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Zionist Internationalism through Number Theory: Edmund Landau at the Opening of the Hebrew University in 1925

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Argument

This article gives the background to a public lecture delivered in Hebrew by Edmund Landau at the opening ceremony of the Hebrew University in Jerusalem in 1925. On the surface, the lecture appears to be a slightly awkward attempt by a distinguished German-Jewish mathematician to popularize a few number-theoretical tidbits. However, quite unexpectedly, what emerges here is Landau's personal blend of Zionism, German nationalism, and the proud ethos of pure, rigorous mathematics – against the backdrop of the situation of Germany after World War I. Landau's Jerusalem lecture thus shows how the Zionist cause was inextricably linked to, and determined by political agendas that were taking place in Europe at that time. The lecture stands in various historical contexts - Landau's biography, the history of Jewish scientists in the German Zionist movement, the founding of the Hebrew University in Jerusalem, and the creation of a modern Hebrew mathematical language. This article provides a broad historical introduction to the English translation, with commentary, of the original Hebrew text.

1. Introduction

At the opening ceremony of the Hebrew University in Jerusalem in 1925, the eminent Göttingen number theorist Edmund Landau delivered a public lecture in Hebrew to a non-mathematical audience which presented a list of 23 problems from elementary number theory. At first, this presentation by a well-known mathematician strikes one as a slightly awkward attempt to popularize a few number-theoretical tidbits. Looking more carefully, however, and bearing in mind the special occasion, the language, and scattered evidence about Landau's political and cultural views, this list of number-theoretical results and conundrums unexpectedly emerges as an important document. Important, because it combines Landau's personal blend of Zionism, German nationalism, and the proud ethos of pure, rigorous mathematics – all against the backdrop of the situation of Germany after World War I. In spite of the peculiarity of Landau's case, his Jerusalem lecture thus highlights the way the Zionist cause was inextricably linked to, and determined by, European political agendas.

Landau's lecture is thus at the center of our historical investigation, and its English translation stands at the conclusion of the present article (see section 6 below). But this lecture is explicit only in its mathematical assertions. In order to dig out the implications of the lecture that are not purely mathematical, we surround the document with four separate historical contextualizations, each placing Landau's address in the context of independent sources that bring forward certain aspects into relief (see sections 2–5 below).

The first contextualization (section 2) concerns Landau's personal orientation, which is in all respects potentially relevant for understanding his Jerusalem address. His family tradition is mentioned, both his forefathers and his father-in-law. We discuss some proposed analogies between research work in pure mathematics and a life lived within a Jewish religious tradition. Landau's pointedly internal presentation of mathematics oriented only toward facts, with few if any comments – the *Landau style*, as it was already called during his lifetime – clearly was a result of his conscious effort to objectify or purify his mathematical statements and arguments, leaving little room for extra-mathematical allusions. In the Jerusalem lecture, Landau does interrupt his mathematical exposition for an occasional remark, but most of the extra-mathematical allusions are actually implicit in references to famous number theorists of the past and present.

The final sentence of Landau's Jerusalem talk and his few words at the laying of the cornerstone for the Wattenberg building (see section 6) show that Landau's overriding political issue in the early 1920s was the question of international scientific collaboration (especially with British mathematicians, in particular G.H. Hardy) and his opposition to the French boycott of German science after World War I. We illustrate this point with archival sources quoted here perhaps for the first time. It transpires that Landau's openness to international collaboration was real, but he drew the line where he felt his pride as a German scholar was concerned. And in his scientific specialty, number theory, a German tradition of telling the history of this field since C.F. Gauss's *Disquisitiones Arithmeticae* (1801) that goes back to the 1830s gave Landau the opportunity to articulate his German scholarly ethos by placing himself in the illustrious pedigree of Göttingen number theorists.

Further, complementary contextualizations of Landau's talk concern the overall history of Jewish scientists in the German Zionist movement (section 3), the history of the founding of the Hebrew University in Jerusalem (section 4), and the creation of a modern Hebrew mathematical language (section 5).

2. Edmund Landau at Jerusalem

Edmund Landau (1877–1938) was born and raised in Berlin in a distinguished Jewish family. His father Leopold Landau (1848–1920) was a professor of medicine and a gynecologist to the Prussian royal family. Together with Louis Lewin (1850–1929) and others he was an active member of the religious Jewish community in Berlin.[1] Edmund Landau studied mathematics in Berlin and Munich, and taught at Berlin University as a *Privatdozent* beginning in 1901. He married Marianne Ehrlich (1886–1963) on 22 March 1905. The wealthy couple had two daughters. Both Edmund Landau's father and his father-in-law, the Nobel prize laureate (in 1908) Paul Ehrlich (1854–1915)[2] were among the founders in 1912 of the Society of Jewish physicians and scientists for medical-biological interests in Palestine (*Gesellschaft jüdischer Ärzte und Naturwissenschaftler für medizinisch-biologische Interessen in Palästina*). They thus cosigned a public appeal that describes the goals of this association as apolitical, only oriented to the "research in and improvement of the sanitary conditions in Palestine," in collaboration with "Palestinian medical doctors." The program included, among other things, building up "a sizeable medical library with a collection of medical-scientific publications on Palestine," and "holding courses for the skill enhancement of Palestinian doctors."[3]

In spite of his intimate connection with Berlin – both the city and its mathematicians – Edmund Landau moved to Göttingen in 1909 when he was offered the professorship left vacant there by the sudden death of Hermann Minkowski (1864–1909). Göttingen, under the leadership of David Hilbert (1862–1943) and Felix Klein (1849–1925), had at the time replaced Berlin as the leading mathematical center of Germany. As David Rowe has recently stressed (Rowe 2007, 30), all three candidates shortlisted for Minkowski's succession were Jewish, a highly exceptional event in German academia at the time.[4] Apart from Landau, the shortlist contained Adolf Hurwitz (1859–1919) and Otto Blumenthal (1876–1944). Legend has it that a main reason why Hilbert and Klein preferred Landau, beyond his undoubted qualifications, was his uncompromising, difficult character.[5] But it seems only fair to point out that, in comparison with Hurwitz, Landau had the advantage of youth and strong health, and his list of publications in 1909 contained about six times as many items as Otto Blumenthal's.

Apart from short trips, and apart from the Winter semester 1927–28 which he spent at the Hebrew University in Jerusalem, Landau stayed in Göttingen until his retirement under Hitler (we will briefly return to this below), which became effective

[1] On Lewin, see Lipphardt 2008, 195–197; for Leopold Landau, see ibid., 196, n. 34.

[2] Ehrlich's perspective on Jewish institutions of learning was more secular than that of Louis Lewin, but he supported early plans for the Hebrew University (see also section 3 below).

[3] See Lipphardt 2008, 247–248; on Ehrlich, see ibid., 198–199. The founders also included the botanist Otto Warburg (1859–1938), who was at that time (1911–1912) president of the World Zionist Organization, and August Wassermann (1866–1925). The appeal was published in *Jüdische Rundschau* 1912, 17(11): 90. We heartily thank Veronika Lipphardt for drawing our attention to this document.

[4] For a reflection on an all-Jewish shortlist under the conditions of the Weimar Republic, see Felix Klein's letter to Otto Toeplitz of 8 February 1920, quoted in Siegmund-Schultze 2008, 27.

[5] See Reid 1970, 117–119; this account, which probably echoes Richard Courant's (1888–1972) own relationship with Landau, even gets the shortlist wrong. But also Rowe still describes Landau as "notoriously difficult and conceited" in Rowe 2007, 30, without quoting specific documents.

in 1934. Edmund Landau appears to have been the only non-retired professor of Göttingen University registered after World War I as a member of the *Göttingen Synagogengemeinde*,[6] this does of course not imply that he would be regularly seen at the synagogue. As a matter of fact, we have no detailed information about Landau's attitude regarding any Jewish or Zionist organization in Göttingen, in particular after the violent anti-Semitic turn, in 1920, of the major Göttingen newspaper *Göttinger Tageblatt*.[7]

We do know, however, that Landau was one of the few German professors of Jewish origin who actively went along with Zionist projects already in the 1920s.[8] Many of his Jewish colleagues, at least in the twenties, were probably closer to the deep skepticism with which the Dresden philologist Victor Klemperer (1881–1960) would react to Theodor Herzl's writings even much later, when he suffered daily Nazi terror during World War II.[9] Even though Landau's precise attitude towards Zionist ideas and organizations remains difficult to ascertain,[10] his concrete actions are remarkable enough: He learnt Hebrew, apparently with the help of a Jewish mathematician from Palestine[11] and delivered two addresses in this language on the second day of the opening ceremonies of the Hebrew University in Jerusalem, April 2, 1925: a lecture on *Solved and Unsolved Problems in Elementary Number Theory* (בעיות פתורות וסתומות בתורת המספרים האלמנטרית), which is one of the very first modern mathematical texts in Hebrew, and a toast for the cornerstone laying, on Mount Scopus, of the new Wattenberg building for the *Einstein Mathematics-Physics Institute*, as it was then still called. Two years later, Landau would obtain a leave of absence from

[6] See the list of Göttingen University professors "of Jewish origin" (which by mistake also includes several non-Jewish professors) in Wilhelm 1978, 99–105. In fact, Wilhelm found only four members of the synagogue community among all Göttingen University professors: apart from Landau he lists the physician Wilhelm Ebstein (1836–1912), the law scholar Ferdinand Frensdorf (1833–1931, emeritus in 1916), the historian Alfred Stern (1846–1936, who taught in Göttingen only 1872–1873), and the first Jewish *Ordinarius* professor in Germany, the mathematician Moritz Abraham Stern (1807–1894).

[7] On Jewish associations in Göttingen, see Tollmien 1999.

[8] Global data on the Zionist mobilization – or, rather, lack of mobilization – of German academia do not seem to be easily available. To fix a specific sample – which tends to exclude persons who were students in Germany in the twenties – it seems likely that among the 64 German speaking Jewish mathematicians alive in 1925 who are listed in Bergmann and Epple 2009, apart from Abraham Halevy Fraenkel (1891–1965) and Edmund Landau, only Samson Breuer (1891–1974) and possibly Arthur Cohn (1894–1940) may have had an active interest in Palestine before 1933 (see Siegmund-Schultze 2009, cf. Siegmund-Schultze 2008). We thank Reinhard Siegmund-Schultze and Birgit Bergmann for sharing their insights with us. Jewish students in Germany apparently rallied more support for Zionism. Just *how* much more seems again difficult to determine, but see the *Anhang* in Rürup 2008, 477–493.

[9] See Klemperer 1995. For instance, on 27 June 1942, after a few days of studying Herzl, Klemperer envisaged writing an essay "Pro Germania, contra Zion." For an analysis of the variegated forms of self-assertion of Jewish culture in the Weimar Republic, cf. Brenner 2000.

[10] The sources quoted below will indicate what we have explored. Unfortunately, we did not have access, in time for this publication, to Landau's correspondence with British mathematicians, in particular Hardy and Littlewood.

[11] The identity of this teacher is not entirely clear to us; we come back to this point in section 5 below.

Göttingen University[12] and move with his family to Jerusalem where he became the first Professor of Mathematics at the budding university. His stay in Jerusalem, however, was rather brief, and he returned to Göttingen in 1928, against a background of both personal and academic reasons.[13]

Landau's Zionist activities did not go unnoticed by German anti-Semitic circles. The entry on Edmund Landau in the violently anti-Semitic German encyclopedia known as *Semi-Kürschner* (Ekkehard 1929, p. 869) mentions, apart from personal and family information including children and address as well as one of Landau's books (1909a), that "in 1927/28, L. worked as exchange professor in Jerusalem."[14] And in the Summer of 1933, when Landau's legal situation was analyzed in the Ministry regarding the civil service act of April 7, 1933,[15] a Göttingen colleague acting as counselor for the minister noted for the record about Landau: "Zionist, absolutely has to disappear," to which an official (the minister himself?) added in handwriting: "Opinion pleases me, but is contrary to the letter of law."[16] In the end it took a student boycott, on 2 November 1933, to precipitate Landau's early retirement and retreat from Göttingen to Berlin.[17]

[12] Cf. Landau's personal file in the *Universitätsarchiv Göttingen* (hereafter abbreviated as UAG): Kur PA Landau, Edmund [formerly UAG, XVI IX A a], esp. sheet 75. Landau's request for a paid leave of absence during the Winter term of 1927/28, with *Privatdozent* Karl Grandjot (1900–1979) replacing him in his lectures, was unanimously approved by the Göttingen *Mathematisch-Naturwissenschaftliche Fakultät* and hence sent to the Prussian Ministry *für Wissenschaft, Kunst und Volksbildung* in Berlin, along with the personal endorsement of the *Kurator* Valentiner. The ministerial approval (see sheet 79 of the same file) is dated 26 March 1927. However, neither in the Göttingen files nor in their counterparts from the Ministry at the *Geheimes Staatsarchiv* in Berlin-Dahlem could we find Landau's original letter explaining in his own words what he wanted this sabbatical for.

[13] We do not go into the details and refer instead to the two, slightly different, published accounts (Fuchs 1989, Katz 2004) as well as the literature cited there. A long term perspective in Jerusalem is envisaged for Landau in the correspondence with Magnes, who then even wanted to make Landau President of Hebrew University, a plan that Einstein and Weizman opposed. On the Göttingen side, Landau's possible reasons – other than Zionism – for wanting to leave Göttingen around 1927 remain unclear to us; but see our reading of the lecture below. Unfortunately, a comprehensive biography of Edmund Landau is still lacking. One awaits publication of the tenth volume of Landau's Collected Works which may contain a thorough biographical study.

[14] The subsequent and final sentence of this entry reads like a (clearly unintentional) caricature of this whole encyclopedia: *Er bevölkert die Lehrstühle für Mathematik in Ungarn, Lissabon und Europa mit Stammesgenossen*; i.e., "he populates the mathematical chairs in Hungary, Lisbon and Europe with his tribesmen."

[15] According to §3 of this law, Landau was exempted from being dismissed on the grounds of being "non-Aryan" since he had already been a civil servant before World War I.

[16] See *Geheimes Staatsarchiv Berlin-Dahlem*, Rep 76 Va Nr. 10081, sheet 198: *Zionist, muss unter allen Umständen verschwinden. (Erfreuliche Meinung, widerspricht aber dem Wortlaut d. Ges.)* The counseling colleague was the economist Jens Jessen (1895–1944), a former World War I volunteer and a militant national-socialist since the late 1920s. He would later have increasing differences with the regime, in particular because his personal rewriting of economic theory did not receive the official backing he had expected. During the war he was involved with the assassination attempt against Hitler of 20 July 1944 and subsequently executed. Jessen's example highlights a profoundly undemocratic strand of late German resistence against Hitler (Becker, Dahms, Wegeler 1998, 161–162).

[17] See Becker, Dahms, Wegeler 1998, 531–532; Schappacher, Scholz 1992; Schappacher, Kneser 1990, §3.3; see also Segal 2003, 443–450.

In our discussion of Edmund Landau's Jerusalem speeches, it should first be pointed out that he was not exactly known for his talent – nor his desire – to address general audiences,[18] but he was and is remembered as an unusually dedicated academic teacher. More generally, Edmund Landau was known for the relentless formal rigour and precision, down to the tiniest detail, of his lecture courses, books, and papers. In a way, the speech we are translating is also, as we shall see, an example of this proverbial *Landau style* of mathematical exposition, as it came to be called already during his lifetime; but we have to make more precise what this means. There are four noteworthy places, and one infamous occasion, where Landau's style has been commented on:

- Felix Hausdorff's (1868–1942) review (1911) of Landau's *Handbuch von der Lehre der Primzahlen* starts by paying homage to Landau's enthusiasm and energy, highlights Landau's organization of his material in four levels according to the nature of the methods of proof employed, and finally extols the almost absolute exactness (*nahezu absolute Exaktheit*) of the work.
- 18 years later, the young Helmut Hasse's (1898–1979) review (1929) of Landau's 1927 *Vorlesungen über Zahlentheorie* not only uses the expression *Landau-Stil* explicitly (ibid., 60–61), but also warns that, in spite of the "true mathematical life" which "pulses between the lines" and in spite of the "strong personality" behind the text, the style may lead to a merely "formal understanding" as opposed to the *inhaltliches Verstehen* (literally: understanding with regard to essential contents, meant in a holistic sense) that Hasse's generation aspired to.
- In 1933/34, Oswald Teichmüller (1913–1943) and Ludwig Bieberbach (1886–1982) saw Landau's presentation of calculus as a symptom of his Jewishness, and used it to justify the boycott of his Göttingen lecture courses in November 1933 as a quasi-biological aversion of his German Aryan students. It was this boycott that quickly led to Landau's resignation from his Göttingen chair, mentioned earlier.
- Godfrey H. Hardy (1877–1947) and Hans Arnold Heilbronn (1908–1975) in their obituary (1938) of Edmund Landau, explicitly distinguish between two "Landau styles," the first, more circumstantial one represented by the *Handbuch*, and the more mature one that is best exemplified by the *Vorlesungen*. This mature style is marked by its "power to condense" all details of his argument into a minimum number of words.
- Finally, Konrad Knopp (1882–1957) in his obituary of Landau (1951) narrows down the Landau style to the way of writing that Landau adopted after World War I, which is marked by the "omission of each superfluous word – more than that: of each word which is not absolutely necessary." And Knopp insists on the strain that this style puts on the reader to "feel those more general ideas"[19] which lie behind the austere text.

