A debate on magnetic current: The troubled Einstein–Ehrenhaft correspondence

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A debate on magnetic current: the troubled Einstein-Ehrenhaft correspondence

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The issues in the Ehrenhaft –Einstein epistolary

Science has now practically forgotten the polemic figure of Felix Albert Ehrenhaft (1879 – 1952), an Austrian physicist who in the 1900's and 1910's assumed the existence of electric charges smaller than the electron, based on his experimental work. Three decades later, Ehrenhaft came up with what appeared to be another heresy, insisting he had observed isolated magnetic poles, and their displacement forming a "magnetic current". He maintained a correspondence with Albert Einstein on these subjects for about thirty years, trying to convince Einstein of the validity of his arguments, while Einstein attacked Ehrenhaft's conclusions, but followed his experimental work. The personal Ehrenhaft-Einstein correspondence examined here is remarkable and mostly unpublished.[1] Although the collection has been available for consultation for decades now, it has seemingly not caught the attention of the historians, although these letters, telegrams and hand-written notes are a valuable source, bringing out scientific, historical, and epistemological questions.

During the first years of the twentieth century Ehrenhaft was relatively well-known, due to his careful experimental work both with Brownian movement and the measurement of the electron charge. He was in contact with distinguished figures of the new physics which began to develop after 1900, such as Max Planck and Erwin Schrödinger, his colleague at the Vienna University, but the foremost scientist with whom he exchanged ideas was doubtless Albert Einstein, his guest in Austria on several occasions.

Born of Jewish parents, Ehrenhaft later converted to Catholicism, at least nominally, apparently an attempt to minimize resistance against his appointment to a chair at Vienna University in the 1920's. When Ehrenhaft fled from the Nazi

regime to the USA he thought it natural to look for Einstein not only for criticism of his scientific work, but also for help to find some placement in an American institution.

As his discussion with Einstein became centered on the existence of magnetic monopoles, it reached a dramatic point with the intervention of Ehrenhaft's third wife, Lilly Rona. She was an Austrian sculptress, who had previously migrated to the USA; a cunning person, she soon perceived Einstein's feelings towards Ehrenhaft differently from her husband, and dared to directly intervene in the scientific dispute. At a point in their written duel, Einstein started using a verbal weapon he delighted at: poetry, something at which Ehrenhaft was not good at all. It was for Lilly to take the initiative and answer back Einstein's provocations with more poems, letting the verbal battle catch fire.

The resulting intellectual triangulation has been little investigated in the history of science, and this article will synthetically review a significant part of the correspondence to investigate some issues that have not been explored in the existing bibliography. The conflict of Ehrenhaft with Einstein is especially interesting, as they both shared a German cultural background and a Jewish origin. Ehrenhaft remained emotionally attached to Einstein almost until the end of his life, but failed to perceive his feelings were not reciprocated. [2]

2. The life and times of Felix Ehrenhaft

It is rather disappointing to look for information on the life of Felix Ehrenhaft, and until now the only extant source is a personal biography written by Joseph Braunbeck.[3] His personal writings are collected mainly in three places: the Central Libray for Physics at the University of Vienna, the Dibner Library of the Smithsonian Institution (Washington, D.C.) and the Center for History of Physics (College Park, Md). His correspondence with Einstein is a substantial part of the respective collection at the Dibner Library.

Ehrenhaft was born in Vienna on April 24, 1879, the son of an affluent medical doctor. After completing the military service, and graduating as an artillery

officer, he finished his studies at the University of Vienna in 1903, earning both a doctor's degree in physics and the title of mechanical engineer. Next he pursued a research program on colloids, which enabled him to be promoted to "Privatdozent" in 1905, and afterwards engaged in another research about Brownian motion, publishing in 1907 his discovery that this erratic movement exists also in gases.[4] His finding was immediately considered another decisive step towards unveiling the inner structure of the atom, at a time when the atom itself was still a hot scientific debate.[5]

He married in 1908 to his former university colleague Olga Steindler, who became the mother of their two children, and at this time he engaged in the measurement of the elementary electricity quantum, as the electron charge was then called. J.J Thomson had argued that cathode rays were a stream of electrical particles and in 1897, in his celebrated atomic model, he proposed these "electrons" moved in a hypothetical positively-charged fluid. These ideas were further elaborated in the following decade by Thomson himself, aided by his important research school at Cambridge, and other European scientists. Thomson's many achievements gave him a reputation as the best experimentalist of his time.[6]

The new experiments conducted by Ehrenhaft with the electron charge brought him fame, especially in Europe, but later he suffered a rapid prestige downfall, as he reported measured values that contradicted exactly the assumed charge quantization. As it will be discussed later, this led to a controversy with Robert Millikan on the subject.

During World War I Ehrenhaft was mobilized, and fought in the front but later served as ballistics professor in the officer artillery school. Immediately following the war's end, he devoted himself to a new research, whereby he claimed in 1918 to having discovered photophoresis, a phenomenon by which light could move particles in suspension.[7] This was considered by many physicists as just a radiometric effect - like in the well-known Crookes radiometer, a pinwheel with four blades painted alternately black and white, which when illuminated produces a thrust, due to the different luminous absorption of the blades and subsequent air heating that will make the wheel spin around its axis. Ehrenhaft dismissed the

radiometric explanation after a series of new experiments, preferring to explain his observations as the direct effect of light on matter. For particles of size comparable to the wavelength of light, he maintained they might move towards the light source, an effect which he called “negative photophoresis”. This affair increased the reproof he had been suffering from other physicists as a consequence of the previous electron charge controversy.

In 1920 Franz Exner retired as director of the physics institute at the University of Vienna. Ehrenhaft was taken to be a natural candidate for the office, yet he was not elected, because the institute’s senior fellow physicists considered him a dissident of mainstream physics. Exner had played a role in the Vienna environment which went beyond physics, in the tradition of Helmholz and Boltzmann, for he was an intellectual with broad interests, including philosophy and the evolution of culture, an advocate for the interdisciplinary benefits the exact sciences could reap from the social sciences.[8] Ehrenhaft did not exhibit such a profile, and his own agreement with Mach was probably for reasons different from Exner’s; most important for Ehrenhaft was the faith that experimental facts alone formed the basis of knowledge.

Einstein was also consulted in this matter by the University of Vienna and his advice was against the indication of Ehrenhaft.[9] In what appears to have been a political decision, Ehrenhaft received from the university a new independent physics institute to chair, where his influence was expected to be comparatively minor.

Despite their strong scientific differences, whenever Einstein came to Vienna for conferences or congresses during the years 1921-31, he staid as a guest at Ehrenhaft’s house. Ehrenhaft socially entertained Einstein, took him around the city and even once arranged for Einstein to play his violin in a string quartet at a domestic reception. The personal relationship between the two physicists was seemingly cordial at this time, and Einstein invited back the Ehrenhafts, hosting them at Caputh, near Potsdam, in the summer of 1932. Ehrenhaft’s first wife died later during that year, and he married again in 1935 to Bettina Stein.

Fig. 1.A lecture by Einstein in Vienna (undated) – Ehrenhaft is third standing, from right. *Courtesy of University of Vienna, Österreichische Zentralbibliothek für Physik*

This was a period of great unrest in Vienna. Anti-Semite newspaper articles demanded barring public activities of Jewish intellectuals, including the academic world. The murder of philosopher Moritz Schlick in 1936 at the University of Vienna was hailed by the Austrian fascist wing as a "good" solution to the Jewish Question – even though Schlick himself had no Jewish ancestry. In this same year the German physicist Philipp Lenard (1905 Nobel Prize), supported by Johannes Stark (1919 Nobel Prize), published the book *Deutsche Physik,* containing a manifesto against "Jewish physics". The book pleaded for practical physics and attacked what it called theoretical, "modern" speculations, such as relativity and quantum theory. Nazi ideology thus denied the universality of science, proposing instead a German science - *Deutsche Physik, Deutsche Mathematik*- a trend which was supported by only a few authoritative scientists.[10] It has been remarked that

scientists are hardly politically active in the broader sense, and whenever they get involved at all, they are generally confined within their professional interest.

A singular personality trait of Ehrenhaft, as he would also demonstrate in his future contacts with Einstein in America, was his naivety – in spite of his Jewish origins he publicly agreed in principle with right-wing radicals such as Lenard and Stark, if only in terms of physics. Ehrenhaft had fought in World War I as a good soldier, and he might have considered his duty to remain loyal to the Austrian ideology in the coming conflict. Anyhow, his endorsement of epistemological premises of *German Physics,* as the apology of practice against theory, continued even after the war, and Ehrenhaft always chose to ignore its political content and satisfy himself with what he thought was a vindication of his own scientific convictions.[11]

He continued working normally after Hitler seized power in Germany in 1933, and in spite of the mounting Austrian Nazi pressure against Jews and converted Jews, he maintained positions in state commissions, such as membership in the national patent evaluation office and the technical standards committee. However, after the 1938 *Anschluss,* he was arrested by the police and beaten up, had his money confiscated, and was expelled from the University of Vienna, together with many other scientists labeled either as Jewish or politically dangerous to the regime. Even so, Ehrenhaft still hoped he could be left undisturbed by the Nazi government, but then slowly changed his mind. He finally applied for a visa, and in April 1939 left for England to further migrate to the USA in June, leaving his second wife in Vienna, where she died of a devastating cancer a few months later.

Initially Ehrenhaft lived in the USA with his first wife's brother and his own son, a surgeon in the US Midwest, and it is unclear how he supported himself during this time. In Vienna he had been funded by the Rockfeller Foundation, and there was a money reserve there in his name but he was unable to use those funds. He made several contacts with scientists in the USA, including Einstein, trying to find an academic position but to no avail. Eventually he managed to publish some of his latest work – especially the experiments where he claimed to have separated magnetic monopoles.[12]

He moved to New York City in 1940, where he met sculptress Alice Lilly Rona, a Jewish Austrian that had emigrated earlier, and whom he would marry in March, 1942.[13] Born Alice Lili Taussky in 1893 in Temesvar (now Romania), she moved to Vienna to study physics and languages, before joining the studio of Austrian sculptor Gustinus Ambrosius. She bought equipment and assembled a small laboratory that allowed Ehrenhaft to continue with his experiments on water magnetolysis (separation of the component gases through a strong homogeneous magnetic field, supposedly analogous to electrolysis) and magnetic currents. Lilly Rona also followed the scientific conversation between Ehrenhaft and Einstein, and she ended up accusing Einstein of playing a two-faced game. As a result, their relationship turned ever more shattered and embittered, while Ehrenhaft saw himself as a solitary knight riding against the accepted body of knowledge.

Fig. 2 Lilly Rona with 1940 bronze portrait of Ehrenhaft – *Radiocraft, November 1944*

At this point it is convenient to dwell a little longer on the main issues that made Ehrenhaft be so attacked, before appreciating the correspondence which will help envision how those *dramatis personae* themselves acted.

3. Controversies in physics: elementary electric charge and magnetic monopoles

Most contemporary physicists regarded Ehrenhaft's results with suspicion, an echo of the subelectron controversy, and at the same time were puzzled by his experiments.[14] Could Einstein and others have been mistaken about Ehrenhaft's claims? Some of his published work was revisited in 1972, on occasion of a meeting about the history of twentieth-century physics at Lake Como.[15] One of the communications there was by Gerald Holton, and another one by Paul Dirac, both dealing with subelectrons, thus giving an opportunity to know how Ehrenhaft's work was judged in the 1970's.

