Persecution and Patronage:
Oscar Buneman's years in Britain.

Abstract

The German student Oscar Bünemann, in trouble with the Nazi authorities in the mid-1930s, chose to emigrate to Britain and pursue a PhD there. After emigration, his surname appears as Buneman. On the verge of completing his degree in 1940, he was detained as an enemy alien and spent almost a year in internment. Upon release, he found work as an atomic scientist in England, and went on to lead a post-war career as a pioneering plasma physicist in the USA.

We study forced migration of European scientists before and during the Second World War, and scientific patronage in the host countries. Buneman's case is interesting from several points of view. Being a non-Jewish, non-communist, anti-Nazi activist, he belongs to a group not much investigated by historians. His emigration from Germany was facilitated by his family's business contacts in Britain. Being caught up in the wave of detainments of enemy aliens in 1940, he was assisted in pleading for release by the Society for the Protection of Science and Learning, the archives of which abound with information about refugee scientists from Nazi Germany. We have also had access to material not available to previous investigators, kindly provided by Buneman's family.

The following abbreviations are used:
AERE: Atomic Energy Research Establishment at Harwell, England
OB: Oscar Buneman
SPSL: Society for the Protection of Science and Learning
MS SPSL 474/3: SPSL archival file on OB
SUIPR: Stanford University Institute for Plasma Research

Introduction

The topic of forced migration of scientists continues to attract the interest of historians of science. Archival research is still providing new insights into the plight of scholars on the run from Nazism and Fascism in the 20th century. We propose to illuminate the challenges faced by German students and scientists during that calamitous time, as well as the support and patronage offered by fellow scientists, private citizens, and aid organizations in Britain and elsewhere, by the case history of Oscar Buneman, pioneer of numerical simulation of plasmas and of visualisation of computed results, still and animated, and founder of the field of computer simulation using particles.

Our main source is the archive of the SPSL.[1] These records contain a great deal of information about Buneman not available elsewhere. Bunemann himself never published any memoirs. He belongs to a minority among emigrants which has not been investigated much: he was non-Jewish and not a communist, politically active against the Nazis both before and after his emigration, but his main field of interest was mathematics and its applications, not politics. Most of the literature on forced scientific migration is concerned with the emigration of scholars like Richard Courant, Richard von Mises, Albert Einstein, Max Born, Michael Polanyi and others who were already famous at the time of their emigration, cfr e.g. (Nye 2011; Reid 1976).

The persecution Oscar Buneman was subjected to in Germany contrasts sharply with the patronage he was afforded in Britain, although he also had to endure much hardship there, along with many other scientific migrants. We discuss the onset of mass internment of enemy aliens in Britain in 1940, giving details about Buneman's internment in particular, and describe his career after release from internment, focusing mostly on his first years in Manchester. He happened to live at the time when computational physics and plasma physics arose as new fields of science, and being employed at institutions centrally involved in this development, he became a pioneer in these fields. His strong mathematical education was a necessary prerequisite for his later successful career in plasma physics.

[1] Archive of the SPSL, the Society for the Protection of Science and Learning, deposited at the Bodleian Library, Oxford, archival reference MS SPSL 474/3 folios 351-388. The SPSL continues today as CARA, the Council for At-Risk Academics, http://www.cara1933.org .

Early years

Oskar Bünemann was born in 1913 to a German family, then resident in Milan but soon after relocating to Hamburg. The Bünemanns were import/export-merchants. Young family members would typically spend several years in foreign countries to perfect their business and language skills. Several of them were polyglots, many played musical instruments and/or sang, some of them professionally. They had an extensive network of personal and professional contacts, some of whom would later step up and offer assistance to Oscar Bünemann when he came to Britain.

From 1924 he attended the famous Gelehrtenschule des Johanneums, where he studied English, French, Latin and Greek, and privately in addition Esperanto (Meyer-Spasche 2014). He graduated in 1932 with first prize honours.[2] He then started his mathematics and physics studies at the University of Hamburg, aiming for a PhD exam and a teacher's exam.[3] The course of his studies in Hamburg is documented quite well because his Studienbuch (in Hamburg called Anmeldebuch) is kept in the collection 'Oscar Buneman Papers' at the Stanford University Libraries.[4]

At the University of Hamburg, he attended additional courses by Professor Emil Artin designed for much more advanced students: Algebra II and the research workshop 'Arbeitsgemeinschaft'. He also had private contact with Emil Artin, they played and listened to music together.[5]

Nazi prison, emigration, graduate studies

The Nazis came into power on January 30, 1933. Although the new regime at first asserted

[2] '1. Prämie'. Hamburger Staatsarchiv, Archive of the `Gelehrtenschule des Johanneums', Schüleralbum, Regelmässige Oster-Reifeprüfung 1932.

