an argument support the conclusion but do not ensure it*) and "abduction" *(which is the process of explaining what is known; which works in reverse of deduction in the narrow sense).* Forms of such understood deduction in historical cases must be considered in historical contexts.

[5] For more details on this issue, see Kokowski (2004) p. 59–60.

[6] The considerations on the HDMCT (and the MCT especially) outlined above played very important role in my studies in theoretical physics on an almost localized Fermi Liquid. See Spalek, Kokowski ... (1989a), (1989b).



And now let us look at graphs of the rate of ecliptic longitudes of fixed stars (named , after Copernicus, by Swerdlow precession) according to Ptolemy, *Alfonsine Tables* and Copernicus, quoted from the two papers by Dobrzycki (1965) and by Swerdlow (1980), respectively:

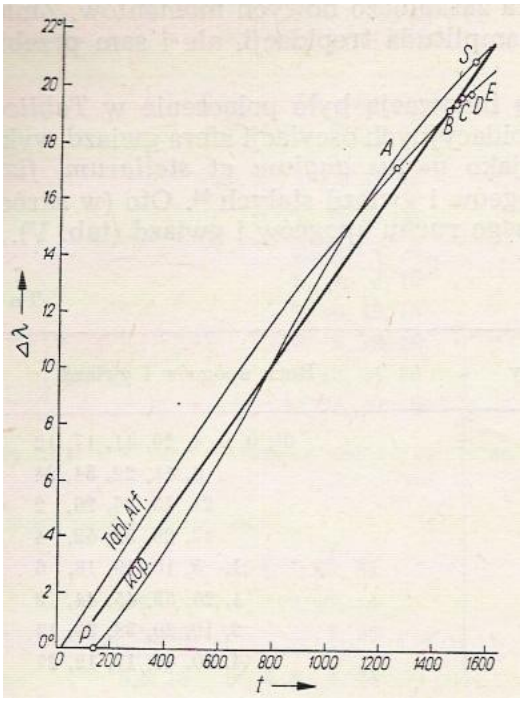


Figure 6 from Dobrzycki (1965), p. 21.

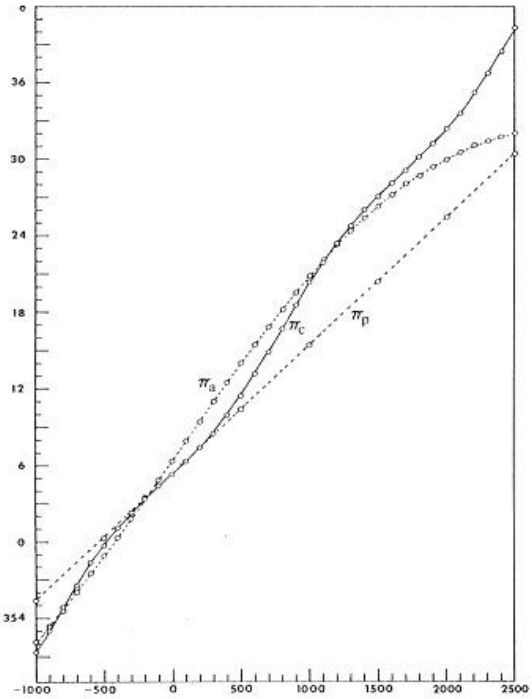


Figure 3 from Swerdlow (1980), p. 218.

The apparent differences between these two figures resulted my descision in 1994 to analyse Copernicus's theories described in the *Commentariolus* and *De revolutionibus*, in the light both of the Hypothetico-Deductive Method of *Korespondenzdenken* (Correspondence-oriented Thinking) and of historical contexts.

(3) Copernicus's methodological views and theory in the light of the HDMCT and of historical contexts.

Simple characteristics of the essence of book I of *De revolutionibus* and the HDM

From my point of view, book I of *De revolutionibus* is a kind of *dialogue and polemic* to book I of the *Almagest* regarding a proper system of the universe and related questions.[7] Furthermore, book I of *De*

[7] Earlier historians of science, and especially astronomy, except of Moesgaard (1974), thought that Copernicus followed the lines fixed by Ptolemy absolutely. For details, see Kokowski (2004) p. 80 fn.1.

revolutionibus openly *engages in polemics* with some most crucial chapters of the *Physica* and *De caelo* of Aristotle.[8]

A more careful inspection proves that the true, but to some degree hidden, heart of book I of *De revolutionibus* was (a) a dialogue and polemic with the Buridanists' method of *persuasiones* (a type of rhetorical and dialectical method of argument) for the motion of the earth by an application of (b) Renaissance humanistic rhetoric and dialectics, *and* (c) Plato and Ptolemy's tradition of comprehending the relationship between mathematics and physics, *and* (d) the scholastic idea of *scientie media*e (i.e. both mathematical and physical sciences).