[18] See, however, Landau 1912.
[19] *. . . jene allgemeineren Ideen zu erspüren . . .*

There is a lesson to be learnt from these examples: not to try and interpret Landau's *style* as a kind of physiognomy of his mind or nature – let alone, his race. But rather to study the rules which Landau obviously imposed on himself to achieve his ideal standard of mathematical exposition.[20] He apparently saw his role as author not to comment on, but to unfold mathematical facts in such a way that only these facts themselves seem to be at work. The only other facts that do figure prominently, especially in Landau's research papers, are painstaking accounts of what other authors have contributed, and when, to the mathematical facts at stake. We encounter both characteristics also in Landau's Jerusalem lecture on number-theoretical problems translated in section 5 below; he adheres to explicit mathematical statements as much as is possible in front of a general audience, and he carefully introduces a small selection of relevant mathematicians by name. This personal side does allow for an occasional spontaneous outburst, as at the end of his presentation of the unsolved problem 6 in his Jerusalem lecture, marking the dedication of the researchers. Beyond this – instead of trying to fathom the "general ideas" behind the mathematics, as Knopp would have it – we will try to lay bare the historical underpinnings of Landau's text.

Landau's 1925 presentation of number-theoretical problems that can be formulated in elementary terms bears little resemblance to David Hilbert's (1862–1943) famous list of problems presented at the 1900 International Congress of Mathematicians (ICM) in Paris, in spite of the fact that both lists[21] run to 23 problems, which is hardly an accident. Landau characteristically hides this allusion to Hilbert's illustrious list in a tongue-in-cheek comment about the handsome number 23 at the end of his lecture.[22] Whereas Hilbert tried, in front of an international audience of colleagues, to set the stage for a new century of research in all active branches of mathematics, Landau pursued the modest goal of allowing a non-mathematical audience a glimpse of problems which interested him in his own research. In view of the audience, he limited himself to very elementary, relatively accessible statements. His characteristic effort to be mathematically explicit shows in the fact that he avoided just dropping names of major conjectures. For instance, both the *Riemann Hypothesis* and *Fermat's Last Theorem* are hinted at via explicit relations between numbers, but not called by

[20] As indirect evidence for this one may quote Landau's description of his personal working habits, comparing them to Adolf Hurwitz's carefully kept mathematical diaries, in his letter to Hurwitz of 24 June 1906 (*Göttingen Handschriftenablteilung*, Cod Ms Math Arch 77): *Ich schreibe nur auf Blätter, von denen ich 9/10 sofort vernichte; ich glaube, dass ich dadurch nichts Wertvolles vernichtet habe; wenn einmal etwas gelingt, schreibe ich es ab und hebe mir nur die Abschrift auf*; i.e., "I only write on loose sheets of which I destroy 9/10 immediately; I do not think that I have destroyed anything valuable in this way. If something happens to work out, then I copy it down and keep only the copy."

[21] Hilbert could not actually read all 23 problems of his written lecture at the Paris Congress (see for instance Grattan-Guinness 2000 or Gray 2000).

[22] Might this number 23 have an even longer history? Books I and VII of Euclid's *Elements* both start with 23 definitions, at least in suitable editions.

their usual names.[23] We see this as a characteristic expression of Landau's "style" even on this mundane occasion.

When he discussed various problems and the then current state of knowledge about them, Landau mentioned a few mathematicians by name, but only for results which they had proved or contributed towards, not for conjectures. In doing so Landau identified a small number of living or past mathematicians by their nationality – as well as their being Jewish, if such was the case – and he called David Hilbert, Godfrey H. Hardy, and John E. Littlewood (1885–1977) his *friends*. In this way, a small, distinguished international community emerges around him on the imaginary stage of Landau's *exposé*, a community which has created and continues to cultivate the objective, transnational, purposefree, and inapplicable domain of number theory.

Looking at Landau's friends, the basic attitude of the Jerusalem lecture may remind one of G.H. Hardy's discourse about "real" mathematics, for instance in the well-known quote[24] from his *Apology* (Hardy 1940, §21):

> It is undeniable that a good deal of elementary mathematics . . . has considerable practical utility. These parts of mathematics are, on the whole rather dull; they are just the parts which have least aesthetic value. The 'real' mathematics of the 'real' mathematicians, the mathematics of Fermat and Euler and Gauss and Abel and Riemann, is almost wholly 'useless' (and this is as true of 'applied' as of 'pure' mathematics). It is not possible to justify the life of any genuine professional mathematician on the ground of the 'utility' of his work.

In Hardy's terms then, what Landau was trying to accomplish in Jerusalem was to convey a whiff of 'real' number theory, while at the same time keeping the exposition as elementary as possible. As for utility, Landau in the final lines of his lecture flatly dismissed all questions of applicability of number theoretical research as if they were clearly beside the point.

The irony of history is of course that Landau's lecture took place at a time when these epithets of number theory were about to disintegrate. This is not only true in view of the applications that serious Number Theory has found since then, for instance in cryptography. But it is particularly true also in another sense which was of immediate, concrete relevance in 1925, when number theory, and science in general, was caught up in a profound political antagonism about scientific internationalism after World War I.[25] This antagonism materialized in the boycott of German science. For the German mathematical community, this boycott officially ended only at the 1928 International Congress of Mathematicians (ICM) in Bologna. But even then,

[23] See problems 18 and 19, respectively.

[24] So well-known, in fact, that it has given rise to the title of a recent introduction to the philosophy of mathematics (Corfield 2003).

[25] Again, this aspect is also present in Hardy's reflections; World War I is mentioned right after the above quote, in the remainder of Hardy 1940, §21 (see also Hardy 1942).

many colleagues – among them all the important Berlin mathematicians – would not overcome their mistrust and refused to travel to Bologna.[26] Landau, however, not only attended the Bologna ICM – acompanied by his wife and one of his daughters – but he actively sought international mathematical contacts on many occasions.

In the year of his Jerusalem address, for instance, Landau applied on 3 June 1925 for a half-week leave of absence from Göttingen during the term, in order to attend the 60-years-jubilee meeting of the London Mathematical Society, "of which I have become an honorary member after the war." Landau stressed that he wanted to honor this invitation "out of general principles," documenting his continuing international contacts.[27]

Another example: on 2 October 1923, the *Kurator* of Göttingen University, Justus Theodor Valentiner (1869–1952) – clearly mindful of the political dimension of the case – had taken the personal initiative to inform the Ministry of Landau's intention to accept an invitation to lecture at Oxford on his specialty in Hardy's stead. Valentiner quoted Landau to the effect that Hardy's attitude towards Germany during the war had been "objective" and that Hardy had attended conferences in Germany since then.[28] Indeed, Hardy clearly expressed his concerns about mathematical internationalism during World War I in the Latin dedication of his 1915 book with Marcel Riesz (1886–1969), whose final manuscript he had to prepare without his coauthor: "To the mathematicians (how many and wherever they may be): that they may soon again take up, as is to be hoped, the confraternity of their works which is currently disrupted, we, the authors, friends and foes at the same time, present and dedicate" this book.[29]

At the same time Landau was certainly not prepared to give up what he considered his German honor in the name of internationalism. We know for example that during or right after World War I, Landau fell out completely with the wealthy Belgian Jewish

[26] For the boycott in general and the difficulties to end it, see Schroeder-Gudehus 1978 (cf. Forman 1973).

[27] See Landau's Göttingen file UAG, Kur PA Landau, Edmund, sheet 73. Incidentally, the letter is also a characteristic example of Landau's painstaking sense of his duties as an academic teacher; Landau explains in detail that thanks to an arrangement made with his assistant Grandjot, the students will not miss a single hour of teaching during his absence: *Berlin 3. Juni 1925. / An das Universitätskuratorium Göttingen. / Hierdurch bitte ich um Urlaub für die zweite Hälfte der Woche nach den Pfingstferien. Ich bin gebeten worden, am 60 jährigen Jubiläum der London Mathematical Society, deren Ehrenmitglied ich nach dem Kriege wurde, teilzunehmen, und möchte aus prinzipiellen Gründen dieser Einladung Folge leisten. / Meine* 2 × 2 *Vorlesungen am Montag, 8.VI. und Dienstag, 9.VI. halte ich selbst; am Donnerstag, 11.VI. und Freitag, 12.VI. würde mich Herr Grandjot vertreten. Er ist genau instruiert und die Übungsaufgaben, die er am Freitag zurückzugeben hat, habe ich hier selbst korrigiert. Für die Studenten geht also keine Stunde verloren.*

[28] See Landau's Göttingen file UAG, Kur PA Landau, Edmund, sheet 71. Valentiner's handwritten draft reads: *Der ord. Prof. der Mathematik Herr Landau ist von Professor Hardy, Oxford, Mitglied der hiesigen Akademie der Wissenschaften, eingeladen worden, Mitte und Ende Oktober an der Universität Oxford gewissermaßen "in seiner Vertretung" (: das soll eine dort übliche Form sein :) Vorlesungen auf seinem Forschungsgebiete zu halten. Herr L[andau] beabsischtigt dieser Einladung – übrigens sehr bald – zu folgen, da Professor Hardy sich während des Krieges gegenüber Deutschland objektiv verhalten und seitdem an Tagungen in Deutschland teilgenommen habe. Ich habe es für richtig gehalten, Anzeige von diesem Plan zu erstatten.*

[29] *Mathematicis quotquot ubique sunt / operum societatem nunc diremptam / mox ut optare licet redintegraturis / d.d.d auctores / hostes idemque amici.* Konrad Knopp also refers to the front matter of this book (Hardy and Riesz 1915), pointing out that Landau is prominently mentioned in the foreword despite the war (see Knopp 1951,14).

mathematician Alfred Errera (1886–1960) "for political reasons on his side."[30] The breakup was probably prompted by the German warfare – and war atrocities – in Belgium which triggered very strong anti-German feelings in Errera.[31]

After the death of the French mathematician Camille Jordan (1838–1922), Gösta Mittag-Leffler (1846–1927) from Stockholm asked Landau in March 1922 to write an obituary for the Swedish journal *Acta Mathematica*, mentioning also the good effect that this could have on reconstructing French-German scientific relations. Landau declined because he felt ill-prepared for the job, but he also addressed the "secondary, highly political purpose" of Mittag-Leffler's proposal: in his opinion, German scientists had already reestablished relations with "almost the whole world" except France, and especially after the "scandalous 'International' Congress of Mathematicians" organized by the French in Strasbourg in 1920 (from which German mathematicians were excluded), Landau felt that it was not for the German scientists to make a gesture, but for the French to start cooperating again.[32]

Also in 1922, Landau was approached to participate as a mathematical correspondent in Georg Karo's[33] initiative to compile a blacklist of scientists who backed the boycott of German science or had written anti-German political pamphlets. Landau declined, stressing that he shared the concern but had doubts about the means employed, yet he offered to collaborate indirectly on this project:[34]

[30] ETH Archives Zurich, Hs 89:310, Landau's letter to George Pólya (1887–1985) of 29[?] July 1921, where he writes, apparently alluding to (Errera 1913): *Lieber Herr Kollege Pólya ! . . . Die Arbeit von ERRERA ist keine Dissertation; die Verantwortung trägt er also allein, wenn ich es auch einmal mit ihm nachträglich durchgesprochen habe. Die Materie liegt mir z.Z. fern, und ich bin z.Z. ganz Waringmonomane. Die Sache wird sich also am schnellsten klären, wenn Sie den Verf. anfragen. Aber bitte, ohne sich auf mich zu beziehen. Denn ich bin mit ihm aus politischen Gründen seinerseits ganz auseinander.*

[31] Errera-Bourla 2000, esp. 177, 185. Errera's anti-German sentiment clearly resulted from World War I, but it continued at least into the 1930s, when Alfred Errera was a member of the Jewish organization *Appel du comité d'action économique* whose goal was a comprehensive anti-German boycott. Errera's attitude towards Zionism (which evolved in the 1930s) also seems to have been different from Landau's; but this would hardly explain the political breakup alluded to by Landau.

[32] We thank Reinhard Siegmund-Schultze for having communicated these letters to us. The originals are in the Mittag-Leffler legacy at Djursholm. The little correspondence is to be published, with an introduction by Reinhard Siegmund-Schultze, in *Revue d'histoire des mathématiques*.

[33] Karo (1872–1963) was a well-known professor of archaeology in Halle, a protestant Christian of Jewish origin. Karo's letter, with samples of potential entries about anti-German colleagues attached, was transmitted to Landau by the Göttingen professor of German language and literature Edward Schröder (1858–1942); see *Göttingen Handschriftenabteilung*, Cod Ms Schröder 562.

[34] Landau's letter to Schröder dated 28 July 1922 reads: *Sehr verehrter Herr Kollege! / Für die Mitteilung des Briefes des Herrn Koll. Karo danke ich Ihnen sehr; ich habe ihn nebst Anlagen mit grösstem Interesse gelesen, bin von der Güte des Zweckes überzeugt, aber sehr im Zweifel, ob diese Organisation die richtigen Mittel wählt. / Wir alle kennen doch aus eigener Erfahrung nur das Gute, das wir über die mehr oder weniger vereinzelten ausländischen Kollegen zu sagen hätten, die sich im Kriege korrekt oder wenigstens nachher als geheilt von ihrer Kriegspsychose erwiesen haben und uns durch Briefe oder Zusendungen von Publikationen oder Besuche nahegetreten oder nahegeblieben sind. Bereits hier kann ein Teil des Materials, da vertraulich, nicht weitergegeben werden; z.B. sind mir Interna der Verhandlungen zweier neutraler Akademien in der Boykottkartellfrage bekannt, die nicht zur Verbreitung bestimmt sind! / Was die Stellung der negativ zu Beurteilenden, d.h. auf die schwarze Liste zu setzenden Gelehrten oder "Gelehrten" betrifft, die diese Brandmarkung im Falle der einwandfreien*

> We all have direct knowledge only of the *good* things which we would have to say about those more or less singular foreign colleagues who behaved decently during the war or who at least have proved afterwards that they were cured of their war psychosis. . . . Already here part of the material is confidential and cannot be communicated . . .
>
> When it comes to those scholars or "scholars" who have to be judged negatively, i.e., have to be put on the blacklist, and who deserve this stigmatization in view of flawless evidence for our accusations, we will usually have to rely only on rumours or even newspaper articles. . . . This renders such accusations very subjective, and since everyone of us would surely have too much of a sense of justice to circulate mere conjectures and rumours, even if it were just for Karo's register, which after all would have to be copied many times, the whole project, if it is realized as seriously and carefully as it would necessarily be done by German scholars, the final outcome will be very meager.
>
> . . . . . .
>
> But this will not prevent me, if the project is realized, from communicating to you (and you may also discretely pass on extracts to the headquarters) my personal value judgment about any mathematician whom you inquire about, concerning his decent or indecent behaviour towards us.

Landau's participation in the Jerusalem celebration of April 1925 reflects his deep concern about international research cooperation in mathematics. When Landau attended this crucial event for cultural Zionism, he was actually pleading three causes at the same time: scientific internationalism, pride of Germany – for instance on behalf of her most distinguished number theorist and analyst Johann Peter Gustav Lejeune Dirichlet (1805–1859) – and Zionism. He thus concluded his toast at the cornerstone ceremony of the Wattenberg building (reproduced in section 5 below) by saying: "May great benefit emerge from this house dedicated to pure science, which does not know borders between people and people. And may this awareness emerge from Zion and penetrate the hearts of all those who are still far from this view."

The specific permeability of the supposedly pure and abstract domain of number theory by nationalist discourse was not an invention of the twentieth century.[35] Dirichlet's case is particularly striking here because, to a historically trained observer, his mathematics appears to be a perfect blend of German and French influences. Indeed, he never traveled without his well-thumbed copy of Gauss's *Disquisitiones Arithmeticae*, but he

Erweisbarkeit unserer Vorwürfe auch verdienen, so sind wir doch meist nur auf Gerüchte oder gar Zeitungsnotizen angewiesen. (Wo natürlich Publikationen von ihnen mit Beschimpfungen Deutschlands oder der deutschen Wissenschaft vorliegen, ist das Material einwandfrei.) Daher haben solche Auskünfte etwas sehr subjektives, und da wohl jeder von uns zu gerecht ist, um Vermutungen und Gerüchten eine Verbreitung zu geben, sei es auch nur in dem doch immerhin zu vervielfältigenden Zettelkatalog des Herrn Koll. K., so wird wohl bei der Sache, wenn sie so ernst und sorgsam gemacht wird, wie es deutschen Gelehrten allein möglich ist, nur ein dürftiges Material herauskommen. / Daher halte ich Vorsicht für geboten. / Dies wird mich aber nicht verhindern, wenn die Sache zustande kommt, Ihnen (auch zu diskreter Weitergabe eines Extraktes an die Zentrale) über jeden mathematischen Kollegen, nach dem Sie mich anfragen, mein persönliches Werturteil, betreffend sein anständiges oder unanständiges Verhalten gegen uns, mitzuteilen. / Bestens grüssend / Ihr ganz ergebener / Landau.

