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Chapter 28
Mach and Relativity Theory: A Neverending Story in HOPOSia?

Gereon Wolters

Abstract Michael Ende's bestseller/*The Neverending Story*/is set in a magical world called "Fantastica". In Fantastica, there are heroes and villains, just as in the world of universities and academies. There is even an entity, or better: a non-entity of shaky existence, das Nichts, the Nothingness – loved by some philosophers like Martin Heidegger. In Fantastica Nothingness is able to create trouble and destruction. The same is true in the land of academic history and philosophy of science – let us call it "HOPOSia". In HOPOSia, particularly in its Anglophone provinces, Nothingness of knowledge and information has succeeded in building up strong opinions about the topic "Mach and Relativity", and has created confusion and disinformation. However, you may slightly relax; our story in HOPOSia is less cruel so far and more peaceful than what happens in Fantastica. Sometimes it has even entertaining aspects. There are similarities, though: If there had not been lies and manipulation of believes, our story would have ended years ago. It went on instead and will possibly do so forever.

28.1 Introduction: Fantastica and HOPOSia

> When it comes to controlling human beings there is no better instrument than lies. Because, you see, humans live by beliefs. Moreover, beliefs can be manipulated. The power to manipulate beliefs is the only thing that counts. –

This is not an exactly optimistic assessment of human judgment and morality. We find it in Michael Ende's bestseller *The Neverending Story*.[1] That story is set in

[1] *Die unendliche Geschichte. Von A bis Z.* Mit Buchstaben und Bildern versehen von Roswitha Quadflieg, Stuttgart (Thienemann) 1979. The standard English translation, by Ralph Manheim, was first published in 1983.

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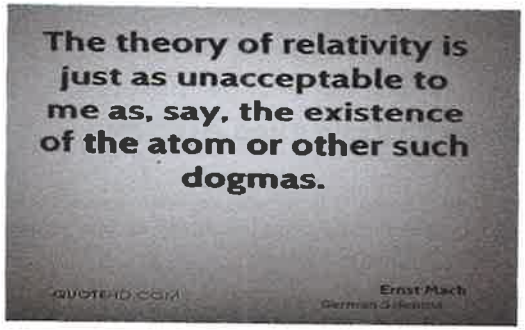
a magical world called "Fantastica". In *Fantastica*, there are heroes and villains, just as in the world of universities and academies. There is even an entity, or better: a *non*-entity of shaky existence, *das Nichts*, *the Nothingness* – loved by some philosophers like Martin Heidegger, to whom we owe the beautiful phrase "Das Nichts selbst nichtet".[2] In *Fantastica* Nothingness is able to create trouble and destruction. The same is true in the land of academic history and philosophy of science – let us call it "*HOPOSia*". In *HOPOSia*, particularly in its Anglophone provinces, in our case Nothingness of knowledge and information has succeeded in building up strong opinions and has created confusion and disinformation.[3] However, you may slightly relax; our story in *HOPOSia* is less cruel so far and more peaceful than what happens in *Fantastica*. Sometimes it has even entertaining aspects. There are similarities, though: If there had not been lies and manipulation of believes, our story would have ended years ago. It went on instead and will possibly do so forever. – Let us proceed step by step, and start with the present state of our (probably) neverending story.

28.2 First Step: What the WWW Teaches us, When We Google "Mach and Relativity"

Among the pictures that pop up in the web, we find a poster, where the "German scientist Ernst Mach" is quoted as saying the following:

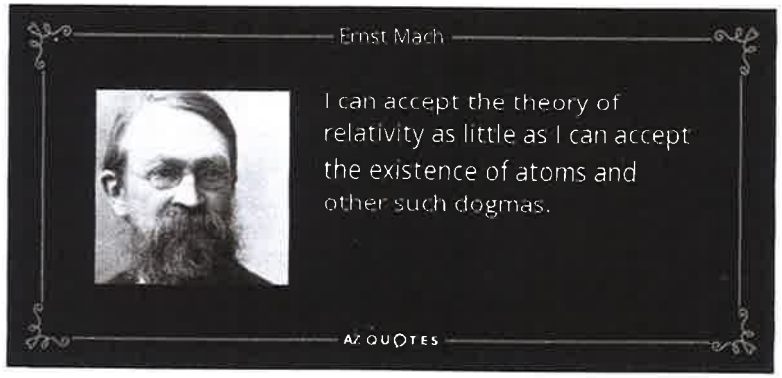


Sorry, my Austrian friends, in the wide transatlantic perspective such a geographical contraction of Germany and Austria may occur as normal. For those,

[2]This phrase is in German as senseless as the English translations "the nothing itself nothings" or "the nothing itself nihilates". – Rudolf Carnap, in his classic "Überwindung der Metaphysik durch logische Analyse der Sprache", has given already more than 80 years ago an equally timeless and devastating logical analysis of such philosophical nonsense (Carnap (1931)).

[3]At this point, I should issue a "trigger warning", in case innocent and sensitive American college students are among my readers. Here is the reason for this precautionary measure: "In the name of emotional well-being, college students are increasingly demanding protection from words and ideas they don't like." (Lukianoff/Haidt (2015)).

however, who might take offence at whatever sort of *Anschluss*, here is a poster neutral as to the nationality of Mach:



The Anglophone web, thus, seems to describe Mach as an anti-relativist and anti-atomist. Just to be on the safe side, let us have a look at *Wikipedia*. To my great relief the posters are confirmed. On relativity the entry "Mach, Ernst" informs us:

> [...]In 1930, he [Einstein] stated that "it is justified to consider Mach as the precursor of the general theory of relativity", though Mach, before his death, would reject Einstein's theory.[4]

The German *Wiki*, however, where the entry "Mach" even carries a quality star does not talk about Mach's position with respect to relativity, although it mentions Mach's influence on Einstein. The same is true for the other *Wikis* I checked with the exception of the Dutch. Just as an aside: Although I am very much in favor of Francis Bacon's *De nos ipsis silemus* (about ourselves we keep silent) I should mention that none of the 10 or so *Wiki* entries I have looked at, quotes my book on the topic *Mach I, Mach II, Einstein und die Relativitätstheorie. Eine Fälschung und ihre Folgen* (Wolters (1987)) – a book to which I frequently have to relate in what follows.[5]

The historical question we must put at this point is: are those texts on the web posters and on *Wiki* reliable? To answer this question, I would like to first deal with Mach's personal context.

[4]Seen May 2016.

[5]The English reader might consult Wolters (2012) for more extensive information than can be given in the present paper.

