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INTRODUCTION

Theology and mathematics prima facie seem to be as far apart as two branches of knowledge can be. Yet there are connections between them. Let us look first at why mathematics can be of interest to theologians. This is due to mathematical examples, methods, models, analogies, and even ideologies.

It is well known that mathematics provides a wealth of examples not only for philosophy but also for theology. Numbers have been, since the Greek philosophers, prime examples of abstract, nonmaterial objects. Also more advanced mathematical concepts can serve as ideas to which reference is made in theology. The concept of infinity is perhaps the best known, and the "paradise" of abstract sets to which Cantor has led us remains the most shining example.

Methods used by mathematicians, primarily mathematical proof, are sometimes borrowed by theologians. For example, Leibniz claimed he did so in some theological arguments, and Spinoza is famous for his attempt to use the axiomatic method.

Mathematics provides tools to visualize theological concepts, as for example did Nicholas of Cusa. Also in science, mathematics enables us to construct models, and according to some authors, similar models can be applied in theology too. Mathematics can be also used in a looser way, by showing instructive analogies, like the examples of structures, or realms of mathematical entities, not graspable to us even if our knowledge grows. The totality of all alephs can serve as one example; the inexhaustibility of the concept of number, demonstrated by Gödel, as another one.

Non-Euclidean geometries shattered the idea that necessary unique truths could be naturally formulated. Moreover and less obviously, mathe-

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matical ideologies, like Intuitionism or Platonism, function in some way as distinct "religions", religions that compete – and "conversions" are possible. Von Neumann said that the shift from one to another, and back, can be felt as humiliation. One can also maintain that these ideologies do not compete but just coexist. This fact can constitute an interesting point of reference for reflections on religions.

Mathematical concepts and achievements influence theology. How deep and valuable are or could be those influences is another matter. This is, however, *not* what is studied in this volume. Here we are interested in the reverse influence, or rather the problem whether there exists an influence of theology on mathematics. This is a much less investigated area. It plays a minor role in collections of studies on the interconnections of mathematics and theology, like, for instance, *Mathematics and the Divine: A Historical Study* ed. by Teun Koetsier and Luc Bergmans (2005), or the issue of *Theology and Science* vol. 9, No. 1 (2011) devoted to mathematics.

In the present volume theology, traditionally conceived as science about God, is understood much more broadly as any reflection rooted in one or several religious traditions. It is a wide-ranging area. At one end it could be more like a rational expression of religiosity, at another, it could come close to a science of religion. All kinds of religious motives and theological concepts that could contribute to the development of mathematical ideas constitute the research field of the present issue of *Studies in Logic, Grammar and Rhetoric.*

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The first paper, "Theological Metaphors in Mathematics" by the undersigned Stanisław Krajewski is both a self-contained review of the problem and a continuation of the present Introduction, mentioning several papers included in the present volume. It shows that infinite sets and infinite processes are treated by mathematicians as if they had divine powers. Although it is now routine, the divine-like approach has been criticized and even today some philosophers criticize "theological mathematics". Other metaphors used by mathematicians are considered, especially phrases used in "the kitchen of mathematics", and some historical examples are mentioned, among them the hypothesis of the ritual genesis of arithmetic and geometry, the religious background of the emergence of zero, the role of Name-worshipping. The paper's thesis is modest: "these examples as such do not unquestionably prove by themselves that religion or theology was directly influencing the development of mathematical ideas. They do suggest, however, the connections that need to be explored further."

Vladislav Shaposhnikov's paper "Theological Underpinnings of the Modern Philosophy of Mathematics. Part I: Mathematics Absolutized" is in spirit very similar to the preceding introductory article, but it deals primarily with the foundations of mathematics. According to Shaposhnikov, theological connections remained in hidden form in the popular philosophy of mathematics. In this quasi-religious approach mathematics has "divine" properties: it is certain, infallible, necessary, consistent, supremely rigorous, universally applicable. This background explains why set-theoretical paradoxes provoked such a huge crisis. Shaposhnikov provides many illustrations of the view that a remnant of theological thinking has been present in the philosophy of mathematics. In a second paper (see below) he tests this view by analyzing the creators of the main foundationalist programs.

Whereas the first two papers review the field investigated in this volume the next six articles deal with specific thinkers, ranging from the 13th to the 20th century. They are arranged chronologically.

The paper "The Art of Ramon Llull (1232–1350)" by Teun Koetsier is devoted to the presentation of the calculus devised by Ramon Llull, or Lullus, who was a theologian and wanted to convince Muslims and others of their errors. His Art is difficult to understand, but it was "so influential that it deserves to be studied." Some authors see it as a precursor of later logical systems. In addition, some of Llull's theological considerations helped create, claims Koetsier, the differential and integral calculus in the 17th century.

Zbigniew Król in the paper "Mathematics and God's point of view" presents the process of the emergence of the so-called "God's point of view" in mathematics. This means the point of view of an eternal, unlimited subject who can grasp in its totality the infinite object like the (entire) straight line. The writings of the 14th century scholar Nicole Oresme are presented in considerable detail. It was he, writes Król, who offered the first fully fledged effective application of God's point of view, and as a result actual infinity was admitted into mathematics.

