

David Hilbert's Radio Address: Comments

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For many years, Hilbert's recording has been accessible to the public via my website, which has become a standard source for it. That website is hosted by the Mathematics Department at San Francisco State University. I wanted to provide a suitable home for the recording that will outlive me. Janet Beery, editor of the MAA online journal *Loci: Convergence* agreed to that, and asked me to provide much more material. The resulting paper is in that journal's format, and these comments are organized accordingly.

Introduction page

1. *Portrait*. This was Janet's choice. Even though it is not contemporary with the events described in this article, I accept it as an iconic photo, part of "branding".
2. Paragraph *In Königsberg on*
 - a. This deals with the time and place, the society, the most basic data about Hilbert, the relation of the full address and the radio broadcast, and the dual purpose: presenting his philosophical point and garnering broader support.
 - b. Originally I had a footnote on the first sentence to explain that Königsberg is now Kaliningrad, in Russia. Readers may not be familiar with that location and will not find "Königsberg" on current maps. The *Convergence* format doesn't permit footnotes, and an endnote wouldn't be effective, so I tried to put that explanation in the main text. Janet moved it to a later position.
 - c. The Society is named in full detail because
 - i. there were four related meetings in Königsberg that week, and
 - ii. the philosophy that Hilbert was countering was introduced at an earlier meeting of the same Society.
 - d. The Society, founded in 1822 in Leipzig, is the oldest German organization for interdisciplinary and public dissemination of science. I opted not to mention that.
 - e. I gave here the detail on Hilbert's early years and retirement because I have to do so sometime and without it readers would get the false impression that this is a retirement speech. The facts are from Reid 1970.
 - f. Sixty-eight was the compulsory retirement age. I opted not to mention that.
 - g. The "opposing opinion" is expanded on the *Hilbert and Mathematical Inquiry* page.
 - h. "German radio" had begun only in 1923. I don't know any details.
 - i. The word "poem" is from Vinnikov 1999.
3. Paragraph *On subsequent pages*. Originally I had a footnote on the Hilbert [1930] 1971 citation, to refer to the bibliography and explain what an author-date citation is. Janet decided that wasn't necessary.

German Transcription page

4. *Audio control*. I should occasionally test this with various browsers. The following problems have occurred with other implementations.
 - a. Sometimes an audio started immediately on navigating to the page.
 - b. Sometimes clicking an audio control started a new separate window.
 - c. Sometimes clicking an audio control seemed to cause a black screen. This happened because it opened audio software in an entirely black window that replaced the main window. That fault is remedied by having the user right-click on the control and opt to open it in a separate window, which the user can then move out of the way.
5. *Portrait*
 - a. This portrait is dated as close to 1930 as I could find. It's dramatic because it looks like Hilbert is reading his radio address.
 - b. It's from Reid 1970, page 244. She specified the date. Reid gave no credit for the portrait. If required, I can almost certainly get permission from Springer, the publisher of her book. However, Janet found it on the St. Andrews website and followed her policy of merely crediting them.
 - c. The 355×400 file `hilbert4.jpg` was online: http://www.algebra.at/primcy_e.htm. I merely cropped it.
6. *Transcription*
 - a. I've compared my transcription with Hilbert [1930] 1996, Vinnikov 1999, and Siebenmann's at <http://topo.math.u-psud.fr/~lcs/Hilbert/HlbrtKD.htm#TOP>.
 - b. Siebenmann has a more extensive website, and I have corresponded with him, but as yet he has not responded.
 - c. Hilbert used small capitals this way in the original publication.
 - d. Neither *ignorabimus* nor Hilbert's final slogan are italicized in the original.
 - e. The other transcriptions use the German character β in *daß*, *genießt*, and *heiße*. Because that may not be familiar to non-German readers, I used the now-semistandard *ss*.
 - f. The other transcriptions use the German quotation marks „ and “. Because these may not be familiar to non-German readers, I used English quotation marks.
 - g. Paragraph *Das Instrument, welches*. Last sentence: Hilbert said *den* but meant *denen*, as in the published version. Vinnikov pointed this out in 1999. I mentioned his noting errors in the annotation for that bibliography entry.
 - h. Paragraph *Trotzdem haben es*. Second sentence: Hilbert said *Reiz, den die* but meant *Reiz, der die*, as in the published version. Vinnikov pointed this out in 1999. I mentioned his noting errors in the annotation for that bibliography entry.
 - i. Paragraph *Der grosse Mathematiker*
 - i. *Tolstoi* is the spelling used in Hilbert's published version.