Holton gives a vivid tale of the polemic Ehrenhaft got into with Robert Millikan about the value of the electric charge *e*. Ehrenhaft had been the first to publish this in 1909, using Brownian movement in colloidal preparations, and his values at that time got closer to what is accepted today, but Millikan improved his method in the next years and obtained ever better values. The problem started for Ehrenhaft when he subsequently announced through the prestigious *Physikalische Zeitschrift* that he had also measured values smaller than *e*, which he called "subelectrons", generally 2*e*/3, but also *e*/3 and *e*/2. Millikan said that this was a result of inadequate methods or erroneous observations, and Ehrenhaft in turn criticized Millikan's data. A new series of experiments by Millikan was viewed as a final blow to the hypothesized subelectron, the academic world at large became convinced, and Millikan received in 1923 the Nobel Prize for the charge measurement.

Ehrenhaft's values and his interpretation were generally discredited, even though he and his collaborators still carried on new experiments which kept reporting fraction charges of electricity. Holton went back to Millikan's original notebooks to analyze his measurements, and concluded that the same values could indeed be taken as evidence for charges smaller than *e*, as pointed out by Ehrenhaft.[16]

Holton suggests that there was more at stake than a rivalry between two methodologies of experimental work. In his lifelong dedication to the teachings of

Ernst Mach (1838-1916), usually referred to as his positivism. Taken as a belief that facts speak for themselves, and that the same things must be observed by any able experimenter, this becomes an issue when ignoring that data can be as much laden with ideas and subjectivities as theories. Mach is also remembered for his stubborn denial of atoms, because he used the argument that an atom is not a phenomenon that can be directly sensed.[17] Ehrenhaft recaptured the gist that animated this scientist-philosopher (who also greatly influenced Einstein), as seen on the occasion of the 1926 inauguration of a monument to Mach at the Vienna University. Einstein sent his salutation, which was followed by the addresses of Moritz Schlick, Hans Thirring, and Ehrenhaft – with the exception of Ehrenhaft, they all distanced themselves from Mach on the subject of atomic evidence, while Ehrenhaf was the only one who said Mach had the courage to fight against the mainstream regarding atomism.[18]

The same can be said in principle about Ehrenhaft and the electron, in a way other than the trivial empiricist interpretation it first seems to be. There was a deeper phenomenological question, which was to decide whether atoms were the smallest entity that can exist. In other words: how could one be sure atoms were indivisible? Is any so-called smallest entity truly an ultimately quantized entity or a further subdivision can be expected beyond that stage? Ehrenhaft sided with those who thought that was not the ideal atom, and if on the other hand the electron could be broken down into further components, was there ground for believing that an ultimate electric "unit" existed?

The issue opposing atomism and anti-atomism with this latter meaning has reappeared several times in the history of science, as for example in the 1960's in the context of quark theory. More recently there have been proposals even going down to subquarks, all of which could render Ehrenhaft's subelectrons more real than they appeared in the beginning of the twentieth century.[19] Yet according to Holton it would be highly improbable that Ehrenhaft could have measured what are now hypothesized as quarks solely with the experimental arrangement he had.

Dirac reminded his Lake Como audience that the most prominent proposed quarks at the time (1972) were subelectrons with 2/3 of the electron charge, and he

cared to reexamine the paper published by Ehrenhaft in *Philosophy of Science* (1941) with experimental data on subelectrons. He accused Ehrenhaft of not being a good physicist because he should have identified such strange results as systematic errors, but Dirac conceded that the data showed exactly 2*e*/3 and 2*e* charges, and wondered the reason for that.

Barnes, Bloor and Henry have addressed the question of interpretation of experimental results, choosing as a case study exactly the historiography construed by Holton centered on the Millikan – Ehrenhaft subelectron debate, and its response by Alan Franklin.[20] Their conclusion was that the debate is not over, since the task of interpreting data is a complex one, often aggravated by the sociological contents of local culture carried onto those interpretations – and similar difficulties arise in their historical analysis.

Dirac's recollections of 1972 also mentioned that in the 1930's Ehrenhaft insisted on having discovered single magnetic poles and sought support for his discovery. Dirac refused, because Ehrenhaft's monopoles were much weaker than those predicted by his own theory.[21] According to Dirac, Ehrenhaft often approached him in the corridors to pour out his woes about the matter, since he

> *was not allowed by the secretaries to speak at these [American Physical Society] meetings. His reputation had sunk so low, everybody believed him to be just a crank… I formed the opinion that he was in any case sincere and honest, but he must have given the wrong interpretation to his experiments.* [22]

We find here a clue to the mysterious disappearance of Ehrenhaft from the main physics scenario: he was treated by many scientists as an eccentric, to say the minimum, someone to be publicly avoided to avoid embarrassment. Dirac's judgement is retrospective and his notion of Ehrenhaft's exclusion from the meetings is not exact, since Ehrenhaft did deliver a lecture at the American Physical Society in 1940, an event whose preparation Ehrenhaft had carefully discussed with Einstein in several of his letters. In his own view his presentation met with success in terms of the public interest it aroused.

Most of the letters written by Ehrenhaft to Einstein are devoted to his alleged experimental production of isolated magnetic poles, and his putative observation of their flow, the magnetic current. The laboratory arrangement for his experiments is described in many of his articles and also repeated in class notes taken during the year 1947 (Fig.3).[23]

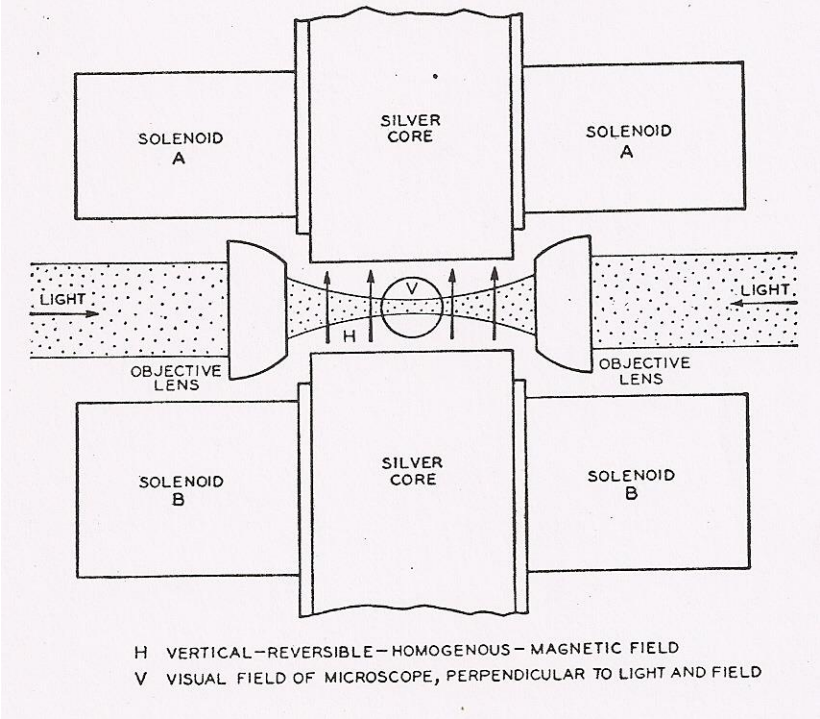

Fig. 4. Condenser and coils in Ehrenhaft's apparatus. *Journal of the Franklin Institute*, vol. 230 (3), September, 1940

He started with a glass cell of square cross section placed between the two poles of a permanent magnet (or also an electromagnet). The cell gathered probes suspended in a gas, and was provided with two thin grounded silver bands, which functioned as a Faraday cage to avoid electrostatic influence. The magnet poles had a diameter varying from 2 to 6 mm, and were conductively interconnected and grounded. To the right side of the poles was a plate condenser, to be directly viewed through a microscope. [24]

The experiment started with a vertical, homogeneous, magnetic field, that could be on-and-off switched, entirely free of remanence (remaining magnetism

after removal of exciting magnetic field). Several tiny bits of matter, neither spherical nor diamagnetic, were suspended, and these particles were brought together by the action of the magnetic field in the absence of light, along the direction of the magnetic force, letting them fall under the influence of the Earth's gravity. By compensating the gravity force the particles floated. An intense light then hit them, from either side or both sides, and it was observed that the particles moved away, some towards the north end, and others towards the south side of the magnetic field, while there was light. The resulting force was proportional to the field strength (Fig.4 – Ehrenhaft stated his precision to be 3%). Switching off the magnetic field this movement was immediately interrupted, thereby causing the particles to fall.

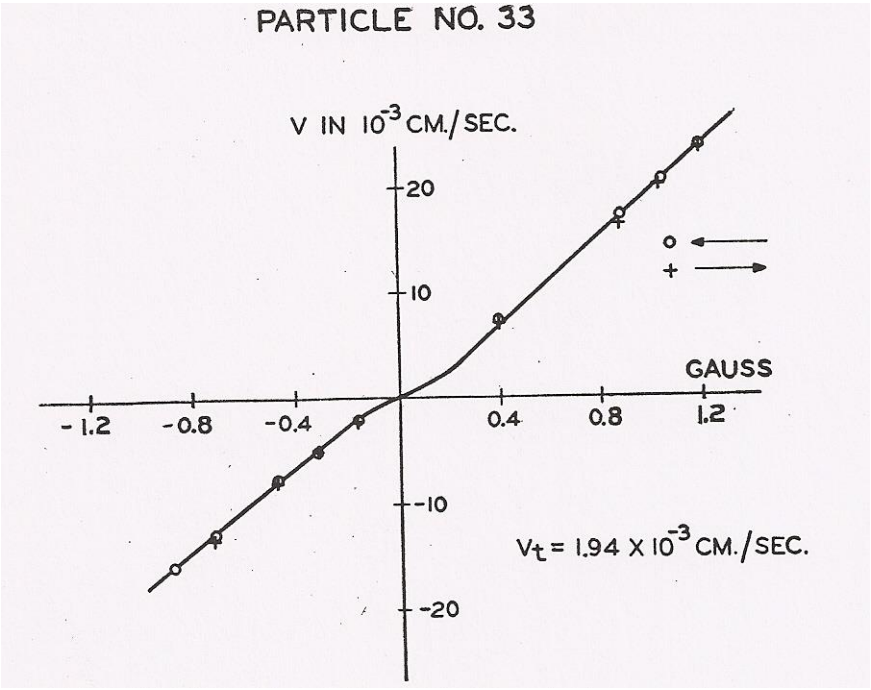

Fig. 3. Magnetophoretic force (V_t velocity of fall). *Journal of the Franklin Institute*, vol. 230 (3), September, 1940

Helge Kragh wrote an interesting essay to analyze the concept of monopoles both from the historical and theoretical viewpoints, including a section devoted to Ehrenhaft's monopole. He starts by supposing the existence of magnetic monopoles with the necessary consequent changes in Maxwell's equations.[25] The quantization

of the electric charge could be explained assuming the existence of monopoles - though it should be pointed out that this would not necessarily imply the minimum charge value must have the known value of *e.*

At least for part of the physics community, the existence of magnetic monopoles is now considered plausible, and most "grand unified theories" presume that, according to the "big bang" hypothesis, in the initial stages of the Universe a huge amount of monopoles were produced. The so-called "monopole problem" is exactly what happened afterwards and why monopoles seem so elusive to detect. These considerations led to the "inflationary universe" model to explain the dilution of the monopoles.[26] Initially, the theories predicted relatively lighter monopoles, but later the values were changed to extraordinarily heavy ones to prevent the enormous attraction they could exert, and which would crunch the universe. All taken into consideration, Ehrenhaft's claims about detection of lighter monopoles around 1940 would not seem so absurd for a theoretical physicist in the late 1970's, and of course it could again be questioned whether such monopoles could have been detected by his apparatus, as it was argued by Holton for subelectrons.