[35] For a survey of this fact, see Goldstein 2007.

learned analysis, and more exactly Fourier analysis, during his formative years in Paris, tapping directly into French mathematical culture. However, the new cultural awakening of Prussia in the 1820s and 1830s, after Alexander von Humboldt's (1769–1859) return to Berlin from Paris, also brought about Dirichlet's subsequent move to Berlin after which he was increasingly portrayed in Germany as an incarnation of the German genius.[36] Landau still echoed this view in 1925 when he discussed his third problem.

The peculiar twist, however, that Landau gave this German tradition in his Jerusalem addresses concerns Zionism. As the preceding quotation already shows, Landau could associate the ideal of pure number theory with the message from Zion. Shaul Katz quotes from a 1927 New York Yiddish newspaper which explicitly interpreted Landau's (later) activity as a professor of mathematics in Jerusalem as a modern return to the Torah studies of his great-grandfather, the Ga'on Rabbi Yehezkel Landau in Prague, or *Noda' bi-Yehuda* (the well-known in Judea), as he is also called after one of his works.[37] Indeed, Landau actually adopted the name Yehezkel in his Hebrew writings.[38]

A few years earlier, in November 1919, in his letter of condolence to Adolf Hurwitz's widow after the death of this Zurich mathematician, Edmund Landau had expressed the idea that an important scientific *œuvre* realized by a Jew may be regarded as a – possibly not orthodox, but perfectly valid – contribution to the global Jewish cause. In this letter, after praising Hurwitz for his human and scientific qualities, and praising Mrs. Hurwitz for having helped her husband live so long in spite of his frail health, and after expressing regret that he would not be able to meet him again on his next visit to Zurich, Landau continued: "And that this great man was a Jew, makes me particularly proud. Even though he did not care in the least for rules and customs, he has done infinitely much for the *Judentum* through his mathematical life's work. This is why I will doubly cherish his memory."[39] What strikes us here is not so much Landau's

[36] On this matter, see Goldstein, Schappacher, Schwermer 2007, 45, and chap. III.1.

[37] In sections 1–4 we have transliterated and translated all Hebrew names and expressions appearing in the text. In sections 5-6, where genuine linguistic questions are addressed, we have also included Hebrew texts and terms in the original.

[38] Katz 2004, 213. We are not aware of any more concrete reference that Edmund Landau would have made to his ancestor; in fact, the Rabbi in his time opposed tendencies of the Berlin Jews.

[39] See ETH Archives, Zurich, Hs 583:33 (photocopy of Landau's handwritten letter): *Göttingen 28.11.19 / Sehr verehrte Frau Hurwitz! / Tief erschüttert erhalte ich die Trauernachricht. Nehmen Sie mein und meiner Frau innigstes Beileid entgegen. Ich verliere in Ihrem Mann einen meiner wärmsten Freunde und Gönner, dessen Anerkennung mich oft, als es nötig war, aufgemuntert hat. Und die Wissenschaft verliert in ihm einen ihrer Heroen. Bei seinem zarten Körper ist es ein Wunder, dass es Ihrer Pflege gelungen war, ihn solange zu erhalten. Jeder, der je Gelegenheit hatte, in seine gütigen und gerechten Augen zu sehen, wird Ihnen dauernden Dank dafür wissen, dass durch Ihre Fürsorge er vielleicht um Jahrzehnte länger der Welt geschenkt blieb. / Meine Frau hat ihn von uns beiden zuletzt wiedergesehen und sprach immer gern von der freundlichen Aufnahme bei Ihnen. Und ich hatte so gehofft, in den nächsten Jahren wieder einmal in die Schweiz zu reisen und in gewohnter Weise einen Tag bei Ihnen zuzubringen. Nun ist der Mittelpunkt des Zürcher mathematischen Lebens fort und ich habe kein Heim mehr in dieser schönen Stadt. / Und dass dieser grosse Mann ein Jude war, macht mich ganz besonders stolz. Auch ohne dass er auf Formen und Gebräuche irgend welchen Wert legte, hat er durch sein mathematisches Lebenswerk unendlich viel für das Judentum geleistet, und darum wird mir sein Andenken doppelt teuer sein. / Mit herzlichen Grüssen, auch an Ihre Kinder, in tiefer Mittrauer Ihr ergebenster Edmund Landau.*

pride that this splendid mathematician was 'one of us,' as the way he immediately ties this with the analogy between living for a mathematical work, and living according to orthodox rules. The German word *Judentum* can mean both *jewry* and *judaism*. Even though the context at first suggests *jewry* here, the double meaning probably resonated with Landau in that he was obviously ready to somehow accept a mathematical *œuvre* as a valid substitute for the religious cult which traditionally defines *judaism*.[40]

During the Great War, the assimilated Jews in various European countries opted in the first place for their respective, belligerent nations, thus making it difficult to find a specifically Jewish position.[41] After the war, Jews in the countries that had lost tended to be accused of not having (or not having effectively) fought in the war. This actually happened to Landau himself in a letter signed "Dr. N." to the editors of *Göttinger Tageblatt* published on Christmas eve, 24 December 1918 (page 3). A day later the paper publicly apologized (again on page 3) to Landau who had apparently sent in documents concerning his military status during the war which excluded him from enrollment in fighting troops. This is Edmund Landau's only response to anti-Semitism between the wars that we are aware of.[42]

This and other aspects of the postwar crisis would abet the search for a Jewish identity and may in part account for the popularization of the science of Judaism during the Weimar Republic.[43] As we mentioned at the beginning of this section, Edmund Landau had certainly been in close contact with Zionist ideas earlier, both through his father and his father-in-law, but we have no sources to trace the evolution of his stand on Zionism. On the basis of his Jerusalem activities, all we can see is how participating in the founding and starting of the Hebrew University enabled Landau to transfer his traditional German scientific ideals to a Zionist setting that he probably hoped would be intrinsically international, and that seemed to offer a safe haven from the cultural and political crisis he was experiencing at home. Thus for Landau, the inauguration of modern mathematics in Hebrew at Mount Scopus, while appealing

[40] We thank Andrew Ranicki, Edinburgh, for a very helpful discussion about the translation of this letter.
[41] A case in point is the little book by Max Simon (1916) which will be discussed a bit more in section 2 below.
[42] In particular, we do not know what effect the wave of violent anti-Semitism in the first years of the Weimar Republic had on him. We also have no explicit documents about his general political appraisal of this Republic. [Back in the Wilhelmian Empire (in a letter to Hurwitz dated 13 February 1907, *Göttingen Handschriftenabteilung*, Cod Ms Math Arch 78, sheet 7–8), he described his political *Weltanschauung* as *liberal (und nicht nationalliberal)* and expressed his satisfaction that the liberals had beaten the social democrats in a recent *Reichstags*-election, while at the same time regretting their continuing powerlessness with respect to the "reactionaries" (*die Reaktion*). As for Landau's national political outlook during World War I, it seems very difficult to determine to what extent his backing of a Faculty vote against the philosopher Leonard Nelson (see Peckhaus 1990, 210–212), which criticizes his philosophical works alongside Nelson's allegedly unpatriotic influence on students, can be interpreted as expressing Landau's political opinion.] The official files do contain his signature on the oath of allegiance to the Weimar constitution (dated 12 February 1920 in UAG Kur PA Landau, Edmund); but then they also contain (dated 2 June 1933, see *Geheimes Staatsarchiv* in Berlin-Dahlem, Rep 76 Va Nr. 10081) his signature on the formula of allegiance to the "National State" required by §4 of the Nazi law of 7 April 1933.
[43] See chap. 4 of Brenner 1996.

openly to Jewish tradition, was profoundly marked by the cultural agenda of postwar Germany, or more generally, of postwar Europe.

In this respect Edmund Landau's attitude strikes us as somewhat analogous to what Miriam Rürup, in her analysis of the educational agenda of German Zionist student fraternities, in particular in their support for the foundation of the Hebrew University, has called the function of Palestine as a "projection screen": helped by an iconography which showed concrete colonization in a sort of biblical scenography, and driven by the desire to overcome lack of recognition at home by building a new, strong and respected Jewish society in Palestine, the student fraternities felt they had a cultural mission.[44] But as explained above, Landau's cultural and political agendas were not the same, and it was even more immediately directed towards Europe. The attitudes are analogous in that both Landau and those fraternities discussed by Rürup readily availed themselves of the spiritual leverage provided by the geographical outpost, but continued to function according to the priorities dictated by their situation back in Germany.

3. Jewish Scientists and the German Zionist Movement

The Hebrew University project had many supporters among leading Jewish scientists of the time. Albert Einstein's (1879–1955) involvement is well known, but also other prominent mathematicians like Tullio Levi-Civita (1873–1941) and Jacques Solomon Hadamard (1865–1963) were members of the university's Academic Council since its inception. However, none of them, like Landau, took the bold step to actually move to Jerusalem, and at a very early stage in the development of the new university. We have already alluded to Landau's family background as partially explaining his attitude, and we have seen that his support of some Zionist projects did not diminsh his basic German patriotism.

German Zionists were always a minority within the German Jewish community as well as within the World Zionist Organization. Nevertheless their relative weight and influence within both frameworks was fundamental, and certainly well beyond their number. This became especially true after World War I. The movement arose from scattered activities of groups of Jewish university students, who sought their own response to the main questions that occupied German Jewish communities over the last two decades of the nineteenth century: integration, political anti-Semitism, and mass immigration of Eastern European Jews. The generation of their parents, and particularly those belonging to the prosperous upper middle classes, were convinced of the ultimate success of the processes of emancipation and integration of Jews

[44] See Rürup 2008, 347, and also the following pages, esp. 351, for the missionary aspect of student trips to Palestine. In the case of the fraternities, the cultural mission was envisaged particularly with respect to Eastern Jews.

into German society. In contrast, the early Zionists, especially students from the lower middle-class, developed an alternative view about the future of European Jews, both German and East-European. Their post-assimilationist views stressed above all a strengthening of their Jewish national awareness together with a return to their Jewish roots, albeit – in most cases – in a secularized version.[45]

Broadly speaking, in contrast to the Zionist movement in Eastern Europe and in the West, the German Zionist movement was relatively uniform and politically cohesive, and from very early on it adopted a particular version of a Palestine-centered approach. Similarly to other Western Zionists, their ideology was motivated neither by personal hardship nor by deep religious convictions. On the other hand, however, anti-Semitism and the problem of Eastern European Jewish emigration was more of a pressing problem for German Jews than for those from, say, Great Britain or America.

Influenced by national ideologies of late nineteenth-century Central Europe, and strongly concerned with immigration and settlement in Palestine, certain German Zionists were sympathetic to ideologies critical of capitalism, and the evils of industrialism. Social betterment through productive labor, collective farming, and moderate socialist views were widespread ideals. In fact, much of the actual planning of the farm-based economy of the Jewish settlement in Palestine was put forward by German Zionists, and particularly by some of the university professors associated with, or sympathetic to, the movement and its aims. Prominent among these was the physician turned economist Franz Oppenheimer (1864–1943). Also Otto Warburg (see footnote 3 above) dealt with the practical aspects of Jewish settlement in Palestine. The burning issue of national land ownership, for instance, was greatly advanced, from the point of view of the Zionists and for the benefit of Jews coming from Russia, by the efforts of a prominent German Zionist leader, the lawyer Max Bodenheimer (1865–1940), under the influence of a professor of mathematics who is of considerable interest for our story: Hermann Schapira.

Zvi Hermann Schapira (1840–1898) was born in the small Lithuanian town of Erswilken (see Köhler 1900). Although his mathematical talent became evident at an early age, he followed the direction stipulated by his family and received full rabbinical training. Only in 1868 did he start his mathematical studies at the *Gewerbeakademie* in Berlin, where Siegfried Aronhold (1819–1884) was one of his teachers. In 1871 he fell ill and was forced to move to Odessa, where he worked in a bank, while keeping alive his interest in mathematics. In 1878 he resumed his mathematical studies at Heidelberg. His main mathematical influence came from Lazarus Fuchs (1833–1902), who was his doctoral supervisor, and from Moritz Cantor (1829–1920) who imbued him with a vivid interest in the history of mathematics. He completed his dissertation in 1880 and, although he was invited to take a position in Kazan, he preferred to remain at Heidelberg. Schapira obtained his *Habilitation* in 1883 and was appointed

[45] On German Zionism in general, and the topics discussed here, see Lavsky 1998 and Berkowitz 1993.

ausserordentlicher Professor in 1887. His research included works on analytic and algebraic iteration. In 1889 he published an authorized translation into German of Chebyshev's book on number theory (Tschebyscheff 1889).

While active in mathematical research and teaching, Schapira maintained a lifelong interest in Jewish affairs. In 1880 he translated, edited, and published what is considered to be the oldest mathematical text written in Hebrew: *Mishnat Hamiddot* (Theory of Measurements).[46] The manuscript of this medieval text was kept in Munich, and was first transcribed and published in 1864 by the Jewish scholar Moritz Steinschneider (1816–1907). Schapira's translation with commentary embodied an elegant synthesis of his many intellectual interests. His broad Talmudic background was readily put to use in his commentary of the mathematical ideas and vocabulary appearing in the text, while the historiographical influence of Moritz Cantor is also evident throughout. Of no less importance was his intrinsic interest in the Hebrew language and the centrality he attributed to its revival and nurture. For many years he contributed to several Hebrew periodicals published in Germany and the revival of Hebrew culture was a main motive in the concepts that accompanied his eventual involvement with Zionism.

Schapira was the leader of the group established in the 1880s in Heidelberg as part of the *Hovevei Zion* (Lovers of Zion) associations that were organized in Germany after their Russian counterparts of the same name. A main aim of these proto-Zionist groups was to foster and enable Jewish settlement in Palestine as a way to solve the problem of Russian Jewry. In 1896 at the First Zionist Congress in Basel, Schapira presented a proposal to establish the Jewish National Fund (JNF), with the expressed purpose of drawing active, financial support of Jews around the world to provide the means for purchasing land in Palestine. This idea was eventually implemented, following a decision taken in 1901 at the Fifth Zionist Congress. The Fund, known in Hebrew as *Keren Kayemet Le'Israel*, soon became central to the realization of the aims of the Zionist movement. It continued to have an enormous practical, political, and symbolic impact for decades.[47]

At the First Zionist Congress, Schapira was also the first to publicly discuss the idea of the creation of a Jewish institution of higher learning in Palestine. He sketched a plan for a religiously oriented institution comprising research and teaching of secular disciplines in the framework of several schools of theology, theoretical sciences, technology, and agriculture. In his vision, this would become the cornerstone of the national revival of the Jewish people. As with his idea of the Jewish National Fund, this one too was elaborated into a more concrete plan at the Fifth Zionist Congress. Chaim Weizmann (1874–1952) then became the main promoter of the idea of a leading, secular research university of European standard.

Schapira and Weizmann represent two successive generations in the development of the Zionist movement. Schapira exemplifies the considerable influence that German

[46] See Schapira 1880. For the general context of this text see Lévy 1996 as well as Lévy 1997.
[47] The Fund is still active today, but it is far from being the unifying kind of national institution that it once was.

Jewish professors could have on the German Zionist movement. Later on, from the early 1890s, some student groups, mainly of Russian origin, became more influential. Some of them became prominent intellectuals as well as Zionist leaders in the decades to come. Among these one can count Weizmann himself, who arrived at Darmstadt in 1892 from Motyli, near Minsk; Shmariyahu Levin (1867–1935), who came from Minsk to Königsberg where he completed his doctorate in philosophy; and Leo Motzkin (1867–1933), who arrived in Berlin from Kiev. After studying in Freiburg, Switzerland, Weizmann became a distinguished chemist at Manchester, and was the first to develop an industrial process of bacterial fermentation to produce acetone. In addition, he was a foremost leader of the World Zionist Organization, and became the first president of the State of Israel in 1949. Levin was directly involved in the creation and later activities of the Technion at Haifa and also with the Hebrew University in Jerusalem. Motzkin started his doctoral studies in mathematics with Leopold Kronecker (1823–1891), but eventually abandoned them in order to devote himself completely to Zionist activities.[48]

A main turning point in the history of German Zionism came in the aftermath of World War I. It gave further impetus to the Palestine-oriented positions of the younger generation and strengthened links with Eastern European Jews. Indeed, at the outbreak of the war, most German Jews fully shared the nationalistic enthusiasm of their fellow Germans in all walks of life. Many felt that the active participation in combat of Jewish soldiers would provide the ultimate proof of loyalty and the last necessary step towards their full integration into German society. Some German Zionist leaders drew a clear connection between German imperialist aspirations and Jewish national interests, and some German officers saw the Zionist movement as fully aligned on the German side (see Zechlin 1969, 119–120). A main task of the cooperation of Jewish organizations with the German authorities was to help Jews in Eastern European territories occupied by the German army.

An interesting example of Jewish responses to the situation created by the war, which touches upon all the questions mentioned above, appears in the booklet (Simon 1916) written by the Strassburg mathematician Max Simon, entitled "The World War and the Jewish Question." Max Simon (1844–1918) grew up and completed his university studies in Berlin (see Lorey 1918). Simon's analysis of the issue of emigration to Palestine is particularly interesting here.[49] Such a move is seen as a drastic solution for the plight of East European Jews, but seems to concern German Jews only marginally, if at all. Simon addressed this issue from the point of view of the German alliance with Turkey and the future of the Ottoman Empire. According to him (Simon 1916, 69), the

[48] His son Theodore (1908–1970) did succeed in an international scientific career; he was appointed to the Einstein Institute for Mathematics at the Hebrew University in 1935, and later on worked in several American intuitions, mainly at UCLA.