- ii. Last sentence: Hilbert said and wrote *gefördert* but Vinnikov and Siebenmann wrote *gefördert*. I chose not to mention that.
- j. Paragraph *Die Ehre des*. Hilbert said *sagte*. This bridged a passage from the full script that he omitted on radio. But Vinnikov and Siebenmann wrote *sagt*. The omitted passage was indeed in present tense but that does not fit in the past tense of the shortened version. I chose not to mention this.
- k. In his published article, Hilbert emphasized his concluding slogan by centering it in his two-column format. Centering didn't look right in full-page format, so I indented it instead.

English Translation page

- 7. *Portrait*. This portrait has been processed considerably. I chose it because it looks as though he is giving his presentation. The "1 + 1 =" on the board is amusing.
- 8. I compared my translation with Vinnikov 1999 and with Ewald's translation of the full address. Neither is really close to mine.
- 9. Neither uses small capitals as I do.
- 10. I italicized *ignorabimus* because it's conventional in English to do so.
- 11. Ewald does not italicize Hilbert's final slogan, but does italicize *ignorabimus*. Hilbert's emphasis would indicate that *will* should be used in the slogan. But that nuance is not commonly understood nowadays: Vinnikov used *shall* in his title.
- 12. In his published article, Hilbert emphasized his concluding slogan by centering it in one column of his two-column format. Centering didn't look right in full-page format, so I indented it twice my usual amount for displayed text.
- 13. *German and English page*
 - a. The German and English texts are intended to be exact copies of the text on the previous two pages.
 - b. I experimented making the lines of English correspond more exactly to the lines of German, rather than making paragraphs correspond. But that made the English somewhat jerky, and invited editing errors. So we decided against that.

Hilbert and Mathematical Inquiry page

- 14. Janet wanted to include biodates for the major characters. In a book I put everyone's dates on their index entries. But this paper has no index. Although the dates contribute to clutter, I agree to include them for all characters whom this paper is about. But not for other scholars who are mentioned only because they participated in this overall study.
- 15. I do not necessarily agree with Janet's inserting links to the St. Andrews website. First, it used to have glaring errors that its managers would not repair. Second, I'd have to vet those articles before I agreed to so endorse them. Also, *Wikipedia* is often a better source than St. Andrews. However, Janet gave a strong argument to do so, and I conceded.

16. Paragraph *The historian David*. I wouldn't want to claim this general background on my own authority because I'm not expert. Rowe 2013 is the best I've seen.
17. Paragraph *Hilbert belonged to*. Kant considered geometry an *a priori* subject, though in a sense different from arithmetic. With the discovery of non-Euclidean geometry, his view soon became problematic. Bertrand Russell's doctoral thesis was about this question.
18. Paragraph *An earlier foray*
 - a. The *Chicago* manual says that I should always capitalize *Du* in *Du Bois*.
 - b. An 1880s German edition of the original publication Du Bois-Reymond [1872] 1874 is online at
<http://babel.hathitrust.org/cgi/pt?id=mdp.39015021015964;view=1up;seq=1>.

Here are its last two paragraphs, pp. 44–45:

Schliesslich entsteht die Frage, ob die beiden Grenzen unseres Naturerkennens nicht vielleicht die nämliche seien, d. h. ob, wenn wir das Wesen von Materie und Kraft begriffen, wir nicht auch verständen, wie die ihnen zu Grunde liegende Substanz unser bestimmten Bedingungen empfindet, begehrt und denkt. Freilich ist diese Vorstellung die einfachste, und nach bekannten Forschungsgrundsätzen bis zu ihrer Widerlegung der vorzuziehen, wonach, wie vorhergesagt wurde, die Welt doppelt unbegreiflich erscheint. Aber es liegt in der Natur der Dinge, dass wir auch in diesem Punkte nicht zur Klarheit kommen, und alles weitere Reden darüber bleibt müssig.

Gegenüber den Räthseln der Körperwelt ist der Naturforscher längst gewöhnt, mit männlicher Entsagung sein '*Ignoramus*' auszusprechen. Im Rückblick auf die durchlaufene siegreiche Bahn trägt ihn dabei das stille Bewusstsein, dass, wo er jetzt nicht weiss, er wenigstens unter Umständen wissen könnte, und dereinst vielleicht wissen wird. Gegenüber dem Räthsel aber, was Materie und Kraft seien, und wie sie zu denken vermögen, muss er ein für allemal zu dem viel schwerer Wahrspruch sich entschliessen:

'Ignorabimus'.