How successful a scientist was Ehrenhaft? Judging from the number of publications, he should be somehow known by his peers, as his contributions appeared for decades in several publications in German, English, and French, including some prestigious ones as *Nature, Science, Physical Review, Comptes Rendus, Annalen der Physik, Physikalische Zeitschrift, Zeitschrif für Physik.*[27] Sometimes a cautionary note was included, as for example in the article "Physical and astronomical information concerning particles of the order of magnitude of the wave-length of light", where the editor added the following remark, at the same time also an indication that other scientists did take notice of Ehrenhaft's work:

> *While it is recognized that Professor Ehrenhaft's conclusions as to the significance of his experiments are highly controversial, the experimental results themselves are such as to have recently excited the interest of several prominent authorities.*[28]

As it will be later discussed in connection with their letter exchange, despite his insistence Ehrenhaft could never get Einstein to witness his experiments in

New York or even to grant his permission to perform them in Princeton. Several letters in the Dibner Library mention that he sent Einstein reprints of his articles, but Einstein kept away replying there must be systematic errors in his measurements.

4. The Dibner Collection correspondence between Ehrenhaft and Einstein

The earliest letter in the Dibner archives is a typed transcript by Ehrenhaft of Einstein's handwritten letter of August 1917, commenting two of Ehrenhaft's articles, and explicitly mentioning negative photophoresis. Ehrenhaft had probably used previously a metaphor comparing theories with the fable of the greater strength of dry twigs when bundled together, and Einstein replied something reminiscent of what came to be known as the Duhem-Quine thesis in the philosophy of science:

> *…but taking one individual piece apart to show it can be broken induces to error. The value of a hypothesis lies in its multiple applications. One can never demonstrate a hypothesis that belongs to a theoretical complex.* [29]

The next item is a more extensive manuscript letter from Einstein, written on March 23, 1932 while returning from Pasadena to Europe on board the ship "San Francisco", where he acknowledged and thanked Ehrenhaft for sending him an (undisclosed) amount of money. Einstein then discussed some of Ehrenhaft's experimental curves, apparently linked to the subelectron question, and said he was especially interested in a most important question, i.e. if uncharged particles would experience any forces in the electrical field and also if the charge differences corresponded to the elementary electric quantum.

There follows a major gap in the correspondence, resumed with a letter by Einstein from May 19, 1939 addressed to Ehrenhaft, now living in London, his first step towards the American exile. Einstein started expressing his joy because Ehrenhaft had

> *now escaped from that Hell. One generally says that the Austrian Nazis are even more infamous than the German ones (if that were possible…).* [30]

Einstein then threw cold water on Ehrenhaft's intention to publish a book in the USA, arguing that there were considerably fewer readers of scientific books than

in the German-speaking countries. The Princeton Institute, he continued, could not give Ehrenhaft a grant or be of any help to him – and ended by stating that there were no theoretical reasons for all electric charges to be multiple of an elementary charge, though there were plenty of empirical motives that fit into that hypothesis.

On July 10, 1939 Ehrenhaft was already living in Iowa City, at his brother-in-law Steindler's, and Einstein wrote to disagree that the velocity of a minute sphere suspended in gas would be little affected by Brownian motion.[31] This subject is retaken in a series of four letters, and in the first one (August 30, 1939) Einstein wrote that, given the content of Ehrenhaft's work, he would like to prevent him from publishing, for this would "*unleash ferocious criticism, which would worsen your practical situation*" [*scharfe Kritik auslösen, die Ihre praktische Situation erschweren würde*].

Ehrenhaft replied (September 2) that his situation was already so difficult that it couldn't possibly become worse, and defended his experimental work, insisting that it was necessary to work with such small particles, because smaller charges would manifest themselves more easily. Einstein immediately (September 3) countered the technical objections of Ehrenhaft with some of his own epistemological conceptions:

> *The experimental physicist's goal is not only to achieve reproducible results of experiments. The determining factors should also be as simple as possible, so that one can thereof deduct elementary laws that may be applicable in other situations.* [32]

At the end of this letter there is a harsh comment by Einstein against Ehrenhaft, with the excuse that he was being very brutish only to make himself well understood, and:

> *Your opinion, that new field laws should be used to clarify the phenomena researched in your work, sounds simply ridiculous; compare: someone proposes to research the stock market oscillations based on Maxwell's equations.* [33]

This final statement may sound amusing when one notices that not Maxwell's equations but Brownian movement had already been used by that time to

analyze stock market oscillations.[34] Anyway, if Ehrenhaft had in mind the existence of monopoles, this did demand new field laws.[35] To propose the existence of magnetic monopoles another person like Dirac could have invoked an aesthetic dissatisfaction with the non-symmetry of Maxwell's equations regarding the electric and magnetic fields, but this was not the case of Ehrenhaft. He had not started from revisionist assumptions regarding the laws of physics, but worked the other way round, in the sense that his experimental results prompted him to revise the theory. In his words,

> *When I came to the conclusion that there are single magnetic poles (magnetic charges), it was therefore not necessary to ask if they agreed with existing theories, but rather whether there are any experimental facts that contradict it.* [36]

Ehrenhaft apparently replied to all objections, as Einstein said in the next letter (September 6) that even so he could not believe at all that the charge depended on the size of the particle, and if it did so, there must exist an unknown source of errors – he concluded in a friendlier mood saying that this letter exchange brought him "*true joy, because through it I can better apprehend the problem"* [*Dieser Briefwechsel macht mir wirklich Freude, weil ich durch ihn besser die Problemlage sehen lerne*].

On January 9, 1940, Einstein wrote and asked Ehrenhaft (now living in New York) not to visit him with his "artist friend" (probably Lilly Rona) for he would be too busy, and said that he had not yet talked with others about Ehrenhaft's expectations concerning work in Harvard.

The correspondence rhythm of February and March 1940 is a frenetic one. Ehrenhaft's letter from February 14, 1940 was appended with a copy of his communication on photophoresis to the forthcoming meeting of the American Physical Society (later printed in the *Journal of the Franklin Institute*). Ehrenhaft's carbon copy of this letter had a *post-scriptum*: his discovery that there were charges smaller than the electron in 1910 led him afterwards to know that light, given certain conditions, could exert upon matter not only compression forces, but also traction. He had discovered magnetophoresis as a symmetrical process to

electrophoresis, following the footsteps of Oersted and Faraday. In his words, "*light dissociates not only electric poles, but also magnetic ones*" [*Licht dissoziiert nicht nur elektrische, sondern auch magnetische Pole*], a knowledge he had "*acquired without any resource to the atomistic hypothesis*" [*ohne jede Voraussetzung irgendeiner Atomistik gewonnen*], here doubtless meaning the assumption of an elementary electricity quantum.

The next day Ehrenhaft wrote again, telling Einstein that after discovering light's action to create magnetic monopoles, he would also speak of magnetic currents, and hinted that in the outer space there is a flow of magnetic current from the Sun to the Earth. On February 16, Einstein replied that Ehrenhaft's opinions were probably wrong, and he also commented on Ehrenhaft's paper to be soon presented at the American Physical Society, making some suggestions but reassuring that its content was very good and efficient. On the following day Ehrenhaft wrote in disagreement with most of Einstein's corrections, emphasizing that in his experiment the magnetic monopoles moved along the lines of force of the homogeneous magnetic field, and not perpendicular to them, adding this was also observed in the case of the Sun's corona radiation.

Einstein (on February 20, 1940) renewed his objections, and asked Ehrenhaft why the magnetic charge should leave the particle after the radiation was interrupted, and why the magnetic monopole only appeared in small particles, which all seemed

> *… to be forced and anti-natural hypotheses, inasmuch as there is no broader experimental basis for them. This does not change anything, that the phenomenon itself is highly interesting.*[37]

Ehrenhaft (February 21) insisted that he was not interpreting wrongly, what he had observed was a real current, evidenced by the displacement of magnetic monopoles, and he had followed Faraday's advice, in that

> *… nothing is so good as an experiment, which removes the errors and leads to unconditional progress.*[38]

Ehrenhaft (February 27, 1940) continued to counter-argument Einstein's previous letter and objected that Lorentz' force was not the explanation for the shape of the Sun's corona - Einstein had insisted on February 16 that Ehrenhaft must mention Lorentz' force, so that people would not think he was an ignorant. Lorentz' force, according to Ehrenhaft, was not a sufficient explanation because with the Sun's magnetic field strength H decreasing rapidly with distance, the spiral where the particle moved should become ever smaller, whereas the solar photographs did not show that.

Ehrenhaft told (March 10, 1940) of the recent death of his second wife, which had delayed his correspondence, and asked if he could visit Einstein in Princeton to discuss the magnetic current experiment. On March 27, 1940, Ehrenhaft thanked Einstein for sending a check of 250 dollars. The series of references concerning money matters (always involving that same amount) had to do with Einstein's friend Janos Plesch, whom Ehrenhaft had met near Berlin in the early 1930's when he visited Einstein.[39] Plesch was a famous medical doctor and rich man who happened to marry an experimental physicist, and had been responsible for gathering the so-called Einstein-Fund in Berlin, which was a permanently renewed total of 10,000 Marks, a considerable amount at the time, laid at Einstein's disposal. Plesch subsequently became a life-long friend of Ehrenhaft's and helped him on several occasions during the exile, including lodging him when he escaped from Vienna to London, where Plesch and his family were living. It is possible that money out of that Fund was still available through Plesch after Einstein went to the USA, and maybe Einstein occasionally used this money to help Ehrenhaft.

In the same letter Ehrenhaft answered the question asked by Einstein's secretary (Helen Dukas) about the Rockfeller grant received while in Vienna. Ehrenhaft avoided giving the money right away to the Nazi authorities, but even so it had been held back in Vienna and could not be recovered. He also mentioned that the Rockefeller Foundation was not anymore supportive of research in physics, preferring biology instead. He had reviewed the literature on the Brownian movement since 1905 and found that the experiments did not confirm Einstein's

respective theory. For that purpose he had counted with the help of a former collaborator and physics student in Vienna, Baron Robert Heine-Geldern (a descendant of the poet Heinrich Heine). Ehrenhaft had also talked with Bell Laboratory (apparently a suggestion given by Einstein) about conducting there his experiment on magnet discharge by light, but they gave no answer, so he concluded that

> *… it is always difficult to conduct pure scientific experiments in a technical laboratory devoted solely to profit.* [40]

Ehrenhaft questioned the numerical determination of the Loschmidt number, a term used in German texts to designate the Avogadro constant, insisting that its correct value could only be obtained if the Brownian movement experiment proposed by Einstein were conducted in a dark room – a conclusion he referred to in a published letter.[41]

On March 28, Einstein told that Ehrenhaft's manuscript (which Einstein had forwarded to Sir William Bragg over two months before) had been refused in London. Also it would be useless for him to write to the Rockefeller Foundation to intercede in favor of Ehrenhaft. In his reply (April 3, 1940), Ehrenhaft said he could understand the Royal Society's viewpoint, since it was "*the last work of a Jew in German land"* [*letzte Abhandlung eines Juden auf deutschem Boden*], hastily written, incomplete and without the experimental construction instructions. He could however not understand James Frank's refusal in the name of *Physical Review* to publish another work of his, and gave Einstein a long list of articles whose study reinforced his conviction that photophoresis could not be a consequence of radiometric effects. To this Ehrenhaft appended a list of seven detailed technical questions concerning the measurements and experimental evidence of photophoresis. The Dibner Library keeps Einstein's refutations thereof and also Ehrenhaft's final rejoinders to the seven questions.

