Calculating the Limits of Poetic License: Fictional Narrative and the History of Mathematics

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1. Introduction:

> The poet's function is to describe, not the thing that has happened, but a kind of thing that might happen, i.e. what is possible as being probable or necessary. The distinction between historian and poet is not in the one writing prose and the other verse–you might put the work of Herodotus into verse, and it would still be a species of history; it consists really in this, that the one describes ***the thing that has been***, and the other a kind of ***thing that might be***. Hence poetry is something more philosophic and of graver import than history, since its statements are of the nature rather of universals, whereas those of history are singulars. By a universal statement I mean one as to what such or such a kind of man will probably or necessarily say or do--which is the aim of poetry, though it affixes proper names to the characters; by a singular statement, one as to what, say, Alcibiades did or had done to him.

These are the famous, opening lines of the ninth book of Aristotle's *Poetics*. When Aristotle wrote these, he was thinking about different, and indeed much broader, questions than those I will discuss here, questions relating to texts of narrative fiction about mathematical themes—or, for short, "mathematics in fiction."[1] Nevertheless, and perhaps unsurprisingly, Aristotle's insights are also helpful in elucidating this narrower issue, as we will now see. In particular, I have emphasized two sentences of this passage that will provide a main thread of my argument: the *thing that has been*, and the *thing that might be*.

In this article, I seek to clarify the role played by poetic license in the triangular relationship involving mathematics, the history of mathematics, and mathematics in fiction. This triangular relationship can be analyzed, in the first place, from the perspective afforded by the Aristotelian

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[1] I have borrowed this term from Carl Djerassi's "Science in Fiction"; see http://www.djerassi.com/.

distinction quoted above. It can also be analyzed from the point of view of the kind of language typically used in texts produced in each of these realms, or, alternatively, from the point of view of the nature of their expected audiences. It will be seen, however, that the most illuminating perspective for this analysis is the one related to the kind of attitude that is expected from the reader in each case, whether critical or based on a suspension of disbelief. To the considerations that pertain to this latter perspective when it comes to texts of any kind, the peculiarities of mathematical texts add some unique twists.

My analysis starts with an inspection of various approaches to the relationship between mathematics and its history, and to how the latter should be written. I then move on to analyze the idea of suspension of disbelief as a narrative strategy, and consider its relationship to historical writing in general. This is done by looking at texts with only a diagonal relation to mathematics, if there is one at all, especially the short stories of Jorge Luis Borges. Against this background, I examine some specific examples of mathematics in fiction and consider how the triangular relationship is manifest there. The two main foci of my discussion are Apostolos Doxiadis's short novel, *Uncle Petros and the Goldbach Conjecture*, and Ira Hauptman's play, *Partition*. Finally, I go the opposite way and analyze how narrative strategies are often imported from fiction to historiography (especially, but not only, in books of scientific popularization) and thus give raise to an over-dramatization of the history of mathematics (and of science in general). The example of Fermat's Last Theorem is the focus of this section. We end up by having two different ways to blur the borderline between fiction and fact, both differently motivated though in many respects having similar effects upon the reader.

It may be convenient to point out in this introductory section that the topic of this article can be viewed as part of a more general one—namely, that of the mutual interaction between science and literature. Recent studies have shown that this relationship has been a convoluted and variable one throughout history: neither the demarcation between the two domains has always been clear-cut, nor has its influence been evidently unidirectional.[2] Rather than historical, however, my own account in this case is essentially "structural." A specific aspect of the more general topic of literature and science that has attracted considerable attention pertains to the question of language, both at the level of the production of scientific and literary texts, and at the level of their reading within a specific social, cultural, and political context. Such studies are naturally related to constructivist approaches to the history of science.[3] I do not follow such an approach here or elsewhere, and in general it can be said that constructivist approaches have been much less followed in relation to mathematics than to other fields of science.[4] Nevertheless, as already suggested, the different uses of language in each of the three realms considered will be also discussed as part of my analysis.

2. Mathematics, History, and Narrative – Three Kinds of Texts:

An illuminating connection between mathematics and the Aristotelian passage quoted above was established in the work of Sabetai Unguru on the history of Greek mathematics. By referring to Aristotle's distinction between history and poetry, Unguru intended to stress a parallel distinction that in his view is fundamental, and should be strictly observed, when writing the history of mathematics. The

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2 For an overview of secondary literature on this topic, see Gillian Beer, "Science and Literature," in *Companion to the History of Modern Science*, ed. Robert C. Olby et al. (London: Routledge, 1990), pp. 783–797; and Pamela Gossin, "Literature and the Modern Physical Sciences," in *The Cambridge History of Science*, vol. 5: *The Modern Physical and Mathematical Sciences*, ed. Mary Jo Nye (Cambridge: Cambridge University Press, 1999), pp. 91–109. For a more elaborate historical account, see Miguel de Asúa, *Ciencia y Literatura. Un Relato Histórico* (Buenos Aires: Eudeba, 2004). A recent issue of *Science in Context* (18:4 [December 2005]) is devoted to historical analyses of the relationships between literature and science, from the eighteenth century onward.

3 For an overview of this topic, see, for instance, Jan Golinski, "Language, Discourse and Science," in *Companion* (above, n. 2), pp. 110–123. For a more recent discussion by the same author, see Golinski, *Making Natural Knowleldge: Constructivism and the History of Science*, 2nd ed. (Chicago: University of Chicago Press, 2005), esp. pp. 103–133.

4 See Leo Corry, "The History of Modern Mathematics—Writing and Re-Writing," *Science in Context* 17 (2004): 1–21.

"thing that has been," which is the *singular*, the idiosyncratic, is the object of historical research, and the historian should strive to understand and convey it in his or her research. The "thing that might be,"while of "more philosophical and of graver import" (and thus arguably more interesting), is none of the historian's professional business. But what Aristotle put forward here as a *general* distinction has a peculiar turn when it comes to mathematics, since it, like Aristotelian poetry, deals with *universal statements*—statements "as to what such or such a kind of [entity] will probably or necessarily" behave like.[5]

If Aristotle found it necessary to clarify the difference between the historical and the poetic approach to describing events of the past, he obviously felt that the borderline between the two could be somewhat elusive. The affinity between mathematics and poetry in the sense described above makes this borderline even more elusive, as Unguru has shown in his own analysis. Indeed, in analyzing mathematics of the past, mathematicians often look for underlying mathematical concepts, regularities, or affinities in order to conclude about historical connection. Mathematical affinity necessarily follows from universal properties of the entities involved, and this has often been taken to suggest a certain historical scenario that "*might be*." But, Unguru warns us, one should be very careful not to allow such mathematical arguments to lead us into mistaking historical truth (i.e., the "thing that *has* been") with what is no more than mathematically possible scenarios (i.e., the "thing that *might* be"). The former can only be found by direct historical evidence.

Incidentally, the classical example of this debate concerns one of Aristotle's historical assertions: namely, that the Pythagoreans discovered the incommensurability of the diagonal and the side of the square. Aristotle says in the relevant passage that they proved this by a *reductio ad absurdum* argument,

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5 See, for instance, Sabetai Unguru, "History of Ancient Mathematics: Some Reflections on the State of the Art," *Isis* 70 (1979): 555–565.

since “odd numbers come out equal to evens” (*Prior Analytics*, 1:23). If we now look at the standard modern proof of the irrationality of √2, we realize that it nicely fits Aristotle's description, since it is indeed based on showing that a number that is assumed odd must necessarily be even. This underlying mathematical affinity is added to Aristotle's account—in the “poetic approach” to the history of mathematics—in order to infer the validity of a purely *historical* claim. It is thus inferred that the Pythagoreans proved the incommensurability of the diagonal of a square with its side exactly as we nowadays prove that √2 is an irrational number.[6] Unguru’s point of view, on the contrary, implies that this conclusion is invalid, and that, moreover, it embodies a historiographical point of view that is utterly wrong.[7]

Along the guidelines provided by the Aristotelian distinction, Unguru, in 1975, called attention to “the need to rewrite the history of Greek mathematics.”[8] His work immediately attracted furious reactions, above all from three prominent mathematicians interested in the history of mathematics: André Weil, Bartel van der Waerden, and Hans Freudenthal.[9] A main argument implicitly underlying their rejoinders concerned the question of authority on matters pertaining to mathematical knowledge. This authority seemed to be transgressed here by an outsider who dared to refute a claim that had never

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[6] As classically presented, for instance, in Carl B. Boyer, *A History of Mathematics* (New York: Wiley, 1968), p. 80.

[7] For an alternative proof that differs from the modern one, see, for example, Victor J. Katz, *A History of Mathematics: An Introduction*, 2nd ed. (Reading, Mass.: Addison-Wesley, 1998), p. 50.