- c. Du Bois-Reymond 1880, 1046:

Der Empfang, der meiner Auseinandersetzung wurde, zeigte mir, dass ich mich in der Sachlage getäuscht hatte. Dem anfangs kühl aufgenommenen Vortrage widerfuhr bald die Ehre, Gegenstand zahlreicher Besprechungen zu werden, in denen eine grosse Mannigfaltigkeit von Standpunkten sich kundgab. Die Kritik schlug alle Töne vom freudig zustimmenden Lobe bis zum wegwerfendsten Tadel an, und das Wort *Ignorabimus*, in welchem meine Untersuchung gipfelte, ward förmlich zu einer Art von naturphilosophischem Schibboleth.
- d. According to *WordPerfect's* Oxford dictionary, shibboleth = a custom, principle, or belief distinguishing a particular class or group of people.
- e. Perhaps I should put these words of Du Bois-Reymond in an endnote with translation. I didn't, because Hilbert didn't refer to them, even indirectly.
19. Figure and caption *Emil du Bois-Reymond*
 - a. This 400×492 photo is from Project Gutenberg at
gutenberg.spiegel.de/autor/1021.
 It's in other collections, too. Supposing that the photographer was around 25 in 1885 and lived to 80, he would have died around 1940, which is about 75 years ago. I think I can assume the photo is in the public domain for that reason. Investigating that page, I found the photo imbedded in a paper by the Kieler professor Klaus Beneke:

<http://www.uni-kiel.de/anorg/lagaly/group/klausSchiver/dubois.pdf>. If necessary, I could write him at k.beneke@email.uni-kiel.de and ask where he got the photo. Google shows the photo at other places, too, and I suspect I could find it in a physical book if I spent enough time digging in Berkeley (but I wouldn't like to do that).

- b. Online is an 1896 photo, in which he looks about ten years older.
 - c. I don't like the hairline table delineations, and would prefer that this portrait and the one to its right have hairline borders. Janet couldn't do that.
 - d. I cleaned a white mark from Emil's coat. It might have been the photographer's signature, but it was illegible.
 - e. We could have flipped Emil's portrait across his vertical axis to make him face Hilbert, but decided that that would be taking too great license.
20. Figure and caption *David Hilbert in*
- a. This 283×400 photo, [David_Hilbert_1886.jpg](#) is from the Wikipedia Commons. They say it's in the public domain because its copyright has expired.
 - b. I've done naught but crop and frame this and convert it to *.eps.
 - c. I think this portrait is in Reid 1970, page 226, with no acknowledgement.
21. Paragraph *Hilbert remained at*
- a. I mentioned geometry in particular because I mention later that this attention to familiar mathematics continued in the 1920s.
 - b. I qualified *leading mathematician* with the adjective *research* because Klein was still around!
22. Paragraph *Hilbert's career during*
- a. I looked at the following resource but decided that it contained no text similar enough to the radio address to mention here:
 - i. Hilbert, David. [1919–1920] 1992. *Natur und mathematisches Erkennen: Vorlesungen gehalten 1919–1920 in Göttingen*. Prepared by Paul Bernays, edited by David E. Rowe. Basel: Birkhäuser, 1992. The title means *Nature and Mathematical Knowledge: Lectures Held . . .*
 - b. Hilbert [1922–1923] 1988 is not in any American library. It will be reprinted in vol. 6 of Hilbert's lectures.
 - i. I have a review by Schappacher, who says this begins with the text of the radio speech.
 - ii. From a snippet for Hilbert [1922–1923] 1988 from an online auction site:

Hilberts Vorlesung gipfelt in dem Ausruf "Wenn wir von griesgrämigen Laien und bedenklichen Philosophen reden hören: 'Wir können es nicht wissen,/ Wir werden es nicht wissen,'so wollen wir lieber auf unsere Fahne setzen: 'Wir müssen es wissen,/ Wir werden es wissen!'" (S. 132).
 - iii. Rather than contacting the editors or reviewer, I decided just to go with this page number.
23. Figure and caption *Königsberg in the 1930s*
- a. This photo, [königsberg.jpg](#), is 800×579. It's from a travel agency: <http://www.ostpreussen.net/ostpreussen/orte.php?bericht=1055>
 - b. I did not process it at all.