When he wrote Einstein on April 7, 1940, Ehrenhaft was about to send a note to *Physical Review* (apparently not accepted) about Einstein's theory – possibly again a reference to Brownian movement, a subject involved in the measurement of the electron and subelectron charges. The next day Ehrenhaft told Einstein he had

just come back from a talk with Kelly, head of the Research Lab of Bell Co. and an ex-student of Robert Millikan's. In a previous letter Ehrenhaft had considered the possibility of working at Bell Lab on the magnetophoresis experiments, but Kelly told him that meanwhile Millikan had written a letter mentioning some negative comments from Einstein to Millikan about the same subject.

On April 10, 1940 Ehrenhaft unusually wrote in English, and complained to Einstein that in a second letter to Kelly, Millikan stated that Ehrenhaft's article (the one sent to William Bragg at the Royal Society) was "*so inferior and below the average American level*" that it could not be published – and how would Millikan know of that? Only by being part of the editorial board, or if Einstein had written to Millikan about this subject, said Ehrenhaft. He agreed that no one was obliged to give him a job in a country where he didn't seem to be welcome, but it was unacceptable to prevent him from having his article published. He felt hurt especially because of the coming international scientific congress to be held in New York, following the last one which had been in Paris before the war (1937), and where Ehrenhaft had the honor of being chosen by 4,000 scientists to deliver the prestigious thanking speech. Ehrenhaft was willing to go to London to defend himself of those accusations. Einstein (April 15) replied that he had asked but had not yet received Kelly's letter cited by Ehrenhaft, and thought it useless to have a conversation with Ehrenhaft, especially because he was overloaded with work and did not have time.

The intense letter exchange is momentarily halted. Did Ehrenhaft already suspect that the embargo stemmed not only from Millikan, but also from Einstein, as it will become clearer from the future correspondence?

The Dibner Library keeps also a letter to Einstein dated May 31, 1940, written "*under real tragical circumstances*" [*in einer wahrhaft tragischen Angelegenheit*] by Richard Kobler, an Austrian engineer and ex-student of Ehrenhaft's in Vienna now living in New York. Kobler told Einstein that "*the 'Ehrenhaft affair' threatens to take such catastrophic proportions*" [*Der "Fall Ehrenhaft" droht naemlich derartig katastrophale Formen anzunehmen*], that he considered it necessary to address Einstein himself. Kobler and other friends had

persuaded Ehrenhaft not to travel to London at all, an uncertain destination at this time, and had thus probably saved his life, even though in England there was assurance of material support for Ehrenhaft and his experiments, exactly what was lacking in the USA. Kobler wanted to talk these matters over with Einstein in Princeton. It is not known whether Einstein answered Kobler and if such a meeting ever occurred.

Einstein wrote again to Ehrenhaft on July 26, 1940, saying he knew nothing concerning any ill feelings between them and evoked again the amount of US$ 250 that Ehrenhaft was unable to use, and that

> *I must admit that for theoretical reasons I am firmly convinced that there cannot be any isolated magnetic pole. The reason is that the quadrupole potential appears to have an immediate physical signification, and this because Stokes' theorem excludes isolated magnetic poles. Even so you may convey your ideas to me and I will tell you what I think of them.* [42]

Perhaps Einstein had in mind that the usual quadrupole derivation matched most of the experimental evidence, which lent support to the assumptions behind Stoke's theorem (the surface integral of the curl of a vector function equals the line integral of that function around a closed curve bounding the surface). Ehrenhaft's position implies that Stokes' theorem is in this case equivalent to the denial of monopoles, and he chose not to use it.

5. A triangular correspondence

At this moment there appears in the correspondence the intrusive register of a third person: Lilly Rona. Her contribution is at first through poems, a form of expression she shared with Einstein - these poems are here fully reproduced to give the flavor of the dispute. In fact it was Einstein who started it, writing to Ehrenhaft the following short verse on August 16, 1940:

So it is not possible
To force convincement
Ultimate repetition

Is after all no argument [43]

Ten days later Lilly Rona replied to Einstein in the same vein,

It is a beautiful speculation
But complicates the discussion
For in my opinion it lacks
Total knowledge of the phenomenon [44]

On September 17, Lilly wrote the following poem to Einstein, implying that Ehrenhaft had studied Morichini's 1812 essay about the dissociation of magnetic poles by light[45],

While you in the regions
Dwell where angels live
I found now that the magnet
Also arises through divine light –
Morichini, eighteen hundred,
Admired this phenomenon.
New physics is enforced
Best wishes your Ehrenhaft [46]

Ehrenhaft resumed the prose correspondence on September 26, saying he was far from forcing convincement upon Einstein, he only wanted to keep him informed, and by the way he had another article ready, this time about Einstein's own research area, namely light. Ehrenhaft was *"convinced that our scientific opposition will in no way damage our old friendship relationships"* [*Ich bin davon ueberzeugt, dass unser wissenschaftlicher Gegensatz in keiner Weise unsere alten freundschaftlichen Beziehungen beeintraechtigen wird*]. On October 15, Einstein wrote that he was sorry, for he could not invite Ehrenhaft for a conversation since he could not hope any longer to achieve an agreement. This very day Ehrenhaft wrote back an interesting answer, not entirely free from positivist tones:

Scientific matters are not matters for agreement, as it usually happens in politics or in men's lives, but scientific knowledge is either right or wrong. The judge of new or rediscovered knowledge remains solely the well

arranged experiment with the consequent conclusions and added-on knowledge. [47]

Einstein remained however firm in his decision, and communicated to Ehrenhaft on October 17, 1940 that a

… new discussion would be useless, because hopeless. Moreover, if the experiment alone decides or has already decided, then my participation is totally superfluous.[48]

Ehrenhaft (October 24) answered that Einstein's behavior was not appropriate to their almost thirty year-old friendship. If Einstein could not receive him anymore, Ehrenhaft from his part could not accept any longer the amount at his disposal with the warranty given by their mutual friend, Plesch, and so with that letter Ehrenhaft returned Einstein a check (of undisclosed amount).

All of this prompted Einstein to write Ehrenhaft the following poem (October 26):

You are really a genius
I was never better punished
What you so did to me
Feels masochistic indeed
It's only ill that you're hurt
Because I protected my time
Reason: I can only repeat
Your poles will give me creeps.
Poles I cannot grasp
Which in light only exist,
And which (it is not to laugh)
In darkness fade out. [49]

Lilly did not let the chance pass by without immediately answering this challenge (October 27),

Your last poem fits well
The ostrich politics
When it, feeling the danger,

Hides the head into the desert sand
The temporary poles shine
Over your head like hot coal
Also with permanent ions
I should spare your nerves
Solitary magnets give you the creeps
As Faust gives the creeps to Gretchen
In the magic of experiment
So it is with you - I don't know how
But it is useless to whine or play the truant
Very new consequences I found
From light I discovered the true essence
Much about that will you read.[50]

Afterwards, in a letter from April 9, 1941, Ehrenhaft explained to Einstein that according to his calculations the Earth's magnetic field ought to be nearly one million times stronger to be capable of moving monopole magnets. In his magnetic condenser, with a more sensitive arrangement and minute particles, he had however succeeded in isolating magnetic poles and proved that light magnetizes, which would explain numerous anomalies observed in Brownian movement in liquids and gases, as well as other phenomena. He repeated that Morichini had been the first to magnetize through light, besides having discovered the photoelectric effect, and said that also Humphry Davy had observed magnetization by light.

On April 22, Lilly wrote Einstein another poem; on her carbon copy she added a note, stating that this was after she received report from different sources, that Einstein cut off Ehrenhaft's possibilities to get a working space in the USA by expressing defaming judgments about her husband. She appealed strongly in this poem to puns on their names, as Einstein can be translated in German for "a stone", and Ehrenhaft "honored one".

How relative things also in life
And changeable in theory they seem
In Einstein's fight for truth I did trust

A rock of Judah he looked to me
Insight and wisdom looked his lot to be
In clarity richer than a precious stone
With reason "one-stone" he could call himself
He was a step towards higher knowledge.

I can't believe he would be "a stone"
In the throat of his friend, who breaks the waves -
A stone of the wall resting on false theory
In the fight against night that light defies.
I can't believe that truth's honor
Depends on small questions –
For this what the honored one knows and sees
The whole world shall untroubled witness.[51]

Einstein decided to write back to Lilly in a well-humored mood on May, 5, 1941:

One is no longer an evil man
Who cannot believe something.
It's not good, even though one succeeds,
When one forces another to believe.
One should not fight for truth,
It wins through its own light.
Try instead serving to find it,
Leave to others the announcement. [52]

The final move of this poetic quarrel was made on May 12, when Lilly wrote

Who cannot trust something
Listens then to the other one,
Who asked for the "high grace"
Shows to go by the fact
And bows, if acknowledged,
To argument without constraint.

When one can't trust then
He gives his grounds
And throws fast and simply
His own opinion in the balance ---

Of ethics and morality is
The second part of the poem
For seeing and not announcing truth
Is the worst of all sins.
To fight for truth's light
Is the highest duty of the noble man
Who fights for it with spirit, and strength
In righteous sense – he is honored. [53]

On May 17, Einstein wrote that he saw no reason for Ehrenhaft to complain, as he could not go against his own convictions. Ehrenhaft answered (May, 29) that he, on the contrary, did have reasons to complain, since Einstein had spoken with colleagues against his experiments, and though Ehrenhaft had volunteered several times to demonstrate them in Princeton, Einstein had never agreed, without substantiating his refusal. Besides, he had heard that Einstein commented with a common acquaintance (the philosopher of science Spencer Heath) that magnetism propagates with the speed of light, which was an idea similar to Ehrenhaft's. Moreover, he continued, Einstein should know that his opinions greatly influenced public opinion, and the monopole question remained a fundamental one for physics. Naturally the defaming could just be the couple's impression, since it was widely held that Ehrenhaft was an iconoclast.

Lilly Rona decided then to write not a poem but a direct letter to Einstein, and in English, on February 2, 1942. She said this was the day when Ehrenhaft had discovered how to measure the magnetic current, having observed it with and without light. She bluntly asked how Einstein was going to repair "*the great injustice done to Felix Ehrenhaft*" through his

> … *attitude towards him and the unfounded and defaming reports about his discoveries* [which Einstein had] *spread out not only among his colleagues but also in financial circles among bankers who had wanted to help him to proceed with his research work.*

To one of these bankers, she continued, Einstein had even said "*hands off…Ehrenhaft is a fantast*", and Lilly had no doubt that Einstein had been the source of all distrust and animosity against Felix Ehrenhaft, and this was unfair to someone of whom Planck said to have "*given the finest methods of measurement to modern physics*". Lilly directly accused Einstein of not having kept private their disagreement, and having instead spread out rumors against her husband. Einstein's own ideas about the infinity of the world - Lilly went on - were followed up with interest by many people, and they could as well

> … *be called fantastic with much more reason than the experimental work of Ehrenhaft, who was about to develop a new source of energy and give it to the world*.