[8] Sabetai Unguru, “On the Need to Rewrite the History of Greek Mathematics,” *Archive for History of Exact Sciences* 15 (1975): 67–114. A related, seldom-cited publication is: S. Unguru and D. Rowe, “Does the Quadratic Equation Have Greek Roots?” *Libertas Matematica (ARA)* 1 (1981): 1–49; and *Libertas Matematica (ARA)* 2 (1982): 1–62. A more recent and comprehensive presentation of this historiographical approach appears in: Michael N. Fried, Sabetai Unguru, *Apollonius of Perga's Conica: Text, Context, Subtext* (Leiden, Brill, 2001).

[9] See Bartel L. van der Waerden, “Defense of a ‘Shocking’ Point of View,” *Archive for History of Exact Sciences* 15 (1976): 199–210; Hans Freudenthal, “What Is Algebra and What Has It Been in History?” *Archive for History of Exact Sciences* 16 (1977): 189–200; André Weil, “Who Betrayed Euclid?” *Archive for History of Exact Sciences* 19 (1978): 91–93.

before been questioned by someone with what they considered to be the required level of disciplinary authority. History or not, this was mathematics at bottom and it was for mathematicians to decide—such, it would seem, was the position implied by Unguru's critics. Weil even had a very convenient opportunity to institutionally emphasis this authority, as he delivered a plenary lecture at the International Congress of Mathematicians (ICM) held in Helsinki in 1978 titled “History of Mathematics: Why and How?”[10]

It is revealing that throughout his lecture, Weil consistently used the term “mathematical history,” rather than “history of mathematics.” Clearly, his main point was not to discuss the “why” or “how,” as his title had it, but rather the “who.” He asked: “How much mathematical knowledge should one possess in order to deal with mathematical history?” And in his answer, as expected, authority plays an important role: “There is no doubt at all that a scientist can possess or acquire all the qualities needed to do excellent work in the history of his science; the greater his talent as a scientist, the better his historical work is likely to be.”

As a founding member of the Bourbaki group, Weil promoted not only many of the basic views of Bourbakian mathematics, but also of Bourbakian historiography. The latter is a most salient example of what Ivor Grattan-Guinness described as “the royal road to me”—kind of historiography.[11] Good history of mathematics is written, according to this view, based mainly on purely mathematical

[10] André Weil, “History of Mathematics: Why and How,” in *Proceedings of the ICM, Helsinki 1978* (Helsinki: Academia Scientiarum Fennica, 1980), pp. 236–244. (Also in Weil, *Collected Papers*, vol. 3 [New York: Springer-Verlag, 1979], pp. 434–442.)

[11] Ivor Grattan-Guinness, “Does the History of Science Treat of the History of Science? The Case of Mathematics,” *History of Science* 28 (1990): 149–173. See especially page 157: “[T]hey confound the question, 'How did we get here?' with the different question, 'What happened in the past?'” On Bourbaki, Bourbakian mathematics, and Bourbakian historiography, see Leo Corry, *Modern Algebra and the Rise of Mathematical Structures*, 2nd rev. ed. (Boston: Birkhäuser, 2004), pp. 329–338.

considerations and should thus be written only by mathematicians, preferably by prominent, retired ones.

From the perspective of more than twenty-five years later, the kind of historiography promoted by Unguru has become mainstream and needs no further justification. This is particularly the case concerning his views about algebra and geometry in Greek mathematics.[12] But, harking back to the opening quotation, what is of real concern for us in the present context is the parallel drawn by Unguru between Aristotle's distinction and the relationship between mathematics and its history. This parallel can be summarized as follows:

	Mathematics	History of Mathematics
In Aristotle's distinction, parallel to ...	Poetry	History
Deals with ...	Universals	Particulars
Attempts to describe ...	... what is possible as being probable or necessary	... the thing that has happened

Diagram 1: Mathematics vs. History of Mathematics
in terms of Aristotle's distinction

Like poetry, mathematics deals with universals; also like poetry, it attempts to uncover the behavior of such or such kind of universal entity by virtue of being what it is. Both poetry and mathematics attempt to spell out what such universal entities embody or—sticking to Aristotle's own wording for the sake of symmetry—to say about them what is "possible as being probable or necessary."[13] History, on the

[12] For an overview of present views on the topic, see a recent collection of articles in *Science in Context* (16:3 [September 2003]), and particularly the guest editor's (Reviel Netz's) introduction, "The History of Early Mathematics—Ways of Re-writing" (pp. 275–286).

[13] Needless to say, the issue of necessary versus probable knowledge in mathematics is a truly complex one, and mentioning it here in passing opens the way to various kinds of justified criticism. Using Aristotle's wording

contrary, has the much less glamorous task of indicating what actually happened—not what might have happened.[14] Only the dreary, particular details of what actually happened are of interest in history, and, as Unguru suggests, whereas universal ideas may suggest possible directions of search, they cannot be a substitute for historical evidence of some kind.

In my current analysis, I would like to go beyond the relationship between these two areas—mathematics and its history—and add yet another vertex to it, namely, that of fictional narrative on mathematics. Taking Aristotle's distinction as a staring point, it seems natural to ask, first, to what extent is it of any help in elucidating the triangular relationship that interests us here. On a first approach, we may simply consider the fact that any fictional narrative falls squarely within the scope of poetry as defined by Aristotle, so that the distinction directly helps in analyzing its relationship to the other two categories. Indeed, from the point of view of the question of universals versus particulars, mathematics in fiction aligns with mathematics—in opposition to the history of mathematics—as indicated in the following table:

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here, however, is intended simply as a helpful "abuse of language," and not as an encompassing statement about this question. For a more detailed, historically oriented discussion of this point, see Leo Corry, "The Origins of Eternal Truth in Modern Mathematics: Hilbert to Bourbaki and Beyond," *Science in Context* 12 (1998): 137–183. Also, the role of probability and necessity in literary texts, and particularly Aristotle's treatment of this question in the *Poetics*, is not at all a straightforward issue. See, for instance, Dorothea Frede, "Necessity, Chance and 'What Happens for the Most Part' in Aristotle's *Poetics*," in *Essays on Aristotle's Poetics*, ed. Amélie O. Rorty (Princeton, N.J.: Princeton University Press, 1992), pp. 197–220; Neil O'Sullivan, "Aristotle on Dramatic Probability," *Classical Journal* 91 (1995–96): 47–63. As Frede makes clear, Aristotle imported this idea of necessity into his discussion of tragedy from his theory of the natural sciences—thus it clearly differs from mathematical necessity. See also G. E. M. de Ste. Croix, "Aristotle on History and Poetry," in *Essays on Aristotle's Poetics*, pp. 25–32.

14 Again, this is just a schematic claim. I do not intend to overlook the role of interpretation in historical writing.

	Mathematics, Mathematics in Fiction	History of Mathematics
In Aristotle's distinction, parallel to ...	Poetry	History
Deals with ...	Universals	Particulars
Describes ...	... what is possible as being probable or necessary	... the thing that has happened

Diagram 2: Mathematics and Mathematics in Fiction
vs. History of Mathematics in terms of Aristotle's distinction

Like all narrative fiction, mathematics in fiction may include real characters and real historical situations as part of the plot, but ideally these appear as archetypes that represent a universal person or situation. Authors of narrative fiction, and in particular mathematics in fiction, may try to remain as close as possible to what they consider to be the historical truth, but it is not inherent in the genre that this should be the case. More importantly, no reason can compel the reader to read the text other than as pure fiction—a point I will stress again below.

At the same time, however, the Aristotelian distinction confronts us with a seemingly odd situation; indeed, it would seem intuitively more natural to associate the two narrative activities (history and fiction) with each other, rather than contraposing them as in diagram 2. This seems all the more odd if we take into consideration that in making his distinction, Aristotle was implicitly taking for granted a classical conception that viewed history as a literary genre—indeed, as a rather inferior one at that. This conception of history as narrative remained strongly ingrained for many centuries, and was apparent even in nineteenth-century historiography. Positivist historians such as Leopold von Ranke (1795–1886), who led the efforts directed at turning history into a discipline based on scientific principles of objectivity and empirical evidence (*Wissenschaft*), continued to stress the fundamentally story-like character of their endeavors.[15] The Aristotelian distinction itself, on the other hand, though it continues to be fundamental to the general question of the relationship between literature and history, needs to be reconsidered from the perspective of more recent developments in literary theory.[16]

One additional possible perspective from which to regard the triangular relationship that we are considering here concerns the kind of language typically used in representative texts of each of the three disciplines. Viewed from this perspective, mathematics in fiction and the history of mathematics do indeed align—as opposed to mathematics—as indicated in the following diagram:

	Mathematics	History of Mathematics, Mathematics in Fiction
Language typically used	Formal, Formalized	Discursive, Natural

Diagram 3: Mathematics vs. Mathematics in Fiction
and History of Mathematics in terms of their use of language

It goes without saying that in their usual appearance, mathematical texts are never fully formalized. They may contain formulas and even entire arguments rendered in purely symbolic terms. But except for

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15 A comprehensive and enlightening discussion of these topics appears in Raya Cohen and Joseph Mali, eds., *Literature and History* (Jerusalem: Zalman Shazar Center for Jewish History, 1999). Unfortunately for most readers of the present article, this handsome collection has been published only in Hebrew. On page 13, the editors provide useful references to classical works on the literary conception of history throughout time, including: G. Collingwood, *The Idea of History* (Oxford: *Oxford* University Press, 1946), pp. 1–45; M. I. Finley, "Myth, Memory and History," in *The Use and Abuse of History* (London: The Hogarth Press, 1986), pp. 11–33; and A. Momigliano, *Studies in Historiography* (London: Weidenfeld and Nicolson, 1966).

