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Giuseppe Castagnetti, Hubert Goenner, Jürgen Renn,
Tilman Sauer, and Britta Scheideler

Foundation in Disarray: Essays on Einstein's Science and Politics in the Berlin Years

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PREFACE

This collection of essays is based on a series of talks given at the *Boston Colloquium for Philosophy of Science*, March 3 – 4, 1997, under the title "Einstein in Berlin: The First Ten Years." The meeting was organized by the *Center for Philosophy and History of Science* at *Boston University* and the *Collected Papers of Albert Einstein*, and co-sponsored by the *Max Planck Institute for the History of Science*.

Although the three essays do not directly build upon one another, we have nevertheless decided to present them in a single preprint for two reasons. First, they result from a project that grew out of an earlier cooperation inaugurated by the Berlin Working Group "Albert Einstein." This group was part of the research center "Development and Socialization" under the direction of Wolfgang Edelstein at the *Max Planck Institute for Human Development and Education*.[1] The Berlin Working Group, directed by Peter Damerow and Jürgen Renn, was sponsored by the Senate of Berlin. Its aim was to pursue research on Einstein in Berlin with particular attention to the relation between his science and its context. The research activities of the Working Group are now being continued at the *Max Planck Institute for the History of Science* partly, in cooperation with Michel Janssen, John Norton, and John Stachel.

Second, by presenting our contributions under a common cover we wish to express our conviction that Einstein's scientific achievements in Berlin and their intellectual, institutional, and cultural context should not be separated. Let us, therefore, briefly characterize each contribution with an emphasis on common perspectives and mutual relations. All three of the essays presented herein interpret Einstein's activities as one among other possible reactions to external challenges, be they the political crisis of the First World War, the intellectual crisis of classical physics, or the demands of a new institutional organization of science. A further common perspective is that the intellectual resources which Einstein drew upon in his reactions were deeply rooted in various nineteenth century traditions which shaped, in particular, his image of science as the lonely search for a conceptually unified understanding of nature by members of an elitist *république des savants*. In spite of his classical understanding of science, of its protagonists, as well as of its place in society, when faced with the challenges of the early twentieth century, Einstein responded quite differently in the scientific, institutional, and political realms.

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1 For a report on the activities of the working group, see Castagnetti, Damerow, Heinrich, Renn, and Sauer, "Wissenschaft zwischen Grundlagenkrise und Politik: Einstein in Berlin." Arbeitsbericht der Arbeitsstelle Albert Einstein 1991-1993, Max-Planck-Institut für Bildungsforschung (1994) [http://www.mpiwg-berlin.mpg.de/staff/tilman/arbeitsbericht_toc.html].

The first essay (“Albert Einstein in Politics – a Comparative Approach“) argues that Einstein’s active involvement on behalf of democracy, so different from the position of a majority of scientists, can only be explained if one considers Einstein’s specific understanding of democracy as well as the historical context of his membership in the social group of natural scientists. Was Einstein’s uncommon political reaction comparable to his conceptual breakthroughs in science? Was he in fact a revolutionary both in politics and science as some have argued?

In the essay it is shown that, in contrast with his scientific thought, Einstein’s political thinking and behavior was not characterized by radical breaks with respect to that of his contemporaries. Instead it is argued that, like many humanities professors and some exact scientists, Einstein’s thinking and behavior bore elitist traits and was influenced by his self-image as a ‘scientist’. But by generalizing the model of the “true scientist“ to a model of an ideal individual opposed to dominant values of the society, Einstein increasingly assumed the role of an involved intellectual. This role, with its critical distance from the dominant social and political standards, set him apart from the majority both of humanities professors and of natural scientists. Einstein’s political thinking and acting as an intellectual was, however, nevertheless largely structured by traditional ideas about the dominant role of the individual, and in particular, of the morally and intellectually “elevated“ individual in society. Thus, as an intellectual, Einstein felt that he belonged to an “elite of values,“ a position that determined his understanding of democracy. His political thinking was *not* pluralistic, in the sense that he did not acknowledge competing social groups with conflicting interests. In summary, while witnessing the contemporary disarray of the social and political foundations, Einstein remained under the spell of rather old-fashioned and naive ideas about society, and essentially denied part of the social and political reality with which he was confronted in his Berlin years.

The second essay (“The Rediscovery of General Relativity in Berlin“) addresses Einstein’s trail blazing scientific break-through during his Berlin years, the creation of general relativity in 1915. This breakthrough is interpreted as a reaction to a foundational crisis of moribund classical physics that was, at least as Einstein clearly realized, only sharpened, rather then resolved by the special theory of relativity of 1905; the conflict between Newton’s theory of gravitation and the demand by both field theory and special relativity that no physical action propagate faster than the speed of light. At first sight the task of reconstructing the complicated path which Einstein followed in founding the field equation of general relativity in 1915 confronts the historian with two main alternatives: if his difficulties were predominantly of a technical nature, the discovery of the field equation could be recounted as a comedy of errors with a brilliant beginning, some deviations, and a happy conclusion. If Einstein’s difficulties were, however, of a conceptual nature, his eventual success would have to be interpreted as a case of serendipity, as a lucky finding that cannot be accounted for by the quality of his heuristic starting point.

These two extreme alternatives, however, both fail to provide a rational account of the conceptual development from classical and special relativistic physics to the physics of general relativity. They also fail to take into account any non-trivial interaction between heuristics and formalism.

An analysis of this interaction, as evidenced in one of Einstein's research notebooks, suggests a third, alternate account of Einstein's discovery of the gravitational field equation. In the course of his work on the problem of gravitation, two distinct and complementary strategies (the "physical" and the "mathematical" strategy) emerged for the construction of suitable candidates for the differential operator entering the left hand side of a tentative gravitational field equation. These two strategies guided a mutual adaptation of Einstein's heuristics and the mathematical formalism which he explored during his search for a field equation, thus accounting for conceptual development in the case of general relativity. The creation of general relativity is thus analyzed not as a result of Einstein's creativity, but as a process of conceptual transformation in a situation of crisis. But the essay also emphasizes that Einstein's success in following his two strategies is closely linked to the fact that his heuristics aimed, from the beginning, at a conceptual integration of different knowledge traditions of classical physics.

A contemporary attempt to exploit Einstein's integrative capabilities in the conceptual realm for an organization of science is the topic of the third and concluding essay ("Directing a Kaiser Wilhelm Institute: Einstein, Organizer of Science?"). The foundation of the *Kaiser-Wilhelm-Institut für Physik* under Einstein's directorship, promoted by an influential group of Berlin physicists, administrators, and industrialists, was an attempt to take advantage, in the search for a theory of atomic physics and radiation, of Einstein's ability for conceptional integration. The creation of the institute aimed, at the same time, at an adaption of research funding both to increased differentiation within physics and to the ever more important role of Planck's quantum as a germ of crystallization of a growing field of knowledge. The essay argues, however, that Einstein, with his independent mind, his stress on intuition and on individual achievement, and with his single-handed search for conceptual unity, did not fit into such plans. As a director he had little interest in managing his institute and, when involved in science politics proper, was not very successful. The failure of the attempt to exploit Einstein's integrative capabilities in the conceptual realm for an organization of science can be interpreted as indicating a new stage in the social organization of science. In fact, the integration of knowledge from physics and chemistry that was required for the formulation of the later quantum mechanics could no longer be achieved by the intellectual work of a single outstanding individual such as Einstein.

The texts of the essays presented here differ only slightly from the lecture versions. A longer version of the essay by Jürgen Renn and Tilman Sauer under the title "Heuristics and Mathematical Representation in Einstein's Search for a Gravitational Field Equation" is available as a Preprint of the Max Planck Institute for the History of Science. It will be published in a forthcoming volume of the Einstein Studies series based on the Fourth International Conference on the History of General Relativity, Berlin 1995. Full versions of the essay by Giuseppe Castagnetti and Hubert Goenner and of the essay by Britta Scheideler and Hubert Goenner are in preparation and will also be available as Max Planck Institute preprints in the near future.

Berlin, in May 1997

Giuseppe Castagnetti
Hubert Goenner
Jürgen Renn
Tilman Sauer
Britta Scheideler

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Albert Einstein in Politics - A Comparative Approach

Britta Scheideler
Max-Planck-Institut für Wissenschaftsgeschichte, Berlin
and Hubert Goenner
Institut für Theoretische Physik, Universität Göttingen

1. Einstein - an Exceptional Democrat among Scholars?

Just as in physics the picture of Einstein in politics is one of an outstanding figure: namely that of an exceptional democrat among scholars. His active involvement on behalf of democracy, which stands in contrast to a majority of scientists, has been explained to date by his particular biography. However, this approach does not take two key issues into consideration:

1. Einstein's specific understanding of democracy, which differs from today's understanding of a liberal democracy, and

2. the historical context of Einstein's membership in a social group, namely professors of natural sciences.[1]

The political behavior of the group of humanities professors has been explained convincingly by their specific self image as a moral and intellectual elite. "As scientists they proclaimed moral and political norms [...] which should serve as a standard for the rest of society."[2] The question of whether the natural scientists saw themselves in a similar way, points to a gap in research to date in the field. Social history studies comparable to those examining the self-image of humanities professors are not available for natural scientists.[3] In this paper, therefore, we merely outline the political behavior especially of exact scientists and their interpretation of their political role. Our central question is whether Einstein's political thought and action and especially his understanding of democracy was influenced by his self image as a scientist, and whether this self image also made him a member of a moral and intellectual elite. In the first section we will provide a general orientation, while the second part is concentrated on Einstein's views and politics between 1914 and 1933.

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1 Previous scholarship on Einstein hasn't addressed these social-historical questions critically. Focussed on Einstein as an outstanding figure or as an outsider the majority of biographies does not ask for Einstein as a member of a social group sharing its values and attitudes or participating in ideologies or views widespread at that time (see Hermann 1994, Pais 1982, Seelig 1954 and also Pyenson's detailed study on the social circumstances of Einstein's youth). To a certain degree, Fölsing raises these questions in his biography.

2 Schwabe 1988, p. 16.

2 Natural Scientists and Politics

Schiller memorial day in Berlin, 1905 (Buddensieg et al. 1987, p. 222)

2.1 Politically active Scientists in Comparison

An examination of professors in the Reichstag provides a starting point for a comparison of the natural scientists with their colleagues from other faculties. Among 62 professors belonging to the Reichstag in the years 1871 to 1918, we find only 5% from the exact sciences.[4] In 1900,

3 The professors of natural sciences are not or only marginally taken into consideration in the research concerning the professorship and the educated classes in Germany (see Bildungsbürgertum, vol. 1-4, Brocke 1985, Bruch 1980 and 1982, Jansen 1992, Ringer 1983, Schwabe 1969). Their affiliation to the Bildungsbürgertum respectively to the Mandarins is silently presumed, though the knowledge of the natural sciences went beyond the scope of the canon of humanistic knowledge. This humanistic knowledge was central for the corporative socialization of the Bildungsbürgertum as well as for it's status and self-understanding as an elite of values (see Langewiesche in Bildungsbürgertum, vol. 4, pp. 95-119 and Lepsius in Bildungsbürgertum, vol. 3, pp. 8-18). It is therefore to be examined whether and to which degree the possession of humanistic knowledge determined the status, self-understanding, life-style, communication-networks, the attitudes toward modernity etc. of the professors of the natural sciences from 1890 to 1933. To answer these and further questions concerning the coherence of exact scientists as a social group and the influence of typical patterns of values and roles on their political behavior the authors have begun examining professors of physics, chemistry and mathematics in a comparative study. Such a study can draw material from papers concerning the self-understanding of biologists by Harwood 1993 and 1996 as well as from the studies by Pyenson 1983 and Forman 1967 and 1994.

their percentage of the total university professors was 10%[5], though, and would have been higher if engineering academies had been included. Between 1919 and 1924 not a single representative from the natural sciences belonged to the National Constitutive Assembly or to the Reichstag.

Another criterion for political activity of professors is their participation in associations not bound to political parties, and in political declarations, publications and manifestos. This criterion is more appropriate to the non-pluralistic understanding of politics of the majority of professors who saw themselves as guardians of the common good, in contrast to presumedly selfish interests of political parties and pressure groups.[6]

Even if such a weaker criterion for political activity is used, both exact and natural scientists in general were also less politically active than their percentage of the total number of professors would indicate.[7] In his study Döring lists 647 professors who signed more than one political declaration in the years 1914 to 1933.[8] According to our analysis, the list contains 8% exact scientists whereas, in 1931, they made up 21% of all professors. Jansen, in his study of professors at the University of Heidelberg, uses a more selective criterion: continued active political expression in the form of articles or books published.[9] In this case, the proportion of politically active natural scientists from all fields falls to zero. Thus, in comparison to his colleagues, Einstein's strong political commitment made him an exception indeed.

2.2 Political Behavior and its Reasons specific to Scientists

The lower-than-average political activity of professors from the exact sciences does not indicate political indifference. Presumably, they shared a common nationalistic and conservative position, as is confirmed by several studies.[10] Also, the central ideal of an international spirit in the natural sciences did not reduce chauvinistic sentiments but, at best, induced a greater reservedness in the 'battle of scholars' during the First World War toward their foreign colleagues.[11]

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4 See Brocke in Schwabe 1988, pp. 55-92, here pp. 72-82. The total number of exact scientists was 3.
5 See Ferber 1956, p. 197/98.
6 See Döring 1975, p. 248/49 and Schwabe 1988, p. 22.
7 Among the active members of political associations not affiliated with political parties in the German Empire ("Alldeutscher Verband", "Flottenverband", "Freie Vereinigung für Flottenverträge" or "Verband für Internationale Verständigung"), natural scientists were clearly underrepresented in comparison to their colleagues from the humanities (see Burchardt in Schwabe 1988, pp. 151-214, here p. 211/212; Chickering 1975, pp. 151-153).
8 See Döring 1975, pp. 256-272.
9 See Jansen 1992, p. 24/25, see also p. 102/103.
10 See Bayertz 1987, Forman 1973, Schroeder-Gudehus 1979.
11 See Eckert 1992, Forman 1973, Schroeder-Gudehus 1966 and 1979, Crawford 1992.

A further reason for reduced political activity is to be seen in the higher-than-average induction of natural scientists into military service[12]: military personell were forbidden to take part in political activities. Moreover, natural scientists could be satisfied with the status quo in the German Empire. Contrary to their colleagues from the humanities, they benefited from an increased prestige as a result of industrialization, which lead to a marked increase in positions for natural scientists.[13]

The feeling of political incompetence expressed by some natural scientists, due to their professional distance from politics, was a subjective but not an objective reason for reduced political involvement. Obviously, disciplinary closeness to political themes did not necessarily lead to greater political wisdom by the humanities scholars in solving concrete problems. Their willingness to express political judgements is connected to their image of science. It was formed by neo-humanism, based in particular in the humanities, and contained an urge to render science fruitful for the creation of political systems and Weltanschauungen.[14]

In contrast, an overwhelming majority of exact scientists sought to keep politics seperate from their science. As Forman showed for physicists through his examples of the debate concerning professional journals and controversies between competing professional societies, conflicts within the discipline were not settled but harmonized, if possible.[15] Physicists on the extreme right like Stark were tolerated, and bound to the very organizations they battled against.

With the exception of mathematicians, exact scientists represented scientific concepts and methods not based on neo-humanism. Thus, their interpretation of science did not imply an understanding of political roles similar to that expressed by their colleagues from the humanities.[16] However, it remains questionable whether the majority of exact scientists was content with the more modest role as experts.[17] After all, the generations up to 1890 were educated in humanistic "Gymnasium", an institution designed to instill in students the ideals of a classical education. For this reason, the physicist Voigt could acknowledge that he ascribed a high value to exact thinking in the natural sciences for the formation of personality, but that the real educational force resided in history.[18] This assumes that professors in the exact sciences understood themselves as bearers of culture, but left the role of interpretor of the political and social

12 See Jansen 1992, p. 118, Martinetz 1996, p. 145, Rasch 1991, Willstätter 1949, pp. 249-252 and Übersicht 1915. Studies on the quantitative participation of scientists in World War I are still lacking.

13 See Jansen 1992, p. 15.

14 See Ringer 1983, p. 349. Therefore only a few humanities professors as e.g. Max Weber opted for a distinction between science, politics and weltanschauung (see Weber 1992, pp. 71-111: Wissenschaft als Beruf).

15 See Forman 1967, pp. 161-201 and Richter 1973. For the exclusion of political discussions among the mathematicians in Göttingen see Behnke 1978, p. 28 and 32.

16 See Jansen 1992, p. 102/03 and Pyenson 1983.

17 See in contrast Burchardt in Schwabe 1988, pp. 151-214, here p. 213. Harwood puts the professors with a self-understanding as experts into the category of "outsiders", characterized, in contrast to the mandarins, by their distance from the self-understanding as culture-bearers due to their social origin (see Harwood 1993, p. 210).

course of affairs to their colleagues in the humanities.

We will now investigate, through several examples, what kind of self-understanding made professors from the exact sciences in the generations up to 1890 politically active, and compare it to Einstein's interpretation of his political role.

2.3 Scientists and their Interpretation of their Political Role

The case of the applied mathematician Carl Runge is an example for political activity derived from a self-understanding as a citizen. Before the First World War Runge had not much cared about politics. Only after the summoning of the National Constitutive Assembly did he feel obliged "to implement his will as a citizen. [...] As a result, he became a member of the Göttingen section of the Democratic Party."[19]

Einstein's support for democracy was not motivated by such an ideal of citizenship. On the one hand, as we shall see, his self-appreciation as a moral authority went much further than participation as a citizen. On the other hand, after 1915 he considered "belonging to a state as a business matter, comparable to dealing with a life insurance company."[20]

With the concept of "political understanding of the role as a professor" we shall characterize the self image of those professors who claimed a political leadership role as a consequence of their academic position. Such an interpretation of their role as an elite of values accredited by the state very likely remained an exception for natural scientists because of their differing concept of science. One exceptional case was the Berlin lecturer in physics, Leo Arons. He had been stripped of his right to teach at Berlin University in 1900, because he had been active as a Social Democrat. The whole faculty protested against the interference with the university's autonomy because, to their knowledge, Arons had never acted as a university teacher for 'the party of revolution'.[21] Arons himself considered his political gagging by the authorities as "a degradation of the rank of university teachers."[22] Consequently, after the revolution of 1918, in a public letter he challenged the universities, to take over a leading role as the moral and intellectual elite of the new state.[23]

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18 See Voigt 1912, p. 13. The analysis of about 30 autobiographies as well as of numerous speeches supports our view that the majority of the physicists, chemists and mathematicians born before 1890 felt obliged towards this humanistic educational ideal. See also McCormmach 1976.
19 Runge 1949, p. 171.
20 Einstein 1916a, p. 212.
21 See Fricke 1960, p. 1088.
22 Justification of Arons, quoted from Koch 1919, p. 1100.

That Einstein did not share such a political interpretation of the role as a professor becomes very clear from his reply to Arons public letter: "In this war, the professors have amply shown that, in political matters, one can learn nothing from them. On the contrary, it is imperative that they learn something, namely to shut up!"[24]

Lastly, we examine the cases of three Nobel Prize winners who derived the political understanding of their roles as natural scientists from both the presumably more exact methods of their discipline and its advantage in factual knowledge. In the knowledge obtained through the natural sciences, the chemist Wilhelm Ostwald believed he had found a 'law of nature' for the social and political domains: "energetics". He spread this "scientific Weltanschauung"[25] in articles in journals dealing with social and political matters. The physicists Philipp Lenard and Johannes Stark took on roles as political speakers, and justified this action on the basis of the more precise thinking in the exact sciences. From the outbreak of the First World War Lenard concluded that his colleagues from the humanities had failed to explain and control political developments, and he began to take on their task. He believed that he was particularly competent because "no one can look for truth more earnestly and effectively [...] than the natural scientist [Naturforscher], and it is only on truth that humanity will thrive."[26] "As a natural scientist," who only by an explanation free from contradictions "of the relation between cause and effect [...] could become successful"[27] both Lenard and Stark eventually found the missing mono-causal explanation in Hitler's racial phantasies seen as a theory. Due to their interpretation of natural science as a leading political discipline, their political agitation did not stop at the gates of the university nor among their colleagues.

For Einstein, in contrast to these scientists, principles for society were not transferable from the scientific method or body of knowledge - that would have contradicted not only his understanding of "the essentially constructive and speculative nature [...] especially of scientific thinking"[28] but also his definition of science. Einstein pointedly expressed a view that we already can observe in earlier statements, when he wrote to Solovine in 1951: "What we call science has the exclusive goal of determining what *is*. The determination of *what ought to be* is something different, and not achieveable through [scientific] methodology."[29] In Einstein's eyes, the methodology of the natural sciences only applies to the laws of ethics to the extent that further

23 See Vossische Zeitung, 12 November 1918: Abendblatt. Reprinted in Arons 1918, p. 5/6. See on Arons'es conviction that "the universities should take over the leadership", also p. 10 and 14. While Einstein praised Arons as one of the few academics uninfluenced by the "prejudices of his caste" (Einstein 1919, p. 1055), Max Schippel saw in Aron's "unwavering trust" in the leadershiprole of the universities in fact "a touch of pleasant ideology and bias" (Schippel 1919, p. 1058).