- c. The locations of the features are from an online map of Königsberg. The river is the Pregel, flowing toward the left, 12 km to the Danziger Bucht. The indicated University building is called the Albertina.
 - d. I think that in Kant's time, the university was on the island by the Cathedral.
 - e. Most of these buildings were destroyed by a British air raid in August 1944. The Rathaus and the Cathedral have been partially restored. The rest of the island (Kneiphof) is now an open park.
 - f. Unfortunately, Steinhaus [1950] 1983 gives no historical reference for the bridge problem. Moreover, his solution of it is less than ideal. But the book is gorgeous.
 - g. It might have been better to use *Schloss* rather than *Rathaus*. The Germans do, but the usage is not so familiar in the US.
24. Paragraph *Hilbert's presentation opened*. Hilbert's slogan depends on what *know* means and what *mathematics* means. I opted not to mention that.
25. Paragraph *Hilbert's radio address*. I wrote Siebenmann about his reference to the wax original of the original recording, but received no reply:
<http://topo.math.u-psud.fr/~lcs/Hilbert/HlbrtkD.htm>.
26. Paragraph *Besides the Meeting*
- a. <http://www.tau.ac.il/~corry/publications/articles/Narrative/main3.html> says that Gödel and Hilbert did not meet nor attend each others' talks.
 - b. The annual meeting of the DMV started on Th 4 Sept 1930 and continued all day. It continued on Fr 5 Sept AM, Sa 6 Sept AM. Business meeting, Su 7 Sep 10 AM. This is from JDMV 40 (1931), Mitteilungen section, 29 ff. There is no indication of where in Königsberg did this take place. (A lady who organized a German museum exhibition asked me about that once.)
 - c. The combined meeting of the DMV and the physicists was also called the Sixth Congress of German Physicists and Mathematicians.
 - d. Reidemeisters philosophische Interessen kamen erneut zum Ausdruck, als im September 1930 in Königsberg gleichzeitig vier große Wissenschaftskongresse stattfanden: die Jahresversammlung der Gesellschaft Deutscher Naturforscher und Ärzte, die Jahrestagung der Deutschen Mathematiker-Vereinigung, die 6. Deutsche Physiker- und Mathematikertagung und die zweite Tagung für Erkenntnislehre der exakten Wissenschaften. Reidemeister war an der Organisation dieser Kongresse beteiligt und hatte viele Mitglieder des Wiener Kreises eingeladen. Auf diesen Tagungen hielt David Hilbert seinen berühmten Radiovortrag („Wir müssen wissen – wir werden wissen“) und Kurt Gödel präsentierte – damals noch wenig beachtet – seine Ergebnisse zu unentscheidbaren Sätzen in formalen logischen Systemen. From the German Wikipedia on Reidemeister.
 - e. Vinnikov says: At a meeting on Epistemology of the Exact Sciences on 6 Sept 1930, Gödel had announced modestly an incompleteness result that would, in some sense, demolish it. This meeting took place 5–7 Sep 1930. Look at Gödel collected works, I, 135–137, and V, 327–330 concerning that meeting.

- f. The Deutsche Physikalische Gesellschaft was founded in 1845. I'm not sure this is the organization: I'd have to look at its *Verhandlungen* in person in Berkeley Main. I opted not to pursue this.
 - g. On the epistemology meeting, leftover:
 - i. Gödel announced his work briefly in Königsberg on 7 September. Check 796–797, 967–973, 983–984 of the volume of lectures. In the von Neumann letters, volume I, see references to 15, pp. 135, 137 and 17, pp. 327–330 for this meeting
 - ii. Neumann's address: is that where he mentioned Gödel's work?
27. Figure and caption *David Hilbert's Gravestone*
- a. The photo is from the Wikimedia Commons:
<http://commons.wikimedia.org/wiki/File:HilbertGrab.jpg>.
 That page says it's in public domain subject to certain restrictions, which I think we meet.
 - b. I cropped it, then selected the epitaph portion of the monument and used *PhotoShop's* "Curves" tool to darken the engraved text while changing the color of the stone surface as little as possible.