16 Thus, for instance, for an analysis of the differences between Aristotle's theory of tragedy and modern narratological approaches to literature, see Elizabeth Belfiore, "Narratological Plots and Aristotle's Mythos," *Arethusa* 33 (2000): 37–70.

very extreme cases,[17] significant parts of any mathematical argument are always put forward in, or mixed with, natural language. On the other hand, these texts are never truly discursive, and they will always contain, at the core, a formal, semi-formal, or, at least, a formalizable argument. Texts on the history of mathematics and mathematics in fiction may typically contain formal, semi-formal, or formalizable parts themselves, but once again, they will always contain a discursive core. In a spectrum ranging from the purely formal to the purely discursive, mathematical texts will be closer to the formal pole, whereas historical and fictional texts about mathematics will be closer to the discursive one.

Yet a third perspective from which to analyze the triangular relationship is by looking at, in each case, the audiences to which these various kinds of texts are addressed. Here, the history of mathematics can simultaneously align with both mathematics and mathematics in fiction, as summarized in the following diagram:

	Mathematics, History of Mathematics,	History of Mathematics, Mathematics in Fiction
Expected audience	Specialized	General

Diagram 4: Mathematics and History of Mathematics vs. Mathematics in Fiction and History of Mathematics in terms of their expected audiences

Mathematical discourse typically targets a more specialized readership, whereas mathematics in fiction typically targets a less specialized one. In the history of mathematics, both situations co-exist.

The above three perspectives provide useful hints concerning the triangular relationship investigated here. However, by and large, the most significant and illuminating perspective from which

[17] The paradigmatic example that will always come to mind in this case is *Principia Mathematica* (1910–13), by Bertrand Russell and Alfred N. Whitehead.

this relationship is understood is, in my view, provided by looking at the different basic attitudes required by the reader when faced with texts of each kind. The schematic diagram that summarizes this dimension is as follows:

	Mathematics, History of Mathematics,	Mathematics in Fiction
Expected reader's attitude	Critical	Suspension of Disbelief

Diagram 5: Mathematics and History of Mathematics vs.
Mathematics in Fiction in terms of the reader's expected attitude

This point requires further elaboration, which is considered in some detail in the next section.

3. Suspension of Disbelief:

"Suspension of disbelief" is the fundamental attitude on which the very possibility of the poetic (and narrative) act is based. Without the basic willingness on the part of the reader to accept a priori the rules of the game and the limitations set by the author, no act of poetic interchange can ever take place. The reader must be willing to follow any kind of logic adopted by the author, to give up demands for strict and coherent realism, and to follow the author to wherever he takes the plot and characters. This holds equally true, of course, of poetry, fictional narrative, theater, and television series. However, this generous attitude on the side of the audience is only conditionally granted to the author as a starting point, and should by no means be taken for granted; it is the author's duty to continue developing the plot in such a way as to maintain readers' willingness to suspend disbelief.

The term suspension of disbelief and the idea that it provides the basis for poetic faith was explicitly formulated by the English Romantic poet Samuel Taylor Coleridge in 1817, who stated:

> In this idea originated the plan of the “Lyrical Ballads”; in which it was agreed, that my endeavours should be directed to persons and characters supernatural, or at least romantic, yet so as to transfer from our inward nature a human interest and a semblance of truth sufficient to procure for these shadows of imagination that willing suspension of disbelief for the moment, which constitutes poetic faith.[18]

Incidentally, science played a most significant role in shaping the intellectual horizon of Coleridge, and this poet embodies an interesting example of the interaction between Romanticism and early nineteenth-century science.[19] Most remarkably, in a poem of 1791 titled “A Mathematical Problem,” Coleridge addressed a question that is directly relevant to the relationship between “mathematics and narrative”—or, in this case, “mathematics and poetry.” The introduction to the poem is in a letter to his brother (the reverend George Coleridge), from which, verbatim, I quote here:

> I have often been surprized, that Mathematics, the quintessence of Truth, should have found admirers so few and so languid.--Frequent consideration and minute scrutiny have at length unravelled the cause--viz.--that though Reason is feasted, Imagination is starved; whilst Reason is luxuriating in it's proper Paradise, Imagination is wearily travelling on a dreary desart. To assist Reason by the stimulus of Imagination is the design of the following production. In the execution of it much may be objectionable. The verse (particularly in the introduction of the Ode) may be accused of unwarrantable liberties; but they are liberties equally homogeneal with the exactness of Mathematical disquisition, and the boldness of Pindaric daring. I have three strong champions to defend me against the attacks of Criticism: the Novelty, the Difficulty, and the Utility of the Work. I may justly plume myself, that I first have drawn the Nymph Mathesis from the visionary caves of Abstracted Idea, and caused her to unite with Harmony. The first-born of this Union I now present to you: with interested motives indeed--as I expect to receive in return the more valuable offspring of your Muse.[20]

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[18] Samuel Taylor Coleridge, *Biographia Literaria* (1817), chap. 14.

[19] See Trevor H. Levere, *Poetry Realized in Nature: Samuel Taylor Coleridge and Early Nineteenth-Century Science*, 2nd ed. (Cambridge: Cambridge University Press, 2002).

[20] See D. A. Stauffer, ed., *Selected Poetry and Prose of Coleridge* (New York: Modern Library, 1951).

Coleridge thought that with the help of the muses and with the assistance of imagination, mathematics could be rescued from isolation and languidness. It is not necessary to strictly agree with him in order to realize that the triangular relationship we are analyzing here is illuminated with the help of his concept. Indeed, let us look again at diagram 5, which is the only one where mathematics in fiction appears in contraposition to the other two. There is a fundamental difference in the way we approach a scientific or historical text on the one hand, and a fictional or poetic text on the other. The basic contract between the author and reader in the former case is: “Don't believe a word of what I say. Check by yourself and be as skeptical as you can. That is the test that I must undergo.” In a scientific text, a technical or factual mistake is simply unacceptable. Factual mistakes are also unacceptable in historical texts, and, at the same time, any interpretation followed by a historian is at least amenable to criticism.

When reading a fictional text or poem, such attitudes are beyond the point. Here, the basic contract is very different, which says: “Give me the benefit of temporary suspension of disbelief. I will take you safely throughout the text and you are going to enjoy it.” Deviations from the historical record or from scientific facts cannot only be acceptable in a piece of fictional narrative, sometimes, indeed, they are the driving force. Such deviations may have different effects in fiction if they are caused by obvious mistakes or are purposefully done by the author. In any case, deviations are acceptable in a way that they are not in scientific and historical texts.[21] I will return to this point below.

It can be argued, of course, that one can read a scientific text for the sake of aesthetic pleasure, and that, moreover, it is likely that on first reading a mathematical text, we shall be willing to suspend disbelief and bear with the author's arguments through the end to see where they are leading and how

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[21] For illuminating discussions of this point, see Umberto Eco, *Six Walks in the Fictional Woods* (Cambridge, Mass.: Harvard University Press, 1994), esp. pp. 75–96.

this is done. Although this is undeniable, it is only an option. Critical reading is mandatory: we have not properly read a scientific or historical text unless it be done with a critical eye.

The opposite is the case with a fictional text. We can read it critically (though we will hardly do this upon a first reading); we may bring to our reading the tools of the literary critic or the semiotic researcher or the historian, but again, these are options. The literary or poetic experience associated with the reading of a fictional text is the one associated with suspension of disbelief.