24 Arons 1918, p. 3. See for Einstein as the author of this letter: Borchardt 1930.

25 Ostwald 1927, p. 226.

26 Lenard 1943, p. 79.

27 Lenard 1943, p. 6. See also Stark 1930.

28 Einstein 1979, p. 21. See also Einstein 1916b, p. 279.

ethical rules could be logically derived from ethical premises.[30]

Nonetheless, Einstein's understanding of his role in politics and society was closely tied to his self image as a scientist. His letter to the physicist Hans Thirring in May 1933 makes that clear:

> The representatives of science fail in their duty to defend moral and intellectual values because they have completely lost their passionate love of them - the mentality of Giordano Bruno. This is the only reason why individuals of base and inferior nature have been able to seize power [...].[31]

With this statement, Einstein accorded scientists a significant influence over political events. The scientists' failure to act properly made the takeover by the National Socialists possible. Einstein thus did not draw scientists' political role from their methodology or their knowledge, but from a mentality specific to scientists.

In the following, we examine the connection between Einstein's political involvement and his understanding of a 'true scientist.' When we use Einstein's later term "wissenschaftlicher Mensch"[32], translated as 'true scientist', we want to express his conception of a scientist who lives for his science and has internalized the values it propagates.

3 Science and Society: Einstein's "True Scientist" as Universal Ideal

In his speech on the occasion of Max Planck's 60th birthday in 1918, Einstein characterized 'science' as an autonomous field, independent from social and political goals.[33] He laid out two motives defining a 'true scientist', both of which included a rejection of society. Paraphrasing Schopenhauer, Einstein saw the first reason in a "flight from everyday life with its [...] hopeless dreariness, from the fetters of one's own ever shifting desires."[34] The second motive is a creation of a simplified picture of the world permitting an overview, in order to overcome "the world of personal experience."[35]

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29 Einstein 1956, p. 104. The view that science does not provide principles for society or ethics is already, though more implicitly expressed in Einstein's article “Religion and Science“ from 1930 (see Einstein 1954, p. 39; see also p. 12 and 40).

30 Einstein 1984, p. 53-55: Die Gesetze der Naturwissenschaft und die Gesetze der Ethik (1950). See in contrast Holton 1986, p. 78.

31 Nathan and Norden 1975, p. 235. Since Nathan and Norden 1968, sometimes omit passages, we translate from the later german edition Nathan and Norden 1975.

32 See Einstein to Max von Laue, 26 May 1933, Nathan and Norden 1975, p. 234 and Einstein 1984, pp. 56-59.

33 See Einstein 1954, p. 224: "Many take to science out of a joyful sense of superior intellectual power [...], many others are to be found in the temple [of science] who have offered the products of their brains on this altar for purely utilitarian purposes. Were an angel of the Lord to come and drive all the people belonging to these two categories out of the temple, [...] there would still be some men [...] left inside. Our Planck is one of them, and that is why we love him."

34 Einstein 1934, p. 108. As the english translation of Mein Weltbild and other sources by Sonja Bargmann (Einstein 1954) is often not literal we translate in the following from the german original.

Max Planck and Albert Einstein, 1929
(Hermann 1979, p. 62; © Ullstein)

Einstein's further comments are also borrowed from the philosophers Schopenhauer and Spinoza. The scientist, as the artist, by observing and conceiving of the objective world, in its manifest reason and harmony, frees himself by overcoming his will, his passions and his urges. He elevates himself through his pursuit of the truth above "the shackles of selfish desire"[36] and experiences a pantheistic religious feeling. Einstein later described this religious experience as "cosmic religiosity," only to be experienced by "individuals of exceptional endowments, and exceptionally high-minded communities."[37] Einstein's ideas of an international republic of scholars[38] can be understood as such a community, held together by the necessity of international cooperation, common efforts to achieve greater insight, and an intellectual and emotional bond through 'cosmic religiosity'.

Although freedom from selfishness is connected to the recognition of something greater than oneself in autonomous science and art, Einstein made the 'true scientist' his universal ideal: "The true value of a human being is determined primarily by the measure [...] in which he has attained liberation from the self."[39] Einstein's image of society is based on this ideal.

4 Einstein's Image of Society

Our presentation of Einstein's image of society is the result of an analysis of the available sources up to 1933 according to leitmotives. Although, or perhaps because, Einstein himself did not reflect upon his socio-political views and their internal logic, certain basic, constant values and

35 Einstein 1934, p. 108.
36 Einstein 1934, p. 18.
37 Einstein 1934, p. 16.
38 See Einstein 1934, p. 19.
39 Einstein 1934, p. 10.

modes of his thinking can be recognized. The model of the true scientist corresponds to Einstein's late-idealistic, ideal individual, that is determined by "kindness, beauty and truth."[40] This ideal assumes that selfishness and lust will be overcome. Freedom from these passions allows the individual to develop into the moral and "independent-minded person" Einstein's model society is based on:

> It can easily be seen that all the valuable achievements, material, spiritual, and moral, which we receive from society have been brought about [...] by creative individuals. [...] The health of society thus depends quite as much on the independence of the individuals composing it as on their close social cohesion.[41]

Since the ideal individual that Einstein's model society is based on embodies "selfless, responsible dedication to the service of the community"[42], the association of such people can only lead to a homogenous, harmonious society. Through this fixation on the selfless, moral individual, conflicts of interest and the necessity for an institutionalized balancing of interests do not come into play. Einstein's ideal individual therefore forms the element joining his image of society, state and politics. His "political statement" in 1931 thus went: "I believe the most important mission of the state is to protect the individual and make it possible for him to develop into a creative personality."[43]

As Jürgen Renn and Tilman Sauer have shown through the example of the conflict between the classical theory of gravitation and the special theory of relativity, Einstein integrated different areas of physics in a new theory without doing away with basic principles of these areas.[44] His image of society, in contrast, does not integrate but actually negates existing groups and their different interests through his reduction of society to the moral individual.

This negation of competing social groups shows Einstein's conception of society and state to be non-pluralistic. We will examine how this conception influenced Einstein's understanding of democracy by following his political development until 1933.

From Einstein's fixation on the selfless individual his belief followed "that the fate of a community is primarily determined by the level of its moral standards."[45] He assumed, however, that not everyone was able to achieve the necessary moral level. While the true scientist is able to achieve freedom from the egoistic will and selfish desires, the average man, as Einstein cited Schopenhauer, "can do what he wants, but not want what he wants."[46] Therefore, a self-deter-

40 Einstein 1934, p. 8.
41 Einstein 1934, p. 11/12.
42 Einstein's speech, 25 January 1932, Nathan and Norden 1975, p. 178.
43 Einstein's article in The New York Times, 22 November 1931, Nathan and Norden 1975, p. 167.
44 See their contribution in this volume.
45 Einstein to Thomas Mann, 29 April 1933, Nathan and Norden 1975, p. 237.
46 Einstein 1934, p. 7.

mined, moral minority had to be opposed to the majority of people, which were slaves to their desires, urges and passions. This dichotomy is expressed by Einstein in 1926:

> The rude masses are driven by dark passions that dominate both them and the governments which represent them. [...] Those few who do not share in the coarse emotions of the masses and who, unaffected by such passions, cling to the ideal of brotherly love" form "the community of those who seek to abolish war as the first step toward the moral regeneration of mankind.[47]

5 Einstein as universal intellectual

Einstein's claim to a moral leadership for 'true scientists' and artists thus resulted from this distinction between the masses, driven by primitive urges, and the minority able to determine its will independently. As is evident from his numerous appeals for peace, justice, truth or the dignity of mankind, he took over a role as public advocate for the social implementation of his ideal individual derived from his conception of the true scientist.[48]

Through this universalization of ideals and values, valid in the autonomous sphere of science, Einstein meets the criteria established by the sociologist Bourdieu for universal intellectuals. These intellectuals are further defined by the practice of appealing to the values associated with their autonomous field, such as moral power, unselfishness, reason and truth to become involved in political activity and "exercise a type of moral authority."[49]

Thus Einstein as an intellectual belonged to an elite of values. This self-understanding was connected to his self-image as a natural scientist. By deriving a universal ideal of the individual from his ideal of the true scientist, Einstein yet did not act as a natural scientist, but as the representative and advocate of values, valid independently from natural sciences. This makes the difference between Einstein and those natural scientists mentioned before, whose elitist self-image and political behavior were based on the knowledge or the methodology of natural science. With respect to the humanities professors who derived universal values from their neohumanistic ideal of personal formation Einstein differed to the extent that he tried to replace the dominant patterns by his values. A majority of the academic establishment did not question

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47 Einstein’s contribution to the "Book of Friends" dedicated to the novelist Romain Rolland, Nathan and Norden 1975, p. 97/98.

48 Fölsing is right to say that Einstein could not have been urged into the role as a public person without his willingness (see Fölsing 1993, p. 516).

49 Bourdieu 1991, p. 46. See also pp. 42-51. According to Lepsius, intellectuals, in criticizing society, make use of values about which a certain social consent prevails. Typically, writers, publicists and scientists develop into critically minded intellectuals because they professionally are busy “with the social transfer of abstract conceptions of values“, and also because of their easy access to public media (Lepsius 1964, p. 87-89).

dominating social and political standards as long as they guaranteed the social status of this group.

5.1 Einstein's development to an intellectual

Einstein in Aarau, 1896
(Seelig 1954, p. 16)

What was the reason for Einstein generalizing his ideal of the true scientist to a universal concept of the individual which he turned against the dominant social and political values? The reason is to be seen in his critical distance to the society of the time. From childhood on, he felt alienated from the militarism and subservience of Wilhelmine Germany. His status as an outsider was also determined by the precarious economic and social status of his parents, whose electrotechnical business was always on the brink of failure. As the son in a liberal, Jewish family he belonged to a discriminated minority. Their efforts at assimilation caused significant internal conflicts of values for Einstein between the Jewish religion, enlightened liberal traditions, and an authoritarian pressure to conform. He found this conflict very disturbing, as his radical rejection of all forms of prescribed authority after a brief-but-intense religious phase makes clear.

In addition, he had not completely attended all the institutions of socialization Wilhelmine Germany used to ingrain the values of the time: college preparatory school, the university, and the military. He emigrated to liberal Switzerland when he was 16, which possessed a democratic constitution that corresponded to his ideal of self-determination and his rejection of authority. Also the relevant local contexts, as for example his experiences in liberal Aarau Cantonalschool and his being influenced by his teacher Winteler, must be taken into account.

Einstein's heritage and socialization, as well as the resulting conflicts and possibilities for comparison led him to play an active role in replacing the given political and social ideals. This path separated him from most colleagues, who shared his scientific ideals but fell back on the familiar social and political conceptions mostly of a nationalist, conservative order.

Max von Laue, 1904 (Hermann 1979, p. 46)

His critical distance to the society of the time and its dominant values also separated Einstein from the majority of those educated in the humanistic tradition. They certainly shared his late-idealistic conception of the ideal individual, and his high regard for Goethe and Kant as intellectual and moral authorities. Einstein's opposition of the "rough masses" to the "spiritually and morally elevated"[50] humans was typical of the educated middle classes as well.[51] It was unusual, however, that he employed his ideal of the individual to advocate justice and democracy, and criticize militarism, in society as a whole. The majority of Bildungbürgertum, that is the educated middle-class in the Kaiserreich, in contrast, supported an authoritarian state which guaranteed their social status, but did not embody their cultural ideals. These anti-democratic tendencies also determined to a large extent the educated elite's attitude toward the Weimar Republic.[52]

We may assume that Einstein's success as a 'rebel' in physics strengthened his role as an outsider with a critical distance to the dominating values in society upheld by all those defending the status quo.

5.2 Einstein's contact to the intellectuals' movement

In his role as an outsider Einstein was backed by most authors, artists and publicists that the physicist came in contact with during and after the war. They shared his critical distance to the dominant values and further agreed on an essential pacifist stance, on concentrating on the individual, and on claiming a leading role in society because they provided a moral orientation. Before 1933, Einstein corresponded, or was acquainted, with - among others - Alfred Döblin, Wilhelm Herzog, Alfred Kerr, Käthe Kollwitz, Heinrich Mann, Erich Mühsam, Carl von Ossietzky, Ernst Toller, Arnold and Stefan Zweig or Henri Barbusse and Romain Rolland.

These prominent individuals were considered prototypical 'left-wing intellectuals' already in the 1920's, and Heinrich Mann was nearly a moral institution. In 1910, he had called the "men of spirit and intellect" to action, saying they were obliged by the "spirit [Geist], to protect the dignity of man."[53] This concept of intellectuality and spirituality, expressed in the term 'Geist', entailed not only intellectual capacity, but also the moral authority to represent universal values. In Rolland's 1919 manifesto, "Intellectual workers, Comrades," Einstein and the other signato-

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50 Einstein's press release, 23 May 1932, Nathan and Norden 1975, p. 185. For Einstein’s conviction that there were significant qualitative differences among people see also his letter to a young man in Prague, 4 November 1931, Einstein 1989, p. 84: “In principle I would not be opposed to killing individuals who are worthless or dangerous in that sense [for the protection of society]. [...] What I value in life is quality rather than quantity, just as in Nature the overall principles represent a higher reality than does the single object.“

51 Already around 1900 plans for an alternative society had been discussed by the Bildungsbürgertum in order to defend the leadership claim in society of the educated against the demands of a democratic and pluralistic society. In this way 'power of the best' and 'aristocracy of intellectuals' became key-words in the prewar discourse of the Bildungsbürgertum (see Bruch 1989, p. 83/84).

52 See Faulenbach in Schwabe 1988, pp. 225-246, here p. 245, Sontheimer in Schwabe 1988, pp. 215-224 and Ringer 1983, pp. 186-207.

53 Mann 1960, pp. 7-14: Geist und Tat (1910), here p. 13.

ries appealed to the "Servants of the mind. [...] Truth only do we honor; truth that knows nought of the prejudices of race or caste."[54]

The implementation of these values, which, according to H. Mann and Rolland, demanded a democratic and socialist society, was expected to take place through the moral instruction of the individual by the intellectuals. H. Mann therefore believed in the essential role of the intellectual as the "leader of every democracy", since he provided a model of "what was true, just, [...] of what the eternal ideal individual is."[55]

The intellectual movement "Activism," organized in 1914 by Kurt Hiller, Alfred Wolfenstein and Rudolf Kayser, who was to become Einstein's son-in-law, took this moral claim to leadership one step further in calling for a political "rulership of the moral and spiritual [geistigen] humans".[56]

The role of the committed intellectual that Einstein adopted led to a conflict with his self image as a true scientist, driven to the autonomous sphere of science as an escape from the mundane. In the next section, we will explore Einstein's political thought and activity between 1914 and 1933 in the light of following questions:

- How did the conflict between his roles as a scientist aloof from society and as a politically involved intellectual influence Einstein's behavior in the social and scientific spheres?

- How did Einstein react to experiences that contradicted his ideals?

- How did the fixation on the moral individual influence his political thinking and behavior?

- How do Einstein's non-pluralistic opinions and his belief in a leadership role of the intellectuals relate to his engagement for democracy?

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54 Nathan and Norden 1975, p. 49-51. In Einstein's case too the equivalization of spirit and morality is striking. In his 1932 contribution for Barbusse’s journal *Monde* he admonished that "those whose obligation it is to guard our spiritual heritage [...] stand idly by watching our moral impoverishment" (Nathan and Norden 1975, p. 196). See also on the equivalization as well as on the substitution of the term 'intellectual' by 'Geistiger', Bering 1982, pp. 308-319.

55 Mann 1960, pp. 526-541: Schmutz und Schund (1926), here p. 540 and Mann 1928, p. 144.

56 Hiller 1918, p. 82. See also p. 112/113 and Kayser 1917/18, p. 78. The movement “Activism“ during the war became the main melting pot of pacifist literary activity and of the oppositional currents in the middle-classes (see Koester 1977, p. 345 and Habereder 1981, p. 57). With Hans Blüher and Gustav Wyneken large parts of the youth-movement joined the "Bund zum Ziel", as the association was officially called since mid-1917. Further collaborators to the publications of the union were among others Walter Benjamin, Max Brod, Richard Coudenhove-Kalergi, Otto Flake, Hellmut von Gerlach, Alfred Kerr, Magnus Hirschfeld, Arthur Holitscher, Karl Korsch, Heinrich Mann, Leonard Nelson, Carl v. Ossietzky, René Schickele, Hugo Sinzheimer and Helene Stöcker (see Hiller1969, p. 98 and 107).

6 Einstein's politics between 1914 and 1933

The outbreak of the First World War brought about two experiences that shook Einstein's core beliefs. First, the war contradicted his pacifism and his belief in the right of individual self-determination. Secondly, the "battle of scholars," waged with slanderous attacks as well as nationalistic texts and appeals, was incompatible with his ideal of the moral true scientist and an international republic of scholars.

How Einstein reacted to these experiences contradicting his ideals we will show for the social and the scientific sphere. An example for his reaction in the social realm is his 1915 written article "My Opinion about the War".[57] Here Einstein held the destructive urges of man and the subservience and patriotism promoted in schools responsible for the war he opposed. His appeal urged the people to prevent further wars by rejecting greed and replacing patriotism with cultural values, and was thus based on his ideal of the individual. Einstein also joined the pacifist "League for a New Fatherland" in 1915, a group that in 1918 established as its central goal the development of the individual "on the basis of a truly intellectual and moral culture."[58] The League specified that the achievement of this ideal take place in a socialist republic and through a policy of peaceful coexistence.

From Einstein's reactions in the social realm conclusions can be drawn giving answers to our leading questions. 1. In spite of contradictory experiences he did not give up his ideal of the moral individual. 2. His fixation on the individual determined indeed his political thought and action and 3. his behavior in the social sphere was determined by his role as an intellectual. This becomes clear from his commitment to universal values, instead of a withdrawal in silent opposition.

Einstein's reactions to the "battle of scholars" showed the tension created by his role of an involved intellectual and his self image of a scientist aloof to society. Einstein's colleagues such as Fritz Haber or Max Planck were among the signatories of the October 1914 appeal "To the Civilized World!" which justified the war and "German militarism" through its defense of German culture.[59] The physician Nicolai and Einstein wrote the counter to this piece in 1914, entitled "Appeal to the Europeans," which urged scholars and artists to support a "common world culture" forbidding nationalistic passions.[60] Einstein's ideal of the 'true scientist' was dealt a severe blow by the fact that only two scientists signed the pacifist appeal.

The disappointment Einstein felt and his emotional ties to the community that shared his 'cos-

57 Einstein 1916a.
58 Zuelzer 1981, p. 252.

mic religiosity' are clear in a 1915 letter to the physicist Ehrenfest: "Is not that small group of scholars and intellectuals the only 'fatherland' which is worthy of serious concern to people like ourselves? Should their convictions be determined only by the accident of frontiers?"[61] Although these fears turned out to be true, Einstein stuck by his ideal of the true scientist removed from society.

His explanations for the nationalistic behavior of the scientists seems like an effort to maintain his ideal at any cost. He blamed their failures on the influence of propaganda, and emphasized in 1922 that "the attitude of the individual is everywhere far superior to official pronouncements".[62] Einstein therefore tried to protect scientists from social and political influence by recreating the international republic of scholars as an autonomous, apolitical entity. The scholar's interaction with the society-at-large should be limited to the scientists' and artists' preparation of the proper climate for reconciliation between peoples, through their "creative work, lifting man above personal and selfish national goals".[63] Politics as such were expressly prohibited. Einstein's "conviction that politics should not be allowed to impinge upon scientific endeavors"[64] showed him to be typical of other natural scientists in this respect.

To experiences contradicting his ideal of the 'true scientist' Einstein reacted in the scientific like in the social realm: he did not give up his ideal. In contrast to his reaction in the social realm, in his professional field Einstein did not take a strong position for his universal values: this would have required, for example, a pronounced stand against the cooperation of scientists in the gas warfare. By this neglect of social and political questions within science, his self-image as a 'true scientist' aloof from society becomes obvious, a position contradicting his role as an involved intellectual. Einstein's conception of the 'true scientist' makes it understandable why he did not extend his public involvement on behalf of democracy to agitation among scientists.