The last phrase probably refers to magnetolysis. Lilly ended her heavy indictment against Einstein stating she was "*going to make every possible endeavor to reestablish the honor and the scientific reputation*" of her very dear friend. On March 18, 1942 Lilly complained again to Einstein, attaching a copy of the previous unanswered letter, and hinting that the publication of Ehrenhaft's paper about the magnetic current, which was about to appear in the March issue of the Franklin Journal, might give Einstein an opportunity to correct his regrettable statement, for which it might "*be hard to bear the responsibility*".

It is not known for sure but this second letter was presumably never answered either, and it can only be conjectured that, contrary to Lilly's poems which Einstein cared to reply, the letters could not be taken light-heartedly. This remains the last item in the correspondence file, even though Lilly Rona reproduced another poem written to Einstein in a manuscript of her own article kept in the Dibner Library, "Der Magnet als negativer Katalysator des Wassers":

While in the formula marshes
One gets only wet socks

In the research beds bloom
New magnet wonders.

The magnet with its poles
Unbinds and binds unconcealed,
Can – shame on the theories –
Blast gas out of water produce.

And with this gas blast
Ends the word stream
Making atomic physics pale...
Ehrenhaft – the "Great fantast".[54]

6. An inconclusive aftermath

After the war was over, the University of Vienna asked Einstein (exactly of all people!) to give his opinion whether Ehrenhaft should be invited to come back home. Einstein's answer sounds like a final judgment: Ehrenhaft's subelectrons were a misinterpreted experiment; photophoresis was an interesting result, but could be explained as a consequence of radiometric forces; and magnetic charges and currents were arbitrary interpretations. However, Einstein acknowledged, Ehrenhaft had been the first scientist to measure single elementary electric charges, and he was an able experimental physicist, in spite of drawing so many wrong conclusions, a feature which made him not respected by colleagues. As Ehrenhaft was already in an age for retirement, Einstein recommended that the university award him the emeritus title and provide him with the task of lecturing on the history of physics, a subject about which he knew a lot, adding a final remark that

> *This would be noble and at the same time not dangerous, and he could go to his end without bitter.* [55]

The USA was at that time interested in repatriating some Austrian scientists, probably to irradiate a good image of the American way of life, and to strengthen

personal ties within the academic circles of both countries. Ehrenhaft did go back, while Lilly Rona on the contrary resisted and wished to remain in the USA; in the end it was not possible to reconcile their differences and the couple decided to divorce. A note written by Lilly on February 10, 1944 already anticipates problems – she admired her husband scientifically, but complained very sadly about the burden of being married to such a stubborn man, who only cared about himself, and did not give sufficient credit to his collaborators.[56] In March, 1947, Ehrenhaft was again in Vienna, where he was reinstated as a university professor, finally resuming his researches on magnetism and light, teaching classes and pronouncing conferences.

In 1949 Lilly Rona went to Vienna, trying to publish scientific articles based on the work she and Ehrenhaft had conducted in New York, and she did succeed with an article on gravitation.[57] Ehrenhaft seemingly avoided her publicly, as if embarrassed by her attempts to enter the scientific milieu, though he still exchanged letters with her, as for example arranging for experimental demonstrations in the university.[58] Perhaps Ehrenhaft was too proud to now acknowledge her past participation in his work in the USA.

From 1950 onwards Ehrenhaft was sick, and finally died in Vienna on March 4, 1952. Around this time Lilly Rona filed for some patents in the USA and Europe concerning magnetolysis (this is also recorded in the Dibner collection). She died on April 2, 1958, in New York.

One of the post-war physics students in Vienna who at first had a very skeptical attitude towards Ehrenhaft was Paul Feyerabend, as later recalled in his autobiography.[59] Accordingly, Vienna's university had in 1947 three reputed physicists, Thirring, Przibram and Ehrenhaft. Ehrenhaft's fame was dubbed dubious, so the students decided to unmask him, however the professor conducted his experiments in class in such a simple and convincing manner, that Feyerabend was won over and changed his opinion.

According to Feyerabend, there was "an iron curtain" that protected the established physics from Ehrenhaft, exactly like the one that had shielded Galileo's opponents – the latter argument he developed more fully in his *Against method*

(1975).[60] This may well have been a first incentive for Feyerabend to question "normal science", and to recognize that scientists did not always win just because of the merit or the "truth" of their ideas - for him the history of science showed that victory may lie with whomever is cleverer to produce the right propaganda. The next semester Feyerabend decided to stenograph Ehrenhaft's lectures about magnetolysis and magnetic poles, and sold copies thereof to his fellow students.[61]

A fair reassessment of the conflict between Einstein and Ehrenhaft against the scientific tradition is very dificult. On one side is the ever more celebrated "father of relativity", on the other a neglected physicist. There has been an ongoing research on the subject of magnetic monopoles since Ehrenhaft's efforts, but it is almost entirely theoretical and the bibliography does not usually mention Ehrenhaft's publications in this field, something that could in principle be ascribed to different concepts of what a "magnetic monopole" is, implying different values of mass and strength. Modern experiments, some of which were initially considered as evidence of the practical existence of monopoles, were subsequently reviewed and deemed inconclusive.[62]

From the references encountered in the literature, and in various letters written by American physicists such as W. F. G. Swann, John Zeleny, G.N Stewart, Edwin Kemble, and others, it seems that Ehrenhaft though controversial was considered an able and responsible researcher, and his research important, albeit problematic.[63] To check anything like systematic experimental errors, the best would be to reexamine Ehrenhaft's original arrangements and methods, which haven't been subject to new and more accurate investigation. Subelectrons as well as magnetic monopoles may indeed be hard to find in those conditions but this possibility should not be simply ruled out beforehand. Unfortunately, it is difficult to reconstruct his experiments and interpretations on the basis of the available documentary evidence, and after his death, Ehrenhaft's experimental work has not been continued.[64]

One may feel that the opposition between Ehrenhaft and Einstein had to do with the debate of practice versus theory. Already during the Weimar period, there was a latent conflict in the German-speaking countries between theorists and

experimentalists.[65] Some of the experimental physicists decried relativity and quantum theory, mainly those who did not keep up with the corresponding complex mathematics. Their most outspoken representatives were Stark and Lenard, and when these pushed for an "Aryan" science through the book *Deutsche Physik*, the artificiality of the argument became patent, as there were "pure" Germans as Heisenberg who were against this movement, as well as a Jewish physicist as Ehrenhaft who could scientifically be in favor.

Therefore, even though Einstein and Ehrenhaft indulged in this kind of mutual judgment of theorist and experimentalist, it has to be taken with care. Both scientists had once been examiners at patent offices, and notwithstanding what Einstein publicly avowed, he was well-acquainted with the importance of experimental corroboration of theoretical results.

Jeroen van Dongen wrote two instigating articles which shed more light on the relationship Einstein established with the experimental field, exposing his association after 1926 with the German physicist Emil Rupp to investigate the wave-particle duality using canal radiation.[66] Einstein wanted to test whether light was instantly emitted when an atom was excited, or took a finite time span, and he rejoiced that Rupp would do an experiment, even though working in Heidelberg exactly under the anti-relativist and anti-Semite Lenard. The evidence slowly built up to show that Rupp never observed what he claimed, and just reported what he believed to be Einstein's correct prediction.

There was at this time another division in the German physics community, between northern physicists who accepted the new theories, and southern conservatives who did not. Two of Rupp's supporters, Einstein and Max von Laue, were prominent theoretical physicists in Berlin, while Lenard and Wilhelm Wien held important chairs in the south, and viewed themselves as exponents of a more experimentally oriented tradition.

Van Dongen concludes that, rather than attributing Einstein's and von Laue's reactions to socio-political factors, there is a much more likely cause for their continued trust in Rupp's work: the theorist's prejudices when confronted with experiment. On the part of Einstein, this theoretical prejudice had a counterpoint in

the experimentalist who stops searching for systematic error in his arrangement as soon as he gets the expected results. Moreover, Einstein gradually shifted the importance he attached to experience, and started believing that new insights for the creative theorist were to come from mathematics. This may also apply to his conduct towards Ehrenhaft, even though in Rupp's case the accusations were of fraudulent works, while Ehrenhaft was till the end charged with "systematic errors".

On the other hand, even though Ehrenhaft strongly emphasized the intuitive approach and used in his favor the experimental examples of Franklin, Oersted and Faraday, he knew he could not simply dismiss scientific theory.[67] It is more likely that both scientists diverged in their theoretical foundations, and as a consequence they viewed the same experimental results differently.

Ehrenhaft's personal interpretation of these differences lies in his unpublished recollections on Einstein.[68] In a section under the title "On his [Einstein's] Attitude towards Research", he writes that

> *In my opinion there are two totally different ways of conducting research in physics. I would like to designate these two types as Faraday's method of work, and the second one as Hamilton's…My conversations with Einstein have convinced me that he has always preferred Hamilton's. It is known that Hamilton predicted external and internal conical refraction purely based on the differential equations for crystal optics…one must say then that Einstein predicted the gravity of light entirely in the form of Hamilton.*[69]

In the 1930's Ehrenhaft was willing to disregard the classical electromagnetic theory in Maxwell's formulation, as he found impossible to reconcile it with a series of experimental anomalies. The epistemological attitude taken by both scientists in face of the paradigmatic body of knowledge, when confronted with sets of conflicting experimental data, renews the question: if data do not fit the accepted theories, at what point should one distrust the results or, on the contrary, challenge the theories? The standard answer has been experimental repetition – by the same scientist or in front of other parties, and ultimately by entirely different observers.[70] However, Ehrenhaft repeated his experiments, and

seemed willing to demonstrate them to others, while one may add there have been controversial instances regarding repetition (as in the recent cold fusion debate).

Ehrenhaft appeared not to hesitate in casting doubts on a theory if his interpretation of the experimental results contradicted it. That is also the reason why, on February 15, 1940, Ehrenhaft wrote to Einstein that his experimental findings regarding the existence of magnetic currents naturally demanded a modification of Maxwell's equations. Indirectly referring to Einstein's position, Ehrenhaft complained on March 10, 1940 that

> *I discovered however that the look of many people through the glasses of theory clouds the knowledge of experimental facts.* [71]

Overall, Ehrenhaft maintained a rebel attitude towards the current theories not only in his juvenile years but throughout his life. He appeared to be a really persistent person, perhaps sometimes in a very unpleasant manner, and his personality became abhorrent to other physicists, even to those who had once dared to defy conventional explanations of physical science (as Einstein, or Dirac).