[49] This is contained in the third and last chapter of Simon 1916: *Die jüdische Emigrationsfrage und die palästinensische Kolonisation*.

Turks had to acknowledge their considerable debt to Jewish colonization in Palestine since the 1880s, both economically and culturally. He thus expressed his concern that as a consequence of the war, one of the *entente* powers – Russia, France, or England – could take hold of Palestine instead of the Turks. Many Jews, he said, think that it would be in their best interest for England to take hold of Palestine. This liberal country, they think, would allow more intensive Jewish settlement of the land and, may even offer the Jews a national homeland. But Simon was very skeptical about that scenario in 1916. Turkey and the Jews, he said, had a common interest in the Jewish colonization of Palestine, and only from the Turks could the Jews expect cooperation on the Palestinian matter. The Turks, he thought, were no longer antagonistic to the Jewish colonization plans for Palestine. In fact, the panarabic anti-Zionist activities had sought to ally themselves with the British (Simon 1916, 71–76).

Simon also feared that a possible victory of the *entente* would signify the continuation of the unbearable situation of Russian Jews and the destruction of the hopes for the establishment of a new Jewish center with its own Hebrew culture in Palestine. The victory of the central powers on the other hand, would bring new hopes for freeing a large number of Russian Jews, for a free development of the rights of Jewish population in the liberated territories of the Western part of Russia, and for a significant future of Jewish emigration and settlement in Palestine. He thus concluded: "Whoever observes the World War without any sentimentality and prejudices, with the eyes of a sober Jewish politician who examines the situation objectively, can have no doubt that, as Jews, we must only wish for the victory of the central powers."[50]

Jews living in neutral countries, and especially in the USA, he added, have instinctively felt this way from the beginning of the war, and therefore they have given their support to the central powers. This was not because they had any special sympathy for Germany. But their reaction derived, according to Simon, from the justified evaluation of the best interest of their own people. Simon thus concluded with a call to Jews in the neutral countries to actively support the victory of Germany and the central powers.

The ideas expressed in very different historical circumstances by these two mathematicians, Schapira and Simon, are interesting within the large spectrum of attitudes of German Jews to the political and cultural agenda promoted by the German Zionists. Schapira proposed ideas that would eventually be implemented as core elements of the Zionist program: the Hebrew language as part of the national revival, the Jewish National Fund, and a Jewish institution of higher learning in Palestine. These ideas invited direct support, albeit in varying degrees of commitment, from German Jewry, Zionists as well as non-Zionists. Philanthropy and help to the Jewish brethren from the East, as well as the ideal of universal learning in a context that stressed the

[50] Simon 1916, 79: *Wer so den Weltkrieg frei von jeder Sentimentalität und Voreingenommenheit, mit den Augen des nüchtern und sachlich prüfenden jüdischen Politikers betrachtet, kann gar nicht daran zweifeln, daß wir als Juden nur den Sieg der Zentralmächte herbeiwünschen müssen.*

primacy of the Jewish contributions to universal heritage, were certainly causes that would elicit broad sympathies. Max Simon, in turn, also expressed concern for the destiny of Eastern Jews, but his wish for a victory of the *entente* obviously raised a very delicate issue at the peak of the war, especially for Jews outside Germany (if it ever came to their attention). In any event, the Zionist movement faced a new situation at the end of the war, with Palestine under British rule.

The German nationalist enthusiasm of many Jews diminished in the course of the war, as it increasingly became apparent that even the final proof of loyalty, active participation in combat of Jewish soldiers, would not suffice to appease anti-Semitic feelings that were so deeply rooted. Of special significance was the infamous "Jewish count" organized in October 1916 under the initiative of the German Ministry of War in order to determine the actual number of Jews serving in combat lines. Even though this count showed the opposite of what its promoters intended – the proportion between combatant and non-combatant Jews was 80 to 20 – it brought about a deep crisis among Jewish soldiers (see Angress 1976). Akiva Ernst Simon (1899–1988), for instance, who in 1939 would become professor of philosophy at the Hebrew University, had gone to war in the nationalistic euphoria shared by so many, and the anger and frustration that the count aroused in him was the direct reason for his conversion to Zionism (see Simon 1965, 18).

The establishment of the Weimar Republic, on the one hand, and of the British Mandate in Palestine on the other, changed the outlook of German Zionism after World War I profoundly. Many German Jews felt stronger than ever that total political and social integration was around the corner. On the other hand, the Balfour Declaration of November 2, 1917, granting Jews the right to establish a national homeland in Palestine, rendered the Zionist project much more feasible. The mainstream Zionist conception continued to be based on the combination of two main ideas: (1) the creation of a national homeland in which a renaissance of Jewish culture and Hebrew language would take place, and (2) the return to the soil and productive labor as a basis for a just society based on state-owned capital as the main force behind economic development of this entity.

Yet, some alternative approaches started to develop right after the war. The *Binyan Ha'aretz* ("Building of the Land") group, for instance, attracted many bourgeois Jews involved in commerce and liberal professions who opposed the identification of Zionism with social ideologies. They were willing to support the promotion of a Jewish homeland in Palestine, but they stressed the primacy of private enterprise and private capital as the main economic force of this entity. All in all, between 1920 and 1933 about 40,000 German Jews left their country as emigrants; while about 7,000 among them left for the USA, only slightly more than 3,000 headed for Palestine. Edmund Landau lived in Jerusalem in the winter of 1927/28, between two years of the lowest German emigration to Palestine, with only 84, resp. 87 emigrants (see Lavsky 1998, 104).

4. Founding the Hebrew University

At the Fifth Zionist Congress in 1901, Chaim Weizmann presented for the first time his own program for the creation of a Jewish university in Palestine. Progress reports on this project became a recurring point of interest in the subsequent congresses. At the Tenth Congress, held in Vienna in 1913, the main speaker, Zionist leader Menachem Ussischkin (1863–1941) announced that a considerable sum had been donated for "the crown of our cultural work." Making the direct connection with the First Temple at Mount Moriah, destroyed 2500 years earlier, he solemnly declared: "let us build a temple of culture and knowledge on Mount Zion." In his double role of Zionist leader and world-renowned organic chemist, Weizmann became the main moving force behind the Hebrew University project. In many circles it was presented as an undertaking of the Jewish people as a whole, rather than just a Zionist idea (see Berkowitz 1993, 110–112).

Over the years, Weizmann made efforts to enlist the support and active participation of as many prominent Jewish scientists as possible for the project. In 1913, Weizmann asked Edmund Landau's father Leopold Landau to help him establish contact with Paul Ehrlich, i.e., Edmund Landau's father-in-law. Ehrlich expressed his willingness to support Weizmann's initiative to create a research institute in Jerusalem modeled after the *Institut Pasteur* in Paris as part of the larger University project, but the outbreak of World War I disrupted any concrete plans in this direction, and Ehrlich died in 1915 from a stroke. Edmund Landau's later engagement for the cause of the Hebrew University can be seen as a continuation of this family tradition.[51]

Not surprisingly, Weizmann made enormous efforts to gain Albert Einstein's support for the project. Einstein's overall attitude to it, and to Zionism in general, is interesting in itself: First of all it was the new reality created by the influx of East European Jews into Germany during and after World War I which made Einstein, who formerly had been an assimilationist, embrace Zionism as a way to face the evils of anti-Semitism. He was particularly bothered by the way in which assimilated German Jews often attempted to deviate popular anti-Semitic feelings towards the *Ostjuden*. Yet he took care to preserve a skeptical distance from it, typically presenting himself as a "supporter" of Zionism rather than a "Zionist." Einstein's "spiritualized" concept of Zionism, as he qualified it, emphasized community bonds and cultural motivations which could seem less intrusive than actions to gain control of land and power. The "very same moral tradition" which for Einstein lay at the heart of Zionism "demanded a just solution of the conflict between Arab and Jew, an end that seemed less and less attainable as the political situation in Palestine continued to deteriorate."[52]

The Hebrew University project was the kind of project that would allow him to act on his position. At the insistence of Kurt Blumenfeld (1884–1963), a prominent Zionist

[51] See Weizmann 1949, 141. (Cf. the discussion in Katz 2004, 205–206).
[52] The last quote is from Rowe, Schulmann 2007, 31; see more generally, 136–188; see also Sayen 1985.

leader, Einstein in 1921 accepted Weizmann's invitation to accompany him on a fund-raising tour of the United States. Einstein's only visit to Palestine occured in February 1923, on his way back from Japan. On that occasion, he delivered a scientific lecture in what is considered to be the official opening of the university. The event took place in a British Police Academy hall on Mount Scopus. It was a very festive occasion for the Zionist establishment, and Einstein opened the lecture with one sentence in Hebrew and then apologized for being unable to continue in the language of his own people, before switching to French. On the final day of his trip he wrote in his diary: "They absolutely want me in Jerusalem and are assailing me in closed ranks on that question. My heart says yes, but my reason says no!" (Quoted in Fölsing 1997, 532). Einstein never returned to Jerusalem, not even for a visit. And in 1952, after Weizmann's death, he famously declined Ben Gurion's offer to become the second president of the state of Israel (see ibid., 732–734).

Yet all his life Einstein remained committed to the Hebrew University, and this commitment ultimately materialized in his will that bestowed all his papers to the university. This is not to say that his relationships with the administration were easy. Einstein joined the Board of Governors of the university from its inception in 1925, and also was the founding chairman of its Academic Committee. The first meeting of this committee took place in Tel Aviv in April 1925 in connection with the official Inauguration of the Hebrew University. Einstein was absent. At the next meeting, in September 1925, significant differences over policy with the powerful Chancellor of the university, Judah Leon Magnes (1877–1948), became evident. Einstein resigned from the Board as early as 1928.

The explicitly political opening speeches at the Inauguration of the Hebrew University, on 1 April 1925, were given by personalities such as the British High Commissioner Herbert Samuel (1870–1963), Lord Balfour (1848–1930), and Haim Nachman Bialik (1873–1934), considered the modern Jewish national poet. Also Weizmann gave one of the opening speeches. In his double role of political leader and leading scientist, he combined elements of both worlds and both kinds of emphasis.

Edmund Landau had gladly accepted the invitation to give a more scientific lecture on the second day of the festivities, 2 April 1925. After his father's death in 1920, his involvement in matters related with the Hebrew University and with Jewish academic activities in Palestine seems to have gradually increased. He soon started to study Hebrew, and must have aquired some command of that language by the time he moved to Jerusalem in the Fall of 1927; see section 5 below.

Besides Landau's lecture on problems from number theory, four other scientific lectures were presented on April 2. All five lectures were given in Hebrew, thus emphasizing a specific national side of the whole enterprise. The first academic speaker was the bio-chemist Andor Fodor (1884–1968); his lecture was about "Correlative Processes in the Natural Sciences." Fodor had opened the institute for chemistry one year earlier, becoming the first professor of the new university. Weizmann had arranged his appointment after hearing from Fodor that a position in Halle, Germany, had been denied to him on anti-Semitic grounds (see Deichmann and Travis 2004). Fodor became a major force in establishing a strong Jerusalem tradition of research in chemistry and biochemistry (see Chayut 1994, 251, and Kirsh 2003). In his lecture, Fodor described how the traditional teleological model for biological explanations had been abandoned in favor of one where, similar to physics, causes and effects are first sought for.

Two of the talks were in the humanities. Joseph Horovitz (1874–1930) from Frankfurt was one of the world's leading orientalists and a foremost Koran researcher. His talk dealt with the history and development of the "Arabian Nights." Horovitz's personality and ideas embody interesting aspects of the approach of some German Jewish intellectuals to the Zionist movement. Himself not an active Zionist, he was a member of the Board of Governors of the Hebrew University and the promoter of the creation of its Institute for Oriental Studies. Horovitz had visited Palestine as early as 1906, and he was among the first to stress the urgent need to reach a compromise with the local population as a fundamental condition for the viability and sustainability of the Zionist project. He was an inspiring force behind the creation in 1926 of the *Brit-Shalom* (Peace Alliance) movement that actively sought coexistence and cooperation between Arabs and Jews in Palestine (see Heller 2003, 10–11). In fact, following the inauguration ceremony in Jerusalem, Horovitz was invited to meet a group of intellectuals at the Tel Aviv home of Arthur Ruppin (1876–1943), who one year later would establish *Brit-Shalom*. Horovitz spoke there about "Views on Zionism in the Arab-Islamic world." He stated his opinion that no negative view had yet been consolidated among Arabs, and that no such negative view would arise if the Jewish people returning to their land would see themselves as part of the oriental world, rather than as an outpost of the West (see Keidar 1976, 228–231).

As for Ruppin, he was a German Jew who arrived in Palestine in 1907 and became a leading figure in Zionist settlement activities. He held a degree in law and had published in 1902 a book on Darwinism and the social sciences.[53] Later on he would become professor of sociology at the Hebrew University. Other figures associated at various times with *Brit Shalom* included Magnes as well as several German immigrants who became prominent figures in Jerusalem: Gerschom Shalom (or Scholem) (1897–1982), the philosophers Martin Buber (1878–1965) and Shmuel Hugo Bergmann (1883–1675), as well as Akiva Ernst Simon.

A further talk in the humanities was delivered by Talmud Professor Abraham (Adolf) Büchler (1891–1939). Büchler was the rector of the Jews' College, London, from 1907 until his death. Like Horovitz, he was a member of the university's Board of Governors from its beginning, and he was also among the main forces behind the creation of the Institute for Jewish Studies. In the ceremony, he spoke about land inheritance laws in the Jewish tradition.

[53] For diverging appraisals of Ruppin's intellectual roots and his Zionist administrative activities, we refer to Penslar 1991, 80–102, and Bloom 2007.

Finally, the fifth talk was given by an applied mathematician, Selig Brodetsky (1888–1954), a Cambridge-educated professor at Leeds, and a prominent Zionist leader. In 1949, Brodetsky became the second president of the Hebrew University, albeit for a short period of time. Internal academic politics seem to have been more difficult than he expected and the job affected his health very negatively. In 1951 he returned to England (see Brodetsky 1960, 285–307). Brodetsky was an expert in the mathematical theory of airplanes. His speech at the inaugural ceremony was a historical overview, avoiding technicalities, of principles of dynamics from Aristotle to Einstein.

At the cornerstone laying of the Wattenberg building, Brodetsky also spoke, this time in English, and stressed the importance of applied mathematics as the connecting link between the two disciplines jointly represented in the building. He expressed the hope that the Einstein Institute "may rival my alma-mater [i.e., Cambridge University] in brilliance of achievement in mathematics and physics, sciences to which men of Jewish race have made contributions of a higher order." For reasons of internal academic politics, it was not long before the institute became the Einstein Mathematics Institute, while physics obtained a separate institute.

Around 1926, Landau expressed an interest in coming to Jerusalem in order to become the first professor of mathematics at the new university; we have already mentioned in section 1 above his paid leave of absence from Göttingen which enabled him to go to Jerusalem. Landau also negotiated the transfer of Felix Klein's private library from Göttingen to Jerusalem (Klein had died in June 1925). This served as the basis for the new mathematical library in Jerusalem, and many of those books are still kept in the Einstein Institute of Mathematics at the Giv'at Ram Campus in Jerusalem. The operation was supervised by Binyamin Amira (1896–1968).[54]

5. Creating a modern Hebrew mathematical language

As mentioned above, Edmund Landau had started to learn Hebrew well before he moved to Palestine. He might even have taken (Biblical) Hebrew already at his high school *Collège Français* where it was a voluntary subject.[55] But we have no evidence for this. Later on, he was obviously proud of his knowledge and of his connection to his roots and, indeed, as he moved to Jerusalem in 1927, he adopted the name of his famous ancestor, the *Noda' bi-Yehudah*, and became Professor Yehezkel Halevy Landau. This is how he signed all his Hebrew documents, including the one we are translating here.

[54] See Katz 2004, 207–208, cf. Fuchs 1989. On Amira's relation with Edmund Landau, see also section 5 below.

[55] See Velder 1989, 460–464. This tricentennary volume of the *Collège Français* in Berlin also contains (388–393) a biography of Edmund Landau which at the same time reflects on the teaching of mathematics and the French textbooks used in it when he was a student there. As for Hebrew, this language was even mandatory in other non-Jewish German *Gymnasia*.

An obituary notice of Landau presumably written by Issai Schur (1875–1941), underlines in particular Landau's passionate love for the Hebrew University, and states that, if he still needed help in 1925 with the final formulation of his Hebrew address, in 1927 he was already able to deliver several months of courses in Hebrew.[56]

Landau's Hebrew text is accomplished, though somewhat pompous, as one may expect from someone who learnt a language with dedication, but without ever having had the opportunity to use it on a daily basis in plain, colloquial contexts. The process of creating a modern mathematical Hebrew language – as part of the overall revival of Hebrew – is intriguing; its detailed history remains to be written. However, Landau's speech being perhaps the first text in modern Hebrew to deal with relatively advanced mathematical topics, we want to indicate here at least the main threads of the complex process in which Hebrew mathematical terminology developed.