Hilbert's Sources partial page

- 28. *Portrait*. This was Janet's idea. I like her inclusion of the photo! It looks like Hilbert is pointing to a source and thinking, "It's right in here!".
- 29. Paragraph *David Hilbert's full*. It was surprisingly hard to ferret out some of these text excerpts.
- 30. Paragraph *Hilbert mentioned Gauss's*
 - a. I decided that Homer and Schiller are too famous to require further identification here. But literature citations are included in the endnotes.
 - b. I haven't found anyplace where Gauss himself said that his phrase referred to the Lotus-Eaters.
 - c. In the body text I wrote about mathematicians' ironic recognition of seduction by Lotus Eaters/number theorists. Janet wondered if I would also describe this as "fond recognition". I had actually looked up 'ironic' in WordPerfect's Oxford dictionary: "2. happening in the opposite way to what is expected." I tried to avoid any implied approval or disapproval, present-day or in Kronecker's time.
- 31. Paragraph *Concluding, Hilbert recounted*
 - a. I decided not to report that Henri Poincaré was the cousin of Raymond Poincaré (1860–1934), president of France during World War I.
- 32. Paragraph *The other three*
 - a. <http://www.tau.ac.il/~corry/publications/articles/Narrative/main3.html> says that Gödel and Hilbert did not meet nor attend each others' talks.
 - b. The annual meeting of the DMV started on Th 4 Sept 1930 and continued all day. It continued on Fr 5 Sept AM, Sa 6 Sept AM. Business meeting, Su 7 Sep 10 AM. This is from JDMV 40 (1931), Mitteilungen section, 29 ff. There

- is no indication of where in Königsberg did this take place. (A lady who organized a German museum exhibition asked me about that once.)
- c. The combined meeting of the DMV and the physicists was also called the Sixth Congress of German Physicists and Mathematicians.
 - d. Reidemeisters philosophische Interessen kamen erneut zum Ausdruck, als im September 1930 in Königsberg gleichzeitig vier große Wissenschaftskongresse stattfanden: die Jahresversammlung der Gesellschaft Deutscher Naturforscher und Ärzte, die Jahrestagung der Deutschen Mathematiker-Vereinigung, die 6. Deutsche Physiker- und Mathematikertagung und die zweite Tagung für Erkenntnislehre der exakten Wissenschaften. Reidemeister war an der Organisation dieser Kongresse beteiligt und hatte viele Mitglieder des Wiener Kreises eingeladen. Auf diesen Tagungen hielt David Hilbert seinen berühmten Radiovortrag („Wir müssen wissen – wir werden wissen“) und Kurt Gödel präsentierte – damals noch wenig beachtet – seine Ergebnisse zu unentscheidbaren Sätzen in formalen logischen Systemen. From the German Wikipedia on Reidemeister.
 - e. Vinnikov says: At a meeting on Epistemology of the Exact Sciences on 6 Sept 1930, Gödel had announced modestly an incompleteness result that would, in some sense, demolish it. This meeting took place 5–7 Sep 1930. Look at Gödel collected works, I, 135–137, and V, 327–330 concerning that meeting.
 - f. The Deutsche Physikalische Gesellschaft was founded in 1845. I'm not sure this is the organization: I'd have to look at its *Verhandlungen* in person in Berkeley Main. I opted not to pursue this.
 - g. On the epistemology meeting, leftover:
 - i. Gödel announced his work briefly in Königsberg on 7 September. Check 796–797, 967–973, 983–984 of the volume of lectures. In the von Neumann letters, volume I, see references to 15, pp. 135, 137 and 17, pp. 327–330 for this meeting
 - ii. Neumann's address: is that where he mentioned Gödel's work?

Their Own Words partial page

Galileo

33. Although I use the surname Galilei for the bibliographic entry, I use the forename Galileo in English prose, which is conventional.
34. Drake's translation is 79 words: fair use.
35. Galileo's text is 75 words: fair use.
36. Galileo's words look like modern Italian. Did he really write that way or is this edited or translated from older Italian?
37. I copied the translation from page 238 of
 - a. Stillman Drake, *Discoveries and Opinions of Galileo* (New York: Doubleday & Co., 1957), 231-280, because I hadn't copied it from the work I cited.
38. The tidbit of information about the quotation is from

- a. Molinsky, Michael. 2014. Quotations in context: "Mathematics is the language with which God has written the universe." *CSHPM/SCHPM Bulletin* 54 (May, 2014), 12–13.
39. More dates
- a. Drake, Stillman (1910–1993)
 - b. Barbèra, Gaspero (1818–1880)
 - c. Molinsky, Michael
 - d. Mascardi, Giacomo (1567–1634)

