

On the 125th anniversary of his birth: My “encounters” with Otto Neugebauer

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Abstract. Otto Neugebauer was arguably the most influential historian of mathematics in the 20th century. His main merit was the interpretation of the mathematical content in Old Babylonian texts (around 2000–1600 BCE) and in Neo-Babylonian astronomical texts (around 600–0 BCE) which have come down to us as cuneiform clay tablets. The lecture focused on Neugebauer’s other activities for mathematics, highlighting their astonishing breadth and effectiveness. These include his role as “architect” of the new building for the Mathematical Institute in Göttingen in the 1920s, his work as a founder and director of two leading mathematical abstracting journals in the 1930s and 1940s, his experiences as a non-Jewish refugee from Nazi Germany, and his appearance as a keen and often sarcastic observer of political events. The paper has some overlap with my article (2016) but adds new literature and a discussion of the transition of Neugebauer’s research interests to mathematical astronomy, as revealed in his talk at the ICM in Oslo 1936. In the final section, some work on Babylonian astronomy is mentioned which continues and draws on Neugebauer’s research.

Dedicated to my partner and fellow historian June Barrow-Green (London), who has improved the content and language of my manuscripts for nearly two decades and has thus played a significant role in my winning the Otto Neugebauer Prize.

Introduction

This paper is a reworking of my Neugebauer prize lecture from July 2024 in Sevilla. I never met Neugebauer (Figure 1), not least because of travel restrictions which affected me as an East German before 1990, the year when Neugebauer died in American exile. However, I have worked as a historian on important contributions

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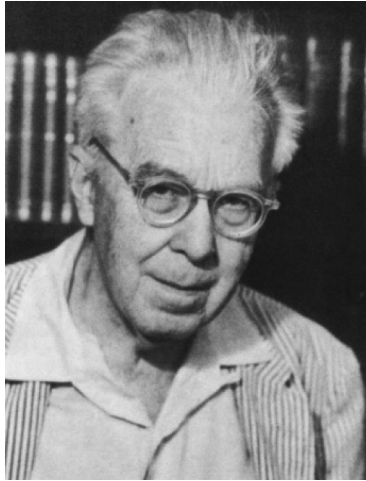


Figure 1. Otto Neugebauer (1899–1990) from ca. 1975 [36, pp. 139–140]. Courtesy of *Centaurus*; used with permission.

of Neugebauer’s to the community of mathematicians, in particular his organizational work, above all in mathematical reviewing. I doubt that a personal meeting with Neugebauer would have been very useful for shedding light on these questions. In his summarizing book on the “History of Ancient Mathematical Astronomy” (HAMA), the 76-year-old Neugebauer wrote categorically, apparently reacting to methodological criticism of his work by a young generation of historians:

I have tried to come as close as possible to the astronomical problems themselves without hiding my ignorantia behind the smoke-screen of sociological, biographical and bibliographical irrelevancies. [23, p. vii]

My historical “encounters” with Neugebauer, however, show that Neugebauer on various occasions had to take a political and philosophical stance. Moreover, even in his work on Babylonian mathematics and astronomy, Neugebauer revealed occasionally political and philosophical positions, as will be shown below. I am not a specialist in ancient Babylonian mathematics which would require, among other things, knowledge of the old Sumerian and Akkadian languages.¹ I will therefore restrict my remarks about Neugebauer’s most important accomplishments between 1935 and 1975 (MKT, UAA, MCT, ACT, and HAMA; see references below) to some more general and cursory ones (in Sections 2, 6–8, and 11).

For more details on Neugebauer’s life and work, the reader is referred to the biography by Neugebauer’s student, Noel M. Swerdlow, and to the collection edited by

¹For more details, see [6, 9, 23, 28].

Alexander Jones et al. in 2016.² Neugebauer’s archive is kept at the Shelby White and Leon Levy Archives Center of the Institute for Advanced Study (IAS) in Princeton. It contains manuscripts but almost no correspondence.³ An important source is the Nachlass of Neugebauer’s friend, Erich Bessel-Hagen (1898–1946), which is located at the University Library in Bonn [11]. Bessel-Hagen’s archive contains 160 letters between him and Neugebauer. It was used for the first time in [33].

1. Start as a mathematician

Neugebauer was born in Innsbruck (Austria) in 1899. He studied physics and mathematics in Graz, München, and Göttingen. When he arrived in Göttingen in 1922, physics and its geometrical aspects (relativity theory, B. Riemann, H. Weyl) were among his foremost interests, not history. However, in this context, he had already shown some interest in the history of non-Euclidean geometry and in Hilbert’s axiomatics, as his early manuscripts and lecture notes in Princeton show [29]. Given existing biographical accounts, it seems unlikely that he engaged in a systematic study of ancient cultures before he studied physics and mathematics.

At first, the young Neugebauer was inspired by the enthusiasm and the brilliance of the mathematicians in Göttingen, including David Hilbert, Emmy Noether, and Edmund Landau. The mathematician Richard Courant (1888–1972) in Göttingen became his mentor and life-long friend. Courant was the successor to the great Göttingen scholar Felix Klein (1849–1925), who had always advocated the equal cultivation of pure and applied mathematics. After Klein’s death in 1925, Courant involved his protégé in the publication of Klein’s “Lectures on the development of mathematics in the 19th century” [10]. One reads in the preface by the editors Courant and Neugebauer from 1926:

At a time when also within science the practitioners are much too impressed by the present and tend to look at this as in unnatural enlargement and exaggerated importance, Klein’s work enables the opening of the eyes of many for the connections and lines of development of our science in its totality. [10, p. v]

Occasionally, Neugebauer shared some of the hubris of the Göttingen mathematicians, among whom it was fashionable to belittle those considered dilettantes. But at the same time, he strongly felt the inadequacy of his own mathematical talent, particularly at the beginning of his career, when he was still looking for a topic to work

²See [9, 26, 29, 33, 35, 36].

³Neugebauer destroyed most of his private correspondence [26, p. 274].

on. On 21 April 1924, Neugebauer wrote to Bessel-Hagen, who at the time was also a student in Göttingen:

The constant and constantly growing doubt about my mathematical talent tends to paralyze my energy. [33, p. 67]

Around this time, Neugebauer felt the need to change his environment, so he went to Harald Bohr (1887–1951) in Copenhagen. Bohr, the brother of the famous physicist Niels Bohr, happened to be a good friend of Richard Courant. He was a specialist in almost periodic functions, and Neugebauer became his co-author in the paper [2] which would remain Neugebauer's only mathematical publication.