[3] Zentrum für Studierende (2010), archived file card (Karteikarte) for the student Oskar Bünemann, 1932-1934; Universität Hamburg

[4] Oscar Buneman Papers (SC 0450). Department of Special Collections and University Archives, Stanford University Libraries, Stanford, Calif. 35 boxes, 17 linear feet; accessed in Nov-Dec 2011; The exploration of these papers is ongoing. Online Archive of California: Guide to the Oscar Buneman Papers, http://www.oac.cdlib.org/findaid/ark:/13030/kt2m3nf2sw/entire text/ .

[5] Gertrud Bünemann, sister of Oscar Buneman, (* April 1920), retired senior teacher (Oberstudienrätin i.R.) for music at the Helene-Lange-Gymnasium in Hamburg, several private communications since the fall of 2010

itself less actively and aggressively in the internationally open Hanseatic city of Hamburg than in Bavarian Munich, the consequences of Nazi rule were none the less palpable immediately. In the summer of 1933, OB served in a labour camp for 3 months. After that he started underground political activities[6] which were detected in April 1934. He was arrested and sentenced to 18 months of prison. Eight young friends, 6 male and 2 female, were sentenced in the same trial.[7] During OB's time in investigative arrest and in prison, Professor Artin provided mathematical problems `to while away the dreadful hours of his solitary confinement' .[8]

While his release from prison was approaching, his family and friends prepared his emigration to England. Professor Artin suggested that he should continue his studies with Professor Louis Mordell in Manchester. He also wrote a letter to Mordell, assuring him that he would find in OB a very cabable student who would be able to continue his studies at a very advanced level.[9] Shortly before his release he was admitted to the Honours School of Mathematics at the University of Manchester, second year, starting in October 1935. His scientific interests now shifted from pure mathematics to applied mathematics, physics and electrical engineering. He soon distinguished himself, being named 'the best man of the year'. As an undergraduate in Manchester, he was financially supported by an English friend of the family and by his parents. He graduated B.Sc. in 1937, with first class honours, and was awarded the 'Derby Mathematical Scholarship with Supplementary Grant'.

Bunemann's main contact persons during the first years at Manchester University were Professor Mordell, Professor Blackett (Nobel Prize in Physics 1948) and Professor Hartree. He got his MSc degree in 1938 with a thesis on stability theory for ordinary dynamical systems (Bunemann 1938a). This research resulted in two publications (Bunemann 1938b;c).

Having completed his MSc he was then awarded the Beyer Fellowship which would support him while pursuing a PhD. This was a considerable distinction as there were only two such fellowships awarded per year in the whole group of science subjects.

Professor Hartree later wrote:[10]

[6] MS SPSL 474/3 folio 353

[7] Urteil des Oberlandesgericht Hamburg, September 3, 1934. No longer available in the Oberlandesgericht Archives, where many documents were destroyed after the Second World War. Oscar Buneman Papers (SC 0450). Department of Special Collections and University Archives, Stanford University Libraries, Stanford, Calif.

[8] Michael Buneman, son of Oscar Buneman (* Aug 1945 in Berkeley), various private communications since May 2010

[9] Ibid: Gertrud Bünemann, Michael Buneman, SPSL

[10] MS SPSL 474/3 folio 369, 27 Jan 1941

> `my knowledge of him dates from Oct. 1935, when he entered the University' [. . .]
> `I have known him not only in his work as an undergraduate and post-graduate student, but also in more informal ways, particularly in connection with musical activities both in the University and at home.'

On November 21, 1938 the General Board of Faculties, Science and Technology Section, accepted an application from Oscar Buneman which proposed to carry out research in aerodynamics for 2 years, aiming for a PhD supervised by Professor Hartree and Dr Squire.[11] OB submitted his thesis in April 1940,[12] and on May 3, the commitee accepted an application to examine his thesis "Solutions of the Spheroidal Wave Equation" (Buneman 1940). The internal examiner was to be Dr Squire.[13]

The oral examination was scheduled to take place on June 8, 1940. Meanwhile, Bunemann started to apply for teaching jobs, supported by letters of recommendation from Professors Hartree (May 5) and Mordell (May 7).