Just a few days after the end of the war and the November Revolution of 1918, Einstein gave a speech before the League for a New Fatherland that provides insight into his understanding of

59 The manifesto is reprinted in Wehberg 1920, p. 16/17. Shocked by the disintegration of the intellectual republic of scholars, Planck in 1915/16 tried to look towards a limiting of the damage done. He set himself into a slight distance from the manifesto in a letter to the Dutch physicist Lorentz aimed at publication. Unfortunately, Planck’s view expressed in this letter: "that there are domains of intellectual and moral life that lie beyond the struggles of nations, and that honorable cooperation in the cultivation of these international cultural values [...] [is] indeed compatible with ardent love and energetic work for one’s own country“ had already been proved wrong by two years of war (Max Planck to Hendrik A. Lorentz, published 12 April 1916 in the Rotterdam "Handelsblad", reprinted in Heilbron 1986, p. 78).

60 Nathan and Norden 1975, p. 22/23. For details on the appeal see Goenner and Castagnetti 1996, p. 8/9.

61 Einstein to Paul Ehrenfest, 23 August 1915, Nathan and Norden 1975, p. 30.

62 Nathan and Norden 1975, p. 78/79. See also Einstein to Hendrik A. Lorentz, 21 September 1919, Nathan and Norden 1975, p. 53.

63 Einstein’s contribution for the Club for the Cultivation of Social and Scientific Relations in New York, September 1920, Nathan/Norden 1975, p. 60.

64 Einstein to Hendrik A. Lorentz, 16 August 1923, Nathan and Norden 1975, p. 82.

democracy. The two basic pre-requisites for a functioning democracy are "the belief in the sound judgement and will of the people and the willing submission"[65] to this will. At this point, the question becomes why this belief in a sound will of the people, that Einstein himself could scarcely share, was so important. As early as 1915, Einstein summed up his observation that the common man is easily manipulated in the quotation "vox populi, vox Rindvieh"[66], that is vote of a sheep. It seems that Einstein postulated a sound will of the people because a subordination to the will of the majority, which might contradict his universal values, was unacceptable. In his desire to ingrain such a sound will in the people, Einstein's harmonious conception of society is reflected, in which moral individuals work for the good of the whole. There is just no room for competing social groups with differing interests and values.

An essential character of liberal democracy is pluralism, that is the recognition of competing social groups with different values and interests.[67] Einstein's non-pluralistic understanding of democracy became clear in the economic, political and social crises from 1919 on. Bitter over the failure of his ideal of a harmonious society, rather than of a "sound will of the people," Einstein now spoke of "base mobs"[68], easily molded by the press and the schools into "unresisting tools"[69] of interest groups. These groups appear in Einstein's writings only in a negative light, as "commercial and political interests" that "systematically corrupt the sound common sense of the people."[70] Conflicts of interest are not recognized as legitimate and directed to the proper forums for solution, but morally decried.

Einstein also condemned politics based on different interests. He did not discuss the function of parties or the parliament at any point in his writings. Moreover in 1930 he thought it "necessary [...] that one man should do the thinking and directing and generally bear the responsibility" in a democracy. He went on to say "but the led [...] must be able to choose their leader."[71] His suggestion that the President of Czechoslovakia be awarded the Nobel Prize in 1921 for "never sacrificing his noble convictions to the success of Realpolitik"[72] reveals his understanding of politics as the implementation of ethical goals.

Einstein's fixation on the moral individual corresponded to his suggestions for solving social problems by educating and ennobling mankind[73] through the arts and the occupation with sci-

65 Nathan and Norden 1975, p. 44. Very likely this speech was not given before students in the Reichstag, as Nathan and Norden suppose, but in the meeting of the League for a New Fatherland on November 13, 1918. In a report concerning this meeting a speech of Einstein is mentioned and which agrees with its contents (see Berliner Tageblatt und Handels-Zeitung 47, no. 583 (14 November 1918), p. 3: “Eine Versammlung des Bundes ‘Neues Vaterland’“).

66 Einstein to Hendrik A. Lorentz, 2 August 1915, Nathan and Norden 1975, p. 30.

67 See Fuchs 1988 and Steffani 1969.

68 Einstein to Marie Curie, 25 December 1923, Nathan and Norden 1975, p. 83.

69 Einstein to Sigmund Freud, 30 July 1932, Nathan and Norden 1975, p. 206.

70 Einstein 1934, p. 9.

71 Einstein 1934, p. 8/9.

ence. He was active in the Commission for Intellectual Cooperation to improve primary and secondary education, and even appeared at meetings for adult education as a speaker. For Einstein the education of the individual took precedence over the alteration of social and political structures. In 1932, he wrote to Maxim Gorki: "May your work continue to ennoble men, whatever form their political organization may take. Destiny will always be decided by what the individual feels, wills and does."[74] Thus, Einstein primarily evaluate economic, social and political structures on how well they allowed the development of the idealized individual.

In 1930, with the threat to democracy from totalitarian ideologies already rising, Einstein traced the "present manifestations of decadence" back to the fact that technical and economic progress had lead to a more intense battle for survival and loss of autonomy, limiting the individual's development.

> Organization has to some extent taken the place [in technology, science and the arts] of charismatic personalities [Führernaturen]. [...] In politics not only are leaders lacking, but the independence of spirit and the sense of justice of the citizen have to a great extent declined.[75]

Einstein's suggestion for a solution consisted in a well-planned division of labor, so that enough leisure remained for the individual to improve himself. His assumption that the specialization in the society and the degree of organization achieved can be easily turned around and that each individual will use its leisure to improve himself could be questioned though.[76]

The theoretical physicist Einstein accepted specialization just as little in physics.[77] He insisted on an "understanding of science as a whole"[78] that allowed an image of the world and a fruitful

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72 Einstein to Nobel-Komitee, 19 January 1921, Nathan and Norden 1975, p. 60. From this quotation, one may be tempted to use the terminology of Max Weber and call Einstein a representative of a policy of “Gesinnungsethik“. In contrast to “Verantwortungsethik“ it aims at a political realization of ethical values without taking into account both the imperfectness of men and the consequences of political actions (see Weber 1992, p. 237/38). In his letter to Willem de Sitter, 5 April 1933, Einstein, however, stresses the responsibility of those active politically when supporting the view "that political leaders must all really be pathological because a normal person would not be able to bear so tremendous a responsibility while being so little able to foresee the consequences of his decisions and acts“ (Einstein 1989, p. 55). This letter and Einstein’s remarks concerning corruption by power (see Einstein to Kurt Hiller, 9 September 1918, Nathan and Norden 1975, p. 42) lead us to assume that he was held back from accepting direct political functions because of such a responsibility, and because of the endangering of his ethical convictions due to political acting “that uses violent means and is based upon a concept of Verantwortungsethik“ (Weber 1992, p. 248).

73 See Einstein 1934, p. 14.

74 Nathan and Norden 1975, p. 221.

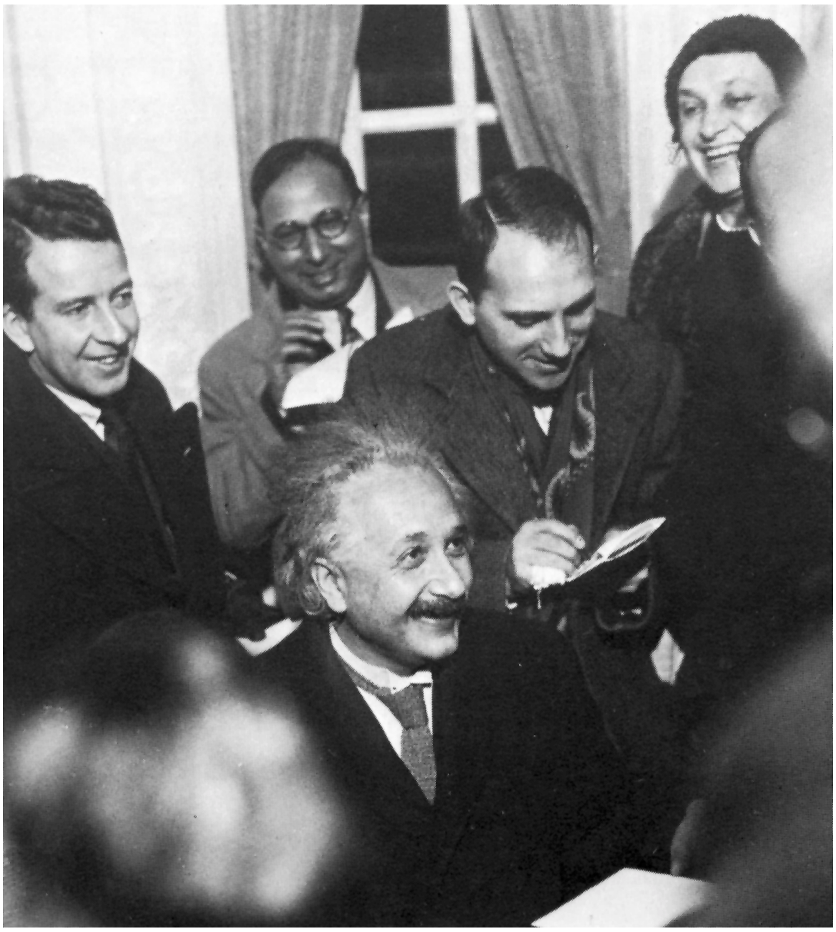
75 Einstein 1934, p. 12.

76 Einstein’s refusal to acknowledge developments which did not allow for regression becomes clear from his remarks about modern arts. Although he recognized that the idea of an education of mankind through the arts had become incompatible with modern arts, he did not give up this idea, but complained that “painting and music have definitely degenerated and largely lost their popular appeal“ (Einstein 1954, p. 14). His attitudes toward specialization in society and modern currents in the arts shows Einstein to be participating in the widespread culture-criticism in the Weimar Republic.

77 See the contribution by Giuseppe Castagnetti and Hubert Goenner in this volume.

78 Einstein 1934, p. 33.

development of the individual. He therefore condemned specialization, "which degrades the researcher to the level of a common skilled laborer."[79]



Einstein in New York, 1930
(Hermann 1979, p. 9; © Bettmann Archive, New York)

From 1928 on, Einstein's involvement changed to a stronger emphasis of the educational and leadership claims by the intellectuals. He no longer expected solutions to the most pressing issues, such as disarmament, from the long-term success of his ideal individual, but from enlightenment and mobilization of the broader public. Einstein's faith in democratically-elected governments appears to have been meager, since he held the rulers to be both representatives of a people captured by past traditions[80] and deeply corrupted through their access to power[81].

He transferred the task of enlightening the public to the "intellectual leaders of the world"[82],

79 Einstein 1934, p. 33.
80 See Einstein to the Women's International League for Peace and Freedom, 3 July 1930, Nathan and Norden 1975, p. 124.
81 See Einstein to J. Hadamard, 24 September 1929, Nathan and Norden 1975, p. 118: "We cannot afford to wait until the governing classes in the various countries decide voluntarily to accept interference with the sovereign power of their nation. Their lust for power will prevent them from doing so."

and suggested a "radical pacifist association of renowned authors, artists and scholars"[83] to be headed by the physicist Langevin. Einstein's emphasis in the roles to be played by artists and scholars thus changed from indirect ennoblement to direct moral and political involvement. The experience that, in society, it is not moral individuals but competing interest-groups and organizations who are leading, did not make Einstein question his image of society. His fixation on the selfless individual remained and only his patterns of action changed in that the morally advanced individuals should take over leadership and the education of the masses. Einstein's letter to Freud from the beginning of the thirties illustrates both his self image as a member of an elite that propagated universally-valid values and his non-pluralistic understanding of democracy:

> Political leaders or governments owe their power partly to the use of violence, and partly to their election by the masses. They can not be considered representatives of the intellectually and morally superior part of the nation. The intellectual [geistige] elite does not exert any direct influence on the history of the world today[...].[84]

This situation was to be changed through an international "association of intellectuals" which should "gain a significant and wholesome moral influence on the solution of political problems"[85] by taking the proper positions in the press.

With the failure of the Weimar Republic, the idea of an 'elite rule' gained ground in left-leaning circles. The "Weimarer Kreis" of pro-republic professors such as Alfred Weber, Lujo Brentano or Friedrich Meinecke, developed the concept of a "Führerdemokratie." The 'Führerdemokratie' consisted of competition between elites --not parties!-- for the peoples' votes in regularly scheduled elections.[86]

Rudolf Kayser's 1932 book on Spinoza, which Einstein read at the end of that year, can also be understood as praise for the political institutionalization of the moral influence of the intellectuals. In the book, Spinoza's idea of a democracy with "aristocratic leadership" through individ-

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82 Einstein's message to the meeting of the War Resisters' International, August 1931, Nathan and Norden 1975, p. 158.

83 Einstein to Victor Margueritte, 19 October 1932, Nathan and Norden 1975, p. 199.

84 Nathan and Norden 1975, p. 203. The letter is written either 1931 or 1932.

85 Nathan and Norden 1975, p. 203.

86 See Döring 1975, p. 252. See also pp. 207-231. The "Weimarer Kreis" is linked to the liberal-democratic spectrum on the left of Weimar intellectuals. However, the endeavors of numerous of its members for limiting the plurality of values in democracy and to opt for aristocratic corrections dissolve the commonly used dichotomy between intellectuals on the left and right side, of modernists and those critical of modernity. Therefore, in the recent literature concerned with the various lines of discourse among intellectuals in Weimar republic, the suggestion was made to see a decisive distinction not between left and right but rather to ask for alternative positions within each of the particular discourses (see Gangl in Gangl and Raulet 1993, p. 9-11). As an example, among the statements concerning modernity in the 'sense' of political plurality the dividing line runs between concepts of a society tolerating contingency and concepts aiming at a removal of contingency, for instance, by a claim to universal values in the name of reason (see Ruddies and Vondung in Gangl and Raulet 1993, p. 35 and 128). For the breadth and multiplicity of cultural criticism cutting across all political camps see also Peukert 1987 und Harwood 1996.

uals "of high intellectual rank"[87] is discussed very positively. This position is not surprising, since Kayser was a co-founder of the activist intellectual movement that had called for a political aristocracy of intellectuals in 1916.

As we have seen, Einstein's political thinking and actions were based on an elite and non-pluralistic attitude. His "spiritually and morally elevated"[88] humans were not to exercise political power, however - they were merely to exert a moral influence on the solution of political problems. Why did Einstein reject a claim to political leadership for the moral and intellectual elite? After a discussion with Einstein in mid-1918, the leading representative of the 'Activism,' Kurt Hiller, sent the physicist his brochure "A German Upper House," which called for a political "rulership of the moral and spiritual [geistigen] humans".[89] Einstein justified his rejection by pointing to the corruption that accompanied a great deal of power.[90] In addition, Einstein's concept of the true scientist and artist, contributing primarily to the improvement of the individual through science or art, excluded a direct role in politics.

7 Conclusion: Einstein between Science and Society

1. Einstein's political thought and action was closely connected to his self image as a scientist. Essential for this self-image was his belief that by observing the objective world the true scientist overcomes his selfish desires and is thereby qualified to provide moral standards for the social and political realm. Such a self-understanding as a member of an elite of values was not unusual among humanities scholars and with some natural scientists. What set Einstein apart was the universalization of his ideal of the true scientist to a concept of an ideal individual and its use as a counter pole to the dominant social and political standards. This role as an intellectual, based on his critical distance from the status quo, separated him from the majority both of humanities scholars and natural scientists.

2. Einstein's non-pluralistic understanding of democracy followed from his self-image as a member of a moral and intellectual elite proclaiming universal values. This self-image was incompatible with the recognition of competing social groups with different values and interests. Through its fixation on the selfless, moral individual, Einstein's political thinking was shown to be elitist, non-pluralistic and idealistic due to its understanding of politics as the implementation of ethical goals.

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87 Kayser 1932, p. 294. See also Kayser 1917/18, p. 78.
88 Einstein’s press release, 23 May 1932, Nathan and Norden 1975, p. 185.
89 Hiller 1918, p. 82.
90 See Einstein to Kurt Hiller, 9 September 1918, Nathan and Norden 1975, p. 42.

3. Einstein's reduction of complex structures in society, the state and politics to the individual differed from his work in physics, in which he integrated independent fields in a conceptual synthesis without reducing them to a single principle set in advance. Also for this reason he was so much more successful in his scientific than in his social efforts aimed at creating a simplified, manageable concept of the world.

4. Social experiences that contradicted Einstein's thinking did not cause him to question his ideals. In physics, on the contrary, he analyzed contradictions seriously and was prepared to conceive of scientific concepts as temporary, or even to abandon them. This willingness made learning processes possible which did not take place in the social realm. Einstein's differing reactions can be explained by his view of the true scientist seeking to flee everyday life, which leads to a more intense occupation with scientific than with social phenomena.

5. Einstein's role as an involved intellectual contradicted his self image as a true scientist aloof from society. This conflict between roles hindered him to become politically and morally involved in the scientific realm to the same extent that he was in society at large.

Einstein expected social and political involvement from natural scientists also in 1933. The fact that their occupation with the objective world did not lead them to a selfless defense of ethical values he could only explain through weakness of character.[91] To the physicist von Laue he wrote on May 26, 1933:

> I do not share your view that the scientist [wissenschaftliche Mensch] should observe silence in political matters, that is human affairs in the broader sense. [...] Does such restraint not signify a lack of responsibility?[92]

Einstein apparently did not recognize the contradiction between his call to action and his ideal of the socially aloof true scientist. In spite of the Prussian Academy of Science's unfounded criticism of him, Einstein stood by his ideal. In April 1933, he assured the Secretary of the Academy, Max Planck, his friendship "regardless of what has taken place 'on a lower level,' so to speak."[93]

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91 See Einstein to Thomas Mann, 29 April 1933, Nathan and Norden 1975, p. 237: "Many others who could have provided intellectual leadership [zu geistiger Führung Berufenen] had neither the courage nor the strength of character necessary to draw a clear demarcation between themselves and those who, through resorting to violence, have made themselves the representatives of the state." Einstein easily could explain the takeover of the National Socialists by the manipulativeness of people: "I see it this way: In Germany a small group of pathological demagogues was able to capture and exploit the support of a population which is completely uneducated politically" (Einstein to Paul Ehrenfest, 14 April 1933, Nathan and Norden 1975, p. 234). In contrast, he lacks an explanation for the behavior of scientists and artists: “The only curious thing is the utter failure of the so-called intellectual aristocracy [in Germany]“ (Einstein to Willem de Sitter, 5 April 1933, Einstein 1989, p. 55).

92 Nathan and Norden 1975, p. 234.

93 Einstein to Max Planck, 6 April 1933, Nathan and Norden 1975, p. 233.

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The Rediscovery of General Relativity in Berlin

Jürgen Renn and Tilman Sauer

A Comedy of Errors or a Case of Serendipity?

This paper is based on joint work with Michel Janssen, John Norton, and John Stachel. It grew out of the cooperation inaugurated by the Berlin Working Group "Albert Einstein," mentioned in the introduction. The aim of the group was to pursue research on Einstein in Berlin with particular attention to the relation between his science and its context. In this contribution, however, the context of Einstein's intellectual achievement is present not in the more obvious forms of institutional and political constellations influencing his work and its reception, but in the form of historically given conceptual and mathematical tools available for solving a specific problem, the conflict between the special theory of relativity and Newton's law of gravitation. Einstein's solution to this problem, the creation of the general theory of relativity, is interpreted as an exploration of these conceptual and mathematical tools in response to this conflict. It will become clear from what follows that Einstein's process of discovery is, in its historically concrete form, inseparable from his unique philosophical perspective on physical problems. But the main point of the following analysis of the interaction between formalism and physical heuristics in the creation of general relativity is that the essential dynamics of this intellectual process is governed by historically specific intellectual tools available to Einstein as to his contemporaries.

Einstein first dealt with the problem of a relativistic theory of gravitation in 1907.[1] He was then confronted with the task of revising the classical Newtonian theory of gravitation in the light of the relativity theory of 1905 since he had to write a review paper that would have to cover the implications of this theory for various areas of physics. Indeed, contrary to the field theory of electrodynamic interactions, Newton's theory of gravitation implies an instantaneous action at a distance, incompatible with the requirement of special relativity that the propagation speed of physical interactions is limited by the speed of light. Hence the revision of Newtonian gravitation theory entered Einstein's intellectual horizon as a necessity of the day, imposed by the need to integrate new results with the traditional body of knowledge.

The advent of the theory of special relativity had sharpened the conflict, but an incompatibility of classical mechanics and electrodynamics had widely been recognized by physicists before.

1 Einstein 1907.

Hence not only Einstein but also several of his contemporaries addressed the problem of formulating a field theory of gravitation that was to be in agreement with the principles suggested by the theory of the electrodynamic field, and most importantly with the new kinematics of relativity theory. In addressing this problem, however, Einstein quickly decided to take a step different from that of his contemporaries. Instead of formulating a special relativistic law of gravitational interaction, he searched for a generalization of the relativity principle and for a new theory of gravitation that closely associated gravitation with inertia. The peculiarity of Einstein's approach is embodied in the two heuristic principles that guided his search from the beginning and that will be designated here throughout as the "Equivalence Principle" and the "Generalized Principle of Relativity," although these principles did not bear any specific names in Einstein's first paper on the subject. In his 1907 paper the first principle was formulated as the assumption of physical indistinguishability between a homogeneous gravitational field and a uniformly accelerated frame of reference. The second principle was adumbrated by the question:[2]

> Is it conceivable that the principle of relativity also applies to systems that are accelerated relative to each other?