One of the most important cultural phenomena before the Zionist revival of the Hebrew language, was the European Jewish Enlightenment, or "Haskalah," beginning in the late eighteenth century. Inspired by classical enlightenment values and motivated by the wish to achieve a fuller integration of Jews into European society, the Enlightened Jews, or "maskilim," promoted the study of secular topics among Jews, including a new kind of academic-oriented view of Jewish history (see Feiner 2004a and Feiner 2004b). In striving to distance themselves from the Yiddish-Rabbinical culture then dominant among Ashkenazi Jews, they advocated a revival of the Hebrew language and Hebrew literature. In a first stage, from about 1780 to 1855, they aimed specifically at developing a language that would be as close as possible to the original, Biblical Hebrew. Their lexicon was almost completely taken from the Bible, as were their syntax and style. Later varieties of, or later additions to, this original language, had appeared throughout generations, mainly in the writings of sages (ספרות חז"ל), from the time of the Mishnah and the Talmud (from the third century AD, on), which had assimilated a significant input from Aramaic. Such varieties of Hebrew were judged as inadequate for fulfilling the declared aims of the movement. In addition, Biblical Hebrew was perfectly suited for the kind of literary works written by maskilim at the time, which were primarily based on Biblical stories. Sacred Language (לה"ק - לשון הקודש) was the term used to refer to the Hebrew language, but in this context the term did not convey a truly religious connotation.

At a later stage of the Haskalah, roughly between 1855 and 1880, the new Hebrew literature in Europe shifted to more mundane topics and, more generally, the very role of language as a vehicle for dealing with reality underwent significant changes. Foreign

[56] The obituary is signed "J. Sch." (see Schur 1938, 7): *Mit leidenschaftlicher Liebe hing er am Palästinawerk, insbesondere am Schicksal der Universität in Jerusalem. Er war Mitglied des Kuratoriums der Universität, und es ist seiner Initiative zu verdanken, dass die mathematischen Lehrstühle der Universität so trefflich besetzt sind. Mit bewundernswerter Energie wusste er noch in reiferem Alter der Schwierigkeiten der hebräischen Sprache Herr zu werden. Nachdem er im Jahre 1925 bei der Abfassung einer hebräisch zu veröffentlichenden Abhandlung zum Teil noch fremder Hilfe bedurft hatte, konnte er schon 1927 monatelang in Jerusalem eine längere Vorlesung in fließendem Hebräisch halten.* We thank R. Siegmund-Schultze for having brought this document to our attention.

literature was translated into Hebrew. Hebrew texts dealing with scientific topics started to appear, not only in books but also, more importantly perhaps, in Hebrew journals of a new kind that were published throughout Central and Eastern Europe (see Soffer 2004). Within this process, the Biblical language adopted by the early maskilim proved to be too limited for their broadening needs. As a consequence, words and expressions originating in the Talmud as well as in the Hebrew medieval tradition were increasingly incorporated, foreign terms were also sometimes adopted, some existing words started to be used with new meanings in mind, and also new words were especially invented to cover specific needs that continued to arise.

Among the flurry of Hebrew publications spawned by the Jewish Enlightenment movement there were also scientific texts. The issue of an appropriate Hebrew lexicon for them came up frequently. Schapira and Steinschneider, already mentioned above, were two typical Jewish scholars who worked under the influence of Haskalah ideals, and who devoted their efforts to writing in Hebrew about mathematics. Another, nearly contemporary figure and highly interesting maskil to be mentioned in this context is Chaim Selig Slonimski (1810–1904). A remarkable Talmudist proficient in several European languages as well as in Latin, Slonimski was among the first (if not the very first) to write books on science for a broad Jewish audience, focusing especially on astronomy, physics, and mathematics.[57] For Alexander von Humboldt's (1769–1859) eightieth birthday, Slonimski published a Hebrew biography, with the explicitly stated goal to interest Jewish readers in science, and to render a well-deserved homage to this "great scholar who, besides being a leading scientist, was also a steadfast defender of the Jews."[58] In 1862, Slonimski established in Warsaw one of the prominent Hebrew weekly journals, *Ha-Zefirah*, in which also Schapira published on a routine basis. This journal was later published in Berlin, where it continued to appear until 1913 (see Soffer 2007).

Slonimski's books illustrate the characteristic issues involved in creating an adequate modern mathematical lexicon in Hebrew. For instance, in the introduction to his 1865 *Sefer Yesodei Hachkmat Hashiur* (roughly: "A Book of Basic Mathematics."), which he defined as a book for self-instruction, one reads:

> And as for terms and special words that are used in this book, most of them I took from their usage by previous authors, as they appear in the ancient books of our people, or similarly as they appear in the writings of the sages, or as I explain in the relevant places. In places where I needed to add new terms, I copied the terms as they are used, without translating them from the languages of the nations; but only such terms did I leave

[57] Slonimski also worked out some elementary number-theoretical procedures in connection with the construction of a calculating machine which he presented at the Academies in Berlin (1844) and in St. Petersburg, where he was awarded in 1845 the second Demidov prize (see Radovskii and Kolman 1961 and Crelle 1846).

[58] Slonimski 1849. For A.v. Humboldt's correspondence network around pure mathematics, which included scholars of Jewish origin like Carl Gustav Jacob Jacobi (1804–1851) and Gotthold Eisenstein (1823–1852), see H. Pieper's chapter III.1 in Goldstein, Schappacher, Schwermer 2007.

> unchanged as are used by the learned of all nations. And likewise I did, in accordance with previous authors, in writing the algebraic letters in the alphabet of the sacred language. In the books of the nations, algebraic texts use mainly letters from the Latin alphabet, and only very seldom, when in need, letters from the alphabet of the sacred language. In our text this is better done the other way around. Thus I was compelled to change the order of reading algebraic formulae, to be from right to left, contrary to the way they are read in the languages of the nations, because reading them from left to right in a Hebrew book is an obstacle for the reader and is misleading.

Like his fellow maskilim writing other kinds of texts, Slonimski actually took great pains to use Hebrew words wherever possible in his mathematical book – sometimes modifying the accepted sense of terms – rather than transliterating foreign words. But the peculiar case of mathematics presents specific difficulties. As stated in his introduction, only in a few cases did he follow the terminology used by "the learned of all nations," though he was not strictly consistent in this. Thus, for instance, while "mathematics" itself appeared as *hokhmat hashi'ur* (חוכמת השיעור), i.e. roughly: "the learning of ratios," and "geometry" as *medidah* (מדידה, i.e., "measurement"), "algebra" was simply transliterated. Sometimes, close to one of the newly introduced terms, a German translation appeared, such as in the case of "Differential-Rechnung," for which he used *heshbon pishionot* (חשבון פשיונות). *Heshbon* (חשבון) was and remained the accepted term for calculus, while the Talmudic term *pishion* (פשיון – meaning "dissemination," "expansion," or "dispersion") is completely out of use nowadays, not only in mathematics.

A complete analysis of the development of Slonimski's mathematical and scientific lexicon falls outside the scope of the present article; but let us indicate at least some of the terms he suggested for elementary mathematical concepts:

Numerator (of a fraction)	מונה	*moneh*: "counter" (Slonimski adds in parentheses צעהלער, i.e., a transliteration of the German *Zähler*)
Denominator (of a fraction)	איכה	*ikhah*: an archaic Biblical term for "how" (Slonimski adds in parentheses נענער, i.e., *Nenner*)
Power (of a number)	מדרגה	*madregah*: "stair"
Exponent	רכס	*rechess*: "crest"
Edge (of a polyhedron)	צלע	*tzelah*: "rib"

But what is of perhaps greater relevance here is to see the kind of difficulties involved in the task, of which Slonimski's was an early, well elaborated attempt. And as he indicated in his introduction, a particularly interesting question concerned the ways of choosing mathematical symbolism for Hebrew texts, as well as deciding on the correct direction for writing formulae. His own choice was not the one that was eventually adopted by Landau and thereafter in modern Hebrew mathematical texts. In Slonimski's proposal, an algebraic expression such as $x = \frac{1}{2}a \pm \sqrt{\frac{1}{2}a - \frac{1}{4}b^2}$ would be written in this way (read from right to left, of course):

.(^{2}ב¼ – א½)√ ± א½ + = ק

The most important figure associated with the revival of the spoken Hebrew language, Eliezer ben-Yehuda (1858–1922), emerged from the same kind of Haskalah background. Born in the town of Luzhky, near Vilna, and strongly influenced in his youth by the Haskalah movement, he moved to Jerusalem in 1881. Very soon after his arrival, he started working towards establishing Hebrew as the language to serve as the everyday means of communication for Jews coming to Palestine from all regions of the world. He regarded this common language as the key ingredient for the national revival of the Jewish people. At the turn of the twentieth century he established the *Vaad Halashon Haivry* (Committee for the Hebrew Language) which would become the most prominent vehicle for the realization of his plans; in 1953 it became the Academy of the Hebrew Language. The *Vaad* was actively directed by a group of Hebrew teachers intent on "adapting the Hebrew language for use as a spoken language in all aspects of life: at home, at school, in public life, in commerce, in industry, in art, and in science." As part of their efforts, they periodically published lists of new terms to be used in various aspects of life. In many cases the lists played a central role in creating the current lexicon of the Hebrew language as spoken nowadays in Israel. In 1913, they published one such list containing mathematical terms, such as the following:

Numerator (of a fraction)	כמה	*kamah*: literally "how many," also "quantifier"
Denominator (of a fraction)	מנה	*manah*: portion or ratio, but also related with "counting" (למנות)
Power (of a number)	מדרגה	*madregah*: "stair"
Exponent	רכס	*rechess*: "crest"
Edge (of a polyhedron)	פה / חוד	*peh*: "mouth"; or *khod*: "cusp"

Besides the *Vaad*, various primary and secondary schoolteachers' associations took upon themselves the task of turning Hebrew into the main and only teaching language in schools of the *Yishuv* (the Jewish residents of Palestine). Fierce theoretical discussions, as well as open power struggles, arose occasionally between these teachers' associations and the *Vaad*. The teachers were of the clear opinion that the members of the *Vaad* (mostly inhabitants of Jerusalem) lacked the professional qualifications that they had in the various fields of school learning and, moreover, that their own day-to-day experience in the classroom of all rural and urban areas of the *Yishuv*, put them in a much better position to develop the necessary lexicons to be used in their work (see Efrati 2004, 49–80).

One person soon distinguished himself as an independent developer of the adequate Hebrew mathematical lexicon: Dr. Avraham Baruch Rosenstein (1881–1950), a renowned mathematics teacher at the emblematic Gymnasia Herzliya in Tel-Aviv (see Razi-Stein 1991). The Gymnasia was established in 1905, as the first high-school to conduct its teaching entirely in the Hebrew language. The city of Tel Aviv – "the first Hebrew city" – was founded 11 April 1909. Hebrew rapidly took over the city in all day-to-day activities. Still, the lack of a proper language in all fields of study was felt to be a problem at the Gymnasia, with some of the founding teachers suggesting that scientific disciplines ought to be taught in French.

Rosenstein joined the staff of the Gymnasia in 1911 shortly after completing a dissertation in mathematics in Vienna. He immediately undertook the task of creating an appropriate lexicon for his teaching, and, more importantly, of writing the necessary textbooks in all fields of high school mathematics and physics. Over the years, he authored or co-authored twenty-five books that continued to be used across the country until the 1950s. As an enthusiastic former student put it, thanks to the efforts of Rosenstein, high-school pupils at Gymnasia Herzliya "spoke algebra, geometry, trigonometry, logarithms and differential calculus as if these disciplines had been created and initially taught in Hebrew" (see Ben Yehuda and Ofek 1971, 83–84).

In his quest for a modern mathematical lexicon, Rosenstein went back to ancient Hebrew sources, including Levi ben Gerson and the medieval sage Avraham Bar Hiyya (1070–1136) who wrote on arithmetic and geometry. He also consulted more recent Hebrew scientific authors such as Slonimski. As early as 1912, he was teaching summer seminars on the Hebrew mathematical lexicon to teachers from all around the *Yishuv*. The participants of his seminars decided to write to the *Vaad* demanding that they define their mathematical lexicon based on the suggestions of the teachers' association (which were actually Rosenstein's) (see Efrati 2004, 71). The list published by the *Vaad* in 1913 from which we quoted above shows that this demand was not met.

Here are some examples of Rosenstein's lexicon:

Numerator (of a fraction)	מונה	*moneh*: "counter", like Slonimski
Denominator (of a fraction)	מכנה	*mekhaneh*: "namer"
Power (of a number)	חזקה	"chezkah": a neologism derived from the root חזק, "strong or powerful"
Exponent	מעריך	*ma'arikh*: a neologism derived from the root ערך, "value"
Edge (of a polyhedron)	מקצוע	*miktzoah*: a forgotten Biblical term, whose original meaning was "corner"

It is important to stress that, while rejecting the specific mathematical choices of the Vaad, the neologisms introduced by Rosenstein did often follow some new kinds of general declensions, introduced into Hebrew by the *Vaad* with the explicit aim of allowing the consistent production of a broad range of neologisms based on existing roots. Thus, for instance, Rosenstein's "chezkah" was an adaptation of the root חזק (*chazak*) to one such new type of declension.

Rosenstein's lexicon is still essentially the one used to this day for all aspects of mathematical Hebrew. No less important than the lexicon itself in shaping the new Hebrew mathematical language, however, was Rosenstein's decision to use Latin characters for all mathematical and physical equations and formulae, rather than Hebrew ones as Slonimski had done previously. Rosenstein wrote them from left to right, as in any European text, and this is the way that equations continue to be written in Hebrew scientific texts.

Landau adopted Rosenstein's lexicon for his 1925 speech without exception, and continued to follow it during his mathematical activity in Jerusalem in 1927–28. It may be assumed that he was aware of earlier Hebrew texts such as Slonimski's, and he may have given some independent thought to the question of a Hebrew mathematical lexicon. But the choice may have also been decided by the person – or persons – who taught him Hebrew. Just who this was, seems not entirely certain.

It is said, if not documented,[59] that Landau learned Hebrew "quickly"[60] with the help of Jacob Levitzky (1904–1956), and it is implied that the 1925 public lecture was his immediate reason for learning Hebrew. In Landau's letter to Magnes written from Hotel Quellenhof in Bad Wildungen (a spa South of Göttingen) on 22 March 1927,[61] he mentions, without giving dates, that he "arranged for a Hebrew teacher to move to Göttingen to teach" him the language. But Jacob Levitzky appears to have lived in Germany continuously from 1922 through 1929 (see Hasse and Noether 2006, 92). He would finally earn his doctorate in Göttingen with Emmy Noether in 1929. Emmy Noether subsequently tried to find a position for him somewhere, stressing that there was "nothing unpleasantly Jewish" (*nichts von unangenehm jüdisch*) about him.[62] Furthermore, Abraham Fraenkel tells us that Levitzky helped him with Hebrew conversation in Kiel during the Winter term 1928/29 (see Fraenkel 1967, 156). Even though Fraenkel's memoirs are not a very reliable source in general, the fact that Fraenkel does not mention Levitzky when he discusses Landau's rapid learning

[59] See Kluge 1983, 89, cf. the echo of this in Segal 2003, 454.

[60] Whatever this means, the source for this qualification seems to be Fraenkel 1967, 164, ". . . *brachte es auch erstaunlich rasch zuwege, die Sprache zu beherrschen.*"

[61] The letter is in the Archives of the Hebrew University; Landau's concern there is to insist that plans for the Institute building for Mathematics (and Physics) be carried through in Jerusalem independently of his prior commitment to come to Jerusalem on a permanent basis.

[62] Hasse and Noether 2006, 86; cf. Siegmund-Schultze 2009, 44. In 1931, Levitzky was appointed to the EIM of the Hebrew University; he was awarded the first Israel Prize in the Exact Sciences in 1953.

of Hebrew, suggests the possibility that the Hebrew teacher that Landau brought to Göttingen may have been somebody else.

Now, a former student of the Gymnasia Herzliya, Binyamin Amira – who subsequently also taught in the Gymnasia for a while – was Landau's student and assistant at Göttingen during five semesters, between 1922 and 1924 (see Katz 2004, 207–208, cf. Fuchs 1989). If it was indeed with Amira that Landau learnt Hebrew in Göttingen, Rosenstein's mathematical terminology would have naturally been part of it.

Finally, let us mention the so-called *Language War* in Palestine which broke out in 1913. The dispute was about the place of revived Hebrew as the official instructional language for the schools of the *Yishuv*. Indeed, Jewish educational institutions had been established at the end of the nineteenth century not only by Zionist initiative, but also as part of the efforts of European Jewish philanthropic organizations such as the French *Alliance Israélite Universelle* and the German *Hilfsverein der Deutschen Juden*. The *Hilfsverein*, for instance, was established in the wake of the great pogroms of the late nineteenth century, with the aim of providing welfare to East-European Jews and helping them immigrate to various places in the world via Germany. They also promoted German culture among non-German Jews in places like the Balkans and the Middle East, and built educational institutions in Eastern Europe and in Palestine (see Moose 1989, 80–92, and Rinot 1972).