2. Start as a historian of mathematics: Egyptian fractions (1926) and beginnings of research on Babylonian mathematics (1927–1929)

When Neugebauer was in Copenhagen, Bohr invited him to write a review of Thomas Eric Peet's edition of the Rhind Mathematical Papyrus, a major source on ancient Egyptian mathematics [29]. This review, written in German, appeared in the Danish journal *Matematisk Tidsskrift* and was Neugebauer's first published article [12]. Neugebauer's review sparked the work that was to form the basis of his doctoral dissertation in Göttingen on Egyptian fractions [13].⁴ Had Neugebauer been a student of Hilbert or Landau, his chances of completing his studies with a dissertation on Egyptian fractions would have been very scant. Luckily, however, he had Courant on his side, someone who valued human character above formal requirements [29, p. 30]. As late as 1963, in his address on Courant's 75th birthday [22], one senses the relief Neugebauer must have experienced when he finally found a field of study which was far removed from the work of the leading and awe-inspiring Göttingen mathematicians, but still tolerated and acknowledged by them, his research in the history of ancient mathematics and astronomy.

Very shortly after his PhD, Neugebauer became interested in Babylonian texts, of which there were far more extant than the few Egyptian sources. As in the case of the Egyptian texts, careful philological work had been done on Babylonian texts before 1900, though not always by scholars with sufficient mathematical knowledge. As early as 1927, Neugebauer obtained his habilitation (teaching permit) in Göttingen with a treatise on the origins of the Babylonian sexagesimal system [14].⁵ Høyrup reports on the immense surprise among historians and mathematicians when, 2 years

⁴In [29, p. 32], details of Neugebauer's doctoral examination are discussed.

⁵Details in [29].

later, Neugebauer found in an Old Babylonian text the solution of second-degree equations for the partition of trapezoids [6, 15].

Neugebauer occasionally used his teaching license to give historical lectures, but he had to earn his living by giving lectures on descriptive geometry, etc. But even more than in historical research or mathematical lectures, Neugebauer was involved in improving the infrastructure of mathematics.

3. Rockefeller and the Mathematical Institute in Göttingen

After the Great War, Courant was heavily involved in several activities aimed at “modernizing” the infrastructure of mathematics in Göttingen and throughout Germany, both in cooperation with Ferdinand Springer (focusing on publications) and together with the American Rockefeller philanthropy. The latter activities culminated in the erection of a new mathematics building in Göttingen in 1929 [30]. As Courant’s biographer Constance Reid remarked:

For this work Courant turned to Neugebauer, whose artistic gifts and knowledge of engineering, his draughtsmanship from his studies in Graz, and his awareness of the needs of mathematicians made him the perfect choice. Courant and Neugebauer were eleven years apart in age and completely different characters. [27, p. 108]

“Courant’s word was maybe,” as the mathematician Hans Lewy told Reid, “Neugebauer’s was yes, yes, no, no.” But the two were fast becoming an administrative team, with the purposeful disorganization of Courant balanced by the efficiency of Neugebauer.

Working behind the scenes, Neugebauer helped draw up new blueprints for a T-shaped building designed with an eye toward functionality and comfort. This design called for two large lecture halls, special rooms for drawing and applied mathematics, a colloquium room for a more intimate atmosphere, and a spacious *Lesezimmer* (reading room) that would house the institute’s large and rapidly growing library [16]. Construction went on for 2.5 years before the new quarters could open in November 1929. In 1930, one Rockefeller officer supervising the Göttingen project wrote back to his superiors in the USA:

Neugebauer is a very able fellow, has had real charge of the details of the building of the new institute here, forceful, pleasing to meet, efficient, and probably worthwhile if his program is at all good. [33, p. 73]

In fact, Neugebauer did not get Rockefeller support for his historical work before 1933, in particular no travel stipend. Only much later as a refugee in Copenhagen was he supported by Rockefeller and other foundations, and then mostly for his editorial work in mathematical reviewing.

4. Mathematical reviewing: *Zentralblatt* (1931) and its conflict with the old *Jahrbuch*

Another dimension of Neugebauer's work for the wider community of mathematicians was his activities in mathematical publishing. This happened in collaboration with the Springer publishers in Berlin, who had taken much responsibility for German mathematics after the Great War. Springer, with whom Courant was closely connected through personal friendship, had published Neugebauer's PhD thesis on Egyptian fractions as a book in 1926 [13]. Springer also paved the way for an outlet which would publish many historical papers of Neugebauer's, in particular MKT and UAA (see references below), in the years to come: the short-lived *Quellen und Studien zur Geschichte der Mathematik, Astronomie und Physik* (Sources and Studies on the History of Mathematics, Astronomy and Physics). The journal was launched in 1929 and ended about a decade later. It was edited by Neugebauer, Julius Stenzel, and Otto Toeplitz [29, p. 26] and assisted by Neugebauer's friend Bessel-Hagen.

But Neugebauer's cooperation with Springer went far beyond his own historical interests. Neugebauer's and Courant's foundation of the abstracting journal *Zentralblatt für Mathematik und ihre Grenzgebiete* (Central Journal for Mathematics and its Bordering Subjects) in 1931 took place against the backdrop of institutional and conceptual conflicts within the German mathematical community, in particular between Göttingen and Berlin. These conflicts were now perpetuated by the competition between the new *Zentralblatt* and the older *Jahrbuch über die Fortschritte der Mathematik* (Yearbook on the Progress of Mathematics) from the 19th century. Problems of the modernity of mathematical production, of the relation between the national and the international, and of defining and reviewing mathematical progress were invoked here. The *Jahrbuch* was strongly supported by the future extreme Nazi, the prominent function theorist Ludwig Bieberbach in Berlin. It was published in the name of the Prussian Academy of Sciences and put much emphasis on its systematic, year-wise reviewing, on the historical perspective on mathematics, on the thoroughness which lay in its slowness, and on the mental discipline which allegedly came with insisting on German as the principal language of reviewing. As managing editor (Schriftleiter) of the young *Zentralblatt*, Neugebauer had to – somewhat ironically – support the priority of the research interests of modern mathematicians over historical