In his already mentioned recollections, Ehrenhaft judged that, although Einstein was an excellent physicist,

> *he had in his chest two souls, as well as in the case of Maxwell. But one should say that, the older Maxwell grew, the more he distanced himself from atomic theory. This cannot be so clearly recognized in Einstein.* [72]

Ehrenhaft had a peculiar affection for investigating the history of physics, which he showed on many occasions, including his 1932 lengthy commemorative address on Faraday's discovery of induction. Einstein was also considerably interested in the history of physics, and it is instructive to read how Ehrenhaft judged this:

> *I mention yet another observation. In a longer conversation in Caput, while we sailed I said that there existed too much writing and measuring, and stated that to be knowledgeable in physics since the year 1870 it sufficed to read no more than 25 works. Einstein thought there would be many more. We counted together and arrived at only 17 to 18, naturally excluding measurement tables among others. He agreed. In general, I observed that he*

is little acquainted with the history of physics, and I was amused to observe that he didn't read much either [73]

When commenting on his own methods, Ehrenhaft repeatedly mentioned his preferred examples of Faraday and Oersted, and he often referred to himself as a continuator of their tradition, as in this letter to Einstein (February, 14, 1940):

In direct continuation of Oersted's and Faradays's path I arrived at the other knowledge relative to the conflict among matter, light, electricity and magnetism. [74]

This appeal to the epistemological procedures of Oersted and Faraday may not be casual. Perhaps Ehrenhaft viewed himself also as a continuator of the German *Naturphilosohie* tradition, which certainly bore fruitful scientific results, including Oersted's discovery of the first magneto-electric effect.[75] Even his wording is modeled after Oersted's famous communication (on the "electric conflict") about the movement of a compass needle parallel to a current-carrying conductor. Among *Naturphilosophie*'s features there are some that reappear in Ehrenhaft's interpretation of elementary charges and magnetic monopoles, i.e.: matter fills space continuously by means of its primitive forces of attraction and repulsion; matter is divisible to infinity; there are no discrete fluids.[76]

Ehrenhaft represented perhaps a riddle to Einstein, on personal and scientific grounds: obsessed with an unreturned but trusted friendship, should the Austrian be ignored in the field of physics? Einstein was at least relatively interested in the subelectron and later in the isolated magnetic pole experiments, but certainly not interested in the person of Ehrenhaft. One could say that though there was very little empathy, yet there was a limited support from the part of Einstein. He had not endorsed Ehrenhaft's appointment to a professorship in Vienna in the 1920's, and he was not willing to help him get a position in America in the 1940's; accordingly, he did not endorse his colleague's reinstatement at the post-war Vienna Physics Institute.

Ehrenhaft on the other hand behaved as a very naïf and politically alienated person, and tended to neglect the real outside world and to minimize the attacks he received. His work with the electron charge might have brought him a resting fame,

but he chose instead to emphasize small perturbations that others like Millikan neglected as non-significant errors.[77] Ehrenhaft continued believing in the results of his experiments as indicative of some hitherto hidden explanations for nature, with the result that he paid the high price of ostracism.

Judging from the examined correspondence, Ehrenhaft acted as if he did expect Einstein to repay the kind treatment he had received in Vienna, while Einstein probably felt Ehrenhaft a nuisance disturbing him from his personal affairs, and his politeness started to fade out when Ehrenhaft challenged not only one but many of Einstein's major achievements: electromagnetic theory, as Ehrenhaft's attrition with Maxwell's equations also might hit Einstein's special relativity grounds; the nature of light, which imparted in the Nobel-prize winning photoelectric effect explanation; and, last but not least, Einstein's theory of Brownian movement, a field where Ehrenhaft had great practical experience.

It is worthwhile to remark that when Ehrenhaft wrote to Philipp Frank (February 9, 1940) to provide some anecdotes regarding Einstein, he took the chance to urge Frank, then also in the USA, to go talk with the American scientist Dayton Miller, who had been redoing Michelson-Morley's famous light speed experiment with much more accuracy. Miller did expect to find light speed variations according to differences in the ether velocity relative to the Earth, whereby one may suspect that Ehrenhaft really had in mind checking this basis of Einstein's relativity theory.[78]

Complicating an already strained relationship, Ehrenhaft indirectly brought to the arena a third person, a woman of strong personality, who had no credentials in the scientific world, but assisted him in his American experiments, to the point that she invaded the scientific debate in her flamboyant manner. Maybe the sum of all these factors was too heavy a burden, at a moment of Einstein's life when, though a glorious political figure and the best-known scientist of the world, he was nonetheless relegated to an academic standstill in virtue of his dissent with the dominant quantum theoretical interpretation.[79] All that might have led to no more than silence, or perhaps also to some devastating words to friends and acquaintances about Einstein's fellow physicist, as the Ehrenhaft couple believed.

It may be fitting to conclude this article with an autograph note by Einstein also kept at the Dibner Collection, a somewhat embittered thought of a politically disillusioned man. It sounds as a reminder that history should not be forgotten (and may we add, neither should history of science):

> *Children do not make use of their parents' life experiences, nations do not turn back to History. The bad experiences must always be renewed once more.*[80]

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[1]Manuscript sources: MSS 2898 [*Albert Einstein and Felix Ehrenhaft: Letters, notes, memoranda and queries exchanged between 1939 and 1941 (with preliminary letters 1917-1932). Felix Ehrenhaft: Typescript of unpublished "Meine Erlebnisse mit Einstein 1908-1940". Felix Ehrenhaft: A collection of his lectures, articles and reprints. Lilly (Rona) Ehrenhaft: Personal and scientific papers. Agathe Magnus: Papers concerning patents by Lilly Rona*]. MSS122A [*Albert Einstein: Letter to Felix Ehrenhaft from 3.9.1939*] - Dibner Library of History of Science and Technology, Smithsonian Institution, Division of Rare Books and Manuscripts, American History Museum, Washington, D.C. These items were purchased in 1960 for US$ 2,500 by collector and historian Ben Dibner, apparently part of the personal archives of Lilly Rona-Ehrenhaft. They include 47 items of correspondence (mostly in German) involving Einstein, Ehrenhaft, and Lilly, besides other persons. There are also exemplars of published works of Ehrenhaft, some bearing affectionate handwritten dedications to Lilly. Ben Dibner donated them together with a substantial part of his collection of rare books and manuscripts to the Smithsonian, where they have been available to scholars since 1976. The author is indebted to Mrs. Kirsten van der Veen, librarian at the Dibner Collection, as well as to Mag. Brigitte Kromp, Director of the Central Library for Physics, at the Vienna University, and Joe Anderson, at the Center for History of Physics, College Park, Md. He is most thankful for the careful and stimulating BJHS reports from anonymous peer reviewers.

[2] Ehrenhaft contributed to the Nobel Prize attribution to Einstein. Abraham Pais [*"Subtle is the Lord": the science and the life of Albert Einstein,* 1982] mentions Ehrenhaft's indications in 1916, 1918, and 1922. A recent book devoted to this subject is Aant Elzinga [*Einstein's Nobel Prize: a*

glimpse behind closed doors (Sagamore Beach, MA: Science History Publications, 2006], which relies on the official Nobel archives to conclude the successive nomination was attributable mainly to the physicist Carl Wilhelm Oseen. Ehrenhaft, in his recollections of Einstein ("Meine Erlebnisse mit Einstein. 1908-1932"), tells a different story: the arrangements he conducted with Arrhenius behind the scene would have been responsible for the prize. It may well be that Ehrenhaft is giving himself too much importance in the affair, but the official story may not be wholly reliable either. Although the Nobel Committee officially awarded Einstein "for his discovery of the law of the photoelectric effect", the effect and its "law" had been known for some years and Einstein's achievement was to devise a theory for its explanation, in which he applied Planck's concept of radiation quantization to light - see Edmund Whittaker, *A history of the theories of aether and electricity* (College Park, Md.: American Institute of Physics, 1987 [1951], vol. 1: 356-357.

[3]Joseph Braunbeck, *Der andere Physiker. Das Leben von Felix Ehrenhaft.* Wien: Technisches Museum & Leykam, 2003. This biography is very helpful but should be read with caution because of its sometimes excessive laudatory tone. Einstein's biographies hardly mention Ehrenhaft, and only the older biography by Philipp Frank, *Einstein, his life and times* (1947). [2nd ed. Cambridge (Mass.): Da Capo (Perseus), 2002: 72-73], indicates that after World War I Einstein staid in Vienna at Ehrenhaft's house –it was Ehrenhaft himself who wrote to Frank in 1940 providing information on Einstein, including a series of anecdotes that are included in Frank's book without disclosing the source. Some of these stories are part of the letter from Ehrenhaft to Frank from February 9, 1940, and are retold in Ehrenhaft's recollections, "Meine Erlebnisse mit Einstein", both in the Dibner Collection.

[4] "Das optische Verhalten der Metallkolloide und deren Teilchengrösse", *Annalen der Physik* 11: 489, 1903; "Über die der Brownschen Molekularbewegung in Flüssigkeiten gleichartige Molekularbewegung in den Gasen", *Wiener Berichte* 116: 1175, 1907.

[5]The years between 1897, when Thomson reported on the electron, and 1911, when Rutherford proposed to concentrate most of the atomic mass in a smaller volume of the atom (nucleus), witnessed much discussion about the atomic structure. Many uncertainties on this subject were reflected in various other areas, as in the interpretations of radioactivity, and the constitution of the

periodic table – cf. Michel Serres, (ed.), *Éléments pour une histoire des sciences* (1989). [Transl. Lisboa: Terramar, 1996, vol. 3: 77-80].

[6] Helge Hragh, "Particle Science", in R. C. Olby et al., *Companion to the history of modern science.* London and New Tork: Routledge, 1996: 655-654.

[7] "Die Photophorese", *Annalen der Physik,* 56 (1918): 81.

[8] Cf. Erwin Hiebert, "Common frontiers of the exact sciences and the humanities", *Physics in Perspective* 2 (2000): 6-29. In the scientific field, he could be associated with Mach and the tradition of Vienna indeterminism. An extensive study of Exner as a physicist, and author of the cultural evolutionist *From chaos to the present* can be found in Michael Stöltzner, "Franz Serafin Exner's indeterminist theory of culture", *Physics in Perspective,* 4 (2002): 267-319.

[9] See Einstein's letter to Vienna University of June 25, 1920 in Braunbeck [2003]: 36-37.

[10] Reinhard Siegmund-Schultze, "The problem of anti-Fascist resistance of 'apolitical' German scholars", in Monika Renneberg & Mark Walker (eds.), *Science, technology and National Socialism.* Cambridge: Cambridge University Press, 1993: 312-323.

[11] Paul Feyerabend in *Killing time* (1995) [Transl. São Paulo, UNESP, 1996: 74] remembers when attending Ehrenhaft's classes in 1947 as a physics student that he still approved of the theoretical conceptions of *German Physics,* and Braunbeck [2003: 68] says that Ehrenhaft preferred to ignore the book's preface (with its anti-Semite attacks) in favor of its physical contents. Ehrenhaft repeatedly said he followed Faraday's advice, of skepticism towards the use of theory, precededence to the experiment (cited in F. Ehrenhaft. "Festrede an Michael Faraday", *Physik u. Chemie,* 32 (5), 1932: 14).

[12] *Physical Review* 57: 562, and 659, 1940; *Annales de Physique* 13:151, 1940; *Journal of the Franklin Institute,* 230 nº 3, 1940; ib. 233 nº3, 1942; *Nature* 147: 25, 1941; *Science* 94: 232, 1941; ib. 96: 228, 1942.