Kant

- 40. Kant's text is 48 words: fair use.
- 41. Hilbert deleted Kant's word *aber*, changed the subjunctive *könne* to the indicative *kann*, and changed the somewhat awkward "anzutreffen" to "enthalten".
- 42. More dates: Reimer, Georg Andreas (1776–1842)

Gauss

- 43. Sartorius von Waltershausen's text is 131 words: fair use.
- 44. Sartorius wrote "Arithmetik" but Hilbert changed that to "Zahlentheorie" (number theory). I opted not to mention that.
- 45. Shakespeare's text is 12 words: fair use.
- 46. I have not determined where Gauss referred to this motto in print.
- 47. More dates
 - a. Shakespeare, William (1564?–1616) I opted not to give these dates.
 - b. Foakes, Reginald A. (1923–2013)
- 48. Sartorius von Waltershausen [1856] 1967 is in Berkeley Main: QA29.G3 S3.
- 49. Hilbert made a couple of changes to Gauss's words in the first quotation. It totals 78 words, fair use.
- 50. The second quotation totals 155 words, close enough to my threshold of 150 to amount to fair use. Its opening is a marvelous example of a German *Schachtelsatz*: had it been even one phrase longer, I'd probably have had to split it! The ellipsis at the end stands for another thirteen words and ten lines quoting a poem by Ovid in Latin. This material was published in 1929, so could well have been fresh in Hilbert's mind in 1930. Its endnotes indicate that Gauss used some of the same stuff in his lectures on astronomy, which were probably accessible or recalled by others during the intervening century.

Homer

- 51. The Palmer translation of Homer's text is 227 words, too much for fair use on that account. However, it's in the public domain because it was published in 1884.
- 52. I opted not to mention that the Trojan War may have occurred around 1200 B.C.E. Evidently, modern scholarship puts Troy on the Ionic coast of Asia Minor, Ithaca

on an island near that coast, and the Lotus Eaters perhaps on an island near Tunisia. Homer's geography seems improbable, not worth mentioning.

53. More dates:
- a. Homer (ca. 800–700 B.C.E.)
 - b. Palmer, George Herbert (1842–1933)

Kronecker/Jacobi

54. Kronecker's text is 162 words: almost fair use. However, it's in the public domain because it was published in 1887.
55. Ewald's translation of Kronecker's text is 167 words. This is a little longer than the limit, 150, that I usually apply for fair use. If it is too long for that, the easiest solution would be for me to retranslate the Kronecker passage.
56. Quoted paragraph *In dieser geistvollen*
- a. "Schillerschen" is that way in the original. That's how it's done in German.
 - b. "Jacobi" and "Gauss" are italicized in the original.
57. More dates
- a. Schiller, Friedrich (1759–1805)
 - b. Ewald, William Bragg (1954–)

Schiller/Jacobi

58. Schiller's text is 82 words: fair use.
59. Jacobi's text is 87 words: fair use.
60. I used "wife" for "Weib" in the last sentence of Schiller to convey subservience.
61. I copied this text from
<http://www.textlog.de/schiller-gedichte-archimedes.html>.
 and checked it against the hardcopy edition.
62. My translation from Jacobi [1830] 1881 is very like that in
- a. Körner, T. W. 1988. *Fourier Analysis*. New York: Cambridge University Press. Page 532.
63. More dates:
- a. Borchardt, Karl Wilhelm (1817–1880)

Poincaré

64. Halstead's translation is 259 words: too long for fair use. But it's in the public domain since it was published in 1909.
65. Poincaré's text is 259 words: too long for fair use. But it's in the public domain since it was published in 1909.
66. Poincaré spelled *Tolstoi* that way.
67. More dates
- a. Flamarion, Ernest (1846–1936)

Tolstoy

68. Paragraph *Hilbert recounted that*
 - a. Please change the date 1887 in the first sentence to 1899. As to why, see my annotation in the new version of the bibliographic entry Tolstoy 1899.
69. Hapgood's translation is 280 words: too long for fair use. But it's in the public domain since Tolstoy died in 1910.
70. Some of the shorter ellipses skip over phrases related to art, which Tolstoy discussed in parallel with science.
71. More dates:
 - a. Hapgood, Isabel Florence (1851–1928). She has a very interesting life story.
72. Other sources for Tolstoy's article:
 - a. <http://arvindguptatoys.com/arvindgupta/whatthenmustwedo.pdf>
 - b. <https://archive.org/stream/onthesignificanc03631gut/sgnsa10.txt>
 - c. Here is an article on math. in *War and Peace*. It seems irrelevant.
 - i. http://0-download.springer.com.opac.sfsu.edu/static/pdf/592/art%253A10.1007%252Fs00283-012-9342-8.pdf?auth66=1388873796_4a79fffb9edc6ad6ee35937b3cfb8713&ext=.pdf