With this perspective in mind, I would like to analyze one important example that sheds additional light on the points discussed so far. My example is in the fictional prose of Jorge Luis Borges. Borges was very fond of quoting Coleridge, and his literary output is based on a masterful implementation of the principle of suspension of disbelief. Borges's short stories take the idea behind the principle to unprecedented extremes; their success is based on the willingness of readers to bear with him in spite of the overtly counterfactual, paradoxical, unrealistic, and even illogical texts. Basic to most of his stories is some form of embedding fiction in reality: the characters and plots are so far from daily reality that the reader does not even start doubting them or their deeds. Suspension of disbelief is inherently forced upon the reader from the first line of any of his stories; as they develop, Borges adds sophisticate storytelling mechanisms that prevent readers from abandoning their initial attitude.

A useful example to consider is Borges's famous short story, "Tlön, Uqbar, Orbis Tertius." It tells about a mysterious country called Uqbar and about Tlön, an imagined world whose description is the main subject of the texts of Uqbar's writers. Tlön represents an embodiment of Berkeley's idealistic philosophy, and the story develops and examines the functioning of such a world, thus providing an "epistemological metaphor" (to use a term coined by Umberto Eco in this context) of that philosophy. The narrator first becomes aware of the existence of Tlön through an encyclopedia, as described in the opening passage of the story:

> I owe the discovery of Uqbar to the conjunction of a mirror and an encyclopedia. The mirror troubled the far end of a hallway in a large country house on Calle Gaona, in Ramos Mejía; the encyclopedia is misleadingly titled *The Anglo-American Cyclopedia* (New York, 1917), and is a literal (though also laggardly) reprint of the 1902 *Encyclopedia Britannica*. ... [My friend] Bioy Casares remembered a saying by one of the heresiarchs of Uqbar: Mirrors and copulation are abominable, for they multiply the number of men. I asked him where he'd come across that memorable epigram, and he told me it was recorded in *The Anglo-American Cyclopaedia*, in its article on Uqbar.

Inventing books and then creating a story around them is a typical Borges trick intended to support the initial willingness of the reader to suspend disbelief. If it is written in a book, why should one disbelieve what the story says? On the other hand, seasoned Borges readers and critics will typically be quick to assume that books mentioned in the stories are very likely invented. And so, it was typical for commentators to assume that the *Anglo-American Cyclopaedia* is another of Borges's inventions. A recent, very diligent search by Alan White has shown that this is not the case.[22]

In fact, White discovered the existence of a real *Anglo-American Enyclopedia*, whose 1917 edition is is an exact reprint of the ninth edition of the *Britannica*. The details about the specific volumes mentioned by Borges in the story deserve closer inspection. Indeed, in the story, Borges looks, in vain, for the entry "Uqbar" in a copy of the *Anglo-American Cyclopaedia* that happens to exist in the house where the opening conversation takes place: "On the last pages of Volume XLVI—he says—we found an article on Uppsala; on the first pages of Volume XLVII, one on Ural-Altaic Languages, but not a word about Uqbar." Some days later, Borges has the opportunity to see Bioy's copy of the *Cyclopaedia*, where he had originally read the article on Uqbar, and this copy turns out to be somewhat different from Borges's own.

[22] Alan White, "An Appalling or Banal Reality," *Variaciones Borges* 15 (2003): 1503.

> The tome Bioy brought was, in fact, Volume XLVI of the Anglo-American Cyclopaedia. On the half-title page and the spine, the alphabetical marking (Tor-Ups) was that of our copy, but, instead of 917, it contained 921 pages. These four additional pages made up the article on Uqbar, which (as the reader will have noticed) was not indicated by the alphabetical marking. We later determined that there was no other difference between the volumes.

Now, if we look, as Alan White did, at the real *Anglo-American Encyclopedia*, we find the following very remarkable facts: the last entry of Volume XLVI is indeed Uppsala, which ends up on page 917, whereas the first entry of Volume XLVII is indeed "Ural-Altaic Languages"! So, Borges is inserting his unreal country into the very close gaps reality provides him with. The basic contract between him as author and any prospective reader of the story is that the latter will suspend disbelief while reading; Borges, however, anticipates the case that his reader may deviate from this basic contract and will start to read critically—that is, will try and find out whether the story is "true" or not. In this case, the reader will have a tough time, since, to begin with, he cannot be sure whether the *Anglo-American Cyclopaedia* really exists, and, if he happens to find a copy of it, once he arrives on page 917 of Volume XLVI, he will have to decide if the article on Uqbar could not actually come there, right after Uppsala.

Understanding the details of Borges's storytelling mechanism, then, helps getting a clearer conception of the implications of the idea of suspending disbelief, especially in contrast with the idea of a critical reading of a text. It is thus remarkable that, very often, commentators of Borges's work have failed to make this separation, and have continued to suspend disbelief where they were supposed to be reading critically. In this way, Borges has been credited, for instance, with a deep understanding of physical and mathematical theories, and, occasionally, even with the ability to anticipate such theories in his stories—thus, for instance, in the following assertion: "Borges discovered the essence of bifurcation theory thirty years before scientists formalized it in mathematical terms."[23]

Good reader that he was, Borges never confused these two opposed basic attitudes toward a text: the critical one, and the benevolent one (where disbelief is suspended). One place where this dichotomy is nicely reflected appears in one of his more recondite texts. To the collection *Discusión* three short book reviews were added, among which one finds, perhaps surprisingly, a book that is well-known to mathematicians though much less so to general readers: *Mathematics and the Imagination*, by Edward Kasner and James Newman. This is what Borges says about the book: "Its four hundred pages record with clarity the immediate and accessible enchants of mathematics, those that even a mere man of letters can understand, or *make believe* that he has understood." "Make believe" ("*imaginar*" is the word in Spanish) that one understands: that is what science in fiction is, above all, for Borges. And the reader may willfully play his part in the game and suspend disbelief, provided that the quality of the fiction is good enough to warrant the effort.

Keeping these concepts in mind will help us clarify some basic questions about poetic license in fictional narratives that deal with mathematical topics. In the next section, I shall analyze some specific examples.

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[23] This quotation is taken from Thomas P. Weissert, "Representation and Bifurcation: Borges's Garden of Chaos Dynamics," in *Chaos Bound: Orderly Disorder in Contemporary Literature and Science,* ed. N. Katherine Hayles (Ithaca, N.Y.: Cornell University Press, 1990). Similar points of view appear in: Hayles, *The Cosmic Web: Scientific Field Models and Literary Strategies in the Twentieth Century* (Ithaca, N.Y.: Cornell University Press, 1984); Floyd Merrell, *Unthinking Thinking: Jorge Luis Borges, Mathematics, and the New Physics* (West Lafayette, Ind.: Purdue University Press, 1990). For a thorough criticism of this approach in reading Borges's texts, see Leo Corry, "Algunas Ideas Científicas en la Obra de Jorge Luis Borges y su Contexto Histórico," in *Borges en Jerusalén,* ed. Myrna Solotorevsky and Ruth Fine (Frankfurt am Main: Vervuert/Iberoamericana, 2003), pp. 49–74.

4. Some Specific Examples:

What are the acceptable limits of poetic license when it comes to mathematics in fiction? Are there, or should there be, any limits at all? I would like to address these questions by considering, in some detail, two successful pieces of mathematics in fiction: Apostolos Doxiadis's *Uncle Petros and the Goldbach Conjecture* and Ira Hauptman's *Partition*.

Uncle Petros is the story of an imaginary Greek mathematician, Petros Papachristos, as told by an admiring if baffled nephew, who is also the unnamed narrator of the book. Throughout his life, Petros has been obsessed by proving a number-theoretical conjecture first formulated in 1742 by Christian Goldbach, which asserts that every even number larger than “2” is the sum of two prime numbers. After completing his own training as a mathematician, the nephew becomes obsessed with finding out the true story of his uncle, whom other members of the family generally consider a failure.

The plot of the story is set within a genuine historical framework, which bestows upon its fictional parts an immediate credibility. For one thing, the Goldbach conjecture is indeed an open mathematical problem, which has not been settled to this day; for another, the life of the fictional Uncle Petros is reliably embedded—at both the personal and professional levels—in the Cambridge University of Godfrey Hardy (1877–1947), John Littlewood (1885–1977), and Srinivasa Ramanujan (1877–1920), which is where Petros studied during 1917–19. There is, for example, a description of the analytic versus the algebraic tradition in number theory and their respective statuses at the beginning of the twentieth century in order to provide the framework for Petros's own work. Results connected with the important partition theorem, with which those mathematicians were deeply involved, are mentioned in connection with Ramanujan. Ramanujan’s death in 1920 comes at the right time for Petros, from the standpoint of his endeavor to prove a result that he was afraid Ramanujan would accomplish before him.

In brief, there is a correct historical and mathematical setting of the fictional Petros within reality, and the narrative tension of the plot is comfortably built upon this premise. The book's readers have every reason to suspend disbelief and let the author led them through the story.