[13] Among other works Lilly was commissioned to sculpt busts of Arturo Toscanini, President Eisenhower and Eleanor Roosevelt, which won her public praise.

[14] This view is expressed in several letters kept at the Center for History of Physics (College Park, Md), as in the one written to Einstein by W.F.G. Swann from Bertol Research Foundation on Nov.

16, 1940: “I suppose that most of us would agree that Ehrenhaft’s interpretations of his experiments are likely to be wrong, but I personally feel that there may be something in the experiments themselves which should be further investigated”; in his reply of Nov. 19, Einstein told Swann: “Concerning his results about the elementary charge I do not believe in his numerical results but I believe that nobody has a clear idea about the causes producing the apparent sub-electronic charges he found in careful investigations”.

[15] Paul A.M. Dirac, “Ehrenhaft, the subelectron and the quark”, in C. Weiner (ed.), *History of twentieth century physics. Proceedings of the International School of Physics Enrico Fermi. Course LVII (1972)* [New York and London: Academic Press, 1977: 290]. Gerald Holton’s study was included in *The scientific imagination: case studies.* (1978).

[16] Allan Franklin (*The neglect of experiment.* New York. Cambridge University Press, 1986: 138-164; 215-225) challenged Holton’s conclusions stating that Millikan's data exclusions did not change the final value of *e* arrived at, yet he agreed that Millikan touched up some of his numbers, which reduced the statistical error on *e*. The larger uncertainty might have stirred up disagreement within the physics community. Franklin’s arguments are completely centered on the defense of Millikan’s interpretation and selection of experimental data, and contrary to Holton, he does not contemplate Ehrenhaft’s arguments.

[17] See for example Ernan McMullin, “The development of philosophy of science 1600-1900”, in R.C. Olby *et al*., *Companion to the History of Modern Science (*London and New York: Routledge, 1990: 834-836). Ehrenhaft was attacked by scientists who were pro-Millikan and it was rather consequent he was supported by the anti-atomists and empiricists around Mach .

[18] Braunbeck [2003]: 42-44.

[19] Any theory that conceives of an inner structure for so-called elementary particles might face the problem of continuity versus discontinuity - an example dealing with the topic of the elementary charge is the proposed structure for the electron based on helical plasma-like filaments advanced by Winston M. Bostick in “The morphology of the electron”, *International Journal of Fusion Energy*, vol. 3, nº 1, 1985.

[20] Barry Barnes, David Bloor, and John Henry. *Scientific objectivity: a sociological analysis.* London: Athlone / Chicago: University of Chicago Press, 1996: 18-45.

[21] Helge Kragh briefly mentions Dirac's refusal to discuss monopoles with Ehrenhaft in *Dirac: a scientific biography* [Cambridge (Mass.): Cambridge University Press, 1990: 216-217].

[22] Dirac, *op.cit.* [1977: 290]. On a later occasion, after the alleged monopole detection in 1975 in a cosmic ray experiment, Dirac addressed the matter, and did not mention Ehrenhaft at all – see Paul Dirac. *Directions in physics.* New York: Wiley-Interscience (1978).

[23]"Einzelne magnetische Nord-und-Südpole und deren Auswirkung in den Naturwissenschaften (10 Vorlesungen gehalten im Sommer-Semester 1947 v. Dr. Felix Eherenhaft – Gastprofessor an der Universität Wien" (mimeo). See also "Photophoresis and its interpretation by electric and magnetic ions", *Journal of the Franklin Institute*, vol.233, nº 3, March, 1942: 235 – 256.

[24] Ehrenhaft relied very much on his condenser arrangement, first developed for the electron charge measurement. More technical details are found in Andreas Makus, "Der Physiker Felix Ehrenhaft (1879–1952) und die Bestimmung der Elementarladung. Ein Versuchsnachbau". *Blätter für Technikgeschichte.* Technisches Museum Wien. Band 64, 2002: 25-45.

[25] Helge Kragh. "The concept of the monopole. A historical and analytical study". *Studies in the History and Philosophy of Science*, vol. 12, nº 2 [1981]: 141-172. His final comment relates to Einstein's special relativity theory: if it is not assumed that all material velocity is subluminal, then Maxwell's equations for charges exhibiting superluminal speeds will be symmetric, and magnetic monopoles can be admitted. Perhaps one should keep this in mind to later fully appreciate Einstein's reactions to Ehrenhaft's monopoles.

[26] The story of this cosmological model is told by one of its authors, Alan Guth, in *The inflationary universe: the quest for a new theory of cosmic origins.*[Reading, Mass.: Addison-Wesley, 1997], see especially chapter 9.

[27] The Central Library for Physics at the Vienna University lists about a hundred of his communications covering roughly half a century, starting in 1902. Most were published in the main physics magazines in German, though in the 1940's he also published in English (*Nature, Science*,

Physical Review), besides French (*Comptes Rendues*). In view of that one could say he was not an unknown physicist then.

[28] *The Journal of the Franklin Institute*, Vol. 230, Nº 3: 1, September, 1940.

[29] *… das einzelne Stoekchen loszuloesen und zu zeigen, dass man es abknicken kann, scheint mir irreleitend. Der Wert einer Hypothese liegt in der Vielheit ihrer Leistungen. Beweisen laesst sich eine Hypothese, die einem theoretischen Komplex angehoert, niemals.*

[30]*…dass Sie aus jener Hölle nun herausgekommen sind. Es wird allgemein gesagt, dass die österreichischen Nazi noch gemeiner seien als die deutschen (wenn möglich).*

[31] Brownian motion consists of the displacement of minute particles (dust, pollen, etc.) floating on liquids or suspended in gases, subject to random forces due to the thermal agitation of the fluid molecules. Einstein in his famous 1905 article on Brownian motion established a numerical relationship that could be experimentally tested to determine the value of Avogadro's number (the number of molecules in a mole of gas).

[32] *Das Ziel des Experimental-Physikers ist nicht nur, reproduzierbare Erfahrungs-Ergebnisse zu erzielen. Es sollen auch die determinierenden Faktoren so einfach sein als möglich, damit man Elementargesetze daraus ableiten kann, die man auf andere Situationen anwenden kann.*

[33] *Ihre Andeutung, man solle neu Feldtheorien zur Erklärung der in der Arbeit untersuchten Phänomene anwenden, wirkt ohne Andeutung darüber, wie dies geschehen soll, einfach lächerlich; Vergleich: es macht einer den Vorschlag, man solle die Kurschwankungen auf der Börse aus den Maxwell'schen Gleichungen herzuleiten versuchen.*

[34]Around 1900, Louis Bachelier first proposed that financial markets followed a 'random walk' which could be modeled by probability calculus, and Brownian motion theory in "random walk" models have been applied to the modeling of markets; cf. Kelvin Hoon Sun,"Brownian Motion and the Economic World", in www.doc.ic.ac.uk/~nd/surprise_95/journal/vol1/skh1/article1.html (accessed June 28, 2008).

[35]Especifically, that Gauss' law for magnetism admit that div $\mathbf{B} \neq 0$, and Faraday's induction law include a term related to the magnetic displacement current $\mathbf{j}_m$

[36] "The magnetic current", *Science*, vol. 94, nº 2436, September 1941: 232.

[37] *dass solche Hypothesen erzwungen und unnatürlich sind, solange für sie keine breitere Erfahrungsbasis vorliegt. Dies ändert nichts daran, dass das Phänomen selbst von hohem Interesse ist.*

[38] *Nichts ist so gut wie ein Experiment, welches Irrtümer beseitigt und unbedingten Fortschritt herbeiführhrt.*

[39] The acquaintance of Ehrenhaft with Einstein's medical doctor Plesch is in Braunbeck [2003: 53]. In the correspondence Ehrenhaft-Einstein at the Dibner Library, Janos Plesch is repeatedly mentioned. His relationship with Einstein is also in Jeremy Bernstein, *Secrets of the Old One: Einstein, 1905*. New York: Copernicus, 2005.

[40] *Es ist immer schwer, in einem technischen laboratorium das nur auf Gewinn eingestellt ist, rein wissenschafltiche Forschung zu treiben.*

[41] "Diffusion, Brownian movement, Loschmidt-Avogadro number and light". *Physical Review* nº 57, 1050, June 1st, 1940.

[42] *Ich muss gestehen, dass ich aus theoretischen Gründen fest davon überzeugt bin, dass es keine freien magnetischen Pole geben kann. Der Grund ist der, dass das Vierer-Potencial eine unmittelbare physikalische Bedeutung zu haben scheint und dieses wegen des Stoke'schen Satzes freie magnetische Pole ausschliesst. Sie können mir aber trotzdem Ihre Idee mitteilen und ich werde Ihnen sagen, was ich darüber denke.*

[43] To better show the tone of the poems ant their end rhymes and sometimes also internal ones, the original German version of all poems is also given in the following notes, maintaining the manuscript spelling; in this case: *Also kann es nicht gelingen/ Ueberzeugung zu erzwingen/ Wiederholung ist am End/Doch noch lang kein Argument*

[44] *Schoen ist es zu spekulieren/ Doch erschwert's das Diskutieren/ Denn es fehlt nach meiner Meinung/ Ganz die Kenntnis der Erscheinung*

[45] According to Whittaker, *op. cit.* [1987, vol. 1: 190, *n.*1] the work of Morichini in Rome was published in 1813.

[46] *Waehrend Du in den Regionen/Weiltest wo die Engel wohnen/ Fand ich nun dass der Magnet/ Auch durch Gottes Licht entsteht. /-Morichini, achtzehnhundert -/ Hat dies Phenomem bewundert/ Neue Physic tritt in Kraft/ Besten Gruss Dein Ehrenhaft*

[47] *Wissenschaftliche Angelegenheiten sind nicht Angelegenheit der Einigung, wie solche etwa in der Politik oder sonst im menschlichen Leben platzgreift, sondern wissenschaftliche Erkenntnisse sind entweder richtig oder falsch. Der Richter ueber eine neue oder widerentdeckte Kenntnis bleibt einzig das richtig angestellte Experiment mit den daraus entspringenden Folgerungen und weiteren Erkenntnissen.*

[48] *Eine neuerliche Besprechung des Gegenstandes waere zwecklos, weil aussichtlos. Wenn uebrigens das Experiment allein entscheidet oder schon entschieden hat, so ist meine Mitwirkung ganz ueberfluessig.*

[49] *Sie sind wirklich ein Genie/ Schoen're Strafe traf mich nie/ Was Sie mir da angetan/ Fuehlt sich masochistisch an/ Boes ist's nur, dass Sie beleidigt/ Weil ich meine Zeit verteidigt/ Grund: ich kann nur wiederholen/ Dass mir graut vor Ihren Polen/ Pole kann ich nicht kapieren/ Die im Licht nur existieren/ Und die (ist es nicht zum lachen)/ Sich im Dunkeln duenne machen.*

[50] *Ihr letzter Vers gemahnt durchaus/ Der Politik des Vogel Strauss/ Der, weil er die Gefahr erkannt,/ Den Kopf versteckt im Wuestensand/ Es glueh'n die temporaeren Pole/ Auf Ihrem Haupt wie heisse Kohle/ Und auch mit permanenten Jonen/ Sollt' Ihre Nerven ich verschonen/ Euch graut vor einzelnen Magnetchen/ So wie vor Faust es graut dem Gretchen/ Vor das Experiment's Magie/ Da wird Euch so – ich weiss nicht wie/ Doch nuetzt kein Weihen mehr, kein Schwaentzen/ Ich fand ganz neue Konsequenzen/ Ich fand des Lichtes wahres Wesen/ Sie werden viel noch drueber lesen.*

[51] *Wie relative die Dinge auch im Leben/ Und wandelbar der Theorien Schein/ Glaubt ich doch fest an Einstein's Wahrheitsstreben/ Ein Fels Jehudas schien er mir zu sein/ Einsicht und Weisheit schienen ihm gegeben/ An Klarheit reicher als ein Edelstein/ Mit vollem Recht konnt er "Ein-stein" sich nennen/ Der Stufe ward zu hoehrem Erkennen./ Ich will nicht glauben dass "Ein Stein" er waere/ Am Hals des Freunds, der mit den Wogen ringt /- Ein-Stein der Mauer macht um falsche Lehre/ Im Kampf des Lichtes das die Nacht bezwingt –/ Ich will nicht glauben dass der Wahrheit*

Ehre/ Von kleinlichen Erwaegungen bedingt/- Denn das was ehrenhaft erkannt, gesehen,/ Wird ungetruebt vor aller Welt bestehen.