28.3 Second Step: Some Important Prehistory

The *first thing* I would like to mention is that Mach was by no means a theoretical physicist, although he plays – according to Einstein – a prominent role in the prehistory of relativity, one of the great pillars of modern theoretical physics. Mach was, rather, an experimental physicist and a sense physiologist. His importance for theoretical physics derives from methodological reflections in his work on the history of physics, particularly his *Die Mechanik in ihrer Entwicklung historisch-kritisch dargestellt*. The book that was so important for Einstein's development was published in 1883 and saw during Mach's lifetime seven revised and updated editions. It is, of course, – let me just insert a little advertising – part of the great new *Ernst-Mach-Studienausgabe*, for which the *Institut Wiener Kreis* and its director Friedrich Stadler are responsible (Mach (2012).[6] To sum up, Mach was not in any way involved in theoretical physics research connected with the theory of relativity.

This brings me to my *second point* that is of utmost importance. When in 1905 Einstein published his groundbreaking paper on special relativity, Mach was a very sick man of 67 years.[7] He had been sick for 7 years after an apoplectic stroke he suffered from on a train trip to Jena in July 1898. From this stroke resulted a series of secondary diseases, as hemiplegia that could never be reduced completely, a motoric aphasia that strongly influenced his faculty of speech. Furthermore, he reports in his correspondence problems with his urinary bladder that required catheterizing up to two times a day. In addition, he complains heavy sleep disorders, neuralgias, and frequent falls that confined him to bed for weeks and sometimes months. His state of health was so fragile that at first he was convinced that he would pass away soon. He writes, for example, in the preface to the second edition of the *Analyse der Empfindungen* in April 1900:

> I was unwilling to let slip this last opportunity without once again saying something on a subject which I have so much at heart. I have therefore added the supplements and elucidations most urgently required, principally by inserting short chapters in the original text.[8]

Similarly, in 1912, when Mach was confined to bed after a heavy fall he doubted that he would survive. On October 4, he wrote to Paul Carus, his American publisher and friend: "If this should this be my last letter, I ask you for an amicable remembrance."[9]

[6] As knowledgeable Anglophone colleagues have reported, the English translation of the *Mechanik* is, unfortunately, not consistently reliable.

[7] For a detailed presentation of Mach's medical history, see Wolters (1987), p. 276ff.

[8] Mach (2012), p. 3: "Ich möchte jedoch diese letzte Gelegenheit nicht vorübergehen lassen, ohne über den mir wichtigsten Gegenstand noch einmal das Wort zu ergreifen. Deshalb habe ich die notwendigsten Ergänzungen und Erläuterungen, meist in Form kurzer eingeschalteter Kapitel, eingefügt". (engl. transl., p. IX)

[9] "Sollte dies mein letzter Brief sein, so bitte ich um ein freundliches Andenken." ("Open Court Archive", in: Special Collections, Morris Library, Southern Illinois University at Carbondale).

Given his poor state of health, it is the more surprising that Mach continued working. Because his hemiplegia was on the right side, he even learned to write with his left hand and to use use a typewriter. He was able to bring his Viennese lectures to the press as *Erkenntnis und Irrtum*, to continue working on his *Prinzipien der physikalischen Optik*, to write the first part of his *Kultur und Mechanik* as well as several papers. He seems even to have done experimental work about electromagnetic interference. – This attests to the fact that Mach notwithstanding his poor state of health was full of energy. Here is a moving section in a letter to Paul Carus, of February 12, 1912:

> It is my wife, who has to suffer from my state of health. Certainly, it is not a trifle, to wash an adult person like a child every day and dress him, however without the prospect that he will grow up and become more independent and prudent. The only prospect is on a burial. If she had committed me to the doctors, I would have been long ago not only bankrupt but also for a long time dead. Things went in any case better than I could have thought. Who could have assumed that I would be still alive fourteen years after my apoplexy? I have even written new books since and repaired some defects of older writings in a satisfying way.[10]

Based on his correspondence and his notes, one can say that Mach took his 18-year sufferings with great patience and loyalty. There is no indication that embitterment about his condition might have caused unfair reactions to others. He was, by the way, in general not a friend of polemical arguments.

28.4 Third Step: How Einstein Saw Mach's Role

As is well known, and has never been contested so far, Einstein himself did not have the slightest doubts that Mach had exercised significant influence on the shaping of both special and general relativity. Three quotations may suffice.

The first is from Einstein's long and moving obituary on Mach in 1916, published in *Physikalische Zeitschrift*. Among other things, Einstein writes:

> It is not improbable that when physicists were considering the significance of the constancy of the velocity of light that had Mach's mind been young and fresh at that time he would have come across the theory of relativity. [...] His comments about Newton's bucket experiment show how near to his mind the demands of relativity in the more general sense (relativity of acceleration) lay.[11]

[10] "Wer darunter leidet, ist meine Frau. Denn es ist gewiss keine Kleinigkeit, einen erwachsenen Menschen täglich zu waschen und anzuziehen, wie ein Kind, jedoch ohne die Aussicht, dass es größer, selbständiger und gescheiter wird, sondern nur mit der Aussicht auf ein Begräbnis. Hätte sie mich den Ärzten überlassen, so wäre ich nicht nur längst bankerott, sondern auch längst tot. Es ist ohnehin besser ausgegangen, als ich denken konnte. Wer hätte annehmen können, dass ich 14 Jahre nach meiner Apoplexie noch leben würde. Ich habe seitdem noch neue Bücher geschrieben und manchen Defekt älterer Schriften noch in befriedigender Weise ausgeflickt." ("Open Court Archive", in: Special Collections, Morris Library, Southern Illinois University at Carbondale).

[11] Einstein (1916), p. 103: "Es ist nicht unwahrscheinlich, dass Mach auf die Relativitätstheorie gekommen wäre, wenn in der Zeit, als er jugendfrischen Geistes war, die Frage nach der Bedeutung

The second quotation is from Einstein's "Autobiographical Note" that he wrote in 1948 for the Schilpp-volume:

> It was Ernst Mach who, in his History of Mechanics, shook this dogmatic faith [in classical mechanics as firm and definite foundation for all physics]; this book exercised a profound influence upon me in this regard while I was a student.[12]

The third and last quotation is from an interview Einstein gave in 1955, only 2 weeks before his death, to I. B. Cohen:

> Although Einstein did not agree with the radical position adopted by Mach (with respect to the existence of atoms), he told me he admired Mach's writings, which had a great influence on him[13]

There are four letters of Einstein to Mach. Mach's letters are lost.[14] Einstein's last letter dates from the turn of the year 1913/14. He thanks Mach for what he describes as "friendly interest" in a paper he had published in 1913 together with his friend, the Zurich mathematician Marcel Grossmann. The paper that presents a new field theory of gravitation is an important step towards general relativity. It makes use of the mathematical tool of tensor analysis that Einstein did not know and learned only with Grossmann. Because Mach had obviously written that he did not understand the mathematics of the paper, Einstein admits:

> Unfortunately, the mathematical difficulties which one encounters in pursuing these ideas are enormous for me as well. I am tremendously pleased that the development of the theory brings to fore the depth and importance of your investigations on the foundation of classical mechanics. To this day, I still cannot understand how Planck, whom I have otherwise learned to prize like no one else, could show so little understanding for your endeavors. Incidentally, he also disapproves of my new theory.[15]

This was balm for Mach's soul, not only because the young shooting star of physics appreciated once again Mach's ideas and influence, but also because he defended him against Planck. Planck, in 1908, in a talk at the University of Leiden had launched a completely unprovoked attack on Mach's phenomenalist epistemology. Planck's attack can be justified at best partly as regards content. It is, however, tactless and aggressive as regards form. Planck closed his talk – alluding

der Konstanz der Lichtgeschwindigkeit schon die Physiker bewegt hätte. [...] Die Betrachtungen über Newtons Eimerversuch zeigen, wie nahe seinem Geiste die Forderung der Relativität im allgemeineren Sinne (Relativität der Beschleunigungen) lag." (engl.transl. pp. 157ff.)

[12] In: Schilpp (ed.) 1970, p. 21.

[13] Cohen (1955), p. 72.

[14] Cf. Wolters (1987), Ch. 2, which presents the letters and analyzes their content.

[15] Einstein (1993), p. 583 f. – „Die mathematischen Schwierigkeiten, auf die man bei der Verfolgung dieser Gedanken stößt, sind leider auch für mich sehr große. Es freut mich außerordentlich, dass bei der Entwicklung der Theorie die Tiefe und Wichtigkeit Ihrer Untersuchungen über das Fundament der klassischen Mechanik offenkundig wird. Ich kann heute noch nicht begreifen, wie Planck, den ich sonst wie kaum einen zweiten hochschätzen gelernt habe, Ihren Bestrebungen so wenig Verständnis entgegenbringen konnte. Er steht übrigens auch meiner neuen Theorie ablehnend gegenüber."- Engl. transl., p. 370.

to Mach's refusal to acknowledge the reality of atoms – "in the serene trust in the power of the Word, which for over nineteen hundred years has taught us the ultimate indubitable sign of how to distinguish true from false prophets: *By their fruits shall ye know them!*[16] – I would like to call this the "Jesus-Planck-Criterion for the assessment of epistemological theories" – JESPLAC for short. JESPLAC will accompany us for the rest of this paper.

28.5 Fourth Step: How Mach Saw Relativity

It is time now to inspect the evidence we have of Mach's own assessment of relativity. *First,* one has to recall that in 1905, when Einstein's seminal paper on special relativity appeared, Mach was already a very sick man, who concentrated – as far as his weak forces allowed – on other things than the latest developments in theoretical physics. It is, therefore, no wonder that it took quite some time, before he learned about Einstein's new theory. All evidence suggests that it was the publication of Hermann Minkowski's famous talk at the 80th *Reunion of German Natural Scientists and Physicians* on September 21, 1908 in Cologne. This talk gave the canonical four-dimensional representation of special relativity that holds until this day. Mach had great difficulties to understand Minkowski's paper and asked the young physicist Philipp Frank (1884–1964) to explain it to him. Frank much later reported this story in a letter of 1959 to the East German historian of science Friedrich Herneck. He concludes:

> Back then got the impression that he completely agreed with Einstein's 'special' theory, and particularly with its philosophical foundation. Mach asked me to give him my presentation in written or printed form. This I did, and therefore exists as a printed text of the presentation of Einstein's theory that Mach agreed with.[17]

Frank's recollection that Mach agreed with special relativity fits nicely with Mach's own published pronouncements in this regard. Given Mach's limited competence with respect the latest developments in theoretical physics and his pure state of health, it is certainly not a coincidence that all three statements are just short footnotes.[18] They all occur in the context with the Planck-controversy and visibly

[16] Planck (1909), p. 51 of the reprint: Planck hat „das ruhige Vertrauen auf die Kraft desjenigen Wortes, welches seit nunmehr neunzehnhundert Jahren als letztes, untrügliches Kennzeichen die falschen Propheten von den wahren scheiden lehrt: An ihren *Früchten* sollt ihr sie erkennen!" - Engl. transl. p. 132

[17] Herneck (1966), p. 49: „Ich hatte damals den Eindruck, dass er vollständig mit Einsteins 'spezieller Theorie, übereinstimmte und auch besonders mit deren philosophischer Basis. Mach ersuchte mich, ihm meine Darstellung noch schriftlich oder gedruckt zu hinterlassen. Ich tat das auch, und daher ist die Darstellung der Einsteinschen Theorie, der Mach zustimme, auch in einem gedruckten Text vorhanden." (engl. transl. G.W.) – Frank's „printed text" is Frank (1910).

[18] There is no doubt: Had Mach already lived in *HOPOSia* he would have written a book or at least a long article praising his central role in the development of relativity.

aim at showing that Mach's epistemological ideas, other than Planck had contended, bear delicious scientific fruits, and thus *positively* comply with JESPLAC. The first footnote occurs in a republication of his famous Prague talk of 1871 on the *History and root of the principle of the conservation of energy*. Mach wrote to Paul Carus (January 7, 1910) that the reprint of the talk was, in fact, "provoked" (*veranlasst*) through Planck's attack".[19]

> Space and time are not here conceived as independent entities, but as forms of the dependencies on one another. I subscribe then to the principle of relativity, which is also firmly upheld in my *Mechanics* and *Wärmelehre*. Cf. >Raum und Zeit physikalisch betrachtet< in >Erkenntnis und Irrtum< 1905, H. Minkowski, >Raum und Zeit 1909<.[20]

The second footnote we find in Mach's explicit defense against Planck's attack. He seems to be encouraged by Einstein's gentle reaction in a letter of August 9, 1909 to Mach's sending him the republication of the "Conservation of Energy", and to use this reaction as positive JESPLAC:

> Even if the kinetic physical world picture, which in any case I consider hypothetical without intending thereby to degrade it, could 'explain' *all* physical appearances, I would still hold that the diversity of the world had not been exhausted, because for me *matter, space,* and *time* are also *problems*, which moreover, the physicists (*Lorentz, Einstein, Minkowski*) are also moving closer toward.[21]

The third and last footnote is again clearly in JESPLAC spirit. It can be found in Mach's 1910 paper "Sensory Elements and Scientific Concepts". Note that it is always *Mach*, who employs JESPLAC for *promoting* his philosophy. Planck and all the others, I will take on shortly, use it for *belittling* Mach:

> Similarly, one will have to distinguish between metrical and physical space, with time included in the latter. I have already carried this out in my book *Erhaltung der Arbeit* (1872), p. 35, suggested on p. 56, and in *Erkenntnis und Irrtum* (1906), p. 434ff.; it is also a direction in which essential progress has been made by the work of A. Einstein and H. Minkowski.[22]

[19] In: "Open Court Archive", in: Special Collections, Morris Library, Southern Illinois University at Carbondale).