These principles do not express features of classical or special relativistic physics as it was then understood but rather requirements to be satisfied only by the new theory of gravitation. And indeed, they are since the time of the completion of the theory of General Relativity in 1915, with its generally covariant field equation, often claimed to capture the most essential aspects of this theory, although this claim has not remained undisputed.

If accepted, this claim seems to imply, however, that precisely what later turned out to be the essential and most innovative conceptual developments brought about by General Relativity were already anticipated by Einstein long before he found the field equations of his new theory. Is General Relativity hence the result of a conceptual leap which belongs to a context of discovery that can only be further elucidated by studying the psychological roots of Einstein's creativity but will ultimately remain inexplicable? The history of the discovery of the field equations of General Relativity seems to present a strong argument in favor of this conjecture. In fact, Einstein formulated his heuristic guidelines at the very beginning of his search for a new theory of gravitation and he stubbornly held on to them for roughly eight years, in spite of the considerable difficulties he found in implementing his original ideas. But which exactly were the difficulties that Einstein encountered in formulating the field equations of General Relativity?

At first glance there seem to be two alternatives: If Einstein's difficulties were predominantly of a technical nature, either due to the complexity of the mathematical language to be learned

2 Einstein 1907, p. 454.

and adapted to the problem at hand or due to some false working hypotheses about the mathematical representation to be eliminated along the way, then the conceptual innovation brought about by General Relativity would indeed be contained in nuce already in Einstein's starting point. Consequently, the discovery of the field equations of General Relativity could be recounted as a comedy of errors, with a brilliant beginning, some deviations, and a happy conclusion, yet without explanation of the crucial steps of conceptual development involved. The role of the formalism for this discovery would then be merely that of a medium in which preconceived physical conceptions are expressed more or less appropriately.

If Einstein's difficulties were, however, themselves of a conceptual nature then it rather seems that his eventual success must be interpreted as a case of serendipity, as a lucky finding that cannot be accounted for by the quality of his heuristic starting point. The role of the formalism for Einstein's discovery of the field equations would then be rather that of an ill-mastered language expressing a meaning different from the intended one. In this version, conceptual development would hence be accounted for by a lucky misunderstanding. In other words, these two extreme alternatives both fail to provide any rational account of the conceptual development from classical and special relativistic physics to the physics of General Relativity. They also fail to take into account any non-trivial interaction between heuristics and representation. In the present paper we will analyze this interaction more closely and propose, on the basis of this analysis, a third, alternate account of conceptual development in the case of General Relativity.

THE GENESIS OF GENERAL RELATIVITY AND EINSTEIN'S "ZURICH NOTEBOOK"

The task of a reconstruction of Einstein's discovery of the theory of general relativity has challenged historians of science for a long time. In the course of preparing the editorial project of the Collected Papers of Albert Einstein John Stachel first realized the significance of a research notebook containing calculations by Einstein from the period 1912--13, the so-called Zurich Notebook for the reconstruction of the genesis of the theory of general relativity.[3] In 1984, John Norton published a comprehensive reconstruction of Einstein's discovery process. In this paper, he was able to correct some widespread prejudices about Einstein's path towards general relativity by an analysis of some key pages of the Zurich Notebook.[4] But even after this pioneering work large parts of the notebook remained obscure and poorly understood. In the course of a research project involving Peter Damerow, Werner Heinrich, Michel Janssen, John Norton,

3 Albert Einstein Archives, Jerusalem, Nr. 3-006, partly published in Klein, Kox, Renn, Schulmann et al. 1995, as Doc. 10.
4 Norton 1984,

John Stachel, as well as the authors the Zurich Notebook could now be fully reconstructed and comprehensively analyzed.[5] It turned out that this research manuscript allows for a detailed understanding of Einstein's working procedures and the heuristic principles guiding them. The account presented in the following is based on the results of this collaboration.

The Zurich Notebook contains calculations or short notes on various problems of physics, but mainly on gravitation theory. The dating of these entries to the critical period between summer 1912 and spring 1913, as well as the identification of their chronological sequence, relies on the mathematical notation used, and, most importantly, on a detailed reconstruction of their meaning.

Let us briefly review the principal steps of Einstein's discovery of the theory of general relativity and locate the Zurich Notebook in this context. As mentioned above, in 1907 when Einstein was still an employee at the patent office in Bern he had already laid out crucial elements of the heuristics he would follow in the years to come, in particular the Equivalence Principle and the Principle of Generalized Relativity. As early as 1907 he also considered possible physical consequences of the Equivalence Principle, in particular the gravitational red-shift and the bending of light in a gravitational field. He inferred from the Equivalence Principle that the speed of light must be variable, in contrast to one of the fundamental principles of the special theory of relativity of 1905. In spite of this rapid and impressive initial progress, however, he did not yet begin to work out a theory of gravitation based on a Generalized Principle of Relativity. In fact, when the history of Einstein's work on his theory in the following years is judged from hindsight, it may appear as a sequence of missed opportunities. Not only did Einstein fail to take up on his own first successful steps towards a relativistic theory of gravitation, he also failed for some time to adopt Minkowski's reformulation of special relativity in terms of a four-dimensional space-time manifold, a crucial instrument for the further development of a relativistic theory of gravitation.

Only in 1911, now a professor in Prague, did Einstein come back to the problem of gravitation, when it occurred to him that a physical consequence of the Equivalence Principle, the bending of light in a gravitational field, might be observable for light rays passing near the sun.[6] The publication of this remarkable physical prediction drew the attention of other scientists to Einstein's approach, with important consequences for the further development. In January 1912, it was Max Abraham who published a theory of gravitation with a gravitational field equation, formulated in terms of Minkowski's four-dimensional space-time formulation, which implied Einstein's basic relation between the variable velocity of light and the gravitational po-

5 For preliminary reports, see Castagnetti et al. 1994 and Renn and Sauer 1996.
6 Einstein 1911.

tential as a special case.[7]

Einstein responded with the publication of a different theory of gravitation, based on the Equivalence Principle, but still not formulated in a four-dimensional formulation and restricted only to the special case of static fields.[8] In an ensuing dispute between Abraham and Einstein, it was Abraham who effectively introduced the line-element of a non-flat space-time into gravitation theory.[9]

Although this insight would shortly become the basis of Einstein's further search for the gravitational field equation, it was at this point taken up neither by Abraham himself nor by Einstein --- another missed opportunity. Only after further elaborating his theory for the special case of static fields, and after familiarizing himself with Minkowski's formalism more carefully, did Einstein, at some point in the summer of 1912, eventually adopt a 10-component metric tensor, describing a variable line-element in four dimensions, as the representation of the gravitational potential and hence as the basis for his further search for a relativistic field theory of gravitation.

Before, probably in the spring of 1912, Einstein had conceived of yet another possibility for gaining observational support for a new theory of gravitation – gravitational lensing, at the time so distant from observational possibilities that Einstein did not even publish his prediction of this effect.[10]

In August 1912 Einstein left Prague, where he had stayed for one and a half year, for Zurich. There he remained, as a professor of the Eidgenossische Technische Hochschule (ETH), until he left for Berlin in the Spring of 1914. During his time in Zurich he collaborated with his former ETH classmate, now professor of mathematics at the ETH, Marcel Grossmann, in his attempts to find a gravitational field equation for the metric tensor. Grossmann was particularly helpful in making the literature on invariant theory and on the absolute differential calculus accessible to Einstein. And he also suggested to Einstein some mathematically very plausible candidates for a gravitational field equation.

It has long been known that in this period of time, Einstein missed, so at least it appears from hindsight, another important opportunity. In fact, he had come close to the later field equation of General Relativity by considering the Ricci tensor, given to him by Grossmann as a possible candidate for the left hand-side of such a field equation. Numerous speculations have been ventured for why he needed another two and a half years before he took up this promising line of attack once more. The detailed examination of the Zurich Notebook has meanwhile increased

7 Abraham 1912a.
8 Einstein 1912a and Einstein 1912b.
9 Abraham 1912b.
10 For historical discussion, see Renn, Sauer, and Stachel 1997.

the list of missed opportunities. John Norton found in his first pioneering analysis of the notebook that Einstein not only considered the Ricci tensor in 1912, about three years before he came back to it in November 1915, but that Grossmann showed him also another candidate for the left-hand side of the field equation closely related to the Ricci tensor which was also reconsidered by Einstein in November 1915, and will in the following simply be called the "November tensor."[11]

The analysis of the notebook carried out in the context of our joint research project has revealed yet another surprising missed opportunity. At the end of 1912 or in the beginning of 1913 Einstein even happened to consider, in linearized form, the final version of the field equation of General Relativity, and discarded it as well. But in spite of pursuing these promising candidates, the notebook instead ends with a short derivation of the left hand side of the curious "Entwurf" field equations, so called because Einstein and Grossmann published them in a paper entitled "Entwurf einer verallgemeinerten Relativitatstheorie und einer Theorie der Gravitation" in the spring of 1913.[12]

The "Entwurf" field equations, are represented by a complex mathematical differential operator which is covariant only under some restricted class of coordinate transformations, and for this reason make no sense from the point of view of modern general relativity. The precise transformational properties were unknown to Einstein and Grossmann when they published their paper and hence also the extent to which their field equation represented a realization of a Generalized Principle of Relativity.

While still in Zurich Einstein continued to elaborate on and refine the "Entwurf" theory together with his friends Marcel Grossmann and Michele Besso. He explored the transformational properties of its field equation and developed arguments that were intended to explain its failure to be generally covariant, i.e. not to realize the Generalized Principle to the utmost extent. He also developed new ways of deriving the "Entwurf" field equation from fundamental assumptions and probed the consequences of the theory, in particular --- albeit again without success --- the possibility of explaining on its basis the anomalous perihelion advance of Mercury.[13] He also studied the relation of the "Entwurf" theory to alternative relativistic theories of gravitation, in particular to that formulated by Gunnar Nordstrøm.[14]

In spring 1914, Einstein moved to Berlin to accept a position at the Prussian Academy of Science. The position was particularly created for Einstein. It gave him all rights of a professor at

11 Einstein 1915a.
12 Einstein and Grossmann 1913.
13 For a historical discussion of Einstein's explanation of the anomalous perihelion advance of Mercury, see Earman and Janssen 1993.
14 For a historical discussion of Nordstrøm's theory of gravitation, see Norton 1992.

the Berlin university but exempted him from any teaching obligations. In addition, a Kaiser Wilhelm Institute for Physical Research was to be set up for him. When Einstein came to Berlin hopes ran high that he would use his new position for a conceptual direction and institutional integration of various experimental and theoretical investigations in physics and chemistry aimed at a theoretical understanding of the quantum nature of matter.[15] But Einstein was more concerned with the elaboration of his “Entwurf“ gravitation theory which he pursued after he had left Zurich for Berlin for the most on his own. He published a long exposition of the formal foundations of the theory including a detailed account of the unwonted mathematics.[16] Deeply concerned with the mathematical intricacies of the new theory he developed a new mathematical derivation of the gravitational field equations which also implied a proof of their covariance properties. In a spirit of conversing with a fellow member of the république des savants,[17] he began an intense correspondence with the Italian mathematician Levi-Civita who was in fact one of the few scholars at the time competent to judge Einstein’s achievements.[18] The mathematical representation relied heavily on an adaption of the so-called absolute differential calculus developed by Levi-Civita and Ricci at the beginning of the century.

In the course of elaborating the “Entwurf“ theory Einstein initially found good arguments in its favor but by and by he realized problems.[19] Although Einstein knew the failure of the "Entwurf” theory to explain the Mercury anomaly already since the middle of 1913 he nevertheless continued to hold on to it for two years. When in September 1915 he definitely found out that its field equation is not satisfied by the gravitational field of a uniformly rotating system, spoiling temporary hopes that this might be, after all, the case, he at first also missed the opportunity of giving up this theory. In the fall of 1915 Einstein also had to realize that his earlier, mathematical derivation of its field equation was flawed. But even the discovery of this flaw did not imply the immediate demise of the "Entwurf” field equation as Einstein was quick to add additional assumptions to make its derivation work.

It may thus almost come as a surprise that, in November 1915, Einstein eventually did give up the "Entwurf” theory, after all. It was at this point that he once more turned to the discarded candidate field equations considered in the Zurich Notebook. But he did not take up the correct field equation involving the Einstein tensor, the field equation whose linearized version he had considered three years ago when working with the Zurich Notebook. Instead, he returned to the non-generally covariant candidate which he had also abandoned earlier and which we have called the "November tensor.” For some days, he was convinced to have solved all the problems

15 See the contribution by Giuseppe Castagnetti and Hubert Goenner in this volume.
16 Einstein 1914.
17 See the contribution by Britta Scheideler and Hubert Goenner in this volume.
18 For a historical discussion of the controversy between Einstein and Levi-Civita, see Cattani and De Maria 1989.
19 For a more detailed account of the following chronology of events, see Norton 1984 and Renn and Sauer 1997.

which he had found earlier with this tensor and presented it to the Prussian Academy of Sciences in a communication of November 4.[20] He then abandoned that tensor once again but still did not return to the correct Einstein tensor. He rather examined the Ricci tensor first, in another communication to the Academy of November 11,[21] but only to give it up as well, also for a second time, after about a week. Only then did he at last come back to the Einstein tensor and presented the correct field equations based on it to the Prussian Academy on November 25, 1915.[22]

In order to analyze Einstein's willingness to give up generally covariant field equations and his motives behind these rather erratic looking leaps from one candidate field equation to the other, and in order to understand the reasons for what appear to be so many missed opportunities on his part, one has to take a closer look at his heuristic principles and their effect on his research.

ELEMENTS OF EINSTEIN'S HEURISTICS

The early summer of 1912 represents a crucial turning point in the history of Einstein's discovery of the gravitational field equation because it is then that he realized the significance of the metric tensor and the general line element for a generalized theory of gravitation. Following this insight Einstein started to study (again) the mathematics of Gaussian surface theory, and in the course of a more systematic survey of the relevant mathematical literature became acquainted with Beltrami invariants, and, eventually, with the so-called "absolute differential calculus" of Ricci and Levi-Civita. The mathematical formalism provided by the theory of differential invariants and tensor calculus for Einstein now presented an as yet unfamiliar network of deductive possibilities and constraints which had to be explored and endowed with physical meaning.

Let us briefly review the building blocks out of which Einstein wanted to construct his new theory of gravitation and discuss the crucial principles guiding his heuristics.

Metric Tensor, Special Relativity, and Theory of Static Fields

Einstein assembled the building blocks for his new theory of gravitation on an early page (39L, cp. Fig. 1) of the Zurich Notebook: the metric tensor, Minkowski's four-dimensional reformulation of Special Relativity, and the gravitational equation of his second theory of static gravitational fields

20 Einstein 1915a.
21 Einstein 1915b
22 Einstein 1915c.

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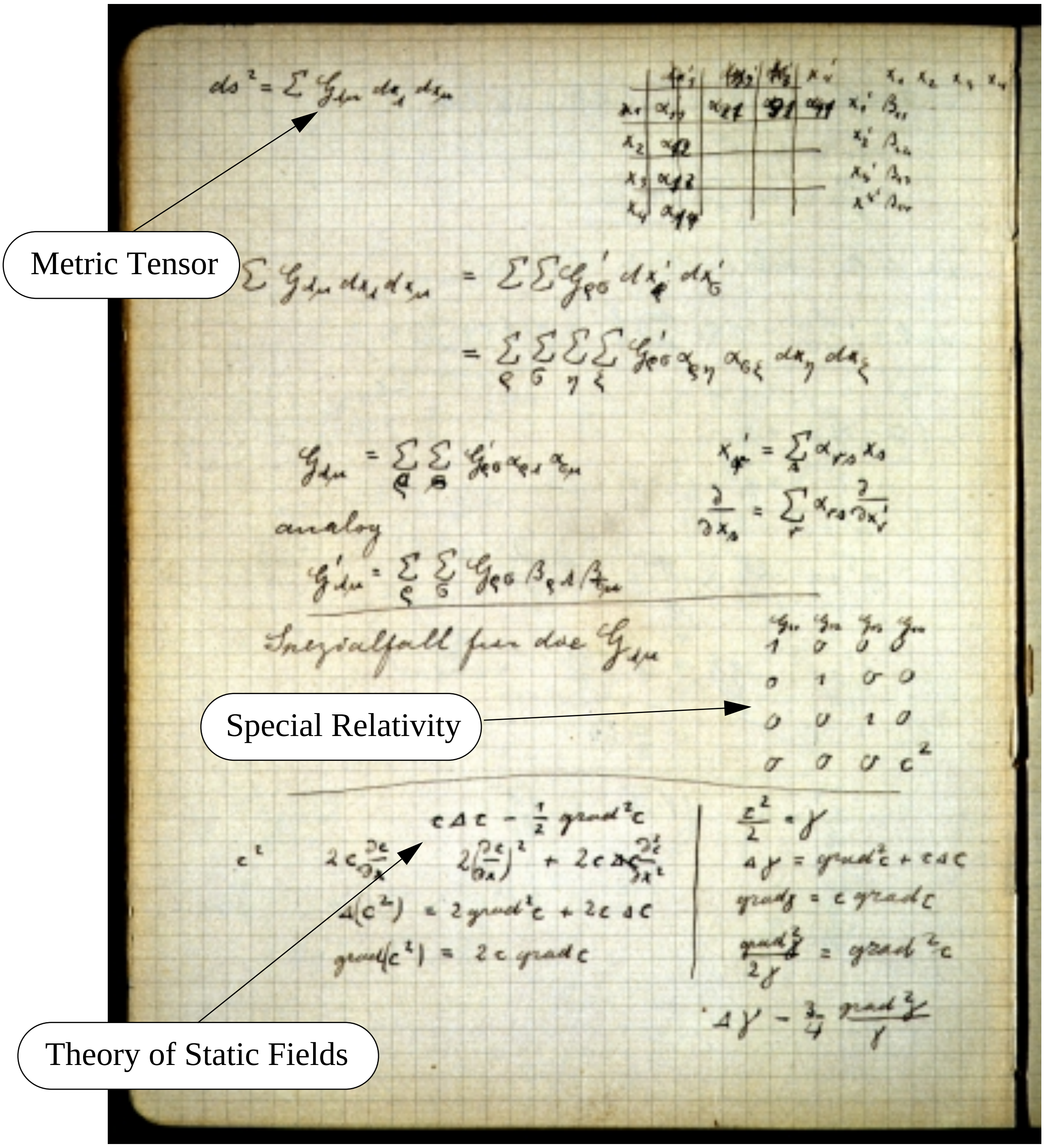


Figure 1: P. 39L of the Zurich Notebook. This page contains the basic elements for Einstein's search for a relativistic theory of gravitation. Reproduced with permission by the Einstein Archives, Hebrew University Jerusalem.

First, the general line element with a metric tensor $g_{\mu\nu}$, appears on this early page of the Zurich Notebook for the first time altogether. The identification of this page as the earliest one in the notebook dealing with gravitation is corroborated by the elementary character of the calculations. Here in fact Einstein was still checking the tensorial character and the transformational properties of the metric tensor by explicit coordinate transformations. In later parts of the manuscript his techniques became much more sophisticated.

Second, the four-dimensional reformulation of special relativity with a special form a diagonal metric with one component of the metric tensor given by the square of the velocity of light represents the special case to which tentative generalizations had to reduce in the absence of gravitational fields according to Einstein. His theory of static gravitational fields with the (spatially variable) velocity of light representing the gravitational potential could also be embedded into a generalized tensorial theory by means of this particular form of a metric.

Third, the "field equation” for static gravitation of this theory which Einstein had published in March 1912 can be related to the differential expression for the velocity of light written on the bottom of the page. Obviously, Einstein’s intention for the transformation, performed on the bottom of p. 39L, was to put the differential equation of his static theory into a form which allowed its interpretation as one particular component of a 10-component tensorial field equation for the metric tensor. The transformed differential equation would thus represent a special limiting case of the general tensorial field equation which should be the expected form of the general equation if one would specialize to static fields.

This calculation therefore closely pertains to the central question governing all calculations of the Zurich Notebook dealing with the problem of gravitation: What is the appropriate differential expression $\Gamma_{\mu\nu}$ which is formed from the metric tensor $g_{\mu\nu}$ and its first and second derivatives and which enters a field equation of the form

$$\Gamma_{\mu\nu} = \kappa T_{\mu\nu}$$

with the stress--energy--tensor of matter $T_{\mu\nu}$ as the source term on the right hand side?