From the outset, some of the schools built in Palestine by the *Hilfsverein* were as committed as any other in the *Yishuv* to the revival of Hebrew. Hebrew was taught in them, but not always exclusively, and certainly there was no official decision to this effect (see Elboim-Dror 1986, 242–240). In 1907, the director of the *Hilfsverein*, Paul Nathan (1857–1927), came up with a new, important initiative of establishing an institution of higher learning for engineering in Haifa, the *Technikum* – which eventually became the *Technion* – as well as a *Realgymnasium* working closely with it – which eventually became the Hebrew Reali High School of Haifa. Against the background of a technological gap increasingly felt at the time in the Ottoman empire, and following an argument that Max Simon would also develop a few years later (Simon 1916, 61), Nathan assumed that the Jewish population of Palestine, if properly trained in the German technological tradition, would be a welcome contribution to the development plans then encouraged by the Ottoman government. Moreover, the rise in the level of living that would ensue from a technologically supported economical development in the region would increase its appeal as a target of immigration for Jews all around the world.

Nathan's initiative was greatly welcomed by the *Yishuv*, but in 1913, as the construction of the new buildings for the *Technikum* and the *Gymnaisum* had almost been completed, the Board of Governors of the *Hilfsverein* in Berlin passed a decision to the effect that all teaching in the *Technikum* would be in the German language. The reason behind this decision was the assumption that no adequate Hebrew books existed that could be used for advanced technological teaching and it thus seemed obvious to Nathan and his colleagues in Berlin that German books would be used anyway. The decision triggered furious opposition of unprecedented intensity among the local Jewish population. Teachers of the Jerusalem Teacher's Seminar (an institution created and supported by the *Hilfsverein*) renounced their posts, while students went on strike. The intense emotions that this debate sparked are manifest in an open letter signed by Ben-Yehuda and some representatives of the teachers' associations:

> The *Kuratorium* of the *Technikum* in Berlin has decided that all general sciences will be taught in the Reali School and in the *Technikum* in Haifa not in Hebrew but in a foreign language. This decision is an open attack against the soul of the Hebrew nation and we consider it to be a national disaster.
>
> We do not oppose the detailed study of any foreign language in the Hebrew schools in the Land of Israel, but no foreign language should be allowed to be the official teaching language, as no such right exists in the schools of any other nation.
>
> An entire generation has worked hard for the sake of the revival of our language as a language of schools and of life, and we will not let anyone convert us in matters of language, much as we would not let anyone convert us in matters of religion.
>
> The language is the soul of the nation. The revival of our language is the basis for the renewal of our people.
>
> In order for others to recognize our right to our language, it is first necessary that the people of Israel will defend the language of Israel, and will bring it to absolute rule in all schools in the Land of Israel.
>
> The Hebrew Language, which is the natural bridge among all parts of our people, must by all means be the learning language of all of our schools, be they Orthodox or non-Orthodox.
>
> The Hebrew language is sacred to us and we will fight on behalf of it, much as our ancestors fought for the sanctity of the nation. (Quoted in Efrati 147)

The "war" ended in February 1914 with a full victory for the Hebrew camp. The *Hilfsverein* agreed that teaching of mathematics and physics at the *Technikum* would be in Hebrew, and that all teachers not yet fluent in Hebrew will be compelled to learn the language in four years. Nevertheless, budget problems and the outbreak of World War I delayed the opening of the institution for several years. The first course was taught there only in 1924, and the official ceremony of inauguration was held 6 February 1925. By this time, the British Mandate had passed a decision in 1922 that recognized Hebrew as one of its official languages, alongside English and Arabic. Less than two months later Landau gave his speech at the inauguration of the Hebrew University. There was no discussion then that Hebrew would be the official language of this new institution of higher learning.

6. Edmund Landau's 1925 addresses, translations, and notes[63]

Landau's toast at the laying of the foundation stone of the Wattenberg Building, Jerusalem April 1925 (Landau 1925a)

I thank you for the honor of having invited me as the representative of the mathematical sciences to deliver some words at this celebration of the cornerstone laying of the Institute for Mathematics and Physics.

Mathematics and physics are sister disciplines. Because of their large size, it would be impossible to house both of them within the same building in any of the great European universities. But here in Jerusalem we are just founding a university today, and we can lay a common cornerstone for a building where the two sciences which have so many points of contact will be cultivated.

As for mathematics itself: it is well known how formidable a role Jews of the European countries played in the development of this science. It is my wish and hope that from among the walls of the building we are founding today, Jewry[64] will continue to impart upon mankind many deserving gifts in the form of discoveries and inventions that will be important for fundamental research and valuable in practice.

May great benefit emerge from this house dedicated to pure science, which does not know borders between people and people. And may this awareness emerge from Zion and penetrate the hearts of all those who are still far from this view.

Landau's mathematical lecture, Jerusalem April 1925 (Landau 1925b)

Professor Yehezkel-Edmund Landau

Solved and Unsolved Problems in Elementary Number Theory

I have acceded with pleasure to the kind request to lecture on one of my research topics, and I am choosing that part of mathematics whose problems[65] are more easily understood by the layman. These problems arise in a natural way whenever we come to calculate with the ordinary, natural numbers 1, 2, 3,. . . . No fractions are encountered in these problems, let alone irrational numbers. The problems can thus be understood even by anyone who is not a professional mathematician and has forgotten school mathematics. But I hasten to add that the solutions to many problems that seem to arise naturally and look like they are very easy to deal with, have not been achieved even with the help of all the tools of modern mathematics and in spite of the efforts of the greatest mathematicians from all peoples of the world. For the purpose of this

[63] All translations and discussion of Hebrew in this article are by Leo Corry.

[64] Cf. our remarks preceding footnote 40 above, where we recalled the fact that the German word *Judentum* may mean both *Jewry* and *Judaism*. The same ambiguity appears in the Hebrew word יהדות (*yahadut*), and it is likely that also in this Hebrew passage, Landau may have intended a connotation which points beyond the mere allusion to Jewry.

[65] The word used by Landau which we systematically translate as "problem" is שאלה (*she'ela*), i.e. literally, "question," rather than בעיה (*beayah*), which would seem more appropriate today.

lecture, it is of course adequate not to give the proofs even for those problems that have been solved.[66] All I want to present to you are some problems concerning whole numbers, solved ones and unsolved ones, which will be found easy to understand.

The concept of prime number has been known for thousands of years. A prime number is a number a greater than 1 for which there is only one way to decompose it into two integral positive factors (as $1 \cdot a$ or $a \cdot 1$). Such a number therefore cannot be divided by any natural number other than 1 and the number a itself. For example, 2, 3, 5, 7, but not $4 = 2 \cdot 2$, $6 = 2 \cdot 3$. The ancient Greeks already knew that it is possible to make up every number greater than 1 in a unique, fixed way from prime numbers.[67] Thus for instance $2 \cdot 2 \cdot 3 = 12$. And so here is already

Problem 1. Are there as many prime numbers as infinity?[68] For, by way of logic alone, one might think, for instance, that 1000 prime numbers would suffice to construct all the numbers, since we are allowed to use every building block as many times as we wish. Likewise, from the prime number 2 one can make up, if not all numbers, certainly as many numbers as infinity. Namely, the powers of 2 : 2, 4, 8, ...

This problem was solved two thousand years ago by Euclid, who showed that there are infinitely many prime numbers.[69]

Problem 2. Are there as many prime numbers as infinity ending in 5 or in 24? Answer: no. In the first case, 5 is the only such prime number, since any number ending in 5 is divisible by 5. In the second case, there is not a single such prime number, since every number ending in 24 is divisible by 4.

Problem 3. Are there as many prime numbers as infinity ending in 21? A positive answer to this question is one of the greatest achievements of one of those mathematicians who preceded me in Göttingen, Dirichlet. He proved the following theorem in general:[70]

[66] Landau will make an exception to this rule; see Problem 4 below. In fact, suppressing proofs was surely against nature for Landau. When he comes to such famous unsolved problems as Fermat's Last Theorem or the Riemann Hypothesis, he will even mention recent potential strategies of proof rather than name the conjectures; see Problems 18 and 19 below.

[67] This so-called Fundamental Theorem of Arithmetic does not explicitly figure in Euclid's *Elements*; but all results needed, as we see it, to prove this result do occur there; the possibility to factorize follows from Euclid's Prop. VII.31/32, and the uniqueness follows from the characterization of prime numbers as integers which, whenever they divide a product, divide at least one of the factors, i.e., Prop. VII.30. Some historians have tried to interpret Prop. IX.14 of the *Elements* as closely related to unique factorization; see, however, the discussion of this in Euclide 1994, 432–435, which also offers a possible explanation of why our statement about unique factorization may have been alien to Euclid's framework.

[68] Here and in the sequel, Landau typically uses this elaborate and nowadays unfamiliar formulation (in Hebrew: רבים . . . עד אינסוף (*rabim . . . ad einsof*)). We do not know from what source he adopted it.

[69] See Prop. IX, 20 of Euclid's *Elements*. Up to here, Landau's Jerusalem lecture runs parallel to his plenary talk Landau 1912 at the Cambridge ICM.

[70] See Dirichlet 1837.

In every arithmetic progression whose first term and increment[71] *have no common factors there are as many prime numbers as infinity.*

That is to say: let us start with a fixed number ℓ (here 21) and let us continually add a second fixed number k (here 100), having no common factor with ℓ. The sequence[72] of numbers thus obtained contains as many prime numbers as infinity. Had ℓ and k a common factor, then the answer would be negative, as in the example[73] $\ell = 24$; $k = 100$ of Problem 2. It should not have been difficult to guess this result, since if we tossed an infinite number of objects (the prime numbers) into 100 boxes (corresponding to the one hundred numbers written with two digits), why wouldn't infinitely many objects end up in every one of the boxes? This is not, however, a proof of Dirichlet's theorem. If it were, then there would also be infinitely many prime numbers ending in 24, which is not the case, as was explained above. The proof was, as I said, a great achievement of which German mathematics can be proud.[74] Dirichlet's proofs succeeded only through the use of deep auxiliary means related to infinite series, and even today one cannot prove the theorem in a very short way.

Problem 4. Can two consecutive prime numbers be found such that the difference between them is as large as we wish? For instance, no other prime number exists between the prime numbers 863 and 877. The difference between these two neighboring prime numbers is thus 14. Can this distance sometimes be >100, >1000, etc.? Answer: yes, and it is not difficult to explain this matter. As an exception, I would like to present the proof here. Let $n > 1$. Let us look at the numbers:

$$n! + 2, n! + 3, \ldots, n! + n.$$

These are successive numbers of which we can have as many as we wish. They are composite numbers (i.e., they are not prime numbers), since they are divisible, respectively, by $2, 3, \ldots, n$, and they are different from these factors.

[71] The term used nowadays for "increment" is הפרש (*hafresh*), which also means "remainder." Landau's term הבדלה (*havdalah*) denotes the traditional Jewish weekly ceremony that marks the symbolic end of the Sabbath, distinguishing it (the sacred) from new week (the secular). From today's perspective, this seems like an unlikely choice for the mathematical term "increment."

[72] Landau uses the term שורה (*shvrah*) which corresponds to the German word *Reihe*. The term used nowadays is סדרה (*sidrah*), from the root סדר (*seder*), i.e., "order."

[73] Landau writes "the example" as (*hamahsal*) המשל, which today sounds archaic. The word literally does mean "example", but it also indicates a fable or a simile. In current parlance, while (*lemashal*) למשל is used to mean "for example", "mashal" is never used by itself to mean "example."

[74] Lejeune Dirichlet grew up as a research mathematician in Paris, where he was influenced in particular by Fourier's Theory. He was then brought to Berlin by Alexander von Humboldt. This move would soon be heralded, for example by Ernst Eduard Kummer (1810–1893), as a return of the German genius for Number Theory to its sources, and Landau echoes here this strong nineteenth-century nationalist discourse (see Goldstein, Schappacher, Schwermer 2007, 45, and chap. III.1).

Problem 5. Does the difference 1 appear as many times as infinity? Answer: no. Because starting with 1, all prime numbers are odd.[75]

Problem 6. Does the difference 2 appear as many times as infinity? (It is known that this difference does appear several times; for example,[76] 17, 19; 101, 103.)[77] The devil knows. What I mean is that besides God Almighty no one knows the answer, not even my friend Hardy in Oxford, who among all those who work with me is the most profound researcher in this field of research.

Problem 7. $4 = 2 + 2$, $6 = 3 + 3$, $8 = 3 + 5$. Perhaps all other even numbers are also sums of two prime numbers? I cannot tell.[78] There are recent investigations in this direction, but they are still far away from the aim they set themselves, to answer this question.[79]

Problem 8. Are there as many prime numbers as infinity of the form $x^2 - 1$, i.e., that come right before a square number? (For instance, like the numbers 3, 8, 15, 35.) Answer: no. Because $x^2 - 1 = (x + 1) \cdot (x - 1)$, which is a composite number starting from $x > 2$.

Problem 9. Are there as many prime numbers as infinity of the form $x^2 + 1$? I do not know,[80] and I know that I do not know, and that it is unknown.[81]

Problem 10. Same question for the form[82] $x^2 + 111y^2$? Yes, this was proved by Dirichlet, again using his method.[83]

[75] Probably a misprint; read "starting with 3, all prime numbers are odd."

[76] Here we have למשל (*lemashal*); cf. our preceding note on the word משל (*mashal*).

[77] This so-called *Twin Prime Conjecture*, to the effect that there are infinitely many pairs of primes differing by 2, in spite of all recent advances in analytic number theory, is still open.

[78] This is the formulation of *Goldbach's Conjecture* which has become standard. It is a slight variant of the conjectures on partitions of given integers discussed in the correspondence between Christian Goldbach (1690–1764) and Leonhard Euler (1707–1783) of May/June 1742. Goldbach's Conjecture is still open at the time of writing these notes.

[79] This is surely an allusion to Hardy and Littlewood 1923. In his address to the Cambridge ICM (see Landau 1912), Landau had still mentioned Goldbach's Conjecture as number (2) in a list of 4 problems which he considered *unangreifbar beim gegenwärtigen Stand der Wissenschaft*, i.e.,"impossible to attack at the present state of science." The other three such problems listed back then were (1) Problem 9 of the Jerusalem lecture, (3) Problem 6 of the Jerusalem lecture, (4) *Liegt zwischen n^2 und $(n + 1)^2$ für alle positiven ganzen n mindestens eine Primzahl?*, i.e., "for every positive integer n, is there at least one prime number between n^2 *und* $(n + 1)^2$?"

[80] The conjecture that there are infinitely many prime numbers of the form $n^2 + 1$, as well as its quantitative versions, appear to be still open at the time of writing these notes. Today they can be seen as special cases of the Bateman-Horn Conjecture (see Bateman and Horn 1962); but for the case at hand here, see Hardy and Littlewood 1923. For a first introduction to this circle of ideas, which incidentally illustrates another type of lectures to a fairly general audience, see the first lecture in Lang 1999, esp. 8–12.

[81] The unique way in which Landau expresses his ignorance here may carry allusions which we are unfamiliar with.

[82] Landau's term תבנית is also the one that has remained in current mathematical use for "form." It is not an obvious choice; we do not know who first suggested it.

[83] Indeed, Dirichlet first explained – if only in a special case which does not cover the composite discriminant $111 = 3 \cdot 37$ – the modifications of his proof of the theorem on arithmetic progressions which are needed for the

Problem 11. Here a deeper question is asked, yet everybody can still understand it. After Dirichlet proved that there are infinitely many primes ending in 3 or in 7, it can be asked, in imprecise language, if the quantities of these numbers are of the same value, i.e., in precise language, if the ratio of these quantities up to a known place gradually approaches unity as much as we wish. Answer: yes. This was proved about 30 years ago by the Jewish mathematician Yaakov Hadamard in Paris, and by the excellent Belgian scholar de la Vallée Poussin.[84] I did this later in a much simpler way, and I proved for the first time a corresponding theorem in the theory of algebraic number fields,[85] a theory of which the ordinary theory of numbers is the simplest of its infinitely many particular cases.[86] Nevertheless, in this lecture I wanted in any case to only speak about the ordinary integers.

Problem 12. Is it possible to estimate the quantity of prime numbers up to x, by means of one of the ordinary elementary expressions depending on x, so that the estimation error will eventually become infinitely small relative to the real value? The greatest of all German mathematicians, Gauss, conjectured, yet only Hadamard and de la Vallée Poussin proved, that the simple expression $\frac{x}{\log x}$ fulfills the said requirement.[87] The estimation of the error remained totally unchanged for 25 years and only a few months ago my friend Littlewood in Cambridge (Trinity College) was able to find a much sharper estimation.[88]

After twelve problems I abandon the prime numbers. It is true that in most cases I confessed my lack of knowledge, and yet I want to add that I am the author of the only textbook on this topic and I did indeed manage to write 961

application to primitive quadratic forms in Dirichlet 1840. However, faced with Landau's claim, the first reflex of a number theorist today would probably be to appeal, not to Dirichlet himself, but to *Chebotarev's Density Theorem* which guarantees that infinitely many primes split completely in the ring class field associated to the order $\mathbf{Z}[\sqrt{-111}]$ of the imaginary quadratic field $\mathbf{Q}(\sqrt{-111})$ (see for instance Cox 1989, §8.B, and Theorem 9.4). If called upon to avoid any post-1840 theoretical baggage to reduce this problem to Dirichlet's theorem on primes in arithmetic progressions, one may observe that, since the quadratic form $x^2 + 111y^2$ is reduced, the number of proper representations of a prime number p by this form equals $2(1 + (\frac{-n}{p}))$ (see, for instance, Landau 1927, vol. I, p. 144). By quadratic reciprocity, the condition $(\frac{-n}{p}) = +1$ forces p into an arithmetic progression of increment $4n$.