[20] Mach (1909), p. 60: "Raum und Zeit werden hier nicht als selbständige Wesen, sondern als Formen der Abhängigkeit der Phänomene voneinander aufgefasst. Ich steuere als auf das *Prinzip der Relativität* los, welches auch in ‚Mechanik' und ‚Wärmelehre' festgehalten wird. Vgl. ‚Zeit und Raum physikalisch betrachtet' in 'Erkenntnis und Irrtum' 1905. Vgl. H. Minkowski, ‚Raum und Zeit' 1909." – engl. transl. p. 95.

[21] Mach (1910), p. 605: "Würde das kinetische physikalische Weltbild, welches ich allerdings für hypothetisch halte, ohne es deshalb degradieren zu wollen, auch *alle* physikalischen Erscheinungen ‚erklären', so würde ich die Mannigfaltigkeit der Welt hiermit nicht für erschöpft halten, denn für mich sind eben *Materie, Zeit* und *Raum* auch noch *Probleme*, welchen übrigens die Physiker (Lorentz, Einstein, Minkowski) allmählich auch näher rücken." – Engl. transl. p. 139.

[22] Mach (2014), 465: "Ähnlich wird man zwischen dem metrischen und dem physikalischen (die Zeit mit enthaltendem) Raum zu unterscheiden haben, wie dies schon in meiner Schrift "*Erhaltung der Arbeit*" 1872, S. 35, 56 angedeutet, in „*Erkenntnis und Irrtum*" 1906, S. 434ff. teilweise ausgeführt worden ist, in welcher Richtung durch die Arbeiten von A. Einstein und H. Minkowski wesentlich Fortschritte begründet worden sind." – Engl. transl. p. 125.

In a collection of typescript notes by Mach of about 1909/10 that were recently given to the Mach papers at *Deutsches Museum* in Munich (HS 2015–008) we find similar sketchy attempts to relate special relativity to his epistemology, particularly in its Minkowskian form. It seems clear that Mach after Planck's Leiden attack was pleased to see a continuity of his thinking with groundbreaking developments in physics, even if he could understand them only approximately.

Apart from these wait-and-see footnotes in JESPLAC spirit, Mach has not published a word about relativity. The reasons for such a restraint are obvious, and I mentioned them already. First, he was not a theoretical physicist. Second, his time of commenting the course of physics from an epistemological point of view, based on proper own understanding, was over. Third, Mach was an old and sick man, who had to devote his vanishing forces to finishing own work and to small popular papers. There does not exist the slightest indication that he intended to immerse himself into the quarrels in the theoretical physics community of his day about matters he could only partly understand.

One could certainly add, as did Einstein in his obituary of 1916, a few more merits Mach actually had in the genesis of special and general relativity. Time constraints do not allow this, unfortunately.

28.6 Fifth Step: The *Optics* Preface – Lies and Manipulations Enter the Story

Given the situation as described so far, even in our sometimes rather bold and imaginative *HOPOSia* probably nobody would have ever claimed that Mach rejected relativity, if there not had been the publication of his *Die Prinzipien der physikalischen Optik* in 1921, i.e. 5 years after his death. The text of the book itself, to a considerable degree handwritten by Mach before his stroke, i.e. before 1898, *does not even mention* relativity. Only the preface, signed "München-Vaterstetten, July 1913 Ernst Mach," – based on a typescript of 1921 by Mach's son Ludwig – surprises both with a straightforward rejection of relativity, devoid of any argument, and of any attempts of its alleged author to be regarded as one of its forerunners:

> I gather from the publications which have reached me, and especially from my correspondence that I am gradually becoming regarded as the forerunner of relativity. I am able even now to picture approximately what new expositions and interpretations many of the ideas expressed in my book on Mechanics will receive in the future from the point of view of relativity.
>
> It was to be expected that philosophers and physicists should carry on a crusade against me for, as I have repeatedly observed I was merely an unprejudiced rambler, endowed with original ideas, in varied fields of knowledge. I must, however, as assuredly disclaim to be forerunner of the relativists as I withhold from the atomistic belief of the present day. The reason why, and the extent to which, I discredit the present-day relativity theory, which I find to be growing more and more dogmatical, together with the particular reasons which have led me to such a view – the considerations based on the physiology of the senses,

the theoretical ideas, and above all the conceptions resulting from my experiments – must remain to be treated in the sequel.

The ever increasing amount of thought devoted to the study of relativity will not, indeed, be lost; it has already been both fruitful and of permanent value in mathematics. Will it, however, be able to maintain its position in the physical conception of the universe of some future period as the theory, which has to find a place in a universe enlarged by a multitude of new ideas. Will it prove to be more than a transitory inspiration in the history of science?[23]

Connoisseurs of Mach's work and of his language could easily dismiss this rather confused, un-Machian gibberish as not authentic.[24] The same holds for anti-relativity quotes, attributed to Mach, that one finds in the preface of Mach's son Ludwig to a new edition of Ernst Mach's *Mechanik* in 1933. When it comes to discarding those texts as forgeries, Ludwig Mach is the central figure.[25]

Born in 1868 at Prague, he studied medicine until 1885. Instead of entering the medical profession, Ludwig joined the Zeiss Company in Jena, famous for building high precision instruments. This was a wise step, indeed, because Ludwig was clearly not suited for working as a physician. Already as a student, however, he had acted as a kind of assistant in Mach's Prague Institute for experimental physics and had published seven papers, some together with his father. Those papers he published as sole author were also a fruit of the collaboration with his father. The papers deal above all with the interference refractometer, and with technical aspects of photography, particularly schlieren photography. Both techniques Mach had used to visibly represent the shockwaves of his supersonic velocity experiments. – In