The plot, however, deviates from the historical record on several points. Most of these are clearly unintended, and they are of the kind that most readers will not even be aware of. Some deviations play an important role within the plot; for example, in a conversation between the narrator and his Uncle Petros, reference is made to a famous lecture given by David Hilbert on the occasion of the 1900 Paris International Congress of Mathematicians. This dialogue is meant to provide a glimpse into the way that absolute certainty was expected to pervade mathematics at the turn of the twentieth century—also the attitude guiding Petros in his own mathematical activities. Hilbert is presented as the champion of this view, as embodied in two famous sayings quoted by the narrator: "*Wir müssen wiessen, wir werden wiessen*" (We must know, we shall know), and "There is no *ignorabimus* in mathematics." The narrator states: "Thus spake the great David Hilbert in the International Congress of 1900. A proclamation of mathematics as the Heaven of Absolute Truth. The vision of Euclid, the vision of Consistency and Completeness."

There are, however, some problems in this description of what Hilbert said on that occasion, and the most immediate one concerns his "*Wir müssen wissen, wir werden wissen*." These words (which were later engraved on Hilbert's tombstone) were not part of his Paris address, but rather given in a talk in 1930 at a gathering in Königsberg to honor Hilbert on the occasion of his being awarded honorary citizenship in his native town. Interestingly, in terms of poetic license, it is Uncle Petros himself who stresses the correct procedure for use of Hilbert's quote within the context of a fictional story. "It is not the background," he says to his nephew as he tries to explain how the import of Hilbert's putative assertion in the speech should be understood, "it's the psychology. You have to understand the emotional climate in which mathematician worked in those happy days, before Kurt Gödel." Being a fictional character himself, Petros is fully aware that what counts in this case is not to describe the things that have been, but rather what a man of Hilbert's "kind would probably or necessarily say" in such circumstances. It is the metaphorical Hilbert, not the historical one, who makes the 1900 speech in the book, and this metaphorical Hilbert could by all means have added these words uttered only thirty years later.

And yet, it is evident that a fiction author like Doxiadis makes considerable efforts to keep his story within well-defined boundaries of historical accuracy, and to allow himself poetic license only where truly necessary. The dramatic effect of his plot is achieved by a proper balance between the two aspects, fiction and historical reality. A close look at those places in the plot where fiction overrides fact may be instructive regarding the triangular relationship of mathematics, history, and fictional narrative under review here. Thus, for instance, the narrator tells us that Petros completed his dissertation in Berlin in 1916 and that his advisor was Constantin Carathéodory—a genuine historical character and the foremost Greek mathematician of his generation, if not well beyond it. Hence the already-established credibility of the story is further supported by the fact that a prominent Greek mathematician, who indeed was professor at the great Berlin school of mathematics, was the advisor of the fictional Petros; however, the true historical fact is that Carathéodory arrived in Berlin only in 1918! Here, we have an accepted historical fact (e.g., a date, place, name, or publication) incorrectly cited in the plot. As we previously saw in the example of Borges's story, mistakes like this one may be intentionally implemented for the purpose of strengthening the fictional effect; when unintended, though, may be the result of either simple oversight or the use of erroneous information. In the present example, the error is so marginal that it can hardly affect either readers' willingness to suspend disbelief or any other aspect of their engagement with the plot.[24]

The case of Hilbert's quotation in Doxiadis's book is much more interesting than the dates of Carathéodory's life in Berlin, and not just because Hilbert is attributed here, thirty years later, with words he supposedly said. The interesting point concerns the image of Hilbert presented by the narrator and endorsed by Uncle Petros: "A proclamation of mathematics as the Heaven of Absolute Truth. The vision of Euclid, the vision of Consistency and Completeness." In this case, we are talking about historical questions that are much subtler and elusive than the date of arrival of a mathematician in a certain city or the exact words he spoke. Historians of mathematics make their living by examining complex claims of this kind, and by trying to assess them critically against new evidence or by fresh readings of well-known texts. And indeed, recent historical research of mathematics during the turn of twentieth century, and in particular the role of Hilbert, has led to regarding the description embodied in the above quotation as essentially erroneous, even if it was widely accepted as correct in the not-too-distant past.[25]

For the same reason, historians nowadays may feel uncomfortable with the fact that Gödel's work had the immediate effect of profoundly changing Petros's current research program, which he had initially expected would lead to proving the conjecture. Nothing of the sort happen to any real

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[24] The mechanism of the reader's possible kinds of reactions to these kinds of mistakes is masterfully discussed in Eco, *Six Walks* (above, n. 21), pp. 101–109. His analysis focuses on the names of Parisian streets appearing in Dumas's description (written in the nineteenth century) of a nightly seventeenth-century walk of D'Artagnan.

[25] From my own recent work, I can mention the following relevant items: Leo Corry, "Axiomatics, Empiricism, and *Anschauung* in Hilbert's Conception of Geometry: Between Arithmetic and General Relativity," in *The Architecture of Modern Mathematics: Essays in History and Philosophy of Mathematics*, ed. Jeremy Gray and José Ferreirós (Oxford: Oxford University Press, 2006); Leo Corry, *Hilbert and the Axiomatization of Physics (1898–1918): From "Grundlagen der Geometrie" to "Grundlagen der Physik"* (Dordrecht: Kluwer, 2004); Leo Corry, "The Empiricist Roots of Hilber's Axiomatic Method," in *Proof Theory: History and Philosophical Significance*, ed. Vincent F. Hendricks et al. (Dordrecht: Kluwer, 2000), pp. 35–54.

mathematicians. For historical and mathematical reasons, the way and pace by which the theorem and its consequences were absorbed by mainstream mathematicians, and even by logicians, was a very complex and slow one. Should all of this bother us as readers of *Uncle Petros*? The answer will most likely vary from reader to reader. Whether intended or not, the author has used a kind of poetic license that in some cases will continue eliciting readers' willingness to suspend disbelief of the story, plot, and characters, and in other cases will not.

Moreover, there is another possible way that fiction overrides fact in Doxiadis's book, and, in my opinion, it is by far the most interesting and challenging one for both author and reader of mathematics in fiction. It relates to the "paratext" of the novel (to use Genette's term): namely, a short sentence added by Doxiadis to the book, extraneous to the plot, thanking two mathematicians, Ken Ribet and Keith Conrad, for carefully reading the revised manuscript and correcting "numerous mistakes." Obviously, this sentence is intended mainly to imply mathematical mistakes, it being more than natural to expect that no one, least of all the author, would tolerate mathematical mistakes in a book of fiction on mathematics, and in general such mistakes would be considered more damaging to the value of the text than unintended historical mistakes.[26] These latter are most unwelcome, of course, but they are never considered to be completely damaging to the book—certainly not as damaging as mathematical mistakes. Moreover, in the final analysis, historical inaccuracies might be considered part of the poetic license process the author consciously implemented. But—and this is the interesting point—whereas we may discern in mathematics in fiction (as in fiction in general) *intended* departures from the historical

[26] Thus, for instance, in his review of *Uncle Petros*, Keith Devlin (http://www.maa.org/reviews/petros.html) found it convenient to open by clarifying possible doubts about the author in this regard; namely by telling us about Doxiadis's bachelor's degree in mathematics from Columbia University and master's degree in applied mathematics from the École Pratique des Hautes Études in Paris.

record through the literary aims pursued by authors, it is much more difficult to imagine similar moves away from the "mathematical record."

Let us consider, for instance, an imaginary book titled *Aunt Maria and the ASM Conjecture*. The main character is the imagined Ecuadorian mathematician Maria Madre-de-Dios, who completed her doctorate degree at the Massachusetts Institute of Technology in 1980 under Gian Carlo Rota and became obsessed with solving the so-called Alternating Sign Matrix Conjecture.[27] Her niece, who narrates the story, happens to be a historian of modern mathematics and thus is well aware of the most current conceptions held by leading researchers in the field and the most recondite debates within the profession. She narrates a story involving Sylvester, MacMahon, Schur, Mills, Robbins, Rumsey, Zeilberger, and all the rest, while ensuring that no high-brow scholar will be able to point out this or that historical inaccuracy in her plot. Throughout the book, however, the ASM Conjecture is (wrongly) described as follows:[28]

let A_n be the number of alternating sign matrices of dimension n x n bordered by +1s; then

$$A_n = \prod_{j=0}^{n-1} \frac{(4j+1)!}{(n+j)!}$$

Moreover, let us assume that the story is so written that, based on this formulation of the conjecture, the author is able to enhance the basis for the credibility of the narrative fiction underlying the plot; for instance, that this is the key to unlocking the mystery of a series of murders in a world-class

[27] On the conjecture and its history, see David M. Bressoud, *Proofs and Confirmations: The Story of the Alternating Sign Matrix Conjecture* (Cambridge: Cambridge University Press, 1999).