The Heuristic Requirements

Finding an answer to this question had two different aspects. On the one hand, Einstein had to find suitable candidates for the gravitational field equations. On the other hand, he had to check for each such candidate whether it actually satisfied all his heuristic requirements.

Einstein’s heuristic criteria were, of course, variable to some extent and were indeed modified in the course of and adapted to the explorative experiences accumulated in the research process. It is the interplay of these general heuristic ideas with the deductive structure materialized in the mathematical representation which governed the calculations contained in the Zurich Notebook and which makes their sequence understandable.

The Requirement of Equivalence. Already in his paper of 1907, Einstein formulated the assumption of complete physical equivalence between a uniformly accelerated reference frame and a constant homogenous gravitational field. He asserted:[23]

> The heuristic value of this assumption rests on the fact that it permits the replacement of a homogeneous gravitational field by a uniformly accelerated reference system, the latter case being to some extent accessible to theoretical treatment.

Einstein's assumption was, however, much more than a means useful to make gravitational fields accessible to theoretical treatment. It was motivated by the requirement of keeping inertial and gravitational mass equal even in a relativistic gravitation theory, a requirement that was by no means self-evident in the contemporary discussion. In classical mechanics, the proportionality of inertial and gravitational mass, which guarantees Galileo's principle of the equality of accelerations in free fall, is merely an empirical statement. Einstein's approach to the new theory of gravitation, on the other hand, is characterized by transforming this empirical statement into a heuristic principle of fundamental importance for this new theory.

Whereas the equivalence between a uniformly accelerated reference frame and a homogeneous static gravitational field forms the essence of the Equivalence Principle, Einstein also attempted to extend this relation to other accelerated frames.

The paradigmatic case for an extension of the Equivalence Principle to other accelerated frames was the "rotating bucket," i.e. a uniformly rotating system of reference. The rotating bucket had been used by Newton and much later by Mach in order to discuss the question of whether inertia is a property of absolute space or, as Mach suggested, caused by the interaction of masses. If the acceleration field of such a rotating frame of reference could be interpreted as a gravitational field, then rotation could be conceived as a state of rest, as Einstein once put it. In other words, locally the centrifugal forces in a rotating frame of reference could be considered as being equivalent to an inertial frame equipped with a special gravitational field somehow caused by the presence of masses. In this way, the equivalence between acceleration fields and special cases of the gravitational field could be exploited in order to realize Mach's idea of interpreting inertial effects as being due to the interaction of masses. As a consequence, the inertial frames of reference of classical mechanics and special relativity did no longer have to be considered as privileged frames of reference fundamentally distinct from accelerated frames of reference. For Einstein this idea became the core of his search for a generalization of the relativity principle.

The Requirement of Generalized Relativity. Einstein attempted to generalize the Principle of Relativity by requiring that the covariance group of his new theory of gravitation be larger

23 Einstein 1907, p. 454.

than the group of Lorentz transformations of Special Relativity. In his understanding, this requirement was optimally satisfied if the field equation of the new theory could be shown to possess the mathematical property of general covariance.

Einstein saw a Generalized Principle of Relativity as guaranteeing the satisfaction of the Equivalence Principle as well. In fact, according to the Equivalence Principle, an arbitrarily accelerated frame of reference in Minkowski space-time can precisely then be considered as being physically equivalent to an inertial frame if a gravitational field can be introduced which accounts for the inertial effects in the accelerated frame. If now gravitato-inertial fields are described by a generally covariant field equation, this must (at least locally) always be possible, since the metric tensor describing the inertial effects in the arbitrarily accelerated frame is then obviously a solution of this field equation and hence represents, in Einstein's understanding, a particular instance of a gravitational field.

In the period under consideration the Generalized Relativity Principle was not yet explicitly distinguished from what Einstein later introduced as "Mach's Principle." It was only the later development which necessitated this distinction. In fact, Einstein initially hoped that accounting for inertial effects in terms of gravitational fields would automatically provide an explanation of these effects by the interaction of masses.

The Requirement of Correspondence. Einstein further required that the new theory would describe, under certain limiting conditions, the gravitational effects familiar from Newtonian physics. For this reason, he expected that the unknown gravitational field equation for the metric tensor would reduce to the Poisson equation for the scalar gravitational potential of the classical theory and that, under the same limiting conditions, the equation of motion of his new theory would yield Newton's second law with the force derived from this classical potential. Finally, he assumed that this Newtonian limit can be obtained from the full field equation via an intermediate step characterized by weak static fields leading to a linearized field equation for the metric tensor.

We subsume these various demands under what we call Einstein's "Correspondence Principle" of General Relativity. The realization of this principle was a crucial condition for conveying physical meaning to the various mathematical constructs he elaborated since only in this way they could be brought into contact with the empirical knowledge embodied in Newtonian gravitation theory.

The Requirement of Conservation. When Einstein began his systematic search for a field equation in 1912, the development of special relativistic dynamics, including the four-dimensional formulation of electrodynamics and of continuum mechanics, offered formulations of basic physical laws which suggested a plausible generalization to a generally relativistic setting. In particular, special relativistic dynamics displayed a generalizable model for the formulation of the conservation of energy and momentum centered upon a four-dimensional stress-energy tensor.

By the fall of 1912, Einstein had indeed found a plausible, generally covariant equation involving this tensor which he interpreted as representing both a generalization of the special relativistic formulation of the conservation of energy and momentum as well as of the Newtonian law of motion for continuous matter in a gravitational field. It was therefore natural to make this equation into a touch stone for the gravitational field equation to be found; we call this requirement the "Conservation Principle.”

These four heuristic requirement played a dominant role in Einstein’s search for a relativistic theory of gravitation, acting in an oscillating manner either as starting points or as touch stones for tentative field equations. As it turned out, they actually overdetermined the problem and Einstein in his investigation of concrete field equations was forced to weigh the different requirements against each other. Attempting to make ends meet he was faced with the necessity of weakening or modifying one or more of them.

EINSTEIN’S DOUBLE STRATEGY

In the course of Einstein’s work on the problem of gravitation two distinct and complementary strategies emerged for the construction of suitable candidates for the differential operator entering the left hand side of a tentative gravitational field equation. These two strategies take the above-introduced heuristic requirements in a complementary manner either as points of departure or as touch stones. The strategies and the role of the heuristic requirements in following these strategies can be identified most distinctly in the reconstruction of the calculations of the Zurich Notebook.

A “mathematical“ strategy started from the requirement of the generalized relativity principle. It consisted in scanning the mathematical literature for suitable differential expressions with a well-known covariance group. Tentative field equations with candidate differential operators thus obtained from the mathematical literature then of course had to be tested for the principle of conservation of energy. It also had to be checked whether the Newtonian limit could be realized in the manner expected by Einstein.

The complementary “physical“ strategy started from the well-known limiting case of special relativity and the apparently also well-established and firmly founded special theory of static gravitational fields. Along this strategy Einstein sought to construct physically plausible generalizations whose specialization to the Newtonian limit was obvious. Here again conservation of energy was an independent heuristic requirement which had to be checked for each candidate field equation. But most importantly, the covariance group of the differential expressions constructed along this strategy was unknown from the beginning. It hence remained to be investigated to what extent the principle of generalized relativity had actually been realized.

The identification of these two complementary strategies turned out to be the key for understanding many of Einstein's considerations and calculations documented in the Zurich Notebook as well as for understanding many of his considerations from the period between 1913 and 1915. In the reconstruction of the genesis of the theory of general relativity the identification of these strategies allows in particular a detailed understanding of the complicated process of expressing physical concepts by means of a mathematical framework with its own logical and deductive structure and vice versa of endowing the objects of the mathematical representation with a meaning in the conceptual framework of physics.

The Discovery and Rejection of the Einstein Tensor in the Zurich Notebook

In a sequence of calculations documented in the Zurich Notebook, Einstein first investigated a plausible generalization of the Laplacian operator entering the classical Poisson equation along the "physical" strategy. But he was then distracted from this path and driven toward the "mathematical" strategy when Grossmann showed him the Riemann tensor. Investigating differential expressions derived from the Riemann tensor along the "mathematical" strategy, Einstein came first to consider the Ricci tensor, the very same object he would consider as the left-hand-side of a gravitational field equation three years later in his second memoir of November 11, 1915. Testing the Ricci tensor against his heuristic requirements, Einstein at first glance found that it violated the principle of correspondence. A couple of pages later, he realized that the Ricci tensor could be reduced by the stipulation of additional restrictive conditions on the admissible coordinates to a form which did satisfy his heuristic requirement of correspondence. When he continued checking this new candidate field equation against his principle of conservation he was faced with another restrictive coordinate condition which had to be assumed in order to satisfy the principle of conservation. Both these coordinate restrictions, however, were readily seen to be incompatible with each other. In an attempt to resolve this conflict, Einstein then added a term to the linearized field equation he was considering and thus effectively introduced the gravitation tensor of the final theory, the Einstein tensor --- if only in linear approximation (20L, cp. Fig.2). Checking this modified field equation against his heuristic requirements, Einstein soon found an incompatibility with his principle of correspondence and consequently discarded this tensor as well. The same heuristic principles which led him to consider the Einstein tensor then forced him, however, to give it up.

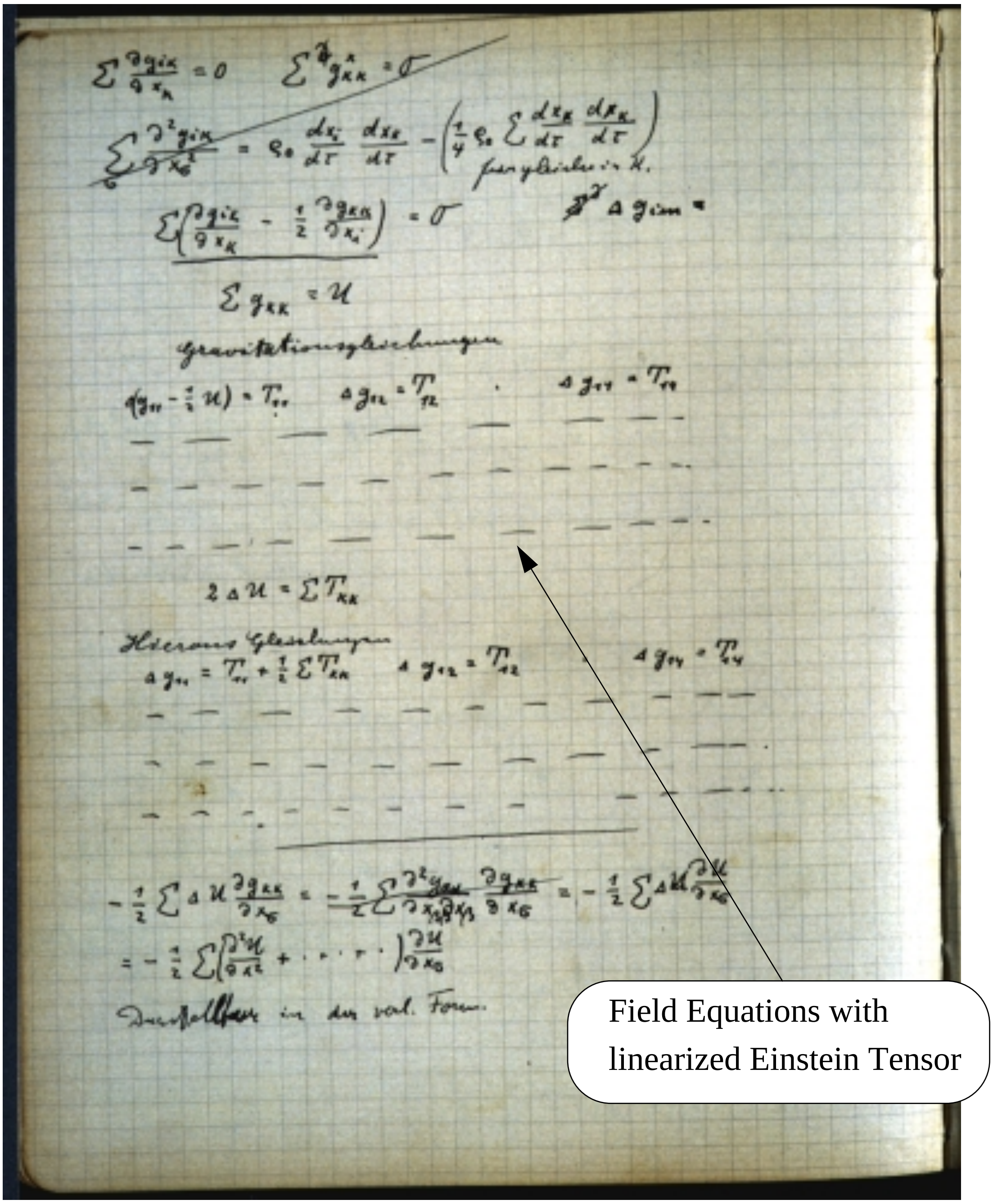


Figure 2: P. 20L of the Zurich Notebook. On this page Einstein of the notebook already wrote down the linearized form of the field equations of the final theory. Einstein would rediscover these equations more than two years later in Berlin. Reproduced with permission by the Einstein Archives, Hebrew University Jerusalem.

After discarding the linearized field equations of his final theory, Einstein did not yet give up to find an acceptable gravitational field equation on the basis of the Riemann tensor. In fact, a couple of pages later Einstein considered the “November tensor,“ i.e. the very same tensor which he would first take up again when giving up the “Entwurf“ theory in Berlin in late 1915. But also with the November tensor, Einstein could not see how his requirement of correspondence could be satisfied. He continued trying to reduce the November tensor further by stipulating various additional restrictive conditions but failed to find a form which would be acceptable if tested against his heuristic requirements. But none of his attempts to find a gravitational field equation on the basis of the Riemann tensor turned out to be successful if tested against his heuristic check list.

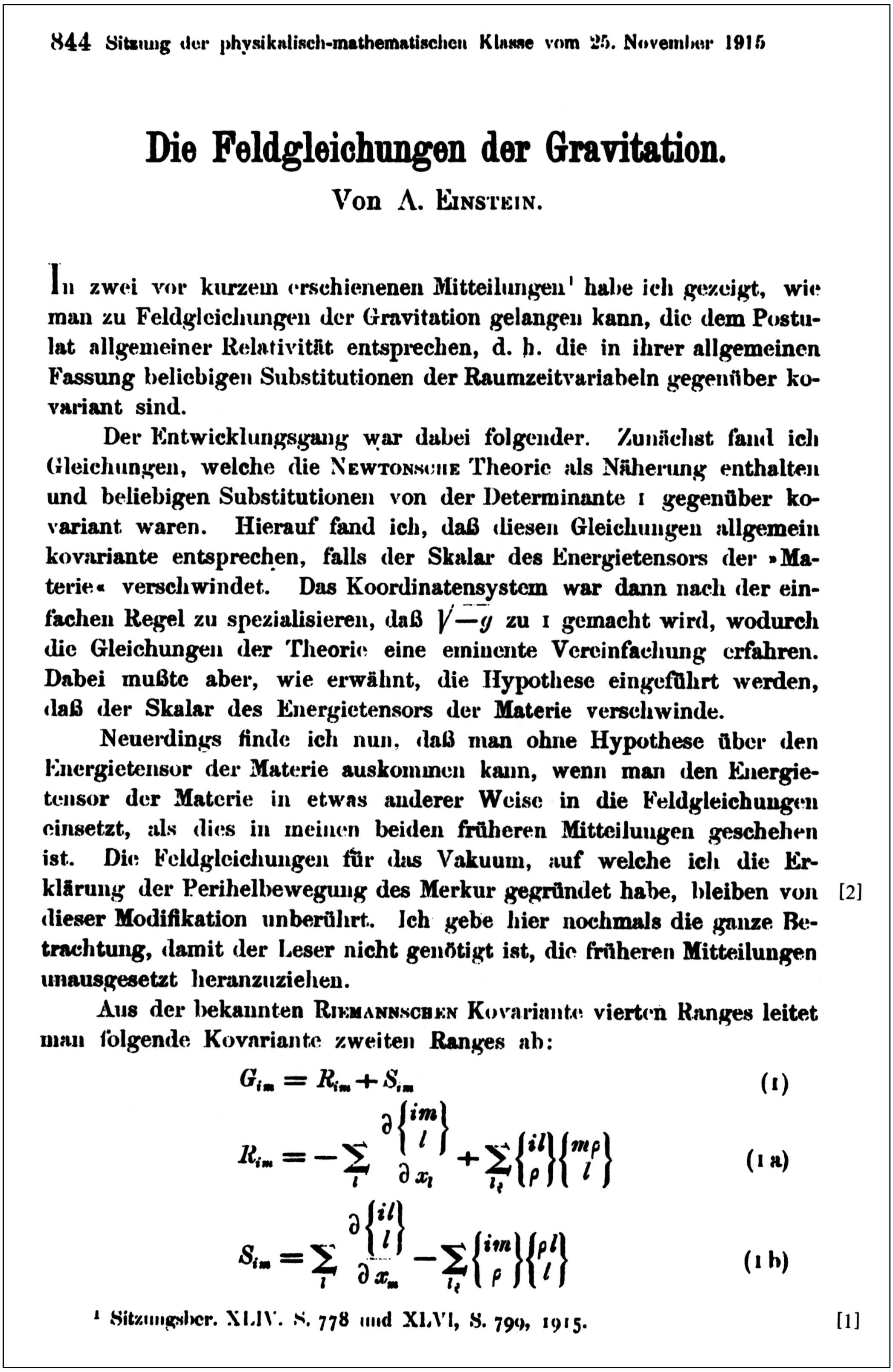
After the failure of the "mathematical” strategy Einstein, at the end of the notebook, returned to the "physical” strategy. He now returned to the consideration of the natural generalization of the Laplacian operator which was not generally covariant but which reduces for weak fields to the Laplacian operator without any additional constraints. For this operator, the satisfaction of the Correspondence Principle represented no difficulty. In order to also comply with the Conservation Principle, Einstein then introduced higher-order correction terms to this operator constructed in just such a way that the conservation principle would be satisfied. This principle was hence now employed in a constructive manner rather than only being used as a criterion for accepting or rejecting candidate field equations. The procedure yielded a rather complex differential expression for the gravitational field equation, but the problem of energy conservation could thus be resolved from the beginning. In March 1913, Einstein and Grossmann published this expression as the left hand side of a gravitational field equation in their "Entwurf einer verallgemeinerten Relativitatstheorie und einer Theorie der Gravitation.”[24] The field equation of this theory is compatible with all of Einstein’s heuristic requirements – but for the relativity principle. In fact, the transformational behavior of the Entwurf field equation was not exactly known and left as an open problem when Einstein and Grossmann published their paper. But since Einstein anyhow was not sure to which extent this principle could be realized, his search for a new theory of gravitation had thus reached a state in which it made sense to elaborate the consequences of this theory instead of continuing to produce alternative versions. Historically, however, this state of the theory proved to be metastable, bound to decay after a couple of years.

24 Einstein and Grossmann 1913.

THE INTERPLAY BETWEEN HEURISTICS AND DEDUCTIVITY

Among the missed opportunities in Einstein's long and winding path towards General Relativity his rejection of gravitational field equations based on the Einstein tensor certainly is the gravest. With the field equations of his final theory already before his eyes – if only in linear approximation – he could happily, or so at least it may appear, have achieved his most brilliant scientific achievement already more than two years before. This missed opportunity in particular seems to present a case against the interpretation of his final achievement as a case of serendipity since, if it were just a matter of stumbling over the correct equations, there would be no essential difference between Einstein's rediscovery of the correct equations in Berlin and their first discovery two years earlier in Zurich.

But the alternative interpretation, according to which Einstein's return to general covariance in 1915 might be due to a last minute conceptual breakthrough by which he redirected his heuristics along a more successful line of attack, has other problems. The conclusive 1915 paper itself as well as the other papers of that period do not bear evidence to such a radical change. Also the commentaries available from Einstein's correspondence or from the papers he published shortly afterwards do not indicate a fundamental revision of his heuristic principles. The Equivalence Principle is still understood as being included in the Generalized Principle of Relativity which Einstein believed is satisfied precisely because of the general covariance of the new field equation. The Conservation Principle is, even in Einstein conclusive 1915 paper, still considered as an additional requirement to be imposed on the field equation rather than as being implied by it via the contracted Bianchi identity. The fundamental features of Einstein's understanding of the Correspondence Principle had not changed either. Einstein still did not have a mathematical framework in which the dynamics and the space-time structure of classical gravitation theory could be obtained from General Relativity by a consistent limiting procedure.



844 Sitzung der physikalisch-mathematischen Klasse vom 25. November 1915

Die Feldgleichungen der Gravitation.

Von A. Einstein.