ZENTRALBLATT FÜR MATHEMATIK UND IHRE GRENZGEBIETE

(REINE UND ANGEWANDTE MATHEMATIK
THEORETISCHE PHYSIK · ASTROPHYSIK · GEOPHYSIK)

HERAUSGEGEBEN VON
P. ALEXANDROFF J. BARTHELS W. BLASCHKE E. COCHRAN H. HAHN
MOSKOW BERGHAUSEN HARTMANN GÖTTINGEN WIES
G. H. HARDY F. HUND G. JULIA O. KELLOGG H. KIENTE
OXFORD LEIPZIG VERMILLITS CAMBRIDGE MASS. GÖTTINGEN
T. LEVI-CIVITA R. NEVANLINNA H. THIRRING B. L. VAN DER WAERDEN
ROM HELSINKI WIEN LEIPZIG

SCHRIFTFÜHRUNG:
O. NEUGEBAUER-GÖTTINGEN

I. BAND



BERLIN
VERLAG VON JULIUS SPRINGER
1931

ERGEBNISSE DER MATHEMATIK
UND IHRER GRENZGEBIETE
HERAUSGEGEBEN VON DER SCHRIFTFÜHRUNG
DES
„ZENTRALBLATT FÜR MATHEMATIK“
ZWEITER BAND
3

GRUNDBEGRIFFE DER WAHRSCHEINLICHKEITS- RECHNUNG

VON
A. KOLMOGOROFF



BERLIN
VERLAG VON JULIUS SPRINGER
1933

Figure 2. First title page of *Zentralblatt* (1931) and title page of A. N. Kolmogorov’s *Ergebnisse* report (1933), also edited by Neugebauer.

reflection. As noted above, he and Courant, in their preface to Klein’s historical lectures, had warned against the “unnatural enlargement and exaggerated importance” of the present.

Neugebauer’s duties went beyond the *Zentralblatt* itself, because he also served as an editor of Springer’s new *Ergebnisse* (results) series, where, for instance, A. N. Kolmogorov’s pioneering “Foundations of the Theory of Probability” appeared in the original German in 1933 (Figure 2).

Similar to Neugebauer’s obligation to prioritize mathematical over historical lectures in Göttingen, Neugebauer’s work in mathematical publishing was something of a “bread and butter job” as he rather drastically described it later. In a job interview in February 1939 at Brown University, Neugebauer allegedly replied to the question whether he would be willing to work permanently as managing editor of the *American Mathematical Reviews*, then in the process of being founded:

Effectively, he said eight years on the Zentralblatt were enough for a man who preferred not to have a life sentence to abstract journal editing. [33, p. 93]

5. The Nazis looming and Neugebauer's emigration to Copenhagen

Before the German Nazis came to power in 1933, Neugebauer saw the “writing on the wall” with the rise of extremism, particularly from the right. One finds a rare outburst of political anxiety on the part of Neugebauer at the end of one of his letters to Bessel-Hagen on the eve of the 1930 elections for the German Reichstag (Figure 3). The elections in September 1930 led to a sensational gain in votes for the Nazi Party (NSDAP), thus confirming Neugebauer's fears.

Philip Davis of Brown University, who knew him well, reports the following remark by Neugebauer from a conversation which testifies to his skepticism vis-à-vis biographical and sociological research on the history of mathematics:

If you never heard the sound of Nazi boots below you in the street you cannot understand the history of the period. [4, p. 130]

When the Nazis came to power on 30 January 1933, they soon introduced laws to dismiss those they defined as “Jews” and those they found “politically unreliable,” in particular Social Democrats and Communists. As a non-Jew and a politically not very active person, Neugebauer was not immediately threatened, but almost all of his friends such as Noether and Courant were thrown out [31]. He and the mathematician Kurt Friedrichs then mounted a campaign to gain signatures for a petition to the Prussian Ministry of Education aimed at reinstating Courant as director of the Göttingen Institute of Mathematics. After much effort, including many refusals, they came up with 28 distinguished “Aryan names,” including Artin, Blaschke, Carathéodory, Hasse, Heisenberg, Herglotz, Hilbert, von Laue, Mie, Planck, Prandtl, Schrödinger, Sommerfeld, van der Waerden, and Weyl [27, pp. 151–152], [29, p. 41].



Figure 3. Political drawing from Neugebauer's letter of 20 August 1930 to Bessel-Hagen alluding to tactical collaboration between Nazis and Communists. The text reads “Hand in Hand fürs Vatterland!” thereby mocking the sanctified notion of “Vaterland” (fatherland) by misspelling. Courtesy of University Library Bonn, Nachlass E. Bessel-Hagen. See also [33, p. 75].

This initiative led nowhere under the circumstances of increasing political intimidation. After a visit to Copenhagen, Courant wrote on 12 September 1933 to Neugebauer, advising him in clandestine language (because mail was monitored) to leave Germany:

Generally, Harald [Bohr] tends to emphasize the transformation theory instead of fixed point theorems. That method is also more rewarding for your work. [33, p. 78]

The insecure situation for *Zentralblatt* and the lack of funds for his historical work contributed to Neugebauer’s increasing problems in Göttingen. Neugebauer’s letters to foreigners asking them to protest against Nazi attacks on *Zentralblatt* made him even more suspicious in the eyes of the regime.

Finally, Neugebauer obtained a position in Copenhagen, financed by Danish foundations and by Rockefeller. He moved the editorial office of *Zentralblatt* to Copenhagen in 1934.

6. Neugebauer on race and racism in science and mathematics, in particular at the Oslo International Congress of Mathematicians (ICM) 1936

In Copenhagen, Neugebauer continued publishing on Old Babylonian mathematics,⁶ and, somewhat later, on Neo-Babylonian mathematical astronomy.⁷ At the same time, he continued – with the assistance of his wife – mathematical reviewing, involving an increasing number of non-German referees. As a rule, Ludwig Bieberbach’s infamous racist publications were quoted only by their titles in *Zentralblatt* but otherwise ignored. No line of commentary or quote is, for instance, given in *Zentralblatt* for Bieberbach’s embarrassing “Stilarten mathematischen Schaffens [Styles of Mathematical Creation]” (1934) [1]. The parallel review of the same paper in the *Jahrbuch* by the Berlin topologist Georg Feigl reproduces a half-page quote from Bieberbach’s paper but gives no commentary either.