[28] For the correct formulation, see http://mathworld.wolfram.com/AlternatingSignMatrixConjecture.html.

mathematics department.[29] I would like to think of this imagined story as a possible blueprint for the ultimate mathematics in fiction, which, to the best of my knowledge, is yet to be carried out. This is a kind of poetic license less frequently found, if found at all, and it offers a true challenge, because it would pose a subtle exercise in intellectual flexibility to prospective readers; it would certainly test recalcitrant mathematicians' ability to suspend disbelief under the adverse conditions implied by having to tolerate for long a mistakenly rendered formula.

Of course, anyone who knows some mathematics and/or history of mathematics automatically becomes (regarding reacting to mathematics in fiction) a suspect recalcitrant mathematician or high-brow scholar. Such readers of mathematics in fiction will certainly find it difficult to pass by in silence the deliberate distortion of the historical or mathematical record, even after having considered Aristotle's useful distinction. This distinction may assist our intellect in reacting with equanimity to poetic license taken by authors in such cases, but it will not always help our emotions to the same extent. We are still fully justified in fearing that ultimately the public perception of science is much more strongly shaped by mathematics in fiction (books and films) than by scholarly research on the history of mathematics. This is equally true for mathematics as it is for the movie *Amadeus* and classical music, for the movie *Downfall* and the public perception of Hitler and the end of World War II, for *The Da Vinci Code* and the history of religion and art, and for Mel Gibson's *The Passion of the Christ* in its own relevant fields. Numerous examples could be added here. There is, of course, a big difference in the symbolic and emotional burden associated with each of these topics and the amount of people to which they are directly relevant. In this sense, the esoteric and essentially neutral character of mathematics and its

[29] In fact, a novel *does* exist that tells the story of a series of murders in a world-class math department; see Guillermo Martinez, *The Oxford Murders*, trans. Sonia Soto (San Francisco: MacAdam/Cage, 2004). It would be illuminating to discuss it against the background of this article; unfortunately, lack of space does not permit me to do so here.

remove from worldly affairs renders, generally speaking, the entire debate about mathematics and narrative fiction in a much more relaxed and detached manner than with other topics.

I would like to consider now a second successful example of mathematics in fiction: the play *Partition,* written by Ira Hauptman and originally set onstage by Barbara Oliver. This play explores the complex relationship between Godfrey Hardy and Srinivasa Ramanujan at Cambridge University during the early twentieth century and their common devotion to number theory. While bound together by this common passion, one could hardly think of two individuals more different in terms of their cultural backgrounds, religious convictions, relationships to other human beings, and even in their respective approaches to mathematics. For Hardy, the concept of rigorous proof embodied the essence of mathematics, which he therefore tried, largely unsuccessfully, to impart to Ramanujan. There are other three characters in the play: Billington, a fictional Trinity College classics professor and friend of Hardy; the goddess Namagiri, who was the personal deity of the real-life Ramanujan in India; and the ghost-like presence of the seventeenth-century mathematician Pierre de Fermat.

In the play, Namagiri interacts with Ramanujan in various aspects of his everyday life and continually provides him with mathematical ideas and insights; in fact, with her finger she literally writes on his tongue some of Ramanujan's fascinating equations. Namagiri also consults Fermat on the possible way to solve Fermat’s Last Theorem (FLT), and at some point, he confesses he does not remember the original proof of his theorem, which had been written many years ago in the narrow margins of his copy of Diophantus's book. Based on a hint by Namagiri, Ramanujan suggests to Hardy a possible way to solve FLT, which is close to the way in which Andrew Wiles, in 1993, proved the Taniyama-Shimura Conjecture, from which the validity of FLT derives.

It is well-known to mathematicians now that Hardy and Ramanujan never worked on FLT. One may guess that, if while watching *Partition*, some mathematicians start shifting uncomfortably in their seats, in most cases it will be because of this deviation from the known historical record. Most mathematicians will find it easier to accept that a Hindu goddess speaks, in English, with a seventeenth-century mathematician about a recondite problem, and that she then conveys, again in English, this acquired knowledge to Ramanujan. Indeed, in a review of the play published in the *Notices of the AMS* by the Cal-Berkeley number-theorist Ken Ribet precisely this point is addressed, and in terms not very different from what has been suggested above. Ribet wrote:

> Professional mathematicians who saw the play were disturbed by the prominent roles given to Fermat and his Last Theorem, since the real Ramanujan and Hardy did no work on this particular problem. I personally was startled by the implicit anachronistic suggestion that Ramanujan was close to finding a proof of Fermat's Last Theorem that relied on Galois representations, modular forms, Euler systems, and Selmer groups.
>
> In order to enjoy the play, one must relax the implicit identification between the historical Hardy–Ramanujan and the characters on stage. Theater-goers who have little problem observing a goddess in discussion with a seventeenth-century mathematician on stage can make their peace with a historical distortion that allows the audience to hook up with a familiar and famous problem. Once I was able to separate the real Hardy and Ramanujan from their counterparts on stage, I found only good things to say about "Partition"."[30]

Although at first reticent to accept the mathematical anachronism implied in the plot, Ribet can nevertheless come to terms with it by implicitly adopting the Aristotelian distinction about the plot and characters featured in the play. But I wonder how this willingness to accept poetic license would work if the play contained an inaccuracy pertaining not to the *history* of the subject, but rather to some part in its core *body* of knowledge, such as the formulation of a result or the details of a certain proof.

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[30] See Kenneth A. Ribet, "Review of *Partition*," *Notices of the American Mathematical Society* 50 (2003): 1407–1408.

Unfortunately, this is not a question that can be easily answered, because of a lack of significant, relevant examples.

Hauptman's choice of FLT as the mathematical focus of her play seems rather natural and is hardly surprising. Indeed, given the enormous public attention that FLT attracted in the wake of Wiles's proof (and about which more is said in the next section), it became a favorite of writers of mathematics in fiction. One of the most ingenious examples of poetic license related to FLT that I can cite appears in a rather unlikely setting: the television series, *The Simpsons*. This is a mathematical joke appearing in a broader context, rather than a real work of mathematics in fiction; and yet, it touches upon the core point of what might be the real test for poetic license in mathematics in fiction. Although minor in scope, this example concerns the body of a well-known mathematical result and distorts it in a rather cavalier and unapologetic way. FLT establishes that for $n > 2$, the equation

$$x^n + y^n = z^n$$

has no nontrivial, integer solution. Two "counterexamples" to FLT appear in several episodes of the series. The first, $1782^{12} + 1841^{12} = 1922^{12}$, is correct up to nine decimal digits, whereas the second, $3987^{12} + 4365^{12} = 4472^{12}$, is correct up to ten. In other words, the mathematical fact has not only been distorted, but it has been distorted in a way that is not immediately detectable; indeed, because of rounding-off errors, these equations will appear as correct in most handheld calculators.[31]

31 See Dick Rogers, "Homer Math Catches Up with the News," *San Francisco Chronicle*, December 16, 2005. Also, the popular television series *Star Trek* included its share of FLT. As the series is set in the future, it turned out at some point that one of the chapters retrospectively contained an unintended mistake created by poetic license. Indeed, in an episode aired in 1989, Captain Picard stated that FLT had remained unsolved for 800 years. Wiles proof of 1994 therefore posed a problem. Hence, in an episode of 1995, the statement in the 1989 episode was subtly corrected when reference was made to "one the most original approaches to the proof [of FLT] since Wiles over 300 years ago." See http://www.twiztv.com/scripts/ds9/season3/ds9-325.txt. FLT also appears prominently in Martinez's *The Oxford Murders* (above, n. 29).

In the next section, I would like to consider the triangular relationship from a different perspective—namely, how the dramatic dimension enters the writing of historical accounts of mathematics, principally of the popular kind.

5. Dramatizing the History of Mathematics:

Dennis Guedj has used the nice metaphor of "the drama of axiomatics"[32] to describe the fact that in an axiomatized mathematical theory, the contents of a theorem are logically implicit in the axioms from the beginning, and that in the derivation of a theorem from the axioms, there is an inexorability of the kind that characterizes a drama. One may perhaps wonder about the details of the path from the axioms to the theorem (i.e., the details of the plot), but there is no escape from the one possible denouement of this story. This metaphor, however, turns highly problematic when its scope is extended beyond the *logical* aspect and its inexorability is attributed to the *history* of mathematics as well. I would like to illustrate this underlying problem by referring to a recent, well-known example: Simon Singh's *Fermat's Engima*.