[23] Mach (1921), p. VIIIf.: "Den mir zugegangenen Publikationen und vor allem meiner Korrespondenz entnehme ich, dass mir langsam die Rolle des Wegbereiters der Relativitätslehre zugedacht wird. Nun kann ich mir heute ein ungefähres Bild davon machen, welche Umdeutungen und Auslegungen manche der in meiner Mechanik niedergelegten Gedanken in Zukunft erfahren werden. Wenn Philosophen und Physiker den Kreuzzug gegen mich predigten, so musste ich dies natürlich finden, und war damit ganz einverstanden, denn ich war, wie ich dies wiederholt dargetan habe, auf den verschiedenen Gebieten doch nur ein unbefangener Spaziergänger mit eigenen Gedanken, muss es aber mit derselben Entschiedenheit ablehnen, den Relativisten vorangestellt zu werden, mit welcher ich die atomistische Glaubenslehre der heutigen Schule oder Kirche für meine Person abgelehnt habe. Warum aber und inwiefern ich die heutige mich immer dogmatischer anmutende Relativitätslehre für mich ablehne, welche sinnesphysiologischen Erwägungen, erkenntnistheoretischen Bedenken und vor allem experimentell gewonnene Einsichten mich hierzu im einzelnen veranlassten, das soll in der Fortsetzung dieses Werkes dargetan werden. Gewiss wird die auf das Studium der Relativität verwendete immer mehr anschwellende Gedankenarbeit nicht verloren gehen, sie ist heute schon für die Mathematik fruchtbringend und von bleibendem Wert, wird sie sich aber in dem physikalischen Weltbild einer ferneren Zeit, das sich in eine durch mannigfache weitere neue Einsichten erweiterten Welt einzupassen hat, behaupten können, wird sie in der Geschichte der Wissenschaft mehr als ein geistreiches Aperçu bedeuten? " – Engl. transl. p. VIII.

[24] As a native speaker of German, who has read almost all of Mach's writings as well as scores of letters of his son, I am surprised to see American researchers claim that the *Optics* preface was written in "the pure Machian style", as Banks (2003), p. 250 quotes approvingly J. Blackmore.

[25] For an extensive biographical account and Ludwig's role, see Wolters (1987), 286ff.

the first years of the twentieth century – thanks to a patent for "Magnalium", an aluminum-magnesium alloy – Ludwig Mach had become a well-to-do young man, and had moved to Berlin. In 1901 he had married, but obviously concealed for quite a while this family enlargement from his parents. In 1905, the young Mach couple moved to Munich. In 1910, Ludwig decided to build a house for his parents on an isolated plot in Vaterstetten near Munich. In May 1913, finally, Ernst Mach and his wife Louise, his sister Marie and Anna, the faithful handmaid moved in from Vienna, while Ludwig and his wife retained their apartment in town.

In World War I, Ludwig lost at least a large part of his fortune, that he, unfortunately, had invested in Austrian war bonds. The following decades until his death in 1951 were a continuous fight on the brink of the psychological and economical abyss.

When Ernst Mach and family moved to Vaterstetten in May 1913, Mach was 75 years old and certainly not in better shape than described earlier. There is no indication that Mach ever left the house during the three Vaterstetten years. In Vaterstetten, soon, begins a development that lead more and more to a sort of deprivation of the right of decision of Ernst Mach by Ludwig, who presumes the right to act as his father's guardian. This presumption is connected with Ludwig's ambition to "continue" the work of his father. Here are a few indications of Mach's incapacitation. When World War I broke out in August 1914, Ludwig – who seems to have acted also as physician of his father – decided that his patient should not be bothered with such bad news. Consequently, Ludwig had to arrange an information ban that included controlling and censuring Ernst Mach's correspondence. The first letter that seems to have fallen victim of Ludwig's censorship was a letter of August 1914 of Mach's faithful friend Joseph Petzoldt (1862–1929). Ludwig was, by the way, in a state of competition with Petzoldt, an ardent adherent of relativity and of Mach's role in its genesis. The reason for this competition is that Ludwig regarded himself not only as the guardian of his father in everyday matters, but also as the chosen one to manage and even continue his work – a gross overassessment of his capacities. Ludwig was a good technician, but poor in theory. He knew neither mathematical analysis nor central pieces of physical theory like Fourier Theory. Therefore, Mach in 1904 had made an addendum to his contract with the publisher Brockhaus, in which he entrusted new editions of the *Mechanik* to Petzoldt and gave him permission "to add his own remarks in appendices". Petzoldt should also participate in the royalties for the book – against his own wishes.

Sometime, probably in the second half of 1915, Ludwig seems to have informed his father about the disastrous course the world had taken for about a year. The first evidence we have for this, is in a letter of Ludwig of October 1915.

Another significant example of Ludwig's incapacitation of his father and of his own guardianship is the fact that in November 1915 Ludwig had sent the manuscript of the *Optik* to the publisher, obviously without informing his father, not to talk about asking his permission. Proof of this is a letter that Mach wrote on February 12, 1916 – 6 days before his death – to the Leipzig physicist Otto Wiener:

> You ask me how matters stand with respect to the *Optics*. Well, you have anticipated so much with your 'theory of light' and the wide theoretical outlook connected with it, that I cannot take any more pleasure in my own expositions. I as an aging man could no longer keep pace with the unimagined development of optics.[26]

The publication of the *Optik* had to be interrupted, because Ludwig was called up for military service. After the war, the publication could be resumed. However, there was a little problem. Ludwig now needed a new theoretical mentor to live his pretensions of managing and continuing his father's work.

One can distinguish three stages in the development of Ludwig's "position" on relativity. The *first stage* coincides with his father's lifetime. Ludwig did not find fault with relativity. In November 1914, for example, he wrote to the fervent relativist Petzoldt about one of Petzoldt's papers: "I share completely your standpoint with respect to the R-thing [i.e. relativity] and owe to your paper a lot of stimulating ideas, the *experimental* revaluation of which seems to me very valuable."[27] – Pay attention to the last part of this sentence. Here we find the core of the rest of the story. Ludwig Mach connects the concept of relativity with own experimental activity. As we will see shortly, he wants to bring his interferometer into play. The *second stage* was reached, when Ludwig had found a new mentor to replace his father. This was the theoretical physicist Friedrich Adler (1879–1960), son of Victor Adler, the founder of the Austrian Social Democratic Workers Party. Adler, in early 1918, had plenty of time because he served an 18-year prison sentence for having shot the Austrian prime minister Graf von Stürgkh in 1916. Adler helped Mach in proofreading of the 3rd edition of the *Wärmelehre* and of the first sheets of the *Optik*. On March 3, 1918 Ludwig, after he had learned that Adler was working on a book against relativity wrote to him: "On relativity theory you will find little in the *Optik*, on radiation nothing. – he [i.e. Mach] declared to me repeatedly that these chapters were still too unsettled for being included in the book." Then he reports about his father's stand: "Until his death he was a trifle ironic about ions and the new views of the relativists."[28] – Fact is that there is not only "little" about relativity in the *Optik* but nothing. This little word

[26] "Sie fragen mich wie es mit der *Optik* steht? Nun haben Sie mit ihrer „Lehre vom Licht" und den daran sich knüpfenden weiten theoretischen Ausblick so viel vorweggenommen, dass mir meine Ausführungen nicht mehr gefallen wollen. Mit der ungeahnten Entwicklung der Optik konnte ich, der alternde Mann, nicht mehr Schritt halten."(Universitätsbibliothek Leipzig, Nachlass Otto Wiener).