In agreement with this tradition of thought, motions of the Earth were treated by Copernicus himself as hypothetical, but more probable than of the immobility of the Earth. We read in *De revolutionibus*, book I, chapter 8, p. 17:

> all these arguments make it more likely (*more probabiblior*) that the earth moves than that it is at rest. This is especially true of the daily rotation, as particularly appropriate to the earth.

It is worth noting that *this quotation has been overlooked by earlier researchers who assumed that Copernicus treated these motions as certain, ontologically true*!

Mathematical details of Copernicus's and Ptolemy's theories and the MCT

In a next stage of the research I analyzed the mathematical details of Copernicus's and Ptolemy's theories developing the approach of some professional historians of mathematical astronomy (especially Noel M. Swerdlow). In a nutshell, I cast a new light upon this approach by considering a strategy determined by the MCT (including the correspondence postulate and the correspondence principle of the two theories) in the historical context of Copernicus's works. Among others, I led a detailed analysis of the way problems such as, slow changes in the obliquity of the earth's equator (according to Copernicus) or the ecliptic (according to Ptolemy), correspond to slow changes in the ecliptic longitude of fixed stars and the effect of the "so-called" first inequality.[9] Thanks to this research I demonstrated that (a) Copernicus's theory is linked with Ptolemy's theory by numerous correspondence principles and, what is more, (b) Copernicus himself in his search for new theory applied the postulate of correspondence between his theory and Ptolemy's (earlier researchers overlooked these methodological problems).[10]

In consequence, it appears that the crucial thesis of the Copernican studies of the last 30 years — which states "the Copernican revolution is a kind of myth"[11] — is simply wrong and is caused by a lack of integration of research. Why? The truth is quite the opposite: the Copernican revolution; because Copernicus's and Ptolemy's theories are linked by numerous correspondence principles (this relationship is analogous to the relationships linking *quantum mechanics* and *classical mechanics* or *relativistic mechanics* and *classical mechanics*).

The question „Did Copernicus provide any physical proof for the motion of the earth?", the HDMCT and historical contexts.

To be able to answer the question mentioned above, we should first notice that 'a physical proof" in modern terminology means 'to explain observed phenomena by postulated physical hypotheses that explain phenomena, and a (hypothetical) mathematical model, that saves phenomena'. However, this method of understanding a physical proof coincides with a mathematical proof in the context applied by Copernicus himself who accepted Plato's and Ptolemy's understanding of the problem explained in *Timaeus* and *Laws* by Plato, and *Almagest* by Ptolemy, respectively. Then, since Copernicus's theory

[8] Earlier historians of science thought that Copernicus followed the lines fixed by Aristotle absolutely. For details, see Kokowski (2004) p. 54 fn.8.

[9] See Kokowski (1996) p. 46–70, Kokowski (2004) p. 62–70.

[10] Before my studies only Moesgaard (1974a) p. 91 noticed that "a correspondence which includes phenomenological equivalence for ancient times only" better describes relationships between these theories [that is Copernicus' and Ptolemy's theories] on the level of saving phenomena opposed to simple "equivalence" of models of these two theories). This right idea was overlooked by other historians of mathematical astronomy, including Swerdlow (1980) (though, on pages 217–218, he noticed "that Copernicus's precession corresponds very closely to Ptolemy's from –300 to + 200, covering the period of the observation used by Ptolemy"), and Swerdlow, Neugebauer (1984).

[11] For details see Kokowski (2004) p. 26–30.

was not worse in the empirical sense than Ptolemy's (since they were empirically equivalent for relatively short periods compared with some time constants of this theory), we must conclude that Copernicus provided many 'mathematical proofs' for the motion of the Earth (in Plato's sense explained in the *Timaeus* and *Laws*), i.e. 'physical proofs' in modern terminology.[12]

Methodological conclusion

The analyses of Copernicus's works: the *Commentariolus* and the *De revolutionibus*, not only, determined that we may find all elements of the HDMCT (including issues belonging to the HDM and the MCT, as both a postulate of correspondence and principle of correspondence between two theories) but also that he used them in consciously developing his theory over the years.[13]

(4) Genesis of Copernicus's methodological views

According to a common belief especially esteemed by all technocratists, that science is almost exclusively a product of modern times. In this context my previous analyses of Copernicus's methodology might be accepted as a slight correction to this view. In this spirit Copernicus would be the founding father of a scientific method. However, this would be the wrong idea. Why? Since, as my contextual analyses show, it appears that the first part of Copernicus's methodology — which in today's terminology I call the hypothetico-deductive method — stems directly from Plato's *Timaeus* and Buridanism, and the second part — which I call the method of *Korrepondenzdenken* (of Correspondence-oriented Thinking) — stems from Ptolemy's *Almagest*.[14]

In the context of Plato's thought I have distinguished two Platonisms: *Plato's mathematical abstractionism* and *mathematico-physical hypotheticism*.