In zwei vor kurzem erschienenen Mitteilungen[1] habe ich gezeigt, wie man zu Feldgleichungen der Gravitation gelangen kann, die dem Postulat allgemeiner Relativität entsprechen, d. h. die in ihrer allgemeinen Fassung beliebigen Substitutionen der Raumzeitvariabeln gegenüber kovariant sind.

Der Entwicklungsgang war dabei folgender. Zunächst fand ich Gleichungen, welche die Newtonsche Theorie als Näherung enthalten und beliebigen Substitutionen von der Determinante 1 gegenüber kovariant waren. Hierauf fand ich, daß diesen Gleichungen allgemein kovariante entsprechen, falls der Skalar des Energietensors der »Materie« verschwindet. Das Koordinatensystem war dann nach der einfachen Regel zu spezialisieren, daß $\sqrt{-g}$ zu 1 gemacht wird, wodurch die Gleichungen der Theorie eine eminente Vereinfachung erfahren. Dabei mußte aber, wie erwähnt, die Hypothese eingeführt werden, daß der Skalar des Energietensors der Materie verschwinde.

Neuerdings finde ich nun, daß man ohne Hypothese über den Energietensor der Materie auskommen kann, wenn man den Energietensor der Materie in etwas anderer Weise in die Feldgleichungen einsetzt, als dies in meinen beiden früheren Mitteilungen geschehen ist. Die Feldgleichungen für das Vakuum, auf welche ich die Erklärung der Perihelbewegung des Merkur gegründet habe, bleiben von [2]
dieser Modifikation unberührt. Ich gebe hier nochmals die ganze Betrachtung, damit der Leser nicht genötigt ist, die früheren Mitteilungen unausgesetzt heranzuziehen.

Aus der bekannten Riemannschen Kovariante vierten Ranges leitet man folgende Kovariante zweiten Ranges ab:

$$G_{im} = R_{im} + S_{im} \tag{1}$$

$$R_{im} = -\sum_{l} \frac{\partial \left\{ \begin{matrix} im \\ l \end{matrix} \right\}}{\partial x_l} + \sum_{l\varrho} \left\{ \begin{matrix} il \\ \varrho \end{matrix} \right\} \left\{ \begin{matrix} m\varrho \\ l \end{matrix} \right\} \tag{1a}$$

$$S_{im} = \sum_{l} \frac{\partial \left\{ \begin{matrix} il \\ l \end{matrix} \right\}}{\partial x_m} - \sum_{l\varrho} \left\{ \begin{matrix} im \\ \varrho \end{matrix} \right\} \left\{ \begin{matrix} \varrho l \\ l \end{matrix} \right\} \tag{1b}$$

[1] Sitzungsber. XLIV, S. 778 und XLVI, S. 799, 1915. [1]

Figure 3: On 25 November 1915, Einstein presented the final field equations of General Relativity to the Prussian Academy of Science in Berlin. The very same equations had been considered by Einstein in linear approximation already more than two years before in the Zurich Notebook.

Nevertheless, in late November 1915, Einstein formulated and accepted the “final“ field equation of General Relativity (Cp. Fig. 3). How then did Einstein succeed in formulating the field equation of General Relativity if not by a conceptual breakthrough? First of all, from a modern perspective his heuristics did cover the mathematical requirements that uniquely define the Einstein tensor. If one looks for a generally covariant, second-rank tensor which is linear in the second derivatives of the metric components, contains no higher derivatives, vanishes in flat spacetime and satisfies the Bianchi identity, then no other alternative is available. Whatever else was implied by Einstein’s heuristics, these mathematical requirements are in fact suggested by his Generalized Principle of Relativity, by his Correspondence Principle, and by his Conservation Principle. Einstein’s problem was that these requirements did not exhaust his heuristics and that their consequences were not fully compatible with it. In the face of such conflicts, he was hence forced to weigh the various components of his heuristics against each other, and he had to be prepared to reduce his ambitious goals, for instance by restricting the demand for general covariance or by weakening his criteria for the satisfaction of energy momentum conservation. But his judgement about the proper equilibrium between his conflicting heuristic components depended on the state of elaboration of their deductive consequences. This is why the balance between the heuristic components turned out to favor different candidates in the course of Einstein’s first examination of the Ricci, the November, and the Einstein tensor in the years 1912--1913 than in the course of his second examination of these tensors in 1915. The interplay between heuristics and deductivity is the crucial intellectual process that prepared the ground for the discovery of the field equation of General Relativity.

In the years following the publication of the "Entwurf” field equations, Einstein had explored many consequences of this theory. In the course of this exploration, he had become familiar with more aspects of the mathematical representation, and in particular began to employ a mathematical representation, the variational formulation, which allowed him to draw far-reaching conclusions about the transformational properties of the theory. The use of variational techniques for some time helped to stabilize the conceptual framework of the "Entwurf” theory, in particular through the identification of the covariance group of the field equations and its interpretation in terms of the hole argument. Eventually, however, properties of the theory were elaborated to a point where they led to manifestly contradictory consequences at various points. Already in 1913, Einstein and Besso had found that the "Entwurf” equations did not account for the anomalous advance of the perihelion of Mercury. In his epistolary controversy with Levi-Civita in the spring 1915, Einstein also had to realize that an alleged proof of the covariance properties of the “Entwurf“ equations was faulty. He then found that the equations would not hold for Minkowski space-time in rotating Cartesian coordinates. Finally, he had to realize that his allegedly unique derivation of the field equations was faulty as well. Eventually turning to a reconsideration of alternatives to the "Entwurf" equations, Einstein first returned to the November tensor, then to the Ricci tensor, and only then published the final field equations with the Einstein tensor.

Faced with this chronology and the stability of Einstein's heuristic convictions the following problem arises: What exactly turned the balance in 1915 in favor of the Einstein tensor, in spite of the remaining conflicts with Einstein's heuristic principles and in spite of the availability of alternatives? The solution came through a technical loop-hole, which until November 1915 had remained unnoticed, but which then opened up the way not to finally resolve but at least to circumvent the most serious objection against the Einstein tensor. This objection resulted from the Correspondence Principle and consisted in the observation that the weak field equation resulting from the Einstein tensor involves a metric with more than one variable component. Such a weak field equation can hence not simply be reduced to the classical Poisson equation for one scalar potential.

But surprisingly, a closer inspection of the Newtonian limit of the equation of motion and, in particular, its interpretation as an independent postulate of the theory --- contrary to the modern understanding --- opened up a way to avoid this dilemma. The geodesic equation describing the motion of a material particle in the curved space-time of general relativity reduces in fact, under the mathematical conditions which correspond to classical physics (weak static fields, low velocities, appropriate coordinates), to the Newtonian equation of motion. Under these circumstances only one component of the metric tensor actually matters, while the other components of the metric can be neglected. As Einstein explicitly noted some years later in his Princeton lectures:[25]

> We see [...] that also in first approximation the structure of the gravitational field is fundamentally different from the one according to Newton's theory; this is a consequence of the tensorial, non-scalar character of the gravitational potential. The fact that this had not been noticed before is due to the fact that exclusively the component g_{44} enters the equations of motion in first approximation.

In other words, here was the loop-hole through which Einstein could escape from the argument that weak static fields have to be described by a metric tensor with only a single variable component corresponding to the Newtonian gravitational potential. If other variable components could exist without affecting the equation of motion in the Newtonian limit, this anomaly became tolerable and now shifted the balance in favor of the Einstein tensor. The fact that the metric associated with this peculiar way of attaining the Newtonian limit also explained the perihelium shift of Mercury protected it against the criticism of being just a dubious technical

25 Einstein 1990, p. 89.

trick and stabilized Einstein’s network of conclusions well beyond what, at that point, could have been achieved by its still fragile internal coherency.

The triumph of November 1915 was hence not the victory of new concepts over old ones but just the temporary stabilization of a complex network made up of still largely traditional concepts, of Einstein’s original heuristic arguments with only slight adjustments, and of unforeseen results on the level of the mathematical representation of the new theory. If this interpretation is indeed correct, then the conflicts between the original heuristics and the deductive consequences of the new theory could not have been settled yet. Einstein’s continued search for a realization of his original ideas after 1915 and beyond the field equation of General Relativity provides in fact strong support in favor of this interpretation. He recognized, for instance, that his strategy of implementing Machian ideas in the new theory via the requirement of general covariance did not work, since General Relativity allows for solutions in which inertial effects are present even without being caused by masses. As a reaction to this unexpected difficulty, Einstein did not simply give up his original goal as part of a context of discovery that had been superseded by his results. He rather strengthened his heuristic requirements by now demanding that the metric tensor is "completely” determined by the masses of the bodies which act as a source of the gravitational field. While he had previously simply assumed that such a determination would be an automatic consequence of his heuristic program, in 1918 he felt compelled to introduce this requirement as an additional condition, complementing his original heuristics. He gave it the name "Mach’s Principle” and made clear that he had hitherto included this requirement in his understanding of the Generalized Principle of Relativity.[26]

That Einstein’s reinforcement of his original heuristics was not a matter of philosophical dispute over what had already been achieved becomes clear from the drastic consequences he was still prepared to draw from it. In 1917 he was even willing to modify the field equation of General Relativity by the introduction of the cosmological term, with the intention of confining the solutions of his theory precisely to those which satisfy his demand for a Machian explanation of inertia. But even when it turned out that the modified theory also had non-Machian solutions, Einstein continued to believe that:[27]

> the General Theory of Relativity only forms a satisfactory system if according to it the physical qualities of space are completely determined by matter alone.

He now hoped that, even if other solutions would be mathematically possible, at least nature would have a preference for a static cosmological model compatible with his Machian understanding of inertia. Only in early 1931 Einstein was forced to recognize that this hope was not

26 For a more detailed discussion of the role of Mach’s principle in Einstein’s heuristics, see Renn 1994.
27 Einstein 1918, p. 271.

born out by the astronomical data in favor of an expanding universe.[28]

Did Einstein after this apparently definite failure of his heuristic program now finally restrict himself to the technical and conceptual exploration of General Relativity as he had established it in 1915? Surprisingly not, because he had other reasons to remain unsatisfied with this theory, reasons which were apparently in flat contradiction with his Machian heuristics. He pursued, at least since 1919, an alternative strategy to modify or further develop General Relativity in such a way that space is not conceived as a field effect ultimately caused by matter, but so that, vice versa, matter is rather being constructed in terms of a universal field representing the physical qualities of space. Einstein's hopes to reach a unified field theory which would integrate gravitation theory with electromagnetism and also explain the quantum structure of matter remained as unfulfilled as his Machian program. But if we take into account these more ambitious goals as a context for Einstein work on gravitation, it seems that the formulation of the field equation of General Relativity in 1915 was, after all, nothing more than an accidental discovery in the framework of a research project that was guided by concepts, heuristic principles, and expectations which cannot be reconciled with those associated with General Relativity as we understand it today.

Einstein's Vision Redeemed

The opposition between Einstein's goals of explaining space in terms of matter or matter in terms of space resembles somewhat today's alternative between the program to quantize gravitation in the framework of quantum field theory and the program to revise the concepts of space and time as they are used in quantum field theory according to General Relativity. The striking fact, however, that one and the same man could entertain such contrary options raises the question of whether there may not be some deeper level to Einstein's heuristics which might also explain its contribution to his success with General Relativity, without reducing this achievement to a pure case of serendipity. In fact, on closer inspection, Einstein's Machian program as well as the apparently opposite goal of a unified field theory turn out to be both the result of his striving for a conceptual unity of physics which overcomes the dualism between particle and field physics. That this fundamental problem occupied his mind is not new. More interesting is Einstein's particular approach to address this issue, which, in our view, accounts to a large extent for the success of his heuristics.

Instead of relying on the concepts of either mechanics or electrodynamics, Einstein took the

28 See the discussion in Renn 1994.

knowledge accumulated in both branches of physics and the structures organizing them as equally fundamental. Contrary to Lorentz's electrodynamics, for instance, Einstein's special theory of relativity treated the relativity principle of mechanics as just as foundational as the laws of the propagation of light established by electrodynamics, at the price of a revision of the concepts of classical physics. Similarly, instead of attempting to resolve Mach's paradox of the privileged role of inertial frames in the context of a revised version of classical mechanics, as did several followers of Mach, Einstein addressed this problem in the context of a field theory of gravitation in which inertial forces could be understood as an aspect of a unified gravito-inertial field. And finally, instead of constraining the understanding of this gravito-inertial field by the chronogeometry of Special Relativity, which to most of his contemporaries had quickly acquired a universal, almost a priori status for physics, Einstein realized that chronogeometry and gravito-inertial structure are equally universal for physics.

Mathematical tools such as the affine connection for describing the gravito-inertial structure were still lacking when Einstein began his work. But even in the absence of such tools Einstein's uncommon openness for philosophical questions had helped him to recognize the universality of the gravito-inertial structure where others just saw one more force to be subsumed under a special relativistic treatment. In spite of the mathematical and conceptual difficulties which he encountered, his heuristic principles guided a reconciliation between gravito-inertial structure and chronogeometry which excluded any prior geometry, thus effectively determining the characteristic features of General Relativity, even as we understand it today. In other words, Einstein's heuristics was so successful not because it anticipated the conceptual novelties of General Relativity but because it moulded the knowledge accumulated in the different branches of classical physics in such a way that its integration into one coherent framework became possible. This makes Einstein's philosophical openness and his integrative outlook on the foundations of physics into an historical lesson from which even today's unifying ventures may profit.

When studying this lesson it is, however, important to keep in mind the very specific historical circumstances under which a single scientist could make such an integrative achievement. First of all, just as the development of Einstein's political thinking was dependent on its social context, Einstein's integrative capabilities in the conceptual realm were dependent on historically specific features of his intellectual biography. An analysis of this intellectual biography even provides surprising relations between the formation of his political views and the emergence of his search for conceptual unity in physics.[29] The example of Einstein's reading of the popular scientific books by Bernstein which link internationalist political views with concrete specula-

29 See also the contribution by Britta Scheideler and Hubert Goenner in this volume.

tions about a conceptual unity of the natural sciences may suffice as an example.[30] Second, not only Einstein's intellectual outfit, but the very problem posed by the demand for a relativistic theory of gravitation has historically specific features that make it impossible to simply transfer his approach to other problems in other fields. This is strikingly illustrated by the failure of the contemporary attempt to exploit Einstein's integrative capabilities in the conceptual realm for an organization of science aimed at fostering a new microphysics – by appointing him Director of the Kaiser Wilhelm Institute for Physical Research. The integration of knowledge, in particular from physics and chemistry, that was required for the formulation of the later quantum mechanics could, in fact, no longer be achieved by the intellectual work of a single outstanding individual such as Einstein.[31]

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Directing a Kaiser Wilhelm Institute: Einstein, Organizer of Science?

Giuseppe Castagnetti
Max-Planck-Institut für Wissenschaftsgeschichte, Berlin
and Hubert Goenner
Institut für Theoretische Physik, Universität Göttingen

Introduction

This paper is a partial resumé of an investigation into Einstein's activity as the director of the Kaiser-Wilhelm-Institut (KWI) für Physik in Berlin in the years 1917 to 1922. Besides archival work done by Giuseppe Castagnetti, we could take advantage of the published volumes of Einstein's Collected Papers.

Our study touches the changing style of physics research from being the pursuit of truth by lonely creative spirits to a cooperative enterprise aimed at knowledge production. The foundation of the Kaiser-Wilhelm-Gesellschaft (KWG) and its institutes in part reflects this development as it took place in other disciplines like biology and chemistry. Its institutes were built around a powerful director and "scientific members" relatively free in their own scientific judgement; both in charge of a number of dependent scientists and of considerable technical staff. The direction of a KWI thus required personalities not only of highest rank in research ability but also capable of leading the work of their junior collaborators and willing to cooperate with other senior colleagues.

We must ask whether Einstein's personality would have fit such a position. As we shall see, a clash between his views concerning the progress of science via the creativity of the single researcher on the one side, and the need for necessary institutional reorganization of research on the other, became unavoidable. This may be closely connected with the way in which Einstein conceptually modelled his idealistic image of a "true scientist": a human being freed from his selfish desires and far from society. In her talk, Britta Scheideler will give a finer description of Einstein's views. His attitude towards science management seems to have been dominated by personal-value relationships: to him progress in physics was progress made by the single outstanding physicist - either alone or in scientific debate. Nevertheless, Einstein did come into contact with the business aspects of research on a large scale. During his time as director of the KWI für Physik General Relativity was put to the test. This turned out to be a complicated matter involving expeditions, large optical telescopes and other high-precision measuring instruments, i.e. tasks which could not be performed by one person alone - creative genius or not. In his book on the Einstein tower, Klaus Hentschel has given a clear description of what was involved. It turns out that even in a field so close to his scientific interests Einstein did not assume a leadership position.

In contrast to all other institutes of the KWG, the KWI für Physik, during the time of Einstein's directorship, had no building of its own and no staff of any importance. It was a mere mail-address institute with a corporate Direktorium (steering board) and without resident scientists. It developed into a funding agency governed by a steering board sharing all decisions. In a way, the KWI für Physik can now be interpreted as a forerunner for a form of science funding at the time new to the exact sciences - its structure being halfway between the "regular" institutes of the KWG and the "Notgemeinschaft der Deutschen Wissenschaft", a funding agency established three years later.[1] This new agency for the support of science and the humanities was founded as an answer to the precarious economical situation in Germany with prices soaring due to inflation, in particular for instruments, printing and literature. Its rationale was the sharing of the means for research - money, instruments, buildings and staff. The necessary consequence was the introduction of a reviewing process for the optimal distribution of scarce funds to where the best scientific returns were to be expected. Apart from the economical pressures, the ongoing differentiation within physics research made imperative a reorganization of decision making in the funding process.

Einstein, in spite of his all encompassing mind, could not appreciate this as a necessity of his time. Nevertheless, the KWI für Physik was, to a certain degree, an attempt to optimize the distribution of scarce funds as well as to coordinate the research. The question is just whether all the people involved, in particular its director, were aware of the ensuing changes in the organization of physics research. Einstein was, as we shall see, less than happy about his role as a director. We have found only a few traces of his interest in the structural organization of research in terms of institutions, funding procedures, or cooperative schemes. Although he served on the boards of quite a few professional institutions, his contribution there seems to have centered on questions internal to physics, i.e. on providing new ideas for theory and experiment. It is safe to say that science politics was not one of the fields Einstein was interested in.

There was another challenge to be taken up by Einstein. The period of his directorship extended over years which were important for the eventual creation of quantum mechanics as we now know it. In this process, the once separated fields of chemistry and physics became intimately

1 In a foundational memorandum of the Notgemeinschaft, the KWI für Physik was praised as an institution "which had used its considerable means, in times of peace, for the financial support of the expensive research of such individual scientists whose work had promised a special benefit for science" (Zierold 1968, p. 572).

intertwined. The development of quantum mechanics was achieved thanks to the cooperation of a large number of people with a few leading figures among them and not as the stroke of a single genius. It is clear that Einstein's dedication to the fields of General Relativity and, later, Unified Field Theory outweighed his interest and work in the area of the growing body of quantum theory. This may be intimately connected to his views concerning a possible conceptual synthesis of Planck's quantum and classical physics.

1 What was expected from Einstein?

In the following, the actual course of Einstein's recruitment to the physics community of Berlin is reduced to a few dates.[2] It must be seen in connection with previous attempts at establishing a physics research institute starting with a memorandum of Lenard in 1906 and pursued by officials of the Prussian Ministry of Education, by the KWG and by some influential Berlin physicists and chemists over the years till the opening of the KWI für Physik in October 1917.

Chronological list of events

1910	Nernst visits Einstein in Zürich and procures him financial support.
1912 February	Consultations about the establishment of a "Radiological Institute".
1912 April	Einstein visits Berlin. Emil Warburg offers him a position at the Pysikalisch-Technische Reichsanstalt (National Institute of Technical Standards).
1913 January	Efforts of Haber to create a position for Einstein at his KWI für physikalische Chemie und Elektrochemie.
1913 June	Planck, Nernst, Rubens and Warburg propose Einstein for membership in the Prussian Academy of Sciences.
1913 July	Planck and Nernst visit Einstein in Zurich. Einstein accepts the membership of the Academy of Sciences and the directorship of

2 Most of the sources and further informations are in Einstein 1993. Part of this story has been told before (Burchardt 1975; Heisenberg 1971; Kant 1987, 1992, 1996; Schlüter 1995; Wendel 1975); a more detailed account will be given in our full paper (Castagnetti and Goenner 1997, forthcoming).

	a new research institute. Einstein's election into the Academy.
1914 March	The KWG and the Koppel Foundation decide to set up a KWI for Physikal Research. Einstein would be the director.
1914 End of March/ Beginning of April	Einstein moves to Berlin.
1914 August	First World War begins. The establishment of the KWI for Physical Research is postponed.
1917 July	The KWG and the Koppel Foundation decide to open the KWI for Physical Research in October 1917.
1917, Oct. 1	Official establishment of the KWI für Physik.
1917, Nov. 26	First constitutive meeting of the two boards of the KWI für Physik.
1917, Dec. 16	First public call for research projects to be funded.
1918 January	Erwin Freundlich becomes assistant of the KWI für Physik.
1918 August	The first research grant is allocated to Debye.
l919, March 15	Second public call for research projects.
1919, April 24	First broad distribution of grants. Money for Grebe and Bachem.
1921	Research grant for W. Gerlach. Stern-Gerlach experiment.
1992 July	Einstein declares his intention to leave the directorship of the KWI für Physik.
1922 October	Max von Laue becomes deputy director of the KWI für Physik.