The paper "Between Theology and Mathematics. Nicholas of Cusa's Philosophy of Mathematics" by Roman Murawski, deals with the important 15th century theologian and mathematician who used ideas taken from one of these domains in the other. He claimed that in geometry the infinite precedes anything finite. The explanation was theological: "everything finite is originated from the Infinite Beginning." He also wrote that he wanted "to improve mathematics by *concidentia oppositorum*." Cusanus consciously attempted "to explain how our (mathematical) knowledge can approach God's knowledge" and then applied those insights "as a principle of the ontology of mathematics."

The remaining papers deal with modern mathematics and foundational studies.

In his paper "From Religion to Dialectics and Mathematics. Schleiermacher's theological contribution to the development of modern tensor calculus in Grassmann's Ausdehnungslehre" Wolfgang Achtner enters the discussion on the influence of the theologian (and mathematician) Schleiermacher on the mathematician (and theologian) Grassman, who is known as the creator of a crucial modern approach to mathematics. According to Achtner, the main contribution of Schleiermacher can be seen in providing Grassman with the idea of layers of reality and the (universal) method of knowledge acquisition. It is worth mentioning here that Brouwer wrote in his dissertation that "Schopenhauer is right in that every new theorem is nothing but a new 'structure in a structure'."[1] Achtner illustrates the metaphysical, if not explicitly theological, source of Grassman's work, giving examples of his understanding of mathematics, e.g., as a science of structures and freely constructed forms. In geometry he could go beyond three dimensions, and in arithmetic, or algebra, he was able to go beyond commutativity.

Moving to the end of the 19$^{\text{th}}$ century, Aaron Thomas-Bolduc in his paper "Cantor, God, and Inconsistent Multiplicities" enters the discussion about the importance of Cantor's religious views for his development of set theory. Specifically, he argues that Cantor considered absolutely infinite collections, the ones that are too large, or inconsistent, to be sets, not as being merely potential, or as being purely mathematical, but as actual. He believed in their reality. One reason for that belief was theological: if those collections were not real that "would imply an imperfection on the part of God."

The second paper by Vladislav Shaposhnikov "Theological Underpinnings of the Modern Philosophy of Mathematics. Part II: The Quest for Autonomous Foundations," is a continuation of the previous one in this volume, and in some points overlaps with the paper by Krajewski. Shaposhnikov tests the thesis that mathematics began to be seen as a substitute for theology by considering Russell, Hilbert, and Brouwer. They had diverging relationships to religion and theology. Russell opposed religions, but clearly thought for a long time that he found in mathematics what he had wished to find in religion. Hilbert was agnostic but he used famous theological metaphors and his new nonconstructive methods were criticized as "theological". Brouwer was a mystic, which, according to Shaposhnikov, influenced his mathematical activities, and the formation of intuitionistic mathematics. "At the deeper level, the Hilbert-Brouwer controversy was a conflict between two *theological* traditions: intellectualist and voluntarist."

The last two papers both refer to Judaism, but they are completely unrelated.

The paper "Ways of Infinity" by Jean-Michel Salanskis attempts to show similarities between two approaches to infinity: that found in modern mathematics and the foundations of mathematics, and on the other hand, the attitude to the Infinite that can be detected in the tradition of Judaism. To define the similarity, he introduces the concept of "epistemological infinity", the idea of an unlimited resource of knowledge and understanding, an infinitely rich prospect of layers of meaning. By this comparison Salanskis indicates an interesting parallel between mathematics and a tradition routinely described as "religious", but his point is that the similar epistemological perspective of the infinite constitutes not so much the presence of religious themes in mathematics but rather a common point that is more "atheistic" than theological.

The last paper, "Physarum Syllogistic L-Systems and Judaic Roots of Unconventional Computing" by Andrew Schumann, presents an entirely modern theory of unconventional computing, an ongoing project of the author and some other scientists. The link to religion is seen in the motivation of the theory. Namely, it is inspired by a non-Aristotelian syllogistic taken from Talmudic logic, and by some deliberations due to Kabbalists handling strings of Hebrew letters. Inspired by religious motives, medieval Kabbalists devised the first finite automata of the sort studied in this paper.

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Most of the papers published in this volume were presented on the basis of their earlier versions at the conference "Theology in Mathematics?" that took place in Kraków on June 8–10, 2014. The conference was organized by the undersigned Stanisław Krajewski together with Julia Jankowska under the auspices of the Copernicus Center in Kraków, headed by Fr Professor Michał Heller, as well as the Institute of Philosophy of the University of Warsaw. The assistance of all the institutions and people who helped organize the conference is acknowledged, especially John Paul II Pontifical University at whose precincts we met, and Julia Jankowska who did much of the administrative work.

NOTE

[1] After Dirk van Dalen, Another look at Brouwer's dissertation, Mark van Atten, Pascal Boldini, Michel Bourdeau, Gerhard Heinzmann (eds.) *One Hundred Years of Intuitionism (1907–2007). The Cerisy Conference.* Basel: Birkhäuser, 2008, 17.