[84] Landau is alluding to a corollary of the *Prime Number Theorem* proved twice in 1896; see the papers by Jacques Hadamard and Charles de la Vallée Poussin (1866–1962) quoted in the references. Today, also the statement of Problem 11 tends to be associated with *Chebotarev's Density Theorem*; for insightful historical / mathematical comments on the matter, see Stevenhagen and Lenstra 1996.

[85] Landau used here the term גוף (*guf*), i.e., the literal translation of the German word *Körper.* It did not stick in this arithmetico-algebraic context; eventually the term adopted was שדה (*sadeh*) which translates to the English word "field."

[86] See Landau 1903a and Landau 1903b; cf. Landau 1908.

[87] This is the so-called *Prime Number Theorem* (cf. Hadamard 1896 and de la Vallée Poussin 1896, as well as Landau 1903a).

[88] See Littlewood 1925.

pages of solved problems of that kind, including in those pages many of my own investigations.[89]

Problem 13. Let us observe the sequence of square numbers $0 \cdot 0 = 0$; $1 \cdot 1 = 1$; $2 \cdot 2 = 4$; $3 \cdot 3 = 9$; $4 \cdot 4 = 16$; etc. This sequence does not contain all the integers. We ask: can all numbers, perhaps, be decomposed as sums of two squares? No, as the example of number 3 teaches us. Can we perhaps represent every number as a sum of 3 squares? No, the number 7, for instance, cannot be written in this way. Perhaps as a sum of 1000, or of another, fixed number of squares? Yes, because Lagrange proved 150 years ago that every number decomposes into four squares.[90] For instance: $98 = 81 + 16 + 1 + 0$.

Problem 14. Is there such a fixed number also for positive cubes (including 0), for fourth powers, etc.? For k-th powers? It is possible, of course, that this fixed number depends on k. Answer: yes. This is the famous "Waring's conjecture" of 1770, and only after 139 years, in 1909, was it proved by my friend David Hilbert in Göttingen.[91]

Problem 15. Let us stay with the simplest case of cubes. What is the smallest number of summands which suffices to produce any number by adding? The number 23 requires, so it seems, 9 cubes, since there is no shorter decomposition than 8, and another 8, and another 7 units. The best number can therefore not be smaller than nine. And indeed, 9 cubes always suffice, as should be understood from an article by Wieferich.[92] From a given point on, even 8 cubes suffice, as I myself have proved.[93]

Problem 16. I continue with the cubes. What is the smallest number of cubes that suffices for any large number? From what was said, it is 1 or 2 or . . . or 8. It is proved without difficulty that the desired number cannot be smaller than 4. Whether it is 8, or smaller than 8, it is not known to this day.[94]

Problem 17. Even if we are asked to decompose all numbers into s cubes, except for some of them up to a percentage which is as small as we wish, then the smallest such s will be at least 4, which is easy to prove, and not greater than 8, as already said above.

[89] The reference is to Landau 1909a, whose two volumes are consecutively numbered and do run to precisely 961 pages. It is hardly by chance that this number is the square of the prime number 31; one may also point out that Landau finished writing this book when he was 31 years old.
[90] See Lagrange's 1772 memoir in Lagrange 1869, 189–201.
[91] See Hilbert 1909.
[92] The reference is to Wieferich 1909b; its unusual formulation may allude to a slight gap in Wieferich's argument, which is easily filled (see the beginning of Landau 1911). Note in passing that when Landau mentions Wieferich primes in Problem 19 below, he does not mention the name again – at least not in the version of the text that we have. For biographical information on Wieferich's sad life, cf. http://www.numbertheory.org/obituaries/OTHERS/wieferich.html.
[93] See Landau 1909b, as well as Landau 1909a, chap. 36.
[94] This is still open. The answer is expected to be 4. So far Landau's 8 has been replaced by 7 (see Vaughan and Wooley 2002, 304–305).

Here Hardy and Littlewood proved recently that the correct number is not greater than 5.[95] Thus, the number is either 4 or 5.[96] To summarize: almost all numbers decompose into 5 cubes. The ways of their proof are more beautiful and marvellous than anything else I have seen and studied in my life. They were also able to determine the exact amount corresponding to bi-squares (= fourth powers). That number is 15. I could never imagine that still in our time someone would be able to solve this mathematical problem that seems intractable to the initiated. To present their proof for bi-squares and for all $k > 4$ took in my class 2 months, at 4 hours a week.

Problem 18. This is actually but an example, in which we will be able to ask the question only after we have given the answer. Let us order according to their size all the reduced[97] fractions between 0 and 1, with denominator up to n. Thus for instance, for $n = 7$:

$$\frac{1}{7}\frac{1}{6}\frac{1}{5}\frac{1}{4}\frac{2}{7}\frac{1}{3}\frac{2}{5}\frac{3}{7}\frac{1}{2}\frac{4}{7}\frac{3}{5}\frac{2}{3}\frac{5}{7}\frac{3}{4}\frac{4}{5}\frac{5}{6}\frac{6}{7};$$

we thus see that for any two neighboring fractions $\frac{a}{b}$ and $\frac{c}{d}$ the number $bc - ad$ (which is always positive, of course, since $\frac{c}{d} - \frac{a}{b} = \frac{bc-ad}{bd} > 0$) always equals 1, and it is also easy to prove[98] this fact.[99]

Problem 19. A classical theorem in number theory (due to Fermat in the seventeenth century) states: let p be any prime number, then $2^p - 2$ is divisible by p. For instance, $2^5 - 2 = 30$ is divisible by 5. And in general, $a^p - a$ is divisible by p. And now I ask: does it sometimes happen that $2^p - 2$ is divisible by p^2, and whether this happens infinitely often? The answer to this question has an enormous importance for a well-known application.[100] Some such numbers p are known. But it is not known if there are infinitely many, or perhaps if there is no such p after a certain p which may be

[95] See Hardy and Littlewood 1925.

[96] This problem was settled by Davenport who showed that the optimal value is 4 (see Davenport 1939).

[97] The term מקוצרים (*mekutzarim*) literally means "shortened." It is not in use anymore in this sense and may have been a typical Gymnasia Herzlyia term.

[98] For the proof see Hardy and Wright 1979, chap. III (who start their Farey series with 0 instead of $\frac{1}{n}$); there the statement is called Theorem 28 and proved in 3 different ways (all of them correct in the edition quoted).

[99] The text of Landau's lecture from the brochure for the opening of Hebrew University seems to have suffered a gap here. It seems more than likely that Landau was going to offer some hints towards Franel's result which he had presented to the Göttingen Academy just half a year earlier, on 21 November 1924 (see Franel 1924). Writing $0 \leq \rho_1, \rho_2, \ldots, \rho_{A(n)} = 1$ the ascending sequence of all reduced fractions with denominator dividing n, Franel, thus refining an earlier result of Littlewood, established that the Riemann Hypothesis is equivalent to the asymptotics $\sum_i (\frac{i}{A(n)} - \rho_i)^2 = O(n^{-1+\epsilon})$. Landau further refined and developed this result in Landau 1924 (see also Landau 1927, vol. II, Teil 7, Kapitel 13, 167–177, as well as Landau 1932).

[100] Landau could hardly assume that his audience knew about Wieferich's result towards the so-called Fermat's Last Theorem. In Wieferich 1909a, it is shown that every odd prime number p for which integers x, y, z relatively prime to p exist such that $x^p + y^p = z^p$, has to satisfy the condition that Landau discusses, i.e., $2^{p-1} \equiv 1 \pmod{p^2}$.

known. The short time will unfortunately not allow me to show you the calculation that $2^{1093} - 2$ is divisible by 1093^2.[101]

Problem 20. The next problem belongs to geometry, but Gauss, with the help of algebra, turned it into a question of number theory. One learns at school that one can draw inside a circle, with the help of ruler and compass, regular polygons of 3, 4, 5, 6, 8, 10, 12, 15, 16, 20 sides, and infinitely many others. (That is, polygons with $2a + 2$, $2a + 2 \cdot 3$, $2a + 2 \cdot 5$, $2a + 2 \cdot 3 \cdot 5$ sides, where a is any integer >0). Let n denote the number of sides in the polygon. Then the following question is asked: is that construction possible for any number n? Or: for which n is the construction not possible? Gauss proved: the construction is impossible for the case $n = 7$. This proof is not extremely difficult. The construction is possible for the case $n = 17$. This was one of his greatest inventions and the corresponding diagram is part of his memorial monument in the city of Braunschweig. In general, the construction is possible only in cases where n contains each of its odd prime factors only once, and every such prime factor is of the form $2^{2^m} + 1$, the number m being positive or equal to zero. If $m = 0$, then we obtain $n = 3$. If $m = 1$, then we obtain $n = 5$. If $m = 2$, then we obtain $n = 17$. If $m = 3$, then we obtain $n = 257$. If $m = 4$, then we obtain $n = 65537$. And now the question arises whether these Gaussian prime numbers are infinitely many. The answer: I do not know. And it is unknown how to prove whether there is any such number after 65537. There may perhaps be none, or perhaps some, or perhaps infinitely many.[102]

Problem 21. With the help of number-theoretical methods also the geometrical problem of the quadrature of the circle was solved. Forty years ago, my teacher Lindemann in Munich proved that it is impossible to transform a circle into a square with the help of ruler and compass. The important point in his proof is that he demonstrated that the well known-number π is not a root of an equation with integer coefficients; that this number is, as is usually said, transcendental.

Problem 22. In geometrical language: the curve $x^2 - Dy^2 = 1$ (where D is a positive integer) is a hyperbola. Are there infinitely many lattice-points on this curve? (Lattice-points are points with integer coordinates.) In arithmetical language: does this equation in the variables x and y have infinitely many solutions which are integers? If D is a square, $= E^2$, then the answer is negative, because in this case $(x + Ey) \cdot (x - Ey) = 1$; that is to say $(x + Ey) = (x - Ey) = \pm 1$, and therefore there are only two solutions $x = \pm 1$, $y = 0$. For any D which is not a square and is > 0, Lagrange proved that there are infinitely many solutions.[103]

[101] 1093 is the smallest Wieferich prime (see Meissner 1914; cf. Corry 2008, 418).
[102] This is still the state of the art at the time of writing these notes.
[103] For orientation about the history of this so-called *Pell's equation*, we refer to Weil 1984.

Problem 23. For the problem corresponding to the previous one, where the left-hand side of the equation has an expression in x and y of degree[104] >2 which cannot be factorized, and on the right hand side, instead of 1, any integer may appear, the Norwegian mathematician Thue proved the unexpected fact that there is always only a finite number of solutions.[105]

At this number of twenty-three problems I want to stop, because twenty-three is a prime number, i.e., a very handsome number for us.[106] I am certain that I should not fear to be asked by you, for what purpose does one deal with the theory of numbers and what application it may have. For we deal with science for the sake of it,[107] and dealing with it was a solace in the days of internal and external war that as Jews and as Germans we fought and still fight today.[108]

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References

Angress, Werner T. 1976. "Das deutsche Militär und die Juden im Ersten Weltkrieg." *Militärgeschichtliche Mitteilungen* 1; 77–146.

Bateman, Paul T. and Roger A. Horn, 1962. "A heuristic asymptotic formula concerning the distribution of prime numbers." *Mathematics of Computation* 16; 363–367.

Becker, Heinrich, Hans-Joachim Dahms, Cornelia Wegeler, eds. 1998. *Die Universität Göttingen unter dem Nationalsozialismus*, 2nd ed. Munich: Saur Verlag.

Ben Yehuda, Baruch and Uriel Ofek, eds. 1971. *The Story of Gymnasia Herzliya.* (In Hebrew). Tel-Aviv: Gymnasia Herzliya Publications.

Bergmann, Birgit and Moritz Epple, eds. 2009. *Jüdische Mathematiker in der deutschsprachigen akademischen Kultur.* Heidelberg etc.: Springer Verlag.

Berkowitz, Michael. 1993. *Zionist Culture and West European Jewry Before the First World War.* New York: Cambridge University Press.

Bloom, Etan. 2007. "The 'Administrative Knight.' Arthur Ruppin and the rise of Zionist statistics." *The Tel Aviv University Year Book for German History* 35; 183–203.

[104] The term מימד (*meimad*) that Landau uses here today signifies "dimension." The current term for "degree" is דרגה (*dargah*), i.e., a grading or step (in a ladder). This also sounds (*dargah*) somewhat similar to "degree."

[105] See Thue 1909. Landau now draws to an end quickly, not insisting on Thue's context of diophantine approximation, nor on further developments, like Carl Ludwig Siegel's thesis refining Thue's technique, which was written under Landau's supervision.

[106] And of course, 23 was the number of problems presented in the written text of Hilbert's famous address to the Paris International Congress of Mathematicians (ICM) in 1900.

[107] For the general historical emphasis on pure science, and in particular on pure mathematics, in the founding of the Hebrew University at Jerusalem, see Katz 2004.

[108] See our comments in section 1 above.

Brenner, Michael. 2000. *Jüdische Kultur in der Weimarer Republik*. Munich: C.H. Beck.

Brodetsky, Selig. 1960. *Memoirs: From Ghetto to Israel*. London: Weidenfeld and Nicholson.

Chayut, Michael. 1994. "From Berlin to Jerusalem: Ladislaus Farkas and the Founding of Physical Chemistry in Israel." *Historical Studies in the Physical and Biological Sciences* 24; 237–263.

Corfield, David. 2003. *Towards a philosophy of real mathematics*. Cambridge: Cambridge University Press.

Corry, Leo. 2008. "Number Crunching vs. Number Theory: Computers and FLT, from Kummer to SWAC (1850–1960), and beyond." *Archive for History of Exact Sciences* 62 (1); 393–455.

Cox, David A. 1989. *Primes of the form* $x^2 + ny^2$. New York, Chichester: John Wiley.

Crelle, August Leopold. 1846. "Démonstration d'un théorème de Mr. Slonimski sur les nombres, avec une application de ce théorème au calcul des chiffres." *Journal für die reine und angewandte Mathematik* 30; 215–229.

Davenport, Harold. 1939. "On Waring's problem for cubes." *Acta Mathematica* 71; 123–143.

Deichmann, Ute and Anthony S. Travis. 2004. "A German influence on science in Mandate Palestine and Israel: chemistry and biochemistry." *Israel Studies* 9; 34–70.

Dirichlet, Johann Peter Gustav Lejeune. 1837. "Beweis des Satzes, dass jede unbegrenzte arithmetische Progression, deren erstes Glied und Differenz ganze Zahlen ohne gemeinschaftlichen Factor sind, unendlich viele Primzahlen enthält." *Abhandlungen der Königlich Preussischen Akademie der Wissenschaften*, 45–81.

Dirichlet, Johann Peter Gustav Lejeune. 1840. "Über eine Eigenschaft der quadratischen Formen." *Abhandlungen der Königlich Preussischen Akademie der Wissenschaften*, 49–52.

Efrati, Nathan. 2004. *From a Language of Individuals to a Nation's Language. Speaking Hebrew in the Land of Israel in the Years 1881–1922*. (In Hebrew). Jerusalem: National Academy for the Hebrew Language.

Ekkehard, E., ed. 1929. *Sigilla Veri (Ph. Stauff's Semi-Kürschner), Lexikon der Juden, Genossen und Gegner aller Zeiten und Zonen, insbesondere Deutschlands, der Lehren, Gebräuche, Kunstgriffe und Statistiken sowie ihrer Gaunersprache, Trugnahmen, Geheimbünde usw.*, vol. 3. Erfurt: U. Bodung Verlag.

Elboim-Dror, Rachel. 1986. *Hebrew Education in Palestine 1854–1914*. (In Hebrew). Jerusalem; Yad Izhak Ben-Zvi.

Errera, Alfred. 1913. "Zahlentheoretische Lösung einer funktionentheoretischen Frage." *Rendiconti Circolo di Palermo* 35; 107–144.

Errera-Bourla, Milantia. 2000. *Une histoire juive: Les Errera. Parcours d'une assimilation*. Brussels: Editions Racine.

Euclide. 1994. *Les Eléments, vol. 2, livres V-IX*. Translation and commentary by Bernard Vitrac. Paris: Presses Universitaires de France.

Feiner, Shmuel. 2004a. *Haskalah and History: The Emergence of a Modern Jewish Historical Consciousness*. Oxford: Littman Library of Jewish Civilization.

Feiner, Shmuel. 2004b. *The Jewish Enlightenment*. Philadelphia: University of Pennsylvania Press.

Fölsing, Albrecht. 1997. *Albert Einstein. A Biography*. New York: Viking.

Forman, Paul. 1973. "Scientific internationalism and the Weimar physicists: the ideology and its manipulation in Germany after World War I." *Isis* 64; 151–180.