[27] "Ich teile völlig Ihren Standpunkt in der R-Sache – und ich verdanke Ihrem Aufsatz eine Reihe von Anregungen, deren *experimentelle* Umwertung mir sehr wertvollerscheint." (Technische Universität Berlin, Universitätsarchiv, Nachlass Joseph Petzoldt).

[28] "Über die Relativitätstheorie werden Sie wenig, über die Strahlung gar nichts in der *Optik* finden – er erklärte mir wiederholt, diese Capitel seien noch viel zu ungeklärt, um in die Darstellung aufgenommen zu werden. [...] Das wäre ja nett, wenn es uns gelänge, experimentell und theoretisch eine Bresche zu schlagen gegen dieses Überwuchern der Speculation. Er hatte bis zu seinem Tode etwas leises [!] Ironisierendes für die Ionen und die neuen Anschauungen der Relativisten." (Adler Archiv (Mappe 130), in: Archiv für die Geschichte der Arbeiterbewegung, Vienna).

"little" points, however, to the project Ludwig had alluded to already in 1914 in his letter to Petzoldt. In his letter to Adler continues: "That would be fine, if *we* succeeded to blow a breach experimentally and theoretically." – The Adler-project failed, because Adler was pardoned in late 1918 and returned to politics. The *third stage* was reached, when Ludwig had read the draft of Petzoldt's appendix to the 8th edition of the *Mechanik* that praised Mach as forerunner of relativity. Ludwig, in the meantime, had found a new, fervently anti-relativist Mentor, the mathematician-philosopher Hugo Dingler (1881–1954). Ludwig writes to his rival Petzoldt on February 14, 1920:

> I cannot *comment in his sense* on relativity [my emphasis], before the publication of the *second part of the Optics* [my emphasis]. You will become thoughtful through Dingler. The fact that E(instein) arrived at his ideas, because of the physical philosophy of the young E.M. (*physikalische Jugendphilosophie*) does not diminish his merits. I still have to deal with the bending of the light of stars in the gravitational field of the sun. If you take the trouble to realize just this once the program outlined in your letter, then I am grateful to you in the name of my father.[29]

This letter is the first known document that mentions a second part of the *Optik*. It makes also clear that what a second part of the *Optik* could reveal is at most *in the sense* of Mach, and depends on experiments Ludwig still has to make, in Ernst Mach's sense, as it were. From 1920 on Ludwig tried to raise money for financing such experiments, not least from anti-relativity Nazi sources. What Ludwig had in mind, was the fantastic project to measure with the help of his interferometer the bending of light rays through trees in his garden. This project was obviously motivated by the broadly published results of two British expeditions that in May 1919 had observed the bending of the light of stars by the mass of the sun on the occasion of a solar eclipse. Ludwig's insane project wandered like a ghost through his life for the next 30 years and is amply documented. His last appearance it made in a law suit against the electricity supplier *Isar-Amper Werke* that in November 1944 had chopped the trees on Mach's estate so badly needed for the experiments designed a quarter of a century ago and for finishing the alleged second volume of the *Optik*. In 1950, Ludwig succeeded in getting a compensation of 5000 *deutschmarks*, but he had to pay ¾ of the costs of the lawsuit.[30]

The third stage of Ludwig's development is characterized by many other curiosities. I mention only one. Dingler, who had come out as an anti-relativist some time before, feared in early 1920 that he had fallen in disgrace with Ludwig

[29] "Ich *kann* vor der Publication des II. Teiles der Optik keine Stellung in seinem Sinn zur Relativität nehmen. Sie werden aber durch Dingler nachdenklich werden. Dass E(instein) auf Grund der physikalischen Jugendphilosophie (von) E. M. zu seinen Anschauungen gekommen ist, schmälert gewiss nicht sein Verdienst! Mit der Ablenkung des Sternlichts im Schwerefeld der Sonne muss ich mich speciell noch auseinandersetzen. Wenn Sie sich der Mühe unterziehen, das Programm Ihres Briefes für den *Mechanik*-Anhang für diesmal zu verwirklichen, dann danke ich Ihnen im Namen meines Vaters." (Technische Universität Berlin, Universitätsarchiv, Nachlass Joseph Petzoldt).

[30] For a presentation of court records, including the verdict, see Wolters (1987), 431ff.

because of his *anti*-relativist stand, because he believed that Ludwig sort of favored relativity as his father had done. Only in January 1921, Dingler learned to his surprise about the alleged existence of the anti-relativity preface. In addition, it is perhaps of interest to know that Ludwig, at least during 1920 and 1921, was addicted to cocaine, which might explain part of his almost abnormal behavior.

There does, of course, not exist a manuscript of the *Optik*-preface apart from the one Ludwig typed and sent to the publisher. In addition, in the huge amount of documentary material, there is no hint at a rejection of relativity by Ernst Mach. What one can observe, however, is Ludwig's pretension to communicate that after experiments of his own he would be in a position to deliver a judgment about relativity "*in the sense*" of his father.

28.7 Sixth Step: Our Story Goes on in *HOPOSia*

The reactions in *HOPOSia* to my forgery thesis are interesting in various respects. There were a few positive, even if not uncritical reactions.[31] More visible, however, is sometimes rather harsh criticism that comes from people that I myself, in turn, had taken on in a rather polemical way, and I am going on to do so in this paper. Most *HOPOSians*, who reject the forgery thesis use JESPLAC against Mach, in order to boost their own epistemological position.

Furthermore, American *HOPOSians*, who deal with the forgery thesis often show a degree of condescendence towards me personally and with respect to my research they would have hardly risked, if I were a member of the Anglophone community, working, say, at an American top-ranked research university.[32]

In the following, I would like to deal only with a few *HOPOSians* who succeed to create confusion from nothing like the Nothing in Ende's *Fantastica*.[33]

I would like to mention four examples[34]:

[31] I would like to mention Howard (1987) and Di Salle (1990).

[32] This is all the easier, because the book is not available for the usually monoglot American reader. An English translation of the book with Kluwer did not materialize. I have never been informed why, but I have some clues . . .