Fermat's Engima is possibly the best selling and most widely known among a relatively large group of popular books on mathematics that has appeared during the past ten years. As such, I think it is fair to say that it has done a greater service to the recent public perception of mathematics than any other individual text. In order to write his book on FLT, Singh certainly needed to expend great efforts in order to gather and digest an enormous amount of relevant mathematical material, and to present it in a more or less popular version. By all means, this was a difficult and laudable task and in order to accomplish it, Singh relied on a far-reaching dramatic structure to support a narrative specifically designed to retain the attention of readers throughout. In doing so, however, the book contains a great

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[32] See http://www.thalesandfriends.org/meeting/abstracts.html#guedj.

amount of misconceptions about the history of mathematics, not only concerning specific details, but also of broader issues—the over-dramatization of the history of mathematics among the latter. For better or worse, over the last decade *Fermat's Enigma* has played a role similar to that, several decades ago, of Eric Temple Bell's *Men of Mathematics*.

This over-dramatized approach is evident even before commencing reading the book, as the publisher (at least in some editions) stated that this is “the epic quest to solve the world's greatest mathematical problem.” The cause is supported by no less a scientist than Sir Roger Penrose, who is quoted as stating that the book is “[a]n excellent account of one of the most dramatic and moving events of the century.” No less than that! And then, on the dust jacket, we read the following:

> FLT became the Holy Grail of mathematics. Whole and colorful lives were devoted, and even sacrificed, to finding a proof. Leonhard Euler, the greatest mathematician of the eighteenth century, had to admit defeat. Sophie Germain took on the identity of a man to do research in a field forbidden to females, and made the most significant breakthrough of the nineteenth century. Evariste Galois scribbled down the results of his research deep into the night before venturing out into a duel in 1832. Yutaka Taniyama, whose insights would ultimately lead to the solution, tragically killed himself in 1958. On the other hand, Paul Wolfskehl, a famous German industrialist, claimed Fermat had saved him from suicide and established a rich prize for the first person to prove the theorem.

Lives “devoted, and even sacrificed” in the pursuit of an abstruse mathematical question is definitely a story worthy of attention, but on closer inspection, every sentence in this description turns out, at best, to be a dramatic overstatement.[33] This spirit of over-dramatization dominates the greater part of the book. The preface, for instance, opens with the following passage:

[33] For a detailed discussion of Singh’s book, including a critical examination of each of the names mentioned in this paragraph and their real connection (or, more often, lack of connection) with work on FLT, see Leo Corry, “El Teorema de Fermat y sus Historias,” *Gaceta de la Real Sociedad Matemática Española* 9 (2006): 387–424.

> The story of Fermat's Last Theorem is inextricably linked with the history of mathematics, touching on all the major themes of number theory. … The Last Theorem is at the heart of an intriguing saga of courage, skullduggery, cunning, and tragedy, involving all the greatest heroes of mathematics.

In this way, the dramatizing effect comes to be closely connected with the "royal-road-to-X" approach mentioned in the first part of this essay. Not only are many intriguing episodes in the history of mathematics captured on behalf of the drama's denouement even if, historically, they have nothing or very little to do with FLT,[34] but many significant and highly interesting mathematical developments that were at the heart of the attempts to prove Fermat's conjecture are completely ignored just because in the final account they did not become part of the triumphant party.[35] To be sure, within the entire story of FLT, the episode involving Wiles and his lifetime interest in FLT is perhaps the one that comes closest to real personal drama of the kind implied by Singh's account. But then, on the other hand, it is precisely because of this over-dramatization of the entire story that the true historical and mathematical import of Wiles's formidable accomplishment in proving the Taniyama-Shimura conjecture cannot be adequately conveyed to the reader.

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[34] This is clearly the case with the inclusion of Galois in the book. He was a most prominent figure of early nineteenth-century mathematics, but has no connection whatsoever with FLT. His inclusion, however, comes as no surprise, because even more than FLT, his life and work are the subjects receiving the highest degree of attention in terms of mathematics in fiction, and have been more consistently over-dramatized in historical or pseudo-historical accounts than others. The reason is simple: whereas the external components of the biographies of most mathematicians are boring and repetitive ("born . . ., studied at . . ., dissertation on . . ., his most important work was . . ., was honored . . ., and so on), Galois's is the only one whose biography boasts the romantic privilege of having been killed in a duel for a woman, in addition to his explosive personality, with incursions into violent politics. A list of fiction works about Galois appears in Laura Toti Rigatelli, *Evariste Galois, 1811–1832* (Boston: Birkhäuser, 1996), p. 144. A more recent example is Tom Petsinis, *The French Mathematician* (New York : Walker and Co., 1998). See also Tony Rothman, "Genius and Biographers: The Fictionalization of Evariste Galois," *American Mathematical Monthly* 89 (1982): 84–106.

[35] Mathematicians such as Harry Schultz Vandiver, Emma and Derrick Lehmer, Samuel Wagstaff, and others proved FLT for ever larger values of *n* by means of computational methods; see Leo Corry, "FLT Meets SWAC: Vandiver, the Lehmers, Computers, and Number Theory," *IEEE Annals of History of Computing* 30 (2008): 38-49.

It would be too easy to explain Singh's approach by saying that this is a popularization, a book that successfully fulfils its aim, and that its over-dramatized aspects more faithfully serve its purpose—namely, introducing a broader audience to the world of mathematics, its people and ideas. Regardless whether one accepts such a claim, it is important to bear in mind that this over-dramatized image of the history of science has been essentially shared by the scientists themselves, and that until relatively recently it was commonly found as well in much of the mainstream academic historiography of science. Indeed, as Yehuda Elkana insightfully stressed more than twenty-five years ago, this view was an outgrowth of a long-ingrained tradition in Western culture that identifies "fate in Greek tragedy with the order of nature," and thus views "natural occurrences and events as inevitable." This point of view, Elkana asserted, was later extended so as to cover not only the natural events in the world, but also the unfolding of human knowledge about the world:

> The conviction emerged and grew, leading up to its positivistic absoluteness in the Victorian frame of mind, that not only there is one reality with it immutable laws, but also that we humans are on a sure course to find out all, or at least cumulatively more and more about the reality: one nature, one truth about nature. Science, the chief glory of Western culture since the scientific revolution, is an inevitable unfolding of knowledge; what we know we had to know -- if not here, then there, if not now, then at another time, if not discovered by one man, then by another.[36]

Alfred North Whitehead, for instance, explicitly identified the spirit of modern science with Greek tragedy, and attributed a central role to fate in the development of our knowledge of nature: "The absorbing interest in the particular heroic incidents as an example and a verification of the workings of fate, reappear in our epoch as concentration of interest on the crucial experiments." And the foremost,

[36] Yehuda Elkana, "The Myth of Simplicity," in *Albert Einstein: Historical and Cultural Perspectives,* ed. Gerald Holton and Yehuda Elkana (Princeton, N.J.: Princeton University Press, 1982), pp. 205–251, quote on pp. 205–206; see also Elkana, *Anthropologie der Erkenntnis: die Entwicklung des Wissens als episches Theater einer listigen Vernunft* (Frankfurt am Main: Suhrkamp, 1986).

recent crucial experiment Whitehead had in mind, and that he could present as an illustration of his views, concerned the results announced by the Eddington eclipse expedition of 1919 that measured the deflection of light rays by the sun's gravitational field and thus reportedly confirmed Einstein's theory of relativity. Whitehead described the announcement on 6 November 1919 by the astronomer royal at the joint meeting of the Royal Society of London and the Royal Astronomical Society, and his description is phrased in terms that are carefully chosen so as to enhance the theatrical character of the scene:

> The whole atmosphere of tense interest was exactly that of the Greek drama: we are the chorus commenting on the decree of destiny as disclosed in the development of a supreme incident. There was dramatic quality in the very staging: the traditional ceremonial, and in the background the picture of Newton to remind us that the greatest of scientific generalizations was, now, after more than two centuries, to receive its first modification. [37]

One needs not question the momentous historical significance of this event in order to wonder if the participants at the meeting actually shared the dramatic feelings that were retrospectively reported by Whitehead six years later. From the vantage of more than eighty years, detailed historical research has brought to light the complex mixture of social, institutional, political, and cultural circumstances that influenced this interesting chapter in the history of twentieth-century science. If anything, the details of this story (which cannot be recounted here)[38] provide an illuminating example of the contingencies surrounding the development of Einstein's theory, and in particular his meteoric rise to fame in the wake of Eddington's expedition. A Greek tragedy is hardly the correct metaphor to describe what really

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[37] Alfred N. Whitehead, *Science and the Modern World* (New York: Free Press, 1969), p. 10.