What reasons may the Berlin physicists and chemists have had for wanting Einstein to become their colleague? For him, they created an exceptional, well-paid position at the Prussian Academy of Sciences and the directorship of a new institute of the KWG. A number of arguments were advanced as a rationale. In his proposal for Einstein's membership in the Academy of Sciences Planck described all the topics to which Einstein had made fundamental contributions, e.g. special relativity, the application of the quantum hypothesis to the new kinetic atomistics and to the "lightelectric and photoelectric effects". He did not forget to stress that "Einstein's preferred field of research is the kinetic theory of matter and its relation to the fundamental laws of thermodynamics" and supported Einstein because "among the big problems of modern physics, there is almost none to which Einstein had not something remarkable to say".[3] Haber's hope was that Einstein could play a similar role for theoretical chemistry as van't Hoff who had introduced thermodynamics into it. For him, Einstein was the only person to be able to achieve a similar success by putting "the theory of radiation and electromechanics" to use for chemistry. By "electromechanics" we may understand "the theory of the electron" or, more broadly, the interaction of atoms and electromagnetic radiation, the quantum mechanical nature of which was largely unexplored and not understood. "This fundamental task can be incomparably advanced by having Mr. Einstein join our institute."[4] After describing the contributions of Planck, Einstein and Nernst to the new field of the quantum, Haber found the words: "With each month more evidence accumulates that the fundamental concept Planck introduced into theoretical physics, with the so-called elementary quantum of action, is indispensable for [understanding] all the processes of the molecular world. [...] We therefore very urgently need new experimental research in order to obtain a usable basis for the physical understanding of nature."[5]

During one of the preparatory discussions, Nernst suggested "to attack the theory of the solid state with massive support" and pointed to von Laue's and Bragg's research in unravelling the structure of crystalline bodies by X-ray scattering. Planck was the only one mentioning the field of research Einstein was presently most engaged in, i.e. gravitation theory, and suggested to help him get support from astronomy in order to test his theory.[6]

Thus, we conclude that Einstein was invited to come to Berlin in order to bring fresh inspiration for the further theoretical and experimental development of quantum physics, its applications to material science and physical chemistry and not at all for generalizing special relativity towards a relativistic theory of gravitation. Einstein must have understood this; in 1913, in a letter to his friend Michele Besso, he comments: "The fraternity of physicists behaves rather passively with respect to my paper on gravitation. [...] Laue is not open to the fundamental consider-

3 Kirsten and Treder 1979, vol. 1, pp. 95-97; Einstein 1993, doc. 445.
4 Einstein 1993, doc. 428.
5 Haber’s memorandum for H. A. Krüss, n. d. [received on 24 April 1914], Staatsbibliothek Berlin, hereafter SBB, Acta Preußische Staatsbibliothek, Generaldirektion, Kaiser-Wilhelm-Institute XXVI.
6 Wendel 1975, p. l97; minutes of the meeting of 9 January 1914, Geheimes Staatsarchiv Berlin, hereafter GStA, I. HA, Rep. 76 V c, Sekt. 2, Tit. 23, Litt. A, Nr. 116, p. 3.

ations, and neither is Planck".[7] Of course, in speaking of quantum theory, we must not understand the term as we do it nowadays. For Planck, the essence of the quantum hypothesis consisted in Nernst's heat theorem.[8] For Nernst himself, quantum theory was an equivalent to the molecular theory of the solid state, to which Einstein had given a fundamental contribution.[9] Jürgen Renn and Tilman Sauer have pointed out Einstein's unsurpassed ability in successfully integrating concepts and methods from one subfield of physics into another. lt may well have been this feature which made Einstein attractive to his Berlin colleagues venturing into the still magic world of the quantum. In this spirit, Haber ended a memorandum with the remark that there is hope "with the help of the KWI for theoretical physics, to keep the leading pace which German science has begun with the achievement of Mr. Planck".[10] In particular, due to his familiarity with and masterly use of statistical methods, Einstein was the optimal candidate in the eyes of his colleagues in Berlin to keep the leading pace.

1.1 A new way of organizing physics research?

A further argument for the assumption that Einstein was recruited by the influential Berlin physics and chemistry professors for his assumed ability to stimulate and coordinate research on a large scale in what we now call the microscopic theory of matter follows from the particular manner in which the new institute was to operate: an approach to organizing research was introduced which was novel to physics. It took as its model an existing structure of the Prussian Academy of Sciences in Berlin, the appropriations committee, which administered the capital endowed to the Academy by private donors. One project receiving money in this way involved historians in a grand collaboration and was entitled "Monumenta Germaniae Historica" (Monuments of German History). A proposal, dated February 1914, for the establishment of a KWI für theoretische Physik states: "The purpose of the institute will be to form for the solution of important and urgent physical problems various associations of particularly competent researchers [...]. Such a cooperation of different scientists of a field is probably almost new in physics, but has been practised since long in other disciplines; in particular the committee for the "Monumenta Germaniae Historica" established by the Royal Academy of Sciences is to be remembered."[11]

In close resemblance with the organizational structure of the project in history, the new institute was built on two bodies: i) a "Kuratorium" (administrative board) of six members, three of

7 Einstein 1993, doc. 499.
8 Planck 1912, p. IV.
9 Nernst 1921, table of contents, p. XI.
10 Haber's memorandum for Krüss quoted above.
11 Kirsten and Treder 1979, vol. 1, p. 147.

which came from the KWG (i.e. W. von Siemens, Nernst and Planck), two from the Koppel Foundation (Koppel and Haber), and one from the Prussian Ministry of Education (Schmidt-Ott); ii) a "Direktorium" (steering board) consisting of its chairman Einstein, Haber, Nernst, Planck, Rubens and E. Warburg. Consequently, there was sizeable overlap between the two boards. All members of the Direktorium also belonged to the Academy of Sciences. Except for Einstein all of them were experienced in science administration and even in science politics. Why was the structure chosen in the case of Einstein so different from the previously established KW-Institutes built around a creative scientist as its powerful director? We could speculate that the founders were perhaps aware of Einstein's lack of experience in leading a big institution. Also they might have tried just to obtain more funds for their own particular fields of research through the reputation of their young and promising colleague.

On the other side, already before Einstein's move to Berlin, there was strong overlap between their research interests and Einstein's. In 1914, the hints coming from so many subfields of physics that quantum phenomena would play an important role in the understanding of matter pointed to the need for a cooperative effort. And what an attractive group of excellent scientists had been brought together in the Direktorium, all with an interest in the quantum! Certainly, Einstein was to become head of the Direktorium not because the Berlin physicists wanted to entrust him with an administrative role but because a new step in the conceptual advancement of physics through coordinated research was attempted. It was deemed necessary because of the scope of the quantum phenomena already discovered, and Einstein was assumed, on the basis of his earlier work concerning the atomistic nature of matter and the quantum aspects of radiation, to be able to exert conceptual leadership of the research carried out by other physicists in this field. To us the fact that the name of the new institute in the official proposal of February 1914 was "for theoretical physics" instead of the previous "for physical research" which, in Lenard's original use had meant experimental physics only, is further indication of the prominent role ascribed to the theoretician Einstein. He was the one chosen to give inspiration, not W. Wien, Rutherford, or Geiger whose names had been discussed and were dropped. However, the institute was born in October 1917 as KWI für physikalische Forschung.[12] The foundation had been initially postponed because of the outbreak of the First World War and the lack of financial support by the Prussian State but a gift by a private donor allowed the opening of the new institute already before the end of the war.

12 The name “Kaiser-Wilhelm-Institut für Physik“ was given by imperial decree on December 1917 (GStA, I. HA, Rep. 89 (2.2.1.), 21306, p. 37)

2 The KWI under Einstein's directorship 1917-1922

2.1 The opening

> Am 1. Oktober 1917 ist das
>
> **Kaiser-Wilhelm-Institut für physikal. Forschung**
>
> ins Leben getreten. Seine Aufgabe soll darin bestehen, die planmäßige Bearbeitung wichtiger und dringlicher physikalischer Probleme durch Gewinnung und materielle Unterstützung besonders geeigneter Forscher zu veranlassen und zu fördern.
>
> Die Auswahl der Probleme, der Methoden sowie des Arbeitsplatzes liegt in der Hand des unterzeichneten Direktoriums. Doch sollen auch von anderen Physikern an das Direktorium gelangende Anregungen von diesem erwogen und die vorgeschlagenen Untersuchungen im Falle der Billigung gefördert werden.
>
> Wenn das Institut auch naturgemäß erst nach Beendigung des Krieges seine volle Wirksamkeit wird entfalten können, so soll doch womöglich schon jetzt mit der Arbeit begonnen werden. Angaben über nähere Einzelheiten sind an den mitunterzeichneten Vorsitzenden des Direktoriums, Professor Einstein (Haberlandstr 5, Berlin-Schöneberg) zu richten.
>
> **Das Direktorium.**
>
> **Einstein. Haber. Nernst. Rubens. Warburg.**

On 16 December 1917, in the advertising section of the Berlin newspaper *Vossische Zeitung* the establishment of the new institute was made public by Einstein: "On 1 October 1917, the KWI for Physical Research has been born. Its intended aim is to induce and support systematic work on important and urgent problems in physics by gaining qualified researchers, and by giving them financial aid. The selection of problems, methods and laboratories is made by the undersigned members of the Direktorium. Nevertheless, suggestions reaching the Direktorium through other physicists could also be thought over and, in case of approval, the proposed projects will be funded. Despite the fact that, of course, the Institute will be fully effective only after the end of the war, the work should possibly be begun already now. Queries for detailed information should be addressed to the cosigner and chairman of the Direktorium, Professor Einstein (Haberlandstr. 5, Berlin-Schöneberg). The Direktorium. Einstein. Haber. Nernst. Rubens. Warburg."[13] Planck's name is missing, because Einstein forgot to place it.[14]

Einstein in his workroom, around 1930
(Grüning 1990, p. 136; © Albert Einstein Archives, Jerusalem)

The address given is Einstein's private address. Haber had offered him some office space, but he prefered to work at home. In the announcement of the opening of the KWI für Physik no hint

13 *Vossische Zeitung*, 16 December 1917, no. 641, 2. Beilage “Finanz-und Handelsblatt“, p. 3.
14 M. Planck to Einstein, 29 December 1917, Albert Einstein Archives Jerusalem, hereafter AEA, 19-261.

is given of the extent to which either experimental or theoretical physics would be supported. The director of the new institute was known as a theoretician whose mathematical constructions, in General Relativity, were well beyond the grasp of most experimental physicists during the twenties. How would he go about transforming "the systematic work on important and urgent problems" into a funding policy, presuming he did care about such a question at all?

The organizational effort put into the new institute remained minimal, at first, with the secretarial work being done, in Einstein's flat, by Elsa Einstein-Löwenthal's oldest daughter Ilse. The few documented meetings almost always took place in the rooms of the Academy after its sessions. There is ample evidence that Einstein soon felt burdened by the correspondence and the bureaucratic procedures to be followed.

2.2 Freundlich as assistant

At first the Institute took only one initiative and not in the field of radiation or quantum physics, but in that of general relativity. In February 1918 Erwin Freundlich was engaged for three years with the task of conducting "experimental and theoretical research for the testing of the theory of general relativity".[15]

Since 1911 Freundlich had shown an interest in an actual measurement of the deflection of light rays by the gravitational field of the sun predicted by Einstein's theory. Einstein had unsuccessfully tried to have him released from his duties as assistant at the Sternwarte Babelsberg, the Astronomical Observatory near Berlin. But the director of the Observatory did not allow Freundlich to work freely. Now the establishment of the KWI für Physik allowed Einstein to direct his forces to the experimental testing of his gravitation theory.[16]

2.3 First applications for grants

The announcement of the institute's opening drew mail from cranks and brought in proposals both for applications in industry and in fields outside of physics. Only a single project corresponded particularly well to the declared intentions of the KWI für Physik. It came from Peter Debye who asked Einstein for a grant to buy instruments for generating "X- rays of arbitrary wave length with sufficient intensity". Debye was particularly interested in X-rays with very

15 Contract between KWI für Physik and E. Freundlich, 4 February 1918, Archiv zur Geschichte der Max-Planck-Gesellschaft Berlin, hereafter AMPG, I. Abt., Rep. 34, Nr. 2, folder Freundlich.
16 Hentschel 1992b, pp. 51-58.

short wavelengths, i.e. high energies, for which he expected "a failure of classical electrodynamics. (I think about a quantization of radiation originating in a free electron)". Debye received the money, but handed it back later, because the manufacturer could supply the instruments only in 1920 when he already had left Göttingen for Zurich.[17]

2.4 The real start: scientists funded and their projects (1919-1922)

While the Direktorium had not met in person since the constitutive meeting of November 1917, on 15 March 1919 it suddenly sent a letter to the physics institutes of all German universities notifying them of the availability of means for the financing of research projects. "On the occasion of the fresh beginning of scientific research in physics, we would like to direct the attention of our colleagues to the fact that the Kaiser-Wilhelm-Institut für Physik has considerable means for scientific institutions as well as for individual colleagues in order to make possible or to facilitate scientific research work. In particular, we think of 1) buying instruments to be used for special scientific investigations; 2) fellowships for carrying out of definite scientific research projects. Proposals with statements explaining the planned scientific investigations as well as the money needed are to be sent to Prof. Einstein [...]. The only point of view underlying the distribution of funds will be the revitalization of physics research."[18] Practically, this meant that the Direktorium gave up for the time being the implementation of a planned particular research program of its own. The money now was to be distributed according to the suggestions coming from the physics community with only the quality of the research and, perhaps, also its topics becoming refereed by the Direktorium. In fact, now a number of valuable applications came in.[19]

Many of the projects were concerned with spectroscopy and radiation phenomena, in which the new concept of Planck's quantum played a dominant role. Others dealt with properties of material systems and with molecular physics. A suggestion to establish a department for radiological research had been already submitted in 1918 by Einstein's later friend for life Gustav Bucky, a physician specialized in the application of X-rays, but had not gained the Direktorium's approval.[20]

Instead of going through the applications accepted in the period 1919-1923, as we do in our paper, we just list names of a number of those who over the years received grants: von Baeyer,

17 P. Debye to Einstein, 2 July 1918 and 20 December 1920, AMPG, I. Abt., Rep. 34, Nr. 1, folder Debye; Kant 1996, pp. 230-231.
18 AMPG, I. Abt., Rep. 34, Nr. 13.
19 The applications and the related documents of the KWI für Physik are in AMPG, I. Abt., Rep. 34.
20 Bucky to Einstein, 11 May and 18 May 1918, AMPG, I. Abt., Rep. 34, Nr. 1, folder Bucky.

Born, James Franck, Gerlach, Hedwig Kohn, Pohl, Peter Pringsheim, Regener, Schaefer, Sommerfeld and Stern. The most successful project funded by the KWI für Physik was the now famous experiment of Walther Gerlach and Otto Stern on the directional quantization of electron orbits in a magnetic field.[21]

Most of the recipients of the grants were related through common scientific interests, the employment of similar instrumental techniques and/or professional "clanship". They held positions as full or assistant professors, Privatdozenten (lecturers) and/or assistants at German Universities or applied for some of their doctoral students. 40 % of them are referred to in Nernst's text book on chemistry (Nernst 1921), 32 % in Sommerfeld's seminal presentation of the state of the art of atomic physics (Sommerfeld 1931). About 80 % of the scientists supported became well-known or, at least, obtained decent academic positions within the German university system and abroad. Only approximately 10 % of the young people funded later left science for work in higher education or industry. Of all who received money, only a group under 30 % really belonged to what could be called "junior partners", in the sense that, in 1928, its members did not yet have a full professorship.

It is not easy to find a logic in the distribution of the grants; documents showing an exchange of scientific views among the members of the Direktorium about the funding have not been found. Certainly, some of the scientific interests of the members of the Direktorium were taken into consideration. In 1919, in addition to the assistantship for Freundlich, Einstein received a modest sum for "mathematical help" to be used for his junior collaborator, the Belorussian mathematician Jakob Grommer. Einstein worked with Grommer for more than ten years on problems relating to general relativity, unified field theory and quantum theory. Einstein had also invited two spectroscopists from the University of Bonn, Grebe and Bachem, to apply for support for a verification of the gravitational redshift of the Sun's spectral lines.[22]

In the following funding periods, Einstein held back his legitimate demands. Grommer obtained only a small sum for "theoretical research related to relativity theory".[23] Freundlich, after 1920 was no longer financed by the KWI für Physik. For himself, Einstein took out the minimal sum of 579.85 M or, roughly one percent of the funds handed out, "for a mercury-arc condensation pump".[24] In all likeliness, this is to be seen in connection with an experiment carried out by Hans Geiger and Walther Bothe of the Physikalisch-Technische Reichsanstalt on Einstein’s suggestion. In 1921 Einstein thought about the elementary process of the emission of light and pro-

21 Einstein and Born 1969, pp. 102-104; Gerlach and Stern 1922; Heisenberg 1971, pp. 46-47.
22 Grebe to Einstein, 17 April 1919, AMPG, I. Abt., Rep. 34, Nr. 3, folder Grebe; a detailed account of the work of Grebe and Bachem is given by Hentschel 1992a.
23 Kirsten and Treder 1979, vol. 1, p. 154.
24 Minutes of the Direktorium's meeting of 26 January 1922, AMPG, I. Abt., Rep. 34, Nr. 12.

posed an experiment devised so as to decide between the wave theory and the light quantum theory of radiation. The experiment did have a negative outcome and was initially interpreted by Einstein in the sense of a particle nature of light, but he later admitted that he had made a big mistake in the interpretation of the results.[25] Surprisingly, Einstein even solicited funds from private donors and from other funding agencies like, e.g., the Rockefeller Foundation for supporting tests of the gravitational redshift or for his collaborator Grommer, without trying to tap the budget of his institute.[26]

As documented in his correspondence, during his time as a director Einstein did show scientific interest for the proposals only in a few cases. This happened, for example, when he turned back two applications on scientific grounds.[27]

2.5 Annual reports

Einstein's less than enthusiastic interest in taking part in the process of science funding and the changing policy of the institute are reflected in the consecutive annual reports of the KWI für Physik. The report for the period April 1919 to March 1920 makes clear that the original idea for the funding had been diluted: "The task of the KWI für Physik is primarily the support of large scale scientific research projects, which cannot be carried through with the means of the single [University] institutes. However, the difficult economical situation and the scarcity of funds for research of the various institutes resulting therefrom made it necessary to stray somewhat away from this plan and to support a larger number of separate research projects. The Direktorium believed that in this way it could serve best to the preservation and improvement of physical research." Then, the 15 accepted projects, "a large part of which was devoted to spectroscopy", are mentioned and the work of Freundlich for testing General Relativity is described in some detail.[28] The central point of Einstein's interest was the theory of general relativity, its testing and further theoretical development. It is here that he took his only initiatives as director of the institute. On the other hand, he supported this kind of research only with amounts of money very modest in comparison with the budget.

The report concerning the next period (April 1920 to March 1921) is remarkably uncommitted. Beside Freundlich's, it does not even mention the name of the supported scientists.[29] Not one

25 Einstein and Born 1969, pp. 85, 98-99, 102.
26 R. Fleischer to Einstein, 29 December 1919, AEA, 43-689; Einstein to J. Loeb, 28 December 1923, AEA, 15-194.
27 Einstein to Gabriele Rabel, 20 November 1919, AMPG, I. Abt., Rep. 34, Nr. 9, folder Rabel; Einstein to E. Schweigler, 17 February 1921, AMPG, I. Abt., Rep. 34, Nr. 10, folder Schweigler.
28 AMPG, I. Abt. Rep. 1 A, Nr. 1665, p. 48.
29 AMPG, I. Abt., Rep. 34, Nr. 13

of the projects supported in 1920 had been directly suggested by Einstein. Only in the cases of Gerhard Hettner and James Franck we can establish a direct relation between an application and a member of the Direktorium. Hettner was a longtime assistant of Rubens and Franck was working at that time at Haber's KWI für physikalische Chemie und Elektrochemie. All the other projects were proposed by university researchers on their own initiative. In the report for the period April 1921 to March 1922 Einstein for the first time described in more detail what he considered the main research activities supported and he singled out three projects concerning atomic physics and black body radiation carried out by Clemens Schaefer, Emil Wagner and Rubens.[30] The influence exerted on the distribution policy by the particular interests of a Direktorium's member is shown by the decision to support A. Wigand's research in cosmic radiation, one of Nernst's fields of interest. In accord with his liking, the KWI für Physik even paid for gasoline for airplanes and for the hydrogen filling of manned balloons used in a project concerned with atmospheric electricity and radiation.[31]

2.6 The institute's funding policy

In analyzing the funding policy of the KWI für Physik, we may say that it was a policy of "no risk": i) Only well known researchers and their assistants were given support; ii) financially, any possible strain on the institute's budget was avoided by a large margin. The KWI für Physik spent much less money than its budget would have allowed, although lack of funds was always an argument used when applications were turned down for reasons other than scientific. In the times of financial stress during the years 1921-23, when most of the institutes of the KWG had to resort to deficit spending, the KWI für Physik increased its stock of money and earned interest. This did not go unremarked by the central administration, which, in 1922/23, used the budget of its physics institute to finance an entomological museum.[32]

Over the years, a definite change in the original funding policy came into effect. The aim originally had been to support "scientific research on a large scale". Later, because such kind of research involving more than one institution had not been proposed from the outside and, obviously, not by the Direktorium itself, the funds were divided up among a number of smaller projects.