> *Platonism$_1$* assumes a sharp dualism of ideas and things; negates a possibility of empirical research in such branches as astronomy and harmonics; and directs a man to purely dialectical (logical), formal abstract considerations. *Platonism$_2$*, while abandoning *Platonism$_1$*, proposes a constructive program of research of natural phenomena. In order to realize it, we must merge purely mathematical considerations (certainty of proofs, measures) with conjectural considerations (mechanisms of explaining phenomena) [Kokowski (2004), p. 128)].

The Platonism$_1$ is very well known to the historians of the exact sciences and of methodology, including researchers of Copernicus's thought.[15] However, the Platonism$_2$ (which appears to be a necessary element to a solid understanding of Copernicus's theory) has been overlooked by earlier researchers.[16]

(5) Reception of Copernicus's views

As specialists very well know, during the Renaissance and the Baroque era only about dozen scholars accepted the motions of the Earth postulated by Copernicus. In contrast, competent astronomers of Copernicus's times (such as astronomers from the Wittenberg school and Tycho Brahe) accepted Copernicus's mathematical models (or at least most of them) transformed to geocentric or geo-heliocentric orders.

In this context, it is necessary to mention two *crucial aspects overlooked by earlier researchers*. Firstly, because of a limited precision of measurements, there was not then and there is not now, any valid physico-mathematical proof that the Earth is placed in the centre of the universe. Secondly, it

[12] It is a complicated and subtle problem. More about it see Kokowski (2004) p. 85–95, 121–130, 137–140.

[13] For details see fn. 9, above.

[14] On Plato, see Kokowski (2004) p. 121–130; on Ptolemy, see Kokowski (2004) p. 137–140, Kokowski (2000) p. 81–87.

[15] Cf. Kokowski (2004) p. 128–9 fn. 5.

[16] To be exact, one should add that after release of my book it appeared that Zbigniew Jordan, historian of philosophy, considered the very same problem of Plato's thought long before I did in 1937, in his brilliant monograph *O matematycznych podstawach systemu Platona. Z historii racjonalizmu* (*On mathematical foundations of Plato's system. From the history of rationalism*), chapter IV [– I would like to thank Prof. Grazyna Rosinska who focused my attention on this issue –], the monograph has been forgotten now even by researchers of Plato's thought! We differ only in some details in our interpretation of this part of Plato's thought (mainly in a terminology). However, Jordan didn't apply it to analyse Copernicus' thought.

was Copernicus who noticed that, because of the limited precision of measurements, an apparent bisection of the celestial sphere by a horizon cannot be treated as such a proof.

In consequence, the following serious question emerged. What was the main factor that caused this partial rejection of Copernicus's geo-kinetic theory? My answer is as follows: Since there wasn't any physical proof for a geocentric order, this factor had to be external to the cultivation of the exact sciences. In my search for of potential candidates, I went to the footnotes of Professor Stefan Swiezawski, the great historian of philosophy, especially of the 15th century (it is odd, but his works[17] are not known by many researchers of the "so-called" Scientific Revolution!). In the context of 15th century philosophy, I considered a family of doctrines which I call *Modern Christian Platonico-Aristotelian syncretism* (starting about 1450, during the pontificate of Pope Nicolas V, Tommaso Parentuccelli (1398–1455; pontificate 1447–1455). Within this doctrine, understood at its purely philosophical level, I distin-guished a whole spectrum of variants:

Modern Christian Platonico-Aristotelian syncretism (starting about 1450)	
Variants	**Advocates**
• Chrystian Platonico-Aristotelian concordism (starting about 1450)	Cardinal Bessarion (ca. 1400–1472) Giovanni Pico della Mirandolla (1463–1494)
• Renaissance Christian Neoplatonism (starting about 1470)	Marsilio Ficino (1433–1499) Franciscus Patricius (1529–1597)
• Modern Christian Aristotelianism (starting in 1455) *It* was *against any form of Platonism and of sympathy to Platonism (e.g. Buridanism);* starting in 1455 with the *Comparationes philosophorum Aristotelis et Platonis by* Georgius Trapezuntius (ca. 1395–1484); assumed a certain role in the Catholic Church up to the 20th century	Georgius Trapezuntius (ca. 1395–1484) Bartolomeo Spina, OP (ca. 1475–1546; since July 1542 to his death in 1546 the Master of the Sacred and Apostolic Palace and the Censor of the Books)

Moreover, in my opinion, the slow reception of Copernicus's theory in the 15th–17th centuries was caused by the rule of Modern Christian Aristotelianism in those times. Note the following three points. Firstly, historians of philosophy determined that a very important advocate of this doctrine was Bartolomeo Spina, OP (ca. 1475–1546).[18] Secondly, historians of the history of science in 1970s showed that Bartolomeo Spina, according to a report by Giovanni Maria Tolosani, OP was the first in Rome to demand the condemnation of Copernicus's work as heretical![19] Let us recall an essential quotation from Giovanni Maria Tolosani, OP (ca. 1470/71–1549), Appendix 4. *De caelo supremo immobili et terra infima stabili, ceterisque coelis et elementis intermediis mobilibus* (written about 1546/47), placed in *De purissima veritate divine adversus errores humanos* (finished in 1544):

> The Master of the sacred and Apostolic Palace had planned to condemn his [Copernicus's] book. But, prevented at first by illness, then by death, he could not carry out this [plan]. This I took care to accomplish afterwards in this little work for the purpose of safe-guarding the truth to the general advantage of Holy Church. (This translation is from Rosen (1975), p. 540.)

Thirdly and finally, it is known that, for the researchers of *Galilleo Affairs*, the views expressed by Giovanni Maria Tolosani on the condemnation of Copernicus's work as heretical was known by Tomasso

[17] See Swiezawski (1970) – (1999).

[18] Heidingsfelder, (1935), esp. p. 1280, idem, (1940); Swiezawski (1974) vol. I, pp. 191–92.

[19] See Garin (1971), (1973); Rosen, (1975); Kempfi (1980/1981); and Granada (1997).

Caccini, OP (1574–1648), one of the most ferocious enemies of Galileo Galilei.[20] Nevertheless, researchers of *Galilleo Affairs* and of the historiography of these affairs, overlooked the problem of Modern Christian Aristotelianism in interpreting the problem of the reception of Copernicus's thought.

Furthermore, there was another doctrine which I called *Biblical literalism regarding cosmological matters*, which was a very important ideological factor in the reception of Copernicanism in 15th–20th centuries. Let us look at a brief characterisation of this factor presented in the table below.

<table>
<tr><th colspan="2">Biblical literalism regarding cosmological matters (starting about 1542)</th></tr>
<tr><th>Essence</th><th>Advocates</th></tr>
<tr><td rowspan="3">Cosmological claims of the Bible as, for example, Joshua's command: "The Sun to stand in Mid-heaven" (Joshua 10, 12–14), have to be literally true, because both the Holy Scripture and the agreement of Tradition foreclosed this question. Advocates of this ideology set aside the thought developed in the style of St. Augustine (i.e. his biblical hermeneutics with a proper comprehension of different senses (literal and nonliteral) of the Bible, the Buridanists (for example Bishop Nicole of Oresme), and Cardinal Nicolaus of Cusa, including physics of Buridan's school and hypothetical physics postulated by Nicolas of Cusa.</td><td>Bartolomeo Spina, OP (ca. 1475–1546; the Master of the Sacred and Apostolic Palace and the Censor of the Books);
Giovanni Maria Tolosani, OP (ca. 1470/71–1549)</td></tr>
<tr><td>The times of the Gallileo affair
Cardinal Roberto Bellarmino, SJ (1542–1621);
Tommaso Cacini OP (1574–1648);
Pope Urban VIII, Maffeo Barberini (1568–1644); pontificate 1623–1644.</td></tr>
<tr><td>20th century
Members of the Tychonian Society founded in 1971 and since 1991 called the Association for Biblical Astronomy</td></tr>
</table>

Notice, if we take the two doctrines mentioned, i.e. *Modern Christian Aristotelianism* and *Biblical literalism regarding cosmological matters*, into account we able to explain a process of assimilation of Copernicanism in Catholic and Protestant Churches better than it was done in earlier interpretations.

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[20] See: Fantoli (2002) p. 38 fn. 46.

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