[33] Therefore, I do not deal with John Blackmore, a sharp critic of the forgery thesis. Mach research owes him much credit for his Mach biography (Blackmore 1992). The book contains an enormous amount of archival documentation. It can be regarded as the beginning of contemporary research on Mach. Blackmore's judgments about Mach and relativity are, unfortunately, completely obfuscated JESPLACwise by his epistemological fight for "representative realism" as shown in Wolters (1987) passim. The, say lively, discussion that ensued, in which Blackmore also brought into position Japanese auxiliary forces (who could not read my book, but knew that I was wrong), did not bring any new idea to the fore. – Nonetheless, I disliked a general negative remark by an American scholar about Blackmore's work at the Vienna Centenary Conference.

[34] In order to avoid useless polemics I do not give the names of HOPOSians living at the time of the conference.

One Mach researcher, who was also present at the Vienna Centenary Conference, calls my forgery thesis in a book on Mach "somewhat fanciful". Unfortunately, he does not tell us why. I guess, he has not read the book that he is slamming for whatever reason.[35] This is a fine example of how from Nothingness can arise something, *creatio ex nihilo* in *HOPOSia*.

Another fine example of this sort of *creatio ex nihilo* is an American scholar, whom I appreciate otherwise. After I had collected ample theoretical and documentary evidence for the thesis that the *Optik*-preface had been falsified and prior to the publication of my book, I talked to the British philosopher Rom Harré. Harré was immediately convinced of my findings, and commented briefly and positively about them, based on a paper of mine. Shortly afterwards our American colleague, writes in a footnote in one of his books, without even mentioning my name[36]:

> Recently it has been claimed that Mach's supposed rejection of relativity theory in the preface to the second edition of the *Optics* [there is, in fact, only a first one! G.W.] was a fabrication of his son Ludwig; see Harée 1986, pp. 15–16. Whatever the merits of this claim, it seems clear that a negative attitude toward relativity theory flows naturally from Mach's general philosophical orientation.[37]

The third American scholar that I will deal with more extensively has given JESPLAC an interesting twist: Mach's allegedly sensationalist phenomenalism bears the bad fruit of rejecting relativity; this he counts as support of his own epistemological realism. – Accordingly, he had to fight my forgery thesis, in order to defend epistemological realism. He achieved this in a very, say, innovative way:

First of all, he accuses me of „the new fashion of aggressive revisionism". "Aggressive revisionism" here obviously means outspoken criticism of somebody, who would like to give himself the aura of infallibility. *Second*, my critic complains that in my work „some of the most crucial historical documentation is absent. "Unfortunately, he does not quote even one piece of allegedly absent „crucial historical documentation". *Third,* it has been myself, who has found much of the relevant documentary material, sometimes literally on the attics. My critic now contends: „No documents seem to be available for independent study of Wolters's conjectures". If we simply dismiss the mental reservation, contained in the word "seems", the contrary is true. All those documents I had found were without any

[35] He does not seem to have read the *Optics* preface either, because in a footnote he contends: "Mach does not say he out-and-out rejects the theory. He merely says that it will form 'an aperçu' in the broader science of the future he envisions." –This is correctly quoted, but the preface says a bit more before the last sentence that contains the "aperçu": "The reason why, and the extent to which, *I discredit the present-day relativity theory* [emphasis G.W.], which I find to be growing more and more dogmatical, together with the particular reasons which have led me to such a view [. . .]" (see text of the preface above).

[36] The condescending attitude to talk about my forgery thesis without mentioning my name I found also with the late Finnish-American scholar Jaakko Hintikka (2001), p. 85 f.. – It results from what I have called "team asymmetry" between European and Anglophone universities in a recent paper on the consequences of English as *lingua franca* in academia (Wolters (2015), 192 f.)

[37] Earman (1989), fn. 16 to Ch. IV.

difficulty accessible for more than 30 years at the *Philosophisches Archiv* of the University of Konstanz, which is an institution of the archival system of the German state of *Baden Württemberg*.[38] I happen to be its founder and director and am not aware of any inquiry to study the respective holdings by our *HOPOSia*-scholar.

Fourth and finally, we find with our *HOPOSian* an impressive masterpiece of innovative dialectics: he agrees with me by attacking me. – I have emphasized and extensively documented that Mach was an old and very sick man who wanted to finish some work he had begun in his healthier days. I have at length pointed out that Mach was not a professional theoretical physicist, that he did not understand special relativity and asked for help, and was happy to be credited as one of its forerunners, particularly in his controversy with Planck. He did not understand the mathematical details of general relativity, either. Thus, in a sense, I could agree with the following conclusion of my critic: "it no longer matters *who* wrote Mach's disavowal dated July 1913. Whether he intended to accept it or to reject it, Ernst Mach would not have known at that point what relativity was about." I could agree, although Mach knew more about relativity than is insinuated here. The dialectical turn of my critic confirms in my view a remark of the great French biologist André Lwoff: „the bad thing about the profession of a researcher are the discoveries of the others".[39]

My favorite *HOPOSian* is in any case Paul Feyerabend, Mach's Viennese fellow compatriot and great admirer. When I first had told Paul about my findings in the mid-eighties and had shown him some documentation, he was enthusiastic and wrote on a postcard of May 7, 1985:

> I am eagerly awaiting to receive the complete text of the comedy thriller 'Mach and the learned world' and am anticipating pleasurable hours. (footnote: I pay for it, if necessary) Hurry up! Your opinion about the *Optik* preface is not only very plausible, it also 'saves' one of the features that I find so admirable with Mach, namely that he did not easily get baffled by the clamor of the idiots, but kept calm slightly ironically.[40]

In this sense, Feyerabend added an "Afterword" to the republication of his paper "Mach's Theory of Research and its Relation to Einstein" in his *Farewell to Reason*:

> It now appears that the foreword to the *Physikalische Optik* and the foreword to the 9th edition of the *Mechanik*, which contain passages critical of the special theory of relativity, were written by Ludwig Mach, Ernst Mach's son, and inserted without Ernst Mach's knowledge. In a word, both texts are a fake. The evidence, which is strong though circumstantial and which to me seems entirely convincing, has been assembled by Dr. Gereon Wolters of the University of Konstanz. I accept his conclusions and the interpretation he bases on them: see 'Atome und Relativitat – Was meinte Mach?', in R. Haller and E. Stadler, eds., *Ernst Mach: Leben, Werk und Wirkung*, Vienna 1986. My remarks on Mach and atomism remained untouched by these discoveries. (Feyerabend (1987), p. 218).

[38] At the end of 2015, the Konstanz material has been joined with the bulk of the Mach papers at *Deutsches Museum* in Munich.

[39] See his autobiography, Jacob (1988), p. 355.