The supported projects did not correspond to a carefully planned research strategy, but to the more or less spontaneous development of research interests in the physics community. The in-

30 AMPG, I. Abt., Rep. 1 A, Nr. 1665, pp. 57-58.
31 Minutes of the Direktorium's meeting of 26 January 1922, AMPG, I. Abt., Rep. 34, Nr. 12.
32 For details on the institute's budget policy, see Castagnetti and Goenner 1997 (forthcoming).

stitute thus confirmed its role as a grants distributor without special directives given by its director. Nevertheless, the research projects financed by the institute reflected notable developments of contemporary physics, especially of quantum physics. From 1918 to 1922, research on spectroscopic subjects represented roughly 40 %, and research on other topics related to the quantum nature of matter amounted to roughly another 36 %. On the other hand, the KWI für Physik supported research related to general relativity in only three cases, namely the work of Freundlich, Grebe/Bachem and Grommer.

3 Why did Einstein give up managing the institute?

Since January 1922, Max von Laue had become a member of the Direktorium. On 12 July 1922, Einstein asked von Laue to take over the directorship of the KWI für Physik as his deputy "from the 1 October for an indefinite time".[33] On 1 October 1922, von Laue became deputy director of the institute.

What were the reasons behind Einstein's retreat which turned out to become permanent? Superficially, Einsteins motivation as declared in the letter to von Laue was a visit to Japan; he would be away from Berlin for several months. However, in a letter to Planck of the same day Einstein expressed his impatience for the public attention of which he had become a target and his intention to step back from the scene.[34] Accordingly, we could suppose that he resigned for political reasons: he no longer wanted to play an official role. Since 1920 he had become the aim of public attacks in the press and in meetings which were partly motivated by political interests.[35] In June 1922, Minister Rathenau had been murdered and Einstein seemed to be in danger, too.[36] But was politics the real reason? We think not, because i) Einstein's function as director of the institute did not imply public presence and, ii) even after his return from Japan, he let himself be used as a figurehead for the institute.[37]

We suggest that the main reasons for his resignation were his discontent with the administrative burden of his office, with the ongoing practice of research financing and, on the other side, his reaching private financial independence. In the summer of 1922, Einstein probably made as much or even more money from the income of his books and public lectures and from his work on the gyrocompass with his friend, the inventor and industrialist Anschütz-Kaempfe, than

33 AMPG, I. Abt., Rep. 34, Nr. 2, folder Einstein
34 AEA, 19-304.
35 Goenner 1993.
36 Fölsing 1993, pp. 595-596.
37 Einstein figures as the Director of the KWI für Physik in all the yearly reports of the KWG till 1932.

from his salaries at the Academy of Sciences and the KWI für Physik taken together. As he himself wrote: "Materially, I am rather independent, to the extent that the remuneration which I obtain from the Academy is practically negligible, such that I can renounce it without disturbing the equilibrium".[38]

4 Einstein's directorship: did he develop a research plan?

4.1 Research interests of the members of the Direktorium

We now try to give the background against which possible relations between the projects funded by the KWI für Physik and the members of its Direktorium, notably its director Einstein, might be established. The general topics supported financially can be described by the following items in alphabetical order:

- *Gravitation*: spectral redshift, light deflection, solar eclipse expeditions;

- *Kinetic theory and radiation*: specific heats, thermodynamics, non-equilibrium thermodynamics (chemical reactions), radiometry, thermometry, ultramicroscopic particles

- *Material Science*: X-ray structure analysis, magnetic properties of metals and alloys, optical, elastical and thermal constants;

- *Nuclear Physics*: cosmic rays, radioactivity;

- *Physics of the atmosphere*

- *Physical Chemistry*: photochemistry;

- *Quantum theory*: quantum statistics, Planck's radiation law, directional quantization in a magneticfield, Zero-point fluctuations;

- *Radiation and the quantum*: Cathode/anode rays, X-rays, photo-effect, emission by collision of electrons and atoms, thermal emission, fluorescence;

38 Einstein to J. Loeb, 22 September 1922, AEA, 15-193; for the details, see Castagnetti and Goenner 1997 (forthcoming).

- *Spectroscopy*: Line/band spectra, absorption, dispersion, broadening of spectral lines, influence of electric and magnetic field.

Einstein's own scientific work during the period was dominated by four great themes:

- the testing of general relativity;

- the continuation of general relativity towards a unified theory including gravitation and electromagnetism;

- elementary particles as solutions of overdetermined partial differential equations;

- the wave-particle dualism of electromagnetic radiation.

As mentioned before, at the beginning of his directorship Einstein's activity went almost exclusively to testing his theory.

4.2 Did Einstein develop a research plan for his institute?

This question asked in connection with Einstein's directorship must be answered with a firm "no". From the start the intention was "that the [Institute] will develop only a modest own experimental activity, and will use the largest part of the sums at its disposal for the support of work carried out in other scientific institutions".[39] Definitely, a coordinating effort would have been required in which more than one research group in possibly more than one location took part.

Of the various possible scenarios for a plan to guide such research two are extreme: maximal rigidity where investigations have to follow firm directives given, and minimal involvement where research is defined by exclusion of projects. While being director, Einstein seems to have followed the course of minimal involvement. He was not ready to give positive directions for what had to be done. In his answer to a circular of the President of the funding agency “Notgemeinschaft der Deutschen Wissenschaft“, Friedrich Schmidt-Ott, asking for scientific projects worthy of support, Einstein wrote: "Yet, I would not dare to indicate the problems, the pursuit

39 Ministry of Education to Ministry of Finance, 2 July 1914, GStA, 1. HA, Rep. 76 V c, Sekt. 2, Tit. 23, Litt. A, Nr. 116, pp. 21-24

of which seems to require primarily support; this would be presumption. Nevertheless, I can give you names of researchers who, according to my opinion, promise important contributions, [...]." Einstein's program was centered on "persons" whom he respected for their scientific achievements. In the list he then gave, we find two later nobel prize winners (Franck and Stern) and a student of one of them (Volmer, later professor for physical chemistry in Berlin), and two prominent physicists and full professors (Kossel and Gerlach).[40]

Consistent with this impression is Einstein's reaction to another circular of Schmidt-Ott. After expressing his concern that large scientific projects would not be carried out for want of assisting young physicists, Schmidt-Ott had asked to name candidate for research fellowships. This was exactly the way Einstein approached the organization of planned research. He answered: "I consider the form of support for science proposed in the circular [...] as very useful. For the KWI I represent, the support of a scientific assistant is, at present, not envisaged."[41] In this context it is surprising that Einstein did not try to get an assistantship for Grommer. After the money he had received in 1920/21 Einstein's "calculational aide" was no longer funded by the KWI für Physik.

Einstein seemingly did not even have in mind something coming close to what could be called a general research program for himself. His ideas flowed freely and were taken up as they came; his scientific work in one single year moved leasurely from one subfield of physics to many others. This claim does not contradict the views that Einstein used a very definite strategy in a particular research topic - as Jürgen Renn and Tilman Sauer showed convincingly for his way from Special to General Relativity[42]. It also does not exclude that Einstein had a basic motivation underlying all his research activities. As he himself put it: "The real goal of my research has always been the simplification and unification of the system of theoretical physics. I attained this goal satisfactorily for macroscopic phenomena, but not for the phenomena of quanta and atomic structure."[43]

However, his stress on the creative contribution to science of the individual researcher prevented him from becoming interested in structural questions connected with cooperative efforts in science. This immediately leads to the question about the role played by the KWI für Physik and its director Einstein for the course of the then developing quantum theory. There is a marked difference between the approaches taken in Berlin and those of Sommerfeld's, Bohr's and other groups. Einstein's views about the common ground of classical field theory and quan-

40 F. Schmidt-Ott to Einstein, 19 July 1922, and draft of Einstein's letter to F. Schmidt-Ott, n. d., on the same page, AMPG, I. Abt., Rep. 34, Nr. 9, folder Notgemeinschaft.
41 Schmidt-Ott to Einstein, 28 February 1922, and draft of Einstein's letter to Schmidt-Ott, n. d., on the same page, AMPG, I. Abt., Rep. 34, Nr. 9, folder Notgemeinschaft.
42 See their contribution in this volume.
43 Dukas and Hoffmann 1979, p. 12.

tum theory might have been one reason. On the other side, his past experience of having created General Relativity all by himself, might have deceived him and his Berlin colleagues with respect to different requirements in a field with immensely many more empirical ramifications.

5 Albert Einstein as an organizer of science?

5.1 Einstein's activity outside the KWI für Physik

In order to obtain a fuller picture of Einstein's position with regard to science politics, we now briefly list his memberships and activities in boards of professional institutions. These activities deserve an investigation in itself.

MEMBERSHIPS OF ALBERT EINSTEIN

since 1913	Member of the Deutsche Physikalische Gesellschaft (German Physical Society
1914-1916	Member of the Vorstand (steering board)
1916-1918	Chairman
1918-1921	Member of the Vorstand
1916-1933	Member of the Kuratorium (steering board) of the Physikalisch-Technische Reichsanstalt (National Institute for Technical Standards)
since 1920	Member of the Kuratorium of the Einstein-Spende, later Einstein-Stiftung (Einstein Foundation)
since 1922	Chairman for life.
1922-1933	Member of the Kuratorium of the Astrophysikalische Observatorium, Potsdam
1922-1924	Member of the Senat (steering board) of the KWG
?-1932	Member of the Astronomische Gesellschaft (Astronomical Society)

Despite all these memberships, Einstein never really cared about institutional questions. If he was committed to any cause in science politics at all it was to procuring the institutional means and the man-power for the testing of General Relativity.

5.2 Albert Einstein as a politician of science?

Obviously, Einstein cannot be considered as having been a science politician in the proper sense. We can only observe how he dealt with his tasks as a director of a KWI and member of steering boards of various institutions. It is revealing that one of the top figures of science politics at the time, Schmidt-Ott, mentions the KWI für Physik only in passing. He has nothing to say on Einstein.[44] Likewise, the secretary general of the KWG, Friedrich Glum, in his memories is almost silent about Einstein. According to him: "Undoubtedly the most important appearance among the directors of KWG then was [...] Fritz Haber."[45]

Management and politics are bound to action, and the type of organizational and strategic action involved here is intimately connected with the concepts of power and of function. It seems that Einstein never thought in terms of power; he was a man of inner values and did not engage in the power plays typical of politics of any sort. Of course, he was eager to promote his ideas and appreciated it when other people took them up. But we do not have evidence of his having shaped the career of others under the aspect of an expansion of his personal area of influence, be it in terms of scientific ideas or of leadership in the physics community. The influence which he exerted, and barely another physicist in the Germany of that time and, perhaps in all of Europe, had a comparable public status, was that of someone setting measures of excellence in the field and (mostly) standing aside of the petty struggle for positions and rank. Whether Einstein thought much about the function of the KWI für Physik remains open, but there are reasons to doubt it. Its original aim of coordinating research on a large scale was abandoned. Obviously, no one in the Direktorium had an idea of what kind of specific research project this should be. What was more important to try to understand: the atom or the structure of solids or the nature of radiation? From the beginning, as we have seen, the physicists and chemists in the Direktorium held differing opinions. It seems that Sommerfeld and Bohr set their stakes in atomic physics, Born and Debye in atomic and, as it would be called later, solid state physics while Einstein's thinking centered on the nature of light and radiation. As reported, Einstein did not want to make decisions concerning the priority or importance of competing problems. In short, he did not provide scientific leadership. So, how could he set a policy for his institute? That this

44 Schmidt-Ott 1952, p. 127.
45 Glum 1964, p. 287.

is not mere speculation is shown by a remark of Einstein made in 1944 and in which he presented himself as even less interested in the directorship of the KWI für Physik than we have assumed up to now: “The story with the institute is a gracious lie. It is true, however, that I knew always how to manage it so that de facto I had no institute on my neck. I just wanted to have my head free, and had no desire to tell others what they should do (nothing of the "Führer").”[46]

5.2.1 Einstein's views on how research ought to be organized

For Einstein, an excellent physicist by definition brought with him excellent research projects. There was no need for lenghthy funding procedures. Furthermore, Einstein probably did not relate his awareness that there are problems which surpass the strength of one single researcher with institutional forms organizing cooperative research. In talking to Rockefeller Einstein said "I trust on intuition" while the industrialist replied "And I on organization".[47] Einstein left organization to others; as mentioned, what came to be named "Einstein Turm" and represented the beginning of "large scale research" in a field he was interested in, was largely the work of other people, notably of Freundlich.[48]

In August 1922 Einstein had contacts with Jacques Loeb of the International Education Board (Rockefeller Foundation), who was looking for German research institutes needy and worthy of support. He wrote to him that he hoped "you will not give your money to organizations, which are bound to thousands of considerations, but directly to those who are able to make something worthwhile of it. Otherwise the money will be spread in little ineffective portions to support superfluous mediocrity."[49] Did he have the practice of the Direktorium in mind when writing this? It seems that the subject was of real importance to him, because in a second letter a month later he wrote again: "If you want to give something for the sake of science in Germany, give it absolutely not to organizations, which always take their decisions according to the principle of minimal odium, but give it in accord with your free judgment to a few capable people."[50]

We cannot have a clearer expression of Einstein's discontent with the practice of supporting scientific research adopted by his institute from the beginning. However, the question then arises why Einstein did not use his position as its chairman and took the initiative but instead applied to other funding agencies. A tentative answer would be that he just did not want to waste his

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46 Einstein to J. Plesch, 3 February 1944, Archiv des Jüdischen Museums Berlin; Plesch 1949, pp. 201-202.
47 Nathan and Norden 1975, p. 173.
48 Hentschel 1992b.
49 Einstein to J. Loeb, 14 August 1922, AEA, 15-192.
50 Einstein to J. Loeb, 22 September 1922, AEA, 15-193.

energy with administrative matters or to quarrel with the other Direktorium members. A couple of years before, Einstein seems to have had a different outlook: “In fact, it would be good if I were to get some sort of institute; I could then work together with others instead of only by myself. This would be much more to my liking.”[51] Perhaps in this letter Einstein still had in mind his student days in Berne in which he had used his friends in the "Olympia Academy" as a sounding board for his ideas.

5.2.2 Personal politics: Filling professorships and procuring jobs

Next to getting a hold on science funding, it is the filling of positions which reflects best both the power and the functional aspect of science politics. Criteria typical for Einstein's evaluations stress the "importance" of scientific contributions of the candidates, in particular through critical thinking and originality. As an example, we have Einstein's description of von Laue: “Laue is in my opinion the most important of the younger German theoreticians. His book on relativity is a real little masterpiece, and much of it is his own intellectual property. Laue is a man of definite formal talent, from whom much that is good is still to be expected.”[52] On second thought, Einstein supported also Max Abraham “who outstrips in importance all [...] mentioned" including von Laue. He considered him "a really important man".[53]

In December 1920, in connection with the filling of a professorship for theoretical physics at the University of Hamburg, Einstein was asked to comment on a list of possible candidates with the names of von Laue, Lenz, Schrödinger, Flamm and Thirring. He replied that except for von Laue's, the achievements of Epstein would surpass those of all others named. "Lenz, Schrödinger, Thirring and Flamm all are able theoreticians of which every one can be really recommended." He then pointed to Reiche from Breslau "who is an excellent theoretician and teacher, although the originality of his achievements perhaps must stand back in relation to those of Schrödinger and Lenz."[54]

From these cases and from instances when he did not back candidates we get the impression that although scientific excellency was first and foremost on Einstein's list of priorities, he nonetheless evaluated the whole personality of the candidate. He relied on his "intuition" which seems to have worked well in scientific matters, but failed in other respects as shown by several examples which could be produced. As director of the KWI für Physik, he also tried to help some of the applicants to get money for their research or a better job (e.g., Seemann, Regener,

51 Einstein to Elsa Einstein-Löwenthal, n. d. [November 1913], in Einstein 1993, doc. 482.
52 Einstein to A. Kleiner, 3 April 1912, in Einstein 1993, doc. 381.
53 Einstein to A. Kleiner, 3 April 1912, in Einstein 1993, doc. 382
54 Einstein to W. Blaschke, 29 December 1920, AEA, 43-278.

Koenigsberger). As a member of the Academy, he tried to influence the appointment of the director of the Astrophysical Observatory in Potsdam and of other positions in astronomy, yet with little success. His efforts to exert some influence on the astrophysical community seem to be the most important part of what could be called Einstein's personal policy, and in which he took more than a passing interest.

6 CONCLUSION

Our conclusions do not claim to be generally valid as far as the organization of physics research in Germany is concerned: we have restricted ourselves to a special historical situation with Einstein in its center, i.e. to a transitional period both for sciences funding and for the development of physics (the advent of quantum mechanics). The foundation of the KWI für Physik was the result of at least three lines of thought: (1) originally, the quest for a new Institute for Physical Research seen as a sister institution to the existing KWI's for Chemistry and for Physical Chemistry and Electrochemistry built around a director with a strong personal scientific interest; (2) the awareness that an organizational form different from the structure of a typical institute of the KWG was needed in order to both i) attack the broad range of conceptual problems connected with the molecular and/or quantum nature of matter and ii) collect enough data through cooperation on a large scale; (3) the wish to bring Einstein to Berlin. The final structure of the KWI für Physik is the result of a hybrid combination of these endeavours.

The compromise, i.e. a collective steering board with Einstein as its director could have been successful, in principle. Leaving aside possible conflicts within the Direktorium, notably between Einstein and Nernst, failure was imminent, however, due to Einstein's personality. As demonstrated here, he did not want to take on the position of a scientific leader; he also did not want to be led by others. Consequently, the inspiration he could give was that of a creative individual: spontaneous and unpredictable. This was a far cry from the planned and systematically carried out research intended by his colleagues. Nevertheless, it is interesting that Einstein complained at a later date that, in science, "leadership natures" more and more became replaced by organization.[55] From Britta Scheideler's talk we will learn that Einstein used this reproach also in politics. He must have interpreted leadership entirely in terms of the generation of leading ideas.

Thus, no strong directives regarding physical problems to be investigated were given by him or by his colleagues in the Direktorium. The proposals solicited by the KWI für Physik from the

55 Einstein 1953, p. 13.

physics community since 1919 were concerned with many different subfields of physics, notably with areas of then current interest as were spectroscopy, radiation and the atomistic structure of matter. A few projects established a direct connection to the research interests of members of the Direktorium; others seemed to follow the paths trodden long since by their proponents. The change from the original idea of a concerted effort to be made in research funding to the ultimate practise of spending money with no directives given, can perhaps be interpreted as an emergency measure. First and foremost, the institute policy reflected the poor economic situation in Germany after the lost war. Later, Einstein's reluctance to play an active role in the sense of defining a course of action into the still mysterious world of the elementary quantum and the atomistic structure of matter may have been a seconding reason. His own scientific work seems not to have been sensibly touched by the existence of the KWI für Physik although, occasionally, he became stimulated by an application.

In terms of science funding in general, however, the KWI für Physik was no failure, although for some projects it took a long time until results were published - if at all. The institute even served as a model for the foundation of Notgemeinschaft der Deutschen Wissenschaft. On the other side, its role in this respect soon was reduced to restricted importance after the new funding agency had been established.

At the first possible opportunity, i.e. when he gained financial independence, Einstein withdrew himself from the managing of the institute. He had no interest in and very little influence on science politics related to physics, in Germany. In Berlin, Haber, Nernst, Planck and von Laue were leaders in this field; elsewhere Sommerfeld and others patiently weaved threads into their nets. Einstein seems to have been content both as the ingenious theoretical physicist following the train of his creative ideas, and to pose as a public idol of the value of science.

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