> Hartree: `His command of English is excellent, and his presentation of his work is clear.[14] In addition of his command of his subject, he has an appreciation of the possible difficulties of those less well-equipped than himself, and I would expect him to be a good teacher, both sound and interesting, at any stage of the subject. He has wide interests outside his work, and, among other things, is a capable violinist. Personally, he is sociable and easy to get on with, and would be an acceptable colleague. I can wholeheartedly him for any post, either research or teaching, for which he may apply.'

> Mordell: `He should make a very good teacher as he is a clear expositor. He takes an active interest in his surroundings, is thoroughly alive to them and has a wide outlook. He has initiative and sense of responsibility. He should prove useful in any school even apart from his teaching. I should like to support very strongly his application for a teaching post.'

As things developed, his applications for a teaching post were thwarted, because on June 3,

[11] From the records of the General Board of Faculties, Science and Technology Section: private communication (by email) from Mr. James Peters and Ms. Janet L. Wallwork, archive of the University of Manchester, June 2013.

[12] MS SPSL 474/3 folio 356

[13] Ibid: private communication (by email) from Mr. James Peters and Ms. Janet L. Wallwork

[14] Also his Stanford students in later years praised the clarity with which OB presented his lectures, and reported that he spoke such good British English he was taken to be a native Englishman (Meyer-Spasche 2014).

1940 Oscar Bunemann was interned as an enemy alien.[15] When the committee met for his oral PhD examination on June 8, it noted that Buneman had been interned and queried whether an examiner could be sent to hold the oral at "the place of internment" as it had been indicated that he would not be released to attend the oral.[16] The official document for his doctoral degree is dated May 1, 1942.[17] In practice, though, the degree was granted to him *in absentia* in the summer of 1940.[18]

Internment as an enemy alien

In times of war, governments tend to view foreign nationals with suspicion. It has been, and still is, common practise to detain citizens of enemy nations without trial. Great Britain has been no exception in this respect. During both world wars, British authorities rounded up and interned thousands of citizens of enemy countries, as well as some of its own citizens under suspicion of collusion with the enemy. More recently, during the two Gulf wars in the 1990s and early 2000s, people were also held without trial on the assumption that they might otherwise aid the enemy.

While the internment of enemy aliens in wartime has attracted a fair amount of attention from historians of belligerent conflict (Cesarani &al 1993; Wilsher 2011; Simpson 1994; Thurlow 1994; Koessler 1942), the topic has generally, perhaps not unreasonably, been regarded as a sideline to the main narrative of the two great wars of the twentieth century. There can, of course, be no comparison with the callousness and cruelty of the internment, deportation and extermination policies of Britain's enemies in the Second World War.

The internment of enemy aliens in Britain in 1939 and 1940 proceeded without trial, although each case was examined by a local tribunal. The legality of such detention was hotly debated and challenged at the time (Lafitte 1940; Simpson 1994; Christgau 2009; Stent 1980). Before the outbreak of war, the government had prepared wartime Defence Regulations under which British nationals could be detained without trial if suspected of planning to or actually aiding the enemy. Detention of foreign nationals could in principle proceed by Royal Prerogative, i.e.

[15] MS SPSL 474/3 folio 366

[16] Records of the General Board of Faculties, Science and Technology Section, Archive of the University of Manchester.

[17] Oscar Buneman Papers (SC 0450). Department of Special Collections and University Archives, Stanford University Libraries, Stanford, Calif.

[18] MS SPSL 474/3 folios 358-360

the executive power vested in the government by the sovereign, although the archives cite the Defence Regulations in many of those cases too.

Detention without trial flies in the face of Habeas Corpus as well as the civil liberties afforded by the English Bill of Rights. No wonder, then, that a controversy erupted in Britain in the summer of 1940, when the trickle of detentions of known and suspected Nazi colluders during the previous winter suddenly turned into a wave of wholesale rounding up of thousands of enemy aliens. Churchill is reported to have quipped "Collar the lot!" after Italy declared war on Britain and France on June 10, 1940 (Gillman &al 1980). It has been estimated that 26400 German, Austrian, and Italian nationals were interned (Conway &al 2001). The tragedy of the S/S Arandora Star, which was sunk by a German submarine on July 2 with hundreds of Italian detainees destined for a Canadian internment camp on board, no doubt contributed to sway public opinion. The matter was also debated repeatedly in the House of Commons, on July 10 and August 22, by which time government policy had reversed (Dove 2005). In the end, moderation prevailed, and most of the detainees were released within months, although some remained interned for several years.