Fraenkel, Abraham. 1967. *Lebenskreise. Aus den Erinnerungen eines jüdischen Mathematikers*. Stuttgart: DVA.

Franel, Jérôme. 1924. "Les suites de Farey et le problème des nombres premiers." *Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen aus dem Jahre 1924, Mathematisch-Physikalische Klasse*: 198–201.

Fuchs, James L. 1989. "Differentials and divisions: Edmund Landau in Jerusalem." *Koroth* 9; 664–683.

Goldstein, Catherine. 2007. "Du Rhin et des nombres: quelques reflexions sur l'usage de la notion de 'transfert culturel' en histoire des mathématiques." In *Sciences et frontiers; delimitations du savoir, objets, passages*, edited by P. Hert and M. Paul-Cavallier, 341–376. Fernelmont: E.M.E.

Goldstein, Catherine, Norbert Schappacher, Joachim Schwermer, eds. 2007. *The Shaping of Arithmetic after C.F. Gauss's* Disquisitiones Arithmeticae. Berlin and Heidelberg: Springer Verlag.

Grattan-Guinness, Ivor. 2000. "A sideways look at Hilbert's twenty-three problems of 1900." *Notices of the American Mathematical Society* 47–7; 752–757.

Gray, Jeremy. 2000. *The Hilbert Challenge*. Oxford: Oxford University Press.

Hadamard, Jacques. 1896. "Sur la distribution des zéros de la fonction $\zeta(s)$ et ses conséquences arithmétiques." *Bulletin Société mathématique de France* 24; 199–220.

Hardy, Godfrey H. 1940. *A Mathematician's Apology*. Cambridge: Cambridge University Press.

Hardy, Godfrey H. 1942. *Bertrand Russell & Trinity: a College Controversy of the Last War*. Cambridge: Cambridge University Press.

Hardy, Godfrey H., and Hans Arnold Heilbronn. 1938. "Edmund Landau." *Journal of the London Mathematical Society* 13; 302–310; reproduced in E. Landau, *Collected Works*, vol. 1, Essen: Thales, without year; 15–23.

Hardy, Godfrey H. and John E. Littlewood. 1922. "Some problems of 'Partitio numerorum, III. On the expression of a number as a sum of primes." *Acta Mathematica* 44; 1–70.

Hardy, Godfrey H. and John E. Littlewood. 1923. "Some problems of 'Partitio numerorum, V. A further contribution to the study of Goldbach's problem." *Proceedings of the London Mathematical Society* (2) 22; 46–56.

Hardy, Godfrey H. and John E. Littlewood. 1925. "Some problems of 'Partitio numerorum, VI. Further researches in Waring's problem." *Mathematische Zeitschrift* 23; 1–37.

Hardy, Godfrey H. and Marcel Riesz. 1915. *The general theory of Dirichlet's series*. Cambridge: Cambridge University Press.

Hardy, Godfrey H. and Edward M. Wright. 1979. *An Introduction to the theory of numbers*. Fifth edition. Oxford: Clarendon Press.

Hasse, Helmut. 1929. Book review of E. Landau, *Vorlesungen ber Zahlentheorie. Jahresbericht der Deutschen Mathematiker-Vereinigung* 38, 2. Abtlg.; 52–61.

Hasse, Helmut and Emmy Noether. 2006. *Helmut Hasse and Emmy Noether. Their correspondence 1925–1935*, edited by Franz Lemmermeyer and Peter Roquette. Göttingen: Universitätsverlag.

Hausdorff, Felix. 1911. Book review of E. Landau, *Handbuch von der Lehre der Verteilung der Primzahlen. Jahresbericht der Deutschen Mathematiker-Vereinigung* 20; 92–97; reproduced in F. Hausdorff, 2001. *Gesammelte Werke*, vol. IV, 513–518. Heidelberg: Springer Verlag.

Heller, Joseph. 2003. *From 'Brit Shalom' to 'Ihud.' Judah Leib Magnes and the Struggle for a Binational State in Palestine*. (In Hebrew). Jerusalem: Magnes Press.

Hilbert, David. 1909. "Beweis für die Darstellbarkeit der ganzen Zahlen durch eine feste Anzahl *n*-ter Potenzen (Waringsches Problem)." *Mathematische Annalen* 67; 281–300.

Katz, Shaul. 2004. "Berlin Roots - Zionist Incarnation: the ethos of pure mathematics and the beginnings of the Einstein Institute of Mathematics at the Hebrew University of Jerusalem." *Science in Context* 17; 199–234.

Keidar, Aharon. 1976. "Brit Shalom: the Early Period (1925–1928)." (In Hebrew). In *Studies in the History of Zionism*, edited by Yehuda Bauer et al., 224–283. Jerusalem: Hasifirya Hatzionit.

Kirsh, Nurit. 2003. "Population Genetics in Israel in the 1950s: The Unconscious Internalization of Ideology." *Isis, Journal of the History of Science* 94; 631–655.

Klemperer, Victor. 1995. *Ich will Zeugnis ablegen bis zum letzten, Tagebücher*. Vol. 2: 1942–1945. Berlin: Aufbau Verlag.

Kluge, Wolfgang. 1983. *Edmund Landau. Sein Werk und sein Einfluß auf die Entwicklung der Mathematik*. Staatsexamensarbeit Duisburg.

Knopp, Konrad. 1951. "Edmund Landau." *Jahresbericht der Deutschen Mathematiker-Vereinigung* 54; 55–62; reproduced in E. Landau, *Collected Works*, vol. 2, Essen: Thales, without year, 9–16.

Köhler, C. 1900. "Hermann Schapira." *Jahresbericht Deutsche Mathematiker-Vereingung* 8; 61–66.

Lagrange, Joseph Louis. 1869. *Œuvres de Lagrange*, publiées par M. J.-A. Serret et M. G. Darboux. Vol. III. Paris: Gauthier-Villars.

Landau, Edmund. 1903a. "Neuer Beweis des Primzahlsatzes und Beweis des Primidealsatzes." *Mathematische Annalen* 56; 645–670.

Landau, Edmund. 1903b. "Über die Primzahlen in einer arithmetischen Progression." *Sitzungsberichte der kaiserlichen Akademie der Wissenschaften Wien, mathematisch-naturwissenschaftliche Klasse* 112; 493–535.

Landau, Edmund. 1908. "Über die Primzahlen in einer arithmetischen Progression und die Primideale in einer Idealklasse." *Sitzungsberichte der kaiserlichen Akademie der Wissenschaften in Wien, mathematisch-naturwissenschaftliche Klasse* 117; 1095–1107.

Landau, Edmund. 1909a. *Handbuch von der Lehre der Verteilung der Primzahlen*. 2 vols. Leipzig: Teubner.

Landau, Edmund. 1909b. "Über eine Anwendung der Primzahlen auf das Waringsche Problem in der elementaren Zahlentheorie." *Mathematische Annalen* 66; 102–105.

Landau, Edmund. 1911. "Über die Zerlegung positiver ganzer Zahlen in positive Kuben." *Archiv der Mathematik und Physik* (3) 18; 248–252.

Landau, Edmund. 1912. "Gelöste und ungelöste Probleme aus der Theorie der Primzahlverteilung." In *Proceedings of the 5th International Congress of Mathematicians Cambridge 1912*, vol. I, 93–108.

Landau, Edmund. 1924. "Bemerkungen zu der vorstehenden Abhandlung von Herrn Franel." *Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen aus dem Jahre 1924*, *Mathematisch-Physikalische Klasse*, 202–206.

Landau, Edmund. 1925a. Professor Landau, "A Speech. (In Hebrew). In The Hebrew University of Jerusalem, *Inauguration*, April 1st 1925, [Nisan 7, 5685], p. 108. Jerusalem: Azriel.

Landau, Edmund. 1925b. "Solved and Unsolved Problems in Elementary Number Theory." (In Hebrew). The Hebrew University of Jerusalem, *Inauguration*, April 1st 1925 [Nisan 7, 5685]. Reproduced in E. Landau, Collected Works, vol. 8, edited by Paul T. Bateman et al. 297–289.

Landau, Edmund. 1927. *Vorlesungen über Zahlentheorie*. Leipzig: Hirzel.

Landau, Edmund. 1932. "Über die Fareyreihe und die Riemannsche Vermutung." *Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen aus dem Jahre 1932*, *Mathematisch-Physikalische Klasse*, 347–352.

Lang, Serge. 1999. *Math Talks for Undergraduates*. New York and Berlin: Springer Verlag.

Lavsky, Hagit. 1998. *Before Catastrophe: The Distinctive Path of German Zionism*. Detroit: Wayne State University Press.

Lévy, Tony. 1996. "La littérature mathématique hébraïque en Europe (XI^{e} - XVI^{e} siècles)." In *L'Europe mathématique / Mathematical Europe*, edited by C. Goldstein, J. Gray, and J. Ritter, 83–99. Paris: Editions de la Maison des sciences de l'homme.

Lévy, Tony. 1997. "The Establishment of the Mathematical Bookshelf of the Medieval Hebrew Scholar: Translations and Translators." *Science in Context* 10; 431–451.

Lipphardt, Veronika. 2008. *Biologie der Juden. Jüdische Wissenschaftler über "Rasse" und Vererbung 1900–1935*. Göttingen: Vandenhoeck & Ruprecht.

Littlewood, John E. 1925. "On the Riemann zeta function." *Proceedings London Mathematical Society* (2) 24; 175–201.

Lorey, Wilhelm. 1918. "Max Simon zum Gedächtnis." *Zeitschrift für mathematischen und naturwissenschaftlichen Unterricht aller Schulgattungen* 49; 268–271.

Meissner, W. 1914. "Über die Lösungen der Kongruenz $x^p - 1 \equiv 1(\bmod p^m)$ und ihre Verwertung zur Periodenbestimmung mod p^x." *Sitzungsberichte Berliner Mathematische Gesellschaft* 13; 96–107.

Mosse, Werner Eugen. 1989. *The German-Jewish Economic Elite, 1820–1935: A Socio-Cultural Profile*. New York: Oxford University Press.

Peckhaus, Volker. 1990. *Hilbertprogramm und kritische Philosophie: Das Göttinger Modell interdisziplinärer Zusammenarbeit zwischen Mathematik und Philosophie*. Göttingen: Vandenhoeck & Ruprecht.

Penslar, Derek J. 1991. *Zionism and technocracy. The engineering of Jewish settlement in Palestine, 1870–1918*. Bloomington: Indiana University Press.

Radovskii, M.I. and E. Kolman. 1961. "From the History of Computing Devices." Based on material from the archive of the Academy of Sciences SSSR. (In Russian). *Istoriko-matematicheskie issledovania*, 14: 551–585.

Razi-Stein, Ram. 1991. "The First in Mathematics." (In Hebrew). *Aleh* 9; 20–24.

Reid, Constance. 1970. *Hilbert*. Heidelberg and New York: Springer Verlag.

Rinot, Moshe. 1972. *The 'Ezrah' Association for the German Jews. A Chapter in the History of Hebrew Education in Palestine*. (In Hebrew). Jerusalem: The Hebrew University.

Rowe, David E. 2004. "Making mathematics in an oral culture; Göttingen in the era of Klein and Hilbert." *Science in Context* 17; 85–129.

Rowe, David E. 2007. "Felix Klein, Adolf Hurwitz, and the 'Jewish Question' in German Academia." *The Mathematical Intelligencer* 29–2; 18–30.

Rowe, David E. and Robert Schulmann, eds. 2007. *Einstein on Politics: His Private Thoughts and Public Stands on Nationalism, Zionism, War, Peace, and the Bomb*. Princeton: Princeton University Press.

Rürup, Miriam. 2008. *Ehrensache. Jüdische Studentenverbindungen an deutschen Universitäten 1886–1937*. Göttingen: Wallstein.

Sayen, Jamie. 1985. *Einstein in America. The Scientist's Conscience in the age of Hitler and Hiroshima*. New York: Crown.

Schapira, Zvi Hermann (transl.). 1880. "Mischnath Ha-Midoth (Lehre von den Maassen). Aus einem Manuscripte der Münchener Bibliothek, bezeichnet Cod. Hebr. 36., als erste geometrische Schrift in hebräischer Sprache herausgegeben und mit einigen Bemerkungen versehen von Dr. M. Steinschneider (Berlin 1864); ins Deutsche übersetzt, erläutert und mit einem Vorwort versehen." *Zeitschrift für Physik und Mathematik* 25, Suppl.; 1–56.

Schappacher, Norbert and Martin Kneser. 1990. "Fachverband, Institut, Staat. Streiflichter auf das Verhältnis von Mathematik zu Gesellschaft und Politik in Deutschland seit 1880 unter besonderer Berücksichtigung der Zeit des Nationalsozialismus." In *Ein Jahrhundert Mathematik*, edited by G. Fischer, F. Hirzebruch, W. Scharlau, and W. Törnig, 1–82. Braunschweig: Vieweg.

Schappacher, Norbert and Erhard Scholz, eds. 1992. "Oswald Teichmüller, Leben und Werk." *Jahresbericht der Deutschen Mathematiker-Vereinigung* 94; 1–39.

Schroeder-Gudehus, Brigitte. 1978. *Les Scientifiques et la paix, la communauté scientifique internationale au cours des années 20*. Montréal: Les Presses de l'Université de Montréal.

Schur, Issai. 1938. "Professor Edmund Landau." *Jüdische Rundschau* 43–17; 7.

Segal, Sanford L. 2003. *Mathematicians under the Nazis*. Princeton: Princeton University Press.

Siegmund-Schultze, Reinhard. 2008. "Antisemitismus in der Weimarer Republik und die Lage jüdischer Mathematiker: Thesen und Dokumente zu einem wenig erforschten Thema." *Sudhoffs Archiv* 92; 20–34.

Siegmund-Schultze, Reinhard. 2009. *Mathematicians fleeing from Nazi Germany. Individual fates and global impact*. Princeton: Princeton University Press.

Simon, Ernst. 1965. *Brücken. Gesammelte Aufsätze*. Heidelberg: Schneider.

Simon, Max. 1916. *Der Weltkrieg und die Judenfrage*. Leipzig and Berlin: Teubner.

Slonimski, Hayyim Selig. 1849. *A Tribute to Alexander von Humboldt on his Eightieth Birthday. An account of his life, his travels, and his books*. (In Hebrew). Berlin: Veit.

Soffer, Oren. 2004. "The Case of the Hebrew Press. From the Traditional Model of Discourse to the Modern Model." *Written Communication* 21–2; 141–170.

Soffer, Oren. 2007. *"There is no place for Pilpul !" HaTzfira Journal and the Modernization of the Sociopolitical Discourse*. (In Hebrew). Jerusalem: Bialik Institute.

Stevenhagen, Peter and Hendrik W. Lenstra. 1996. "Chebotarev and his density theorem." *The Mathematical Intelligencer* 18; 26–37.

Thue, Axel. 1909. "Über Annäherungswerte algebraischer Zahlen." *Journal für die reine und angewandte Mathematik* 135; 284–305.

Tollmien, Cordula. 1999. "Juden in Göttingen." In *Göttingen. Die Geschichte einer Universitätsstadt*. Vol. 3: *Von der preußischen Mittelstadt zur südniedersächsischen Großstadt 1866 bis 1989*. Edited by Rudolf von Thadden and Jürgen Trittel, 688–760. Göttingen: Vandenhoeck & Ruprecht.

Tschebyscheff, Pafnuti L. 1889. *Theorie der Congruenzen (Elemente der Zahlentheorie)*. Deutsch mit Autorisation des Verfassers herausgegeben von H. Schapira. Berlin: Mayer & Müller.

Vallée Poussin, Charles de la. 1896. "Recherches analytiques sur la théorie des nombres premiers. Deuxième partie: Les fonctions de Dirichlet et les nombres premiers de la forme linéaire $Ms + N$." *Annales de la Société des Sciences Bruxelles* 20; 281–362.

Vaughan, Robert Ch. and Trevor D. Wooley. 2002. "Waring's problem: a survey." In *Number Theory for the Millenium*, edited by M.A. Benett, B.C. Berndt, N. Boston, H.G. Diamond, A.J. Hildebrand, and W. Philipp, vol. III, 301–340. Natick, MA: A.K. Peters.

Velder, Christian. 1989. *300 Jahre Französisches Gymnasium Berlin/300 ans au Collège Français*. Berlin: Nicolai.

Weil, André. 1984. *Number Theory. An Approach Through History from Hammurapi to Legendre*. Boston: Birkhäuser.

Weizmann, Chaim. 1949. *Trial and Error. The Autobiography of Chaim Weizmann*. New York: Harper.

Wieferich, Arthur. 1909a. "Zum letzten Fermatschen Theorem." *Journal für die reine und angewandte Mathematik* 136; 293–302.

Wieferich, Arthur. 1909b. "Beweis des Satzes, dass sich eine jede ganze Zahl als Summe von höchstens neun positiven Kuben darstellen lässt." *Mathematische Annalen* 66: 95–101.

Wilhelm, Peter. 1978. *Die Synagogengemeinde Göttingen, Rosdorf und Geismar 1850–1942*. Göttingen: Vandenhoeck & Ruprecht.

Zechlin, Egmont. 1969. *Die Deutsche Politik und die Juden im Ersten Weltkrieg*. Göttingen: Vandenhoeck & Ruprecht.