[38] Two classic, well-documented studies on these issues are: John Earman and Clark Glymour, "Relativity and Eclipses: The British Eclipse Expeditions of 1919 and Their Predecessors," *Historical Studies in the Physical Sciences* 11 (1980): 49–85; and Klaus Hentschel, "Einstein's Attitude towards Experiments: Testing Relativity Theory, 1907–1927," *Studies in History and Philosophy of Science* 23 (1992): 593–624. A more recent source is Jeffrey Crelinsten, *Einstein's Jury: The Race to Test Relativity* (Princeton, N.J.: Princeton University Press, 2006).

happened here; alternative scenarios could no doubt have easily materialized, following only slight changes in the circumstances.[39]

Following a conception developed by Bertolt Brecht and Walter Benjamin,[40] Elkana has suggested that a more adequate metaphor for the history of science is that of the "epic theater," rather than Greek drama. The contrast between these two metaphors is summarized in the following schematic diagram:

	Science as Drama / Greek Tragedy	Science as Epic Theater (Brecht)
Plot	We know what will happen: drama arises because we know that it will happen	"Things can happen this way, but they can also happen in a quite different way" (Walter Benjamin)
Characters	Human emotions, ideas, and behavior are seen as products of, or responses to the unfolding of the human essence	Human emotions, ideas, and behavior are seen as products of, or responses to, specific social situations
Theme	Universal elements of the human situation and fate	Behavior people adopted in specific historical situations

Diagram 6: Science as Greek Tragedy vs. Science as Epic Theater

Elkana views the epic theater metaphor as the one that more adequately describes the history of science, which he characterizes as "undramatic":

> Epic theater, in order to make its point, purposefully avoids historical facts that the audience is aware of, lest they lapse into the tragic mood of knowing what is inevitably coming. Life is unpredictable and events can go in any direction, therefore life is unsensational. What is true of historical inevitability also holds for psychological inevitability, and this, too, is avoided. In short, epic theater is a relaxed, nonsensational, reflective attitude to unpredictable events. To put it in another formulation: the historical question is not what were the sufficient and

[39] See David E. Rowe, "The Einstein Era, 1920–1955," in *The Cambridge Companion to Einstein* (forthcoming 2009).

[40] Walter Bejamin, *Understanding Brecht* (New York: New Left Books, 1973).

> necessary conditions for an event that took place, but rather, what were the necessary conditions for the ways things happened, although they could have happened otherwise. [41]

As we see it now—at variance with Whitehead's description—the case of the eclipse expedition and its aftermath provides an enlightening example of things that happened in a certain way, but could have happened in a very different way. Indeed, I think it is fair to assert, at the risk of a too-broad generalization, that a considerable portion of interesting research in the history of science over the last two decades has become much closer to the epic theater perspective that to the Greek drama one. It will be interesting to see how fictional narratives on science, and particularly on mathematics, as well as popular books on the same topics, catch up with this important development.

6. Concluding Remarks – Can Mathematics in Fiction Interfere with Mathematical Reality?

According to Umberto Eco, we read fictional texts because they come to the aid of our metaphysical narrowmindedness and offer an illusion of order within a world whose complete structure we are unable to grasp and describe. Since we know that fictional universes are created by an "authorial entity," we also know that there is a "message" behind them. The very confidence we hold of the existence of this message is, in the first place, what allows us to decipher it, or at least to think we are on the way toward deciphering it. This explains why we feel comfortable in fictional worlds. The actual world, on the other

[41] Elkana, "The Myth of Symplicity" (above, n. 37), p. 208.

hand, does not offer this confidence; rather, "since the dawn of time, humans have been wondering whether there is a message, and, if so, whether this message makes sense."[42]

We can now ask ourselves: Is this argument valid for mathematics and mathematics in fiction? We surely know that fictional narratives, even if they are about mathematical themes, are created by an authorial entity. But what about the mathematics itself? What can we say about that "actual world" around which authors of mathematics in fiction build their fictional universes? One may question, in the first place, whether this "actual world" is indeed actual, or is it fictional? One may question whether there exists an authorial entity behind this actual world of mathematics. But no one will deny that the kind of comfort that Eco attributes to our experience with fictional worlds is manifest in a very remarkable way in our encounters with mathematics. True, some people experience difficulties in technically mastering the world of mathematics; but once mastered, it provides perhaps the utmost example of a fictional (or fictional-like) world where the certainty of an underlying message is strongly felt, and where, indeed, progress is continually and consistently made on the way to elucidating that message.

Eco also calls attention to that very remarkable phenomenon of intertextuality whereby fictional characters start to migrate from one fictional work to another. When this happens, he says, the characters "have acquired citizenship in the real world and have freed themselves from the story that created them."[43] When one thinks about mathematics in these terms, a rather original explanation seems to arise about the fundamental Platonic attitude of the typical working mathematician. Whatever his or her

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[42] Eco, *Six Walks* (above, n. 21), p. 116. In this book (and in most others of his as well), Eco openly acknowledges the strong presence of Borges's ideas in his formulations. This is the case in particular for this passage, which seems to have been taken directly, for instance, from Borges's "The God's Script." See also Leo Corry, "Jorge Borges: Author of 'The Name of the Rose,'" in *Umberto Eco*, vol. 2, ed. Nicholas Gane and Mike Gane (London: Sage, 2005), pp. 2:389–406.

[43] Eco, *Six Walks* (above, n. 21), p. 127.

professed philosophical beliefs, the typical mathematician will relate to objects of investigation as part of an external reality that can be objectively known.[44] Following along Eco's line, mathematical entities (such as groups, functions, topological spaces, algorithms, or whatever) can be seen as fictions that arise within a certain text, and then start to migrate to ever new ones until they become ubiquitous and eventually acquire their status of autonomous, "actual" entities. A mechanism similar to the one that applies to characters of fictional narrative that at some point liberate themselves from the texts in which they first appeared—Sherlock Holmes is a favorite example of Eco's—seems to be at play in this case.

Finally, if fiction so strongly fascinates us, Eco asks, may it not be "that we interpret life as fiction, and that in interpreting reality we introduce fictional elements?"[45] Little needs to be said here about how, ever since the seventeenth century, science has been interpreting reality with the help of mathematical ideas. The latter can, in this context at least, be considered as fictions that help us interpret reality. The specific example that Eco refers to, however, seems to point in a different direction, which we might also consider here. He shows in detail how the text of *The Protocols of the Learned Elders of Zion* arose from various, purely fictional sources, and how its very existence was effectively taken by its readers to be a confirmation of the message it conveyed. This is a most salient example of fiction intruding into real life with tremendous historical consequences. Can we imagine a similar situation in the case of mathematics? I can think of very few examples of this kind, but there is at least a recent one that cannot be overlooked: Andrew Wiles and FLT.

Wiles's fascination with FLT reportedly started in his childhood when he read Eric Temple Bell's *The Last Problem* (1962). This book, together with Bell's better-known, indeed legendary *Men of*

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44 Or as it has been illuminatingly described by Reuben Hersh: "Most writers on the subject seem to agree that the typical 'working mathematician' is a Platonist on weekdays and a formalist on Sundays"; see Hersh, "Some Proposals for Reviving the Philosophy of Mathematics," *Advances in Mathematics* 31 (1979): 31–50.

45 Eco, *Six Walks* (above, n. 21), p. 131.

Mathematics (1937), are among the most salient examples of histories of mathematics written in the over-dramatized style I discussed above as a series of essentially undocumented legends about mathematical heroes.[46] This approach, which serious historians love to hate, catches the imaginations of young readers. Some of these readers become research mathematicians, which was the case with Wiles. Had the young, mathematically gifted child read a more restrained, less dramatic account of the kind I praised above—because of its historiographical and scholarly qualities—it is rather unlikely that FLT would have kindled Wiles's imagination as it did. He launched his professional career without devoting any research to FLT, and subsequently became prominent in the fields he investigated. But in 1986, when certain recent developments indicated that FLT had become a mathematical task that might be solved by proving a well-defined, though obviously highly challenging conjecture, he decided to take up the challenge, remembering his early interest in it. Thus he was emotionally motivated to undertake the long and difficult quest to prove FLT, which eventually, more than eight years later, resulted in his sensation success. Bell's account then, which was essentially fictional even if related to actual historical events, *did* intrude upon the real world of mathematics and led, with the help of Wiles, to its transformation.

And yet I would like to suggest that the truly ultimate way in which fiction could impact the actual world of mathematics would be if a novel on mathematical issues in which some kind of mathematical idea was suggested (for example, a certain way to solve a celebrated unsolved problem) eventually resulted in a reader formulating an actual solution to the problem. I know of no example of this kind in history, and I doubt that it could happen. Most likely the mechanisms controlling the relation between "reality" and "narrative fiction" are of a different kind when it comes to mathematics.

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[46] And it does not seem beyond the point to stress that Eric Temple Bell (1883–1960) was a rather successful science-fiction author (under the pseudonym John Taine); see Constance Reid, *The Search for E. T. Bell: Also Known as John Taine* (Washington, D.C.: Mathematical Association of America, 1993).

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