[40] "Mit großer Spannung und in Antizipation vergnüglicher Stunden sehr ich den Empfang des *vollständigen Textes* (Fußnote: wenn nötig, zahle ich dafür) der Kriminalkomödie 'Mach und die Gelehrten'entgegen. Beeile Dich! Deine Auffassung vom Vorwort der Optik ist nicht nur sehr plausibel, sie 'rettet' auch eine der Eigenschaften, die ich beim Mach so bewundernswert finde, nämlich, dass er sich vom Geschrei der Idioten nicht leicht aus der Fassung bringen ließ, sondern eine leicht ironische Ruhe bewahrte."

A year later, in a "Zusatz 1988" to the German translation of *Farewell to Reason* Feyerabend has changed his mind:

> Gereon Wolters (*Mach I, Mach II, Einstein und die Relativitätstheorie,* Berlin/New York 1987) claims that the preface to the 9th edition of the *Mechanik* and the preface to the *Physikalische Optik*, that both contain critical remarks on relativity theory, were formulated by Ernst Mach's son Ludwig Mach without his father's knowledge. His argument rests on circumstantial evidence and has a certain persuasiveness. Mach, however, does not need a rescue of this sort. If we assume that the critical remarks are of himself – would that be really so bad? Mach wanted an encompassing theory that did not treat the psychical as separate from the physical. The more dogmatic followers of relativity wanted to pin down research on a more narrow area. Mach made a stand against this. The attempt to "save" Mach with the aid of a forgery theory takes a certain stage of physical research still too seriously to live up to Mach's own attitude.[41]

I am unable to see a connection between Mach's psychophysical theory and "the more dogmatic" (whatever that may be) positions with respect to relativity that are said to have motivated Mach's criticism. The only explanation for Feyerabend's new view on the forgery thesis that comes to my mind is that he wanted his hero Mach a bit more anarchical, a bit more Feyerabendian, as it were.

Given the general situation that I have characterized here with only four examples, we may hope that the unending story "Mach and Relativity" in *HOPOSia* will, indeed, go on. I do not think that the dangerous entry "Early philosophical interpretations of general relativity" (copyright 2012) in the "Stanford Encyclopedia of Philosophy" will change this:

> Finally there was, for Einstein, an understandable awkwardness in learning of Mach's surprising disavowal of any role as forerunner to relativity theory in the Preface, dated 1913, to his posthumous book (1921) on physical optics, published by Mach's son Ludwig. Though Einstein died without knowing differently, a recent investigation has built a strong case that this statement was forged after Mach's death by his son Ludwig, under the influence of a rival guardian of Mach's legacy and opponent of relativity theory, the philosopher Hugo Dingler (Wolters, 1987).[42]

Notwithstanding this "strong case"-assessment of my forgery thesis, I am rather confident and see no indication whatsoever that our story in *HOPOSia* will end any

[41] "Gereon Wolters [. . .] behauptet, dass das Vorwort zur 9. Auflage der *Mechanik* und das Vorwort zur *Physikalischen Optik*, die beide kritische Bemerkungen zur Relativitätstheorie enthalten, von Ludwig Mach, Ernst Machs Sohn, ohne dessen Wissen formuliert wurden. Sein Argument beruht auf Indizien und hat eine gewisse Überzeugungskraft. Doch hat Mach eine Rettung dieser Art nicht nötig. Nehmen wir an, die kritischen Bemerkungen stammten von ihm – wäre das wirklich so schlimm? Mach wollte eine umfassende Theorie, die das Psychische nicht als vom Physischen getrennt behandelt. Die dogmatischeren Anhänger der Relativität wollten die Forschung auf einen engeren Bereich festnageln – dem widersetzte sich Mach." (Feyerabend (1987), German ed. 311).

[42] Ryckman (2014).

time soon. I could imagine that it would do so in a world with Chinese as the *lingua franca,* say a 100 years from now. I see an ambitious postdoc from the Chinese Academy of Science, who happens to know this exotic and dying language German and who is interested in the prehistory of relativity. She thinks that it would be a good idea to have a look at the papers the *Deutsches Museum* in Munich and has the equally brilliant idea to connect this short research stay with visiting the *Oktoberfest* in late September 2116. There she hits one morning, still a bit dizzy from the evening before in the *Paulaner-Bierzelt* but wide-awake, on all the material that I have found. It had rested there for more than a century without anybody ever looking at it. She suddenly gets thrilled and convinces herself that the *Optik*-preface had been forged. She prolongs her stay in Munich beyond the *Oktoberfest* and starts writing a book (in Chinese, of course) that documents this thesis. The book becomes a world-wide success. It is even translated in English to reach those last old school *HOPOSians,* who have not managed to read Chinese.

Such a scenario in *HOPOSia*, however, seems even more fantastic than everything in Michael Ende's *Fantastica*. So, our neverending story about Mach and relativity theory will go on in *HOPOSia*.

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Editorial

Ernst Mach (1838–1916) ranks among the most significant natural scientists and philosophers of the nineteenth and twentieth centuries. In physics, he paved the way for Einstein's theory of relativity and was sceptical about Boltzmann's atomism; in biology, psychology, and physiology, he pioneered with an empiricist and "gestalthaft" "Analysis of Sensations"; in philosophy of science, he served as a model for the Vienna Circle with the Ernst Mach Society, as well as initiated an integrated history and theory of science. His influence extends far beyond the natural sciences—to the Vienna Medical School and psychoanalysis (R. Bárány, J. Breuer, S. Freud), to literature ("Jung Wien," R. Musil), to politics (F. Adler, Austro-Marxism and the Viennese adult education), to arts between futurism and minimal art, as well as to social sciences between the liberal school (J. Schumpeter, F. A. von Hayek) and empirical social research (P. Lazarsfeld and M. Jahoda). In today's pedagogy, his genetic theory of learning is just as respected as his method in historical epistemology. Mach's international impact already showed during his lifetime, in American pragmatism (W. James) and French conventionalism (P. Duhem, H. Poincaré). In 2016, on the occasion of the centenary of Ernst Mach's death, the Institute Vienna Circle organized an international conference on the life, work, and influence of this scientist and philosopher, who worked at the University of Vienna and the Austrian Academy of Sciences for many years and who exerted significant influence on several generations of scholars and scientists, as well as of cultural and political agents. The main goal was to make a critical inventory of Mach's lifework in line with state-of-the-art research and historiography.

The Ernst Mach Centenary Conference, June 15–18, 2016, was organized by the Institute Vienna Circle, University of Vienna, and the Austrian Academy of Sciences. This was certainly the biggest international conference dealing with the life, work, and influence of one of the most fascinating men, as a scholar and scientist with impacts up to the present.

We were pleased to have received an enormous amount of submissions from all over the world, from which the Program Committee chose some 60 papers, so that in addition to the invited speakers there was a presentation of nearly 90 papers in four parallel sessions, including three plenary lectures. A selection of