[52] *Man ist noch lang kein uebler Mann/ Wenn man an was nicht glauben kann./ Nicht gut ist's auch, selbst wenn's gelingt,/ Wenn andrer Glauben man erzwingt./ Man kaempfe fuer die Wahrheit nicht,/ Sie sieget durch ihr eignes Licht./ Such stets durch Dienen sie zu finden,/ Lass aendern ueber das Verkuenden*.

[53] *Wenn man an was nicht glauben kann/ So hoert man sich den Andern an/ Der sich die "hohe Gunst" erbat/ Beweis zu fuehren durch die Tat/ Und beugt sich dann, wenn man erkennt,/ Ganz ohne Zwang dem Argument./ Wenn man dann noch nicht glauben kann/ So fuehre man die Gruende an/ Und werfe gradewegs und schlicht/ Die eigne Deutung ins Gewicht ---/ An Ethik und Moral gebrichts/ Dem zweiten Teile des Gedichts/ Denn Warheit sehn und nicht verkuenden/ Ist wohl die aergste aller Suenden./ Zu kaempfen fuer der Warheit Licht/ Ist edler Menschen hoechste Pflicht –/ Der fuer sie kaempft mit Geist und Kraft/ Aufrechten Sinns – ist ehrenhaft.*

[54] *Waerend in der Formel Suempfe/ Man nichts holt as nasse Struempfe/ Bluhen auf der Forschung Beeten/ Neue Wunder des Magneten./ Der Magnet mit seinen Polen/ Loest und bindet unverhohlen,/ Kann – zum Hohn der Theorien –/ Knallgas aus dem Wasser ziehen.// Und mit dieses Gases Knall/ Ist zu Ende der Worte Schwall/ Die Atomphysik erblasst.../ Ehrenhaft – der "Grossphantast"*. This poem, with slight variations, is reproduced in Braunbeck [2003: 97] without acknowledging its authorship, and informing it was written during Christmas 1942.

[55] Braunbeck [2003: 105]

[56] Manuscript, Center for History of Science, College Park, Md.

[57] "Die Gravitation: ein magneto-photophoretisches Phänomen der kosmischen Strahlung", *Natur und Technik,* Heft 10-12, December 1949.

[58] Letter from Ehrenhaft to Lilly, May 3, 1950 – Dibner Library.

[59] Feyerabend *op. cit.* [1996: 73-76]

[60] The expression "iron curtain" and the comparison between Galileo and Ehrenhaft are Feyerabend's own – see *Killing time*, chapter 6.

[61] "Einzelne magnetische Nord-und Südpole und deren Auswirkung in den Naturwissenschaften", reproduced in Braunbeck [2003].

[62]For downloadable articles covering this issue at arXiv.org (accessed on May 19, 2007), see for example Kimball A. Milton, "Theoretical and experimental status of magnetic monopoles" (February 22, 2006), and F. Alexander Bais, "To be or not to be? Magnetic monopoles in non-abelian gauge theories" (August 5, 2004). Kragh, op. cit. [1981: 159-163] reports on the false 1975 detection in Iowa, and Braunbeck [2003: 136] mentions an alleged 1982 observation in Stanford. As a side note, since 1995 Joseph Newman has called attention - in quite sensationalistic tones - to a machine he invented which supposedly produces a great amount of power with a minimum of electricity. What is interesting in the context of the present article is that Newman's internet homepage (http://www.josephnewman.com –accessed May 5, 2007) reproduces Ehrenhaft's articles on the magnetic current.

[63] See for example the letter (Center for History of Science, College Park, Md.) from Kimble (Harvard University) to Swann (Bartol Laboratory), dated December 10, 1940, commenting on electrophoresis and magnetophoresis: "… in order to stimulate a type of investigation not yet undertaken in this country it is desirable that Professor Ehrenhaft be given an opportunity to continue his work and to demonstrate the effects he has discovered. The financing of his experiments would be a service to science".

[64] One exception was Makus, see fn. 26.

[65] Klaus and Ann Hentschel refer to a "protracted conflict", in *Physics and National Socialism*. [Basel; Boston; Berlin: Birkhäuser, 1996]. See Introduction, especially pp. lxx-lxxviii.

[66] Jeroen van Dongen, "Emil Rupp, Albert Einstein, and the canal ray experiments on wave-particle duality: Scientific fraud and theoretical bias", *Historical Studies in the Physical and Biological Sciences* 37 (March 2007), supplement: 73-120; id. "The interpretation of the Einstein-Rupp experiments and their influence on the history of quantum mechanics", ib.: 121-131.

[67] He even praised theory without experiment in cases like especial relativity – F. Ehrenhaft, "Festrede an Michael Faraday", 1932: 12.

[68] "Meine Erlebnisse mit Einstein (1908 – 1940)", MSS 2898, Dibner Library, Washington, D.C.

[69] *Nach meiner Ansicht gibt es zwei ganz verschiedene Arten physikalische Forschung zu treiben. Ich möchte diese beiden Typen als die Faraday'sche Arbeitsmethode, die zweite als die Hamilton'sche bezeichnen... Viele Unterredungen mit Einstein haben mir klargelegt, dass er immer mehr die Hamiltonsche Methode bevorzugt. Bekanntlich hat Hamilton die äussere und innere konische Refraktion rein auf Grund der Differentialgleichungen der Optik in Kristallen geweissagt ... so muss man sagen, das Einstein die Schwere des Lichtes ganz in der Hamiltonschen Art geweissagt hat.*

[70] See Franklin, op.cit. [1986].

[71] *Ich habe aber doch gefunden, dass der Blick vieler Leute durch die Brillen der Theorie für die Erkenntnis experimenteller Tatsachen getrübt ist*.

[72] *Es sind da zwei Seelen in seiner Brust, ganz ebenso wie bei Maxwell. Man muss aber sagen, dass Maxwell je älter er wurde, um so mehr von der Atomtheorie abwandte. Dies kann man bei Einstein nicht so scharf erkennen.*

[73] *In einer längeren Unterredung in Caput, während wir segelten, habe ich gesagt, dass viel zu viel publiziert und gemessen werde und habe die Behauptung aufgestellt, dass man seit dem Jahr 1870 um auf dem Gebiete der Physik, anteil zu sein, nur 25 Arbeiten zu lesen haben müsse. Einstein meinte, es wären deren viel mehr. Wir haben dann zusammengezählt und kamen nur auf 17 bis 18, natürlich Tabellenmessungen u. ä. ausgeschlossen. Er stimmte zu. Im allgemeinen habe ich bemerkt, dass er in der Entwicklungsgeschichte der Physik wenig bewandert ist und freuete mich zu bemerken, dass auch er nicht viel liest*. [Meine Erlebnisse mit Einstein]

[74] *In geradliniger Fortsetzung des Weges von Oerstedt und Faraday bin ich zu den weiteren Erkenntnissen betreffend den Konflikt zwischen Materie, Licht, Elektrizitaet und Magnetismus gekommen.*

[75] Oersted's debt to *Naturphilosophie* has been minimized by H.A. M Snelders, in Andrew Cunningham & Nicholas Jardine [eds.], *Romanticism and the sciences* [Cambridge: Cambridge University Press,1990: 232] – as well as by Kenneth L. Caneva - in "Physics and *Naturphilosophie*: a reconnaissance", *History of Science*, xxxv: 35 – 106 -, and Timothy Shanahan, "Kant, *Naturphilosophie* and Oersted's discovery of electromagnetism: a reassessment", *Studies in History and Philosophy of Science*, vol. 20, nº 3 (1989: 287 – 305). The contrary view, as in Robert C.

Stauffer, "Speculation and experiment in the background of Oersted's discovery of electromagnetism", *Isis,* 48 (1957: 33-50), is however still very solid and can be fully appreciated by reading Oersted's own works, especially his "New investigations into the question: What is chemistry?", and "Reflections on the history of chemistry" - Hans Christian Oersted, *Selected scientific works.* [Transl. ed. by K. Jelved, A. Jackson, and O. Knudsen. Princeton: Princeton University Press, 1997]. See also Robert Brain, Robert Cohen, and Ole Knudsen, eds. *Hans Christian Oersted and the Romantic legacy in science: ideas, disciplines, practices*. Dordrecht: Springer, 2007. Faraday's influence by *Naturphilosophie* has not been directly established, but Joseph Agassi in *Faraday as a natural philosopher.* [Chicago & London: University of Chicago, 1971: 203 -232] renders his ideas as matching well enough the presuppositions of Schelling's system and leading directly to the unity of all forces in nature.

[76] Schelling's dynamical conception of matter is contrasted with the mechanical atomistic conception in Barry Gower, "Speculation in physics: the history and practice of *Naturphilosophie*". *Studies in History and Philosophy of Science,* vol. 3 , nº 4 (1973: 320 – 321). The more ancient early-eighteenth century rift between "dynamists" and "atomists" is described by Armin.Herman, in "Unity and metamorphosis of forces (1800 – 1850): Schelling, Oersted and Faraday". *Symmetries in Physics (1600 – 1980).* Belaterra (Barcelona): Universitat Autònoma de Barcelona [1983].

[77]Science has witnessed historical moments when small differences became nodal points of a new theory, such as in Kepler's correction of circular to elliptic planetary paths; in principle, this could also apply here.

[78]On this subject see Maurice Allais, "The experiments of Dayton C. Miller (1925-1926) and the theory of relativity", *21st Century Science &Technology*, vol. 11, nº 1, Spring 1998. Though Allais received a Nobel Prize in economy, he has remained a lifelong experimental physicist; his work in Paris on this subject is described by himself in "Should the laws of gravitation be reconsidered?" *21st Century Science &Technology*, vol. 11, n° 3, Fall 1998. In fact, the history of the "ether" in physics did not stop in the first half of the twentieth century, even though its properties did change with time, and if one thing can be said is that this question is far from being settled - see for instance Joseph Lévy, *Invariance of light speed: reality or ficition?* Paris: Encre (1991).

[79] Franco Selleri, *Die Debatte um die Quantentheorie.* 2nd. ed. Braunschweig: Vieweg (1984: 15-17; 57-62; 87-91; 118-120]

[80] This is a loose paper (MSS 122A), autographed and dated - "12.XI.23"