Note that Neugebauer, in common with most of his contemporaries before WWII, occasionally used the notion of “race” in an intuitive sense and did not doubt the existence of different styles of science in different “races.”⁸ But he differed from racists

⁶In particular, MKT (1935–1937). A good introduction to this line of research is by Neugebauer himself [19], properly written in Danish, the language of his country at the time.

⁷In particular, UAA (1938). Good introductions by Neugebauer are [20, 21].

⁸After the war, the unscientific notion of a “race” became discredited due to the Nazis and the Holocaust.

such as Bieberbach by denying priority for one “mathematical style” over others and by his belief in the mutual fertilization of different approaches to mathematics.⁹ Indeed, in July 1933, half a year after the Nazis had come to power and probably as an expression of his dissent from rising racism, Neugebauer had commented in a book review about the positive effects of an “intermingling of cultures and races (in the cuneiform cultures) as opposed to the narrowly restricted Egypt development [17, p. 563].”¹⁰ Implicitly, Neugebauer opposed a biologicistic interpretation of talents within certain “races” – as the Nazis preferred to do – by pointing to the “complicated historical processes” which resulted in different scientific approaches. According to Neugebauer, simple biological or ethnical explanations would amount to replacing history by reference to a “whim of creation” (Laune der Schöpfung). This transpires rather clearly from Neugebauer’s plenary talk in German at the International Congress for Mathematicians (ICM) in Oslo 1936 on “Greek Mathematics and its relationship to pre-Greek mathematics.” Here, Neugebauer says:

It might seem obvious to try to explain this contrast between the numerical methods of the Babylonians and the geometric models of the Greeks by saying that the typically intuitive talent of the Greeks, their sense of geometric form, is revealed here in contrast to the way of thinking of the oriental cultures. It seems to me, however, that such a way of looking at things corresponds roughly to the procedure of solving difficulties in a physical theory by simply invoking a whim of creation. To be satisfied with such ‘solutions’ is to renounce the foundation of our entire scientific methodology. Everything I have to say in the following is intended to show you that it was complicated historical processes that brought about these apparently so clear final results. [20, p. 160]

No doubt Neugebauer saw the specific societal conditions in classical Greece, including philosophy, as a determining factor for the “intuitive talents” of their mathematicians. But he denied Greek mathematics to be the towering point of reference and stressed the equal value of cultures and the benefit of various styles of mathematics for the development of mathematics as a whole. This could at the same time be used as an argument against racist theories of separation between peoples, such as in Bieberbach’s *Deutsche Mathematik*. In an interview which Neugebauer gave on

⁹This insistence was in the tradition of Felix Klein [37] and of his successor Courant, although other self-proclaimed followers of Klein, such as Bieberbach, tried to insinuate racist feelings into Klein.

¹⁰This was a review in *Die Naturwissenschaften* of Johannes Tropfke’s “History of Elementary Mathematics.”

14 July 1936, during the ICM, to the Norwegian daily *Arbeiderbladet*, his insistence on the mingling of cultures for making scientific progress again became clear. Answering the question: “Why is it that the Babylonians were mathematically so talented?” Neugebauer replied:

Probably due to the special blend of different types of people down there. The Babylonians built on the Sumerian culture, which the English have investigated very extensively through excavations at Ur. [5, p. 250]

It is hard *not* to read this as an indirect commentary on Bieberbach!

7. Shifting from Old Babylonian mathematics to Neo-Babylonian mathematical astronomy

The title of Neugebauer’s plenary in Oslo “Greek Mathematics and its relationship to pre-Greek mathematics” is somewhat misleading. It does not reveal that at Oslo Neugebauer gave a first report on the mathematical methods of Neo-Babylonian astronomy. The talk was published a year later in the Proceedings of the ICM.¹¹ There Neugebauer explained in some detail how he made sense of the masses of data contained in the cuneiform tablets, registering periodic movements within the Babylonian zodiac “coordinate system” (angular distances, locations below and above the ecliptic, times, even velocities) of planets, the Moon, and the Sun, only few of them observed, most of them calculated. Neugebauer explained what he meant by the “contrast between the numerical methods of the Babylonians and the geometric models of the Greeks” (see quote above):

Babylonian astronomy describes periodic processes in a first approximation by ‘linear zig-zag functions’ [lineare Zackenfunktionen], i.e. by first-order difference series that oscillate back and forth between two extreme values. However, it is often necessary to describe the course of a function more precisely than by linear interpolation. Second-order difference series are then formed by summing up first-order series and putting them together with suitable signs (labeled ‘tab’ or ‘lai’ ...) ... The numerical methods described here ... are characteristic of Babylonian astronomy as a whole. In complete contrast to it is Greek astronomy, which uses the Babylonian results in all numerical determinations of constants, but has abandoned the purely numerical methods of the Babylonians to describe the movements as a whole and

¹¹Neugebauer’s German lectures “Vorlesungen über babylonische Astronomie” (1936) were apparently never published; cf. [35, p. 305].

1948] MATHEMATICAL METHODS IN ANCIENT ASTRONOMY 1021
[Linear interpolation]

then leads to a continuous function $f(n)$ whose graph looks like Fig. 3. We shall call such functions “linear zigzag functions.” The period of the function $f(x)$ may be called P and it is obvious that

$$P = 2\Delta/d$$

where Δ is the amplitude and d the slope of the increasing branch.

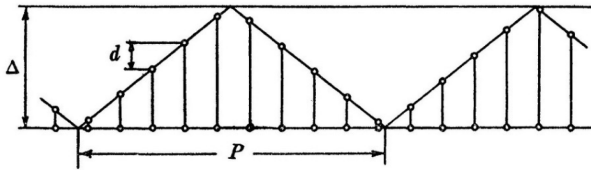


FIG. 3

Figure 4. Neugebauer’s linear zigzag function for the interpretation of periodic celestial motion (From [21, p. 1021], emphasis by this author.) (Neugebauer): Courtesy of AMS; used with permission.

instead operates with kinematic models, namely with the well-known excenter and epicycle models. [20, pp. 157–160]

The Greek models are clearly exemplified in the *Almagest* of Ptolemy (around 150 CE), whom Neugebauer admired immensely as a leading applied mathematician of antiquity. Ptolemy used some of the observational data of the Babylonian astronomers and the sexagesimal number system (based on powers of 60), traces of which are still in use today.