Bibliography partial page

73. Du Bois-Reymond 1880
 - a. I couldn't find a volume number.
 - b. This was published in several editions, which may differ somewhat:
 - i. <http://babel.hathitrust.org/cgi/pt?id=njp.32101065312025;view=1up;seq=1111>
 - ii. <http://gutenberg.spiegel.de/buch/2574/3>
74. Hilbert, David [1900] 1902. That journal is online via the AMS. For this paper and my recent book and *Monthly* paper I stopped remarking when material is online. Google and library sources are good enough now that readers don't need to flounder about. In my opinion there's no point in the reference to David Joyce. But Janet felt that his edition has some special features not shared by the ordinary online versions.
75. Minkowski [1908] 1923. I don't like the translation. I asked Steve Gimbel if there's a better one, and he said no.
76. Poincaré [1906] 1909 is included in *Science and Method*, chapter 1.
77. Item *Reidemeister 1971*. Springer may by now have started including the recording. I don't know how to determine that without spending considerable effort, because I don't trust their advertizing.
78. Sartorius 1856. I opted not to make this a reference to the translation because I believe the translation is rare.
79. Schiller 1795
 - a. The cited edition is online at <http://www.wissen-im-netz.info/literatur/schiller/horen/1795/11/index.htm>.
 - b. The journal seems to have had no page numbers.

- c. I also found the poem on page 78 of Schiller, Friedrich. 1905. *Schillers Gedichte und Dramen*. Edited by Otto Güntter. Stuttgart: Veag des Schwäbischen Schillervereins.

Persons mentioned

80. I decided not to give biodates systematically.

Ackermann, Wilhelm Friedrich (1896–1962) Wilhelm Ackermann
 Bauer-Mengelberg, Stefan (1927–1996)
 Drake, Stillman (1910–1993)
 Du Bois-Reymond, Emil Heinrich (1818–1896) Emil du Bois-Reymond
 Du-Bois-Reymond, Paul David Gustav (1831–1889)
 Ewald, William Bragg, III (1925–) William B. Ewald
 Fitzgerald, Joseph (1837–1908)
 Franzén, Torkel (1950–2006)
 Galilei, Galileo (1564–1642)
 Gauss, Helen Minna Worthington (1881–1970) Helen Worthington Gauss
 Gauss, Karl Friedrich (1777–1855)
 Gödel, Kurt Friedrich (1906–1978) Kurt Gödel
 Halsted, George Bruce (1853–1922)
 Hapgood, Isabel Florence (1851–1928) Isabel F. Hapgood
 Hilbert, David (1862–1943)
 Homer (flourished around 700 B.C.E.)
 Jacobi, Carl Gustav Jacob (1804–1851) C. G. J. Jacobi
 Jeffrey, George Barker (1891– 1957) G. B. Jeffrey
 Kant, Immanuel (1724–1804)
 Kline, Morris (1908–1992)
 Kronecker, Leopold (1823–1891)
 Lorenz, Hendrik Antoon (1853–1928) H. A. Lorenz
 Mascardi, Giacomo (1567–1722)
 Minkowski, Hermann (1864–1909)
 Newson, Mary Winston (1869–1959)
 Palmer, George Herbert (1842–1933)
 Perrett, W.
 Poincaré, Jules Henri (1854–1912) Henri Poincaré
 Reid, Constance (1918–2010)
 Reidemeister, Kurt Werner Friedrich (1893–1971) Kurt Reidemeister
 Rowe, David E. (1950–)
 Sartorius von Waltershausen, Wolfgang (1809–1876)
 Smith, James Thomas (1939–) James T. Smith
 Sommerfeld, Arnold (1868–1951)
 Steinhaus, Władysław Hugo Dionizy (1887–1972) Hugo Steinhaus
 Tolstoy, Leo Nikolayevich (1828–1910)
 Van Heijenoort, Jean Louis Maxime (1912–1986) Jean van Heijenoort
 Vinnikov, Victor
 Wang Hao (1921–1995)