A publication in English by Neugebauer 12 years after his Oslo talk in the *Bulletin of the American Mathematical Society* from which Figure 4 is taken gives a similar but more detailed introduction to Babylonian mathematical astronomy, which is still very readable. Here, one finds an allusion to modern “harmonic analysis”:

To use modern terminology the Babylonian procedure is very close to harmonic analysis. . . . We do not know what were the Babylonian concepts about the physical structure of the universe. It seems safe to say that whatever concepts might have existed they were not directly reflected in the mathematical methods for the lunar and planetary movements. [21, p. 1020]

The reference to “harmonic analysis” on the part of the Neo-Babylonians might suggest that Neugebauer had in mind his joint publication with Harald Bohr, “On linear differential equations with constant coefficients and almost periodic right-hand

side” (1926) [2]. Of course, this publication was much more sophisticated mathematically and a piece of “pure mathematics.” A comparison with the applied mathematics in Babylonian astronomy might therefore be far-fetched unless one understands it in the restricted sense that Neugebauer’s mind throughout his historical research was always primarily mathematical.

As Swerdlow and Rowe have convincingly argued, Neugebauer found the rich textual sources for Mesopotamian mathematics and mathematical astronomy far more important than anything he could ever have written about Greek mathematics, let alone Egyptian mathematics [29]. From 1938 onward, he published in his journal *Quellen und Studien* exclusively on his new topic, Babylonian mathematical astronomy.

Neugebauer’s comparison of Old Babylonian mathematics with classical Greek geometry was the second, largely independent theme of his Oslo talk.¹² The same year, 1936, he published “Zur geometrischen Algebra” [18]. According to the thought-provoking historiographical concept of “geometric algebra,” Greek geometry can be considered to some extent as an analogue (or even as a reformulation) of algebraic reasoning existing either informally in Greek mathematics or earlier. A strong version of this concept was the largely undocumented claim – at least temporarily supported by Neugebauer himself – that there must have existed a direct historical link to older Babylonian algebraic thinking [7]. This claim was criticized by a new generation of historians from the 1960s.¹³ Whatever the merits of the discussion of “geometric algebra” may have been, there is little doubt that it cannot be reduced to an ahistorical insinuation by mathematicians projecting the modern standards of mathematics into the past. The discussion was also broadening historical perspectives, and it followed partly political and philosophical motivations in a manner similar to Neugebauer’s interpretation of mathematical astronomy, namely as a move against the one-sided and uncritical admiration of the Greeks as the most important representatives of “ancient science and mathematics.”

Summing up Neugebauer’s talk in Oslo: He stressed the independent importance of – on the one hand – Old Babylonian mathematics compared to later Greek geometry and – on the other hand – of Neo-Babylonian mathematical astronomy compared to contemporary and to somewhat later Greek astronomy. Indeed, he would never again – at least in the titles of his publications – speak about “pre-Greek mathematics” [36, p. 148], [29, p. 47].

¹²The discussion in [5, pp. 180–183] of Neugebauer’s talk in Oslo undervalues mathematical astronomy and focuses too strongly on “geometric algebra.”

¹³See remarks below in Section 11.

8. Growing international appreciation for Neugebauer's historical work

During his time in Copenhagen, Neugebauer's international reputation as a historian of mathematics and astronomy grew. On 6 September 1933, the historian of science George Sarton, who edited the journal *Isis* from his modest position at Harvard University, wrote a letter to the director of the IAS in Princeton, Abraham Flexner:

As compared with Neugebauer I am only a dilettante. He works in the front-trenches while I amuse myself wayback in the rear – praising the ones, blaming the others; saying this ought to be done, etc. – and doing very little myself. [33, p. 79]

Flexner was obviously impressed and wrote to the leading American mathematician at his Institute, Oswald Veblen, on 8 September 1933:

My disposition would be to invite Neugebauer, because he would bring to this country something absolutely new, namely the historical and humanistic side of mathematics. [33, p. 79]

After a conversation with Niels Bohr that took place near New York City on 14 February 1937, the Rockefeller functionary and mathematician Warren Weaver wrote in his diary:

B. talks with great enthusiasm and considerable feeling concerning the fundamental contribution which Neugebauer is making to our knowledge of ancient civilizations ... There seems to be no question that this is the most significant contribution that has ever been made to the history of mathematics and thus directly to our knowledge of the historical development of science in general. [33, p. 90]

Despite this broad appreciation for Neugebauer as a historian, the Americans, including the Rockefeller philanthropy, found it advisable not to invite (or as sometimes was said “import”) Neugebauer to the USA but rather support him at his place of exile in Copenhagen. The main reason was the overwhelming interest of the American community of mathematicians in Neugebauer's work for mathematical reviewing (*Zentralblatt*) which in 1937 still seemed to be better placed in Europe.

9. Political crises and Neugebauer’s second emigration, from Denmark to the USA

In the middle of the 1930s, the political situation in Europe became ever more nervous and dangerous. From the ICM in Oslo, the Italians had been absent due to sanctions against Italy’s war in Ethiopia, and the Russians were forbidden to attend by Stalin and the Politburo [5]. On 14 March 1937, Neugebauer wrote the following letter from Copenhagen to *Courant* in New York about the intrusion of Stalinism into mathematics:

Dear Courant,

*You will certainly be interested to learn that Kolmogoroff and Khintchine had big scandals in Russia due to their *Ergebnisse*-reports, published in Germany. As a matter of fact, in Russia there is flourishing now the same idiotic nationalism as in the Third Reich. Of course you should not write about these things to Russia, but because of Yellow Books you should be interested to know. For instance, I do not believe that one of the two would now be able to write a Yellow Book without danger.*

Many cordial greetings in haste, Your O.N. [33, pp. 82–83].¹⁴

The situation became unbearable for Neugebauer in 1938, after racist legislation had been promulgated in Italy with consequences for the Italian co-editor of *Zentralblatt*, the differential geometer Tullio Levi-Civita. After P. S. Aleksandrov had been forced by the Russian politicians to withdraw from the editorial board in May 1938, Levi-Civita was excluded by Springer in October that same year, even without informing the managing editor Neugebauer. In November 1938 – about the time of the anti-Semitic November pogrom in Germany (Kristallnacht) – Neugebauer sent a printed postcard to all the reviewers of *Zentralblatt*:

Since one of the editors of the Zentralblatt für Mathematik has been canceled without communicating with him, with me or with the other editors, since further it has been demanded of me to consider other than purely objective points of view in the distribution of reviews, I have resigned the editorship of the Zentralblatt. I have to thank all my contributors most warmly for their

¹⁴In 1933, A. N. Kolmogorov and A. Khinchin had published reports on probability theory with Springer’s German *Ergebnisse* (see Figure 2, right side). Both had agreements with Springer and *Courant* for textbooks on real function theory and probability theory in the prestigious Springer *Grundlehren* series, which appeared in yellow covers. These plans failed under the given political circumstances.

many years of distinguished service and, above all, for the understanding with which they have accommodated themselves to the demands, not always convenient, that had to be placed upon them. O. Neugebauer. [33, p. 86]

After Neugebauer's retreat, Springer continued the publication of *Zentralblatt* in Berlin. The journal now came under even closer political scrutiny from the Nazis and had to coordinate its reviews with the old *Jahrbuch*. As far as Neugebauer was concerned, he severed his connections with Springer totally. In a letter from 9 November 1938 to Neugebauer, Springer had expressed a lack of understanding for Neugebauer's withdrawal from *Zentralblatt*. The publisher then still hoped for a continuation of *Quellen und Studien* with Neugebauer as editor. However, on 3 December 1938, Neugebauer received a letter from Oskar Becker, the philosopher and historian of mathematics in Bonn. In it, Becker demanded the resignation of Toeplitz from *Quellen und Studien* because of his Jewish descent, and he proposed Bessel-Hagen as a replacement. Neugebauer responded with the announcement of his own resignation and proposed Becker and Bessel-Hagen as the new editors:

I have inferred from your letter that also scientists in Germany consider the fact of extensive pogroms a sufficient reason for making it impossible for a scholar of outstanding merit even to work scientifically. . . . You are writing that you as a National Socialist apparently have an opinion differing from mine, in spite of your personal respect for Mr. Toeplitz. I can only reply that I am not in the happy possession of any 'Weltanschauung' and I am therefore in need to consider in each case individually, what to do, without being able to retire to a previously given dogma. [33, p. 87]

As a result, *Quellen und Studien* collapsed. Toeplitz emigrated to Palestine in 1939, and Stenzel's Jewish widow went to the USA in 1939. Neugebauer found a new home in Providence, Rhode Island, where he helped start *Mathematical Reviews* and built a department for the History of Mathematics at Brown University.

The protocol of Neugebauer's 18 February 1939 job interview in Providence, quoted above, shows that he was anxious that the responsibilities for the new reviewing journal should be distributed on broader shoulders than had been the case with *Zentralblatt* in Copenhagen [33, p. 92]. Nevertheless, Neugebauer kept busy with *Mathematical Reviews* in the first 2 or 3 years of its existence. In 1943, the immigrant from Germany and Sweden, the probabilist Willy Feller, 7 years Neugebauer's junior, became managing editor.

10. After the War: Increasing political disillusionment and return to historical research

In a letter to a UNESCO representative, who had offered help in reviving the historical journal *Eudemos*, Neugebauer wrote in December 1947:

I confess that I belong to the dying-out tribe of scholars who deeply dislike organized work. ... I know that more of my remaining lifetime is necessary to complete the studies which interest me deeply. Thus as far as I am concerned I shall spend all my efforts in the continuation of my own research program and the only hope I have is that I am as little as possible disturbed by outside influences. [33, p. 96]

Of course, Neugebauer had done his fair share of work for the community in the past. In all likelihood, he had become disillusioned by the various instances of political interference with his work. Fortunately, the “remaining lifetime” for the then 48-year-old Neugebauer would amount to over four decades with many fundamental publications to come, among them arguably the most important being the three-volume “Astronomical Cuneiform Texts” (ACT 1955).¹⁵

By the same token, he kept his skeptical attitude vis-à-vis sociological and biographical work, at least with respect to the history of ancient science. A particularly telling episode is connected with Neugebauer’s sharp criticism of a review written by the Belgian theoretical physicist Leon Rosenfeld for the Danish historical journal *Centaurus*. The review was of Neugebauer’s revised edition of H.G. Zeuthen’s *Forelæsninger over Matematikens Historie: Oldtiden* from 1893. Rosenfeld praised this book as a “great work,” but then added the following remarks:

Even the very best human endeavour, however, has its weaknesses. [...] I could not imagine those old mathematicians as men of flesh and blood. [...] Zeuthen was obviously too much of a mathematician and too little of a genuine historian to pay proper attention to this human side of the question. [33, p. 100]

In a letter from 17 October 1950, Neugebauer protested to the editor of *Centaurus*, Mogens Pihl. Although his protest ultimately went unpublished, it deserves to be quoted almost in its entirety:

I may say that the only flaw [in the present issue of the journal] I found is the review of Rosenfeld, which I can only consider as monumental nonsense. He

¹⁵This was originally published in London and later taken over by Springer, whose relationship with Neugebauer was apparently not yet fully recovered in 1955.

has obviously not yet understood that historical research is a science and not poetry. He wants to learn something about the motives of men of whom we know hardly more than their time of life. Not to say that I seriously doubt that we know the motives of any scholar, even of our contemporary colleagues. I hope Rosenfeld's lack of insight into the methodology in our field will not exercise too much influence on the editorial policy. [33, p. 100]

One can safely assume that the Marxist physicist Rosenfeld was not as naive as his review might appear at first glance. What he probably wanted to express was a desire to learn more about the societal conditions under which ancient mathematics was produced, in particular the philosophical connections as well as possible applications. With the memories of World War II still vivid, and in view of the developing atomic race, Rosenfeld probably also wanted to make another point – a bit mistaken for the topic in question – namely to stress the responsibility of scientists for their work. One may assume that Neugebauer, the liberal-minded refugee from Germany, felt similarly disillusioned in the post-war environment. As to social factors, Neugebauer had implicitly acknowledged their importance in his polemics against the “typically intuitive talent (implicitly ‘Aryan style’) of the Greeks” (see above). But while Rosenfeld reacted with political activity and increased historical interest, the disillusioned historian, writing from the McCarthy-stricken USA,¹⁶ only felt a sense of embarrassment. As a result, he argued in the extreme opposite direction compared to Rosenfeld, denying that one could make judgments about motives “even of our contemporary colleagues.” On 19 December 1950, he wrote to Pihl in Copenhagen a follow-up letter:

The only reasonable thing to do is to shoot oneself as soon as possible and not to wait for the politicians, the militaries, and the physicists. [33, p. 101]

In order to better understand Neugebauer's political and philosophical views and his disillusionment after the war, one must certainly take into account his general attitude toward Germany and especially the insufficient and uncritical manner in which the Germans went about “coping with the past.” During his entire emigration, Neugebauer had followed political events in Nazi Germany closely, particularly the

¹⁶Jens Høyrup allowed me to use the following anecdote which he has from a Danish colleague, himself a rather unpolitical person: “He told me that he had visited Neugebauer during the McCarthy period. He spoke, scandalized, about the treatment given to Dirk Struik [a prominent Dutch-American differential geometer, communist and historian of mathematics who was under indictment at the time for un-American activities]. Neugebauer got up, and closed the door, and said ‘I have once been forced to move from one continent to another for political reasons. I do not want to repeat that.’” (Email from Jens Høyrup to me, 27 October 2024).

political behavior of the scholars who remained behind. We have already noted his critical and somewhat cynical response to Becker. Even regarding his old friend, the Dutch mathematician Bartel L. van der Waerden (1903–1996), who had once attended Neugebauer’s lectures in Göttingen on the history of ancient mathematics¹⁷ but who later stayed in Germany (at Leipzig) in spite of opportunities abroad, Neugebauer grew increasingly critical. In 1940, he wrote to Bessel-Hagen: “What you write about Bartel is all well but for reasons I cannot explain here I don’t give a damn for him.” In August 1945, Neugebauer wrote to his friend, the topologist Heinz Hopf in Zürich, about van der Waerden, who at the time had political problems due to remaining in Germany even as a Dutch citizen [32]:

I do not mind his remaining a German professor until the end. I do mind his remaining German professor at the beginning. However, I feel very differently than the Lord and I do not intend to do anything positive or negative. I know that Bessel-Hagen behaved excellently and I would like very much to hear about him as soon as he is again localized. [33, p. 97]

To van der Waerden himself, Neugebauer had written a week before: “What has happened to the *Zentralblatt*? I hope it is completely ruined.” When van der Waerden complained that Neugebauer continued to write personal letters in English, not using his mother tongue even though the war had ended, Neugebauer offered the following rejoinder, which, however, probably expressed only half of the truth: “I must remark that the language I use in my letters does not depend on my mother but on my secretary.” [33, p. 97] On 15 August 1946, Neugebauer wrote to his old friend, the mathematician Franz Rellich (1906–1950), who happened to be van der Waerden’s brother-in-law. Rellich was known to have behaved decently during the Nazi years and had been appointed director of the Mathematical Institute in Göttingen in 1946. Neugebauer wrote concerning *Mathematical Reviews*:

*This letter is actually intended to ask you for your advice in a delicate matter. We would like to extend our staff of reviewers to include Germans, but we must avoid inviting people who are politically ‘belastet’ [incriminated].*¹⁸

¹⁷Van der Waerden is known, besides his *Moderne Algebra* (1930–1931) and his book on mathematical statistics (1957), also for his historical books *Science Awakening* (Ontwakende Wetenschap) I (1950) and II (1965), the latter [38] on Ancient Mathematical Astronomy.

¹⁸Niedersächsische Staats- und Universitätsbibliothek Göttingen, Handschriftenabteilung, Cod_Ms_F_Rellich_1_61. Rellich replied on 19 September 1946 with an interesting list of 17 German mathematicians. Only two of them (G. Grüss and W. Magnus) had been professors before 1945, and the two were known as dissidents, as many others on the list. Only five of the

Neugebauer kept reservations against Germany in the years to come which might have been partly because the University of Göttingen did not do much to acknowledge the reasons for his emigration in 1934. In November 1945 – before Rellich’s appointment – the university authorities had submitted to the British Military Government a list of possible candidates for professorships among former emigrants. From this list, Neugebauer, who had been proposed by the British, was excluded because:

He went in 1933 to Copenhagen, without political pressure having been exerted on him, that means voluntarily. There he accepted the chair for history of mathematics which already had been prepared for him. [33, p. 98]

The document has an additional commentary in pencil about Neugebauer: “Out of the question, went voluntarily.” So the proposal of the British was refused by the University of Göttingen. Ten years later, Neugebauer got compensation, but only for the level of “assistant professor.”

11. Later historical work connecting to Neugebauer

As indicated above, Neugebauer’s approach to ancient Babylonian mathematics and astronomy was partly influenced by his perspective as a modern mathematician trained in Göttingen. Other more competent mathematicians such as van der Waerden and Peter J. Huber (born 1934) have followed Neugebauer’s historical interests in their own work, contributing important details.¹⁹ Huber, who was van der Waerden’s student in Zürich in the 1950s [3] and collaborated in the latter’s book on the *Birth of Mathematical Astronomy* which was originally published in 1965 [38], said much later (2010) to a colleague:

For me, all this was an amusing hobby. I felt that history of science was not a serious profession, especially not for young people (and apart from that, the job situation predictably would be difficult). [35, p. 326]

In his “History of Ancient Mathematical Astronomy” (HAMA), Neugebauer praised particularly Huber’s article of 1957 on the daily movement of Jupiter in

17 have entries in the biographical website of St. Andrews University today. Although Rellich may have found most established mathematicians to be unlikely referees for the American journal, the list seems to indicate – by their exclusion – a strong involvement of many of them with the Nazis.

¹⁹Høyrup tells me that Huber is still active in the field: “These later years he has made very interesting work on Old Babylonian linguistics (that is, the linguistics of the ancient scribes).” (Email, 27 October 2024).

Babylonian texts [8] and the “excellent discussion” of linear interpolation methods there [23, p. 412]. Huber went on with a successful career in mathematical statistics,²⁰ influenced in this field also by van der Waerden.

Research in the mathematical aspects of Babylonian astronomy continues. In 2016, some recent progress was reported in the widely read journal *Science*. It relates to two major discoveries of Neugebauer’s on Old Babylonian texts, published in 1929, and on the Neo-Babylonian mathematical astronomy in his Oslo talk of 1936, which have been mentioned above [15, 20]. The author of the *Science* article was the Dutch historian M. Ossendrijver. He wrote about his recent discovery of a Babylonian cuneiform tablet from the last half-millennium BCE:

The idea of computing a body’s displacement as an area in time-velocity space is usually traced back to 14th-century Europe. I show that in four ancient Babylonian cuneiform tablets, Jupiter’s displacement along the ecliptic is computed as the area of a trapezoidal figure obtained by drawing its daily displacement against time. This interpretation is prompted by a newly discovered tablet on which the same computation is presented in an equivalent arithmetical formulation. The tablets date from 350 to 50 BCE. The trapezoid procedures offer the first evidence for the use of geometrical methods in Babylonian mathematical astronomy, which was thus far viewed as operating exclusively with arithmetical concepts. [24, p. 482]

Ossendrijver explains Jupiter’s displacement further for the case of a time period of constant deceleration (linear decrease of velocity) of the planet, where equal areas mean equal distances traveled (see Figure 5, right):

The trapezoid for days 0 to 60 is divided into two smaller trapezoids of equal area. In order to achieve this, the Babylonian astronomers applied a partition procedure that is well-attested in Old Babylonian (2000 to 1800 BCE) mathematics. [24, p. 484]

The author makes clear that the trapezoid in the picture is an interpretation of the text, which contains no geometrical figures. Ossendrijver also explains that “geometrical” here has a different, more abstract meaning compared to the “geometrical models” of Greek astronomers which were discussed above.

The Babylonian trapezoid procedures are geometrical in a different sense than the methods of the mentioned Greek astronomers, since the geometrical figures describe configurations not in physical space but in an abstract mathematical space defined by time and velocity (daily displacement). [24, p. 484]

²⁰ Among other things, Huber is a recognized specialist in the field of “robust statistics.”

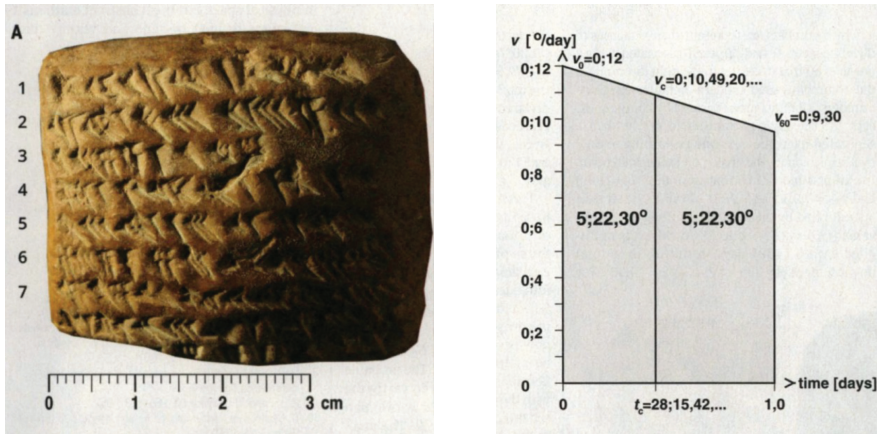


Figure 5. Two figures from Ossendrijver's article in *Science* (2016) [24]. Left: the “newly discovered” Babylonian text. Right: Ossendrijver's interpretation. Courtesy of AAS; used with permission.

In another article of the same year, Ossendrijver points out that historians have enlarged their perspective from a predominantly mathematical standpoint of Neugebauer's to a more general historical one:

Subsequent research on Babylonian mathematical astronomy has proceeded from the advanced stage where Neugebauer left it, ... the aim has shifted from understanding Babylonian mathematical astronomy in our own terms to interpreting its algorithms and the underlying mathematical and astronomical concepts in Babylonian terms. [25, pp. 340–341]

This broader historical view is sometimes interpreted as criticism of Neugebauer's historical methodology, in particular connected to his support for the “geometrical algebra” hypothesis, as indicated above [7].²¹ Nevertheless, all critical remarks do not concern the core of Neugebauer's positive historical discoveries and his

²¹According to Høyrup, “Neugebauer is the... indubitable source for van der Waerden's view of Greek ‘geometric algebra’ as a translation of Babylonian algebraic knowledge into geometric language necessitated by the discovery of incommensurability” [7, p. 143]. The same author quotes Neugebauer's admission from 1969 that “simplicity of a historical explanation” (assuming the translation hypothesis) is “by no means equivalent with historical proof” [7, p. 140]. Høyrup also disagrees with some “idiosyncratic” claims of Neugebauer's with respect to the “algebraic character of Babylonian mathematics” [7, p. 138]. I find some ahistorical insinuation of algebraic thinking in Neugebauer's early work on Egyptian mathematics as well [34]. In recent years, the heuristic potential of the “geometric algebra” hypothesis has been increasingly acknowledged [7].

groundbreaking work as editor and interpreter of Babylonian texts. In any case, Neugebauer’s linguistic expertise and historical sense prevented him from falling into the traps of naive historical views sometimes entertained and exaggerated by research mathematicians.²² Progress in the historiography of Old Babylonian mathematics and Neo-Babylonian astronomy has supplemented Neugebauer’s results on many fronts. Among these investigations figure those on the geometrical background of Babylonian numerical algorithms, on the social, in particular bureaucratic and educational environment, and on linguistic nuances.

It is possible that Neugebauer found some of this broader work as belonging to a “smokescreen of sociological, biographical, and bibliographical irrelevancies” as he said in 1975. I believe, however, to have shown that Neugebauer himself could not avoid considering the social and philosophical environment and that he had to acknowledge the impact of “complicated historical processes” (as he called them) on the shaping of mathematical and astronomical theories. His claim to be “not in the happy possession of any Weltanschauung” was formulated in an extreme situation of political pressure in the 1930s, and his later attack on sociological and related investigations was apparently influenced by increasing personal political disillusionment, as reported by colleagues [4].

Acknowledgments. The archives containing the estates of Neugebauer (Princeton) and Bessel-Hagen (Bonn) as well as the Manuscript Division in Göttingen are thanked for giving access to their sources.

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Neugebauer’s most important publications

MKT Mathematische Keilschrift-Texte (1935/37 in *Quellen und Studien*)

UAA Untersuchungen zur Antiken Astronomie (1938 in *Quellen und Studien*)

MCT Mathematical Cuneiform Texts (1945, completion of MKT in English, with A. Sachs)

ACT Astronomical Cuneiform Texts (1955, completion of UAA in English)

²²Van der Waerden, who had to rely on Neugebauer’s philological expertise, went on to publish speculations about the existence of a “Stone Age Mathematics,” which were largely dismissed by professional historians.

HAMA History of Ancient Mathematical Astronomy (1975, see specific literature below)

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