Many German scientists resident in Britain in 1940 were subjected to internment, and the SPSL devoted considerable effort to pleading with the authorities for their release. While most of them had retained their German citizenship, the overwhelming majority of them were staunchly anti-Nazi and hardly likely to aid and abet the enemy. The efforts of the Society contributed significantly to secure the early release of refugee scholars from internment.

Our information about Oscar Buneman's internment stems from the archives of the SPSL and from remarks, anecdotes and reports of others. He had been introduced to the SPSL in October 1938 by Professor Blackett. The earliest entries about OB in the files of the SPSL are from May 1939. His case as an enemy alien resident in Britain was first considered at a hearing of a local Tribunal in Manchester around October 9, 1939, with Professor Hartree, Professor Mordell and Mr Ison in attendance. Buneman was initially classified as `friendly enemy alien, Category C'. As a category C alien, he remained free until the wave of internments in May/June 1940, which affected about 27000 resident citizens of enemy nations.

OB was interned in Manchester on June 3, 1940 and was released with substantial help of the SPSL in late April 1941.[19] We do not know much about his life during internment because he apparently never told anyone much about that time. His second wife Ruth, whom he met in

[19] MS SPSL 474/3 folio 386

1950, wrote in an email: `He never talked to me about his time in Manchester and about his internment. I believe he wanted to make the most of the present and the future. He concentrated particularly on his ongoing research.'.[20]

The main stations of his internment were the Isle of Man, then Canada, Liverpool, and again the Isle of Man. His first wife Mary, whom he had met in Manchester already before his internment, told their son Michael that `during their Montreal time' (i.e. between the fall of 1945 and the spring of 1946), `they drove past the camp where Oscar had been interned, but did not visit it'.[21]

A group of companions and a `camp university'

There is strong evidence that Klaus Fuchs, Paul Weiss, Oscar Buneman, Max Perutz, Walter Kellermann, Hermann Bondi and Thomas Gold were interned together for quite some time. Max Perutz wrote about a camp university with participants Herman Bondi, Thomas Gold and Klaus Fuchs (Perutz 2002, 76). Thomas Gold reported that Buneman and (Sir Herman) Bondi `were the prime movers in the camp university and I certainly learned a lot more from them than I would have had I remained in Cambridge for those nine months' (Buneman &al 1994). Kellermann wrote that he and Fuchs taught at the camp `university' and that he met Bondi during internment (Kellermann 2007).

How many participants did this camp university have? Sometimes they were just two or three teaching each other from memory and through sophisticated mathematical puzzles, sometimes they had lectures attended by maybe up to 20 persons. Paul Weiss wrote in a letter to the SPSL in 1946 that he taught a lot of mathematics during internment and that in Canada he helped to organise the camp university.[22] `Some of these hastily formed, and ill-equipped places of isolation' . . . `became, in spite of revolting conditions, excellent breeding grounds for budding scientists, and there were many distinguished academics who owed their initial inspiration to the tuition and discussion arranged to break the tedium and hardship of their enforced detention. Herman Bondi was one' (Flowers 2009). The biochemist Max Perutz reported that he got interested in astrophysics from contact with a fellow internee: 'We were herded into a huge empty shed cast into gloom by blacked-out skylights thirty feet above us. A fellow-prisoner

[20] Ruth Buneman (*1929), Los Altos Hills; private communication.
[21] Michael Buneman, son of Oscar Buneman (* Aug 1945 in Berkeley), private communication.
[22] MS SPSL 286/2 folios 228-228v.

kept staring at a blank piece of white paper, and I wondered why until he showed me that a tiny pinhole in the blackout paint projected a sharp image of the sun's disc, on which one could observe the outlines of sunspots' (Perutz 2002, 73).[23] It seems that also OB's interest in astrophysics started during internment. His second wife Ruth reports: `He taught me a lot about the stars. Moving from Germany to England to Canada as a young man, he felt it was wonderful that the stars were constant'.[24]

Though all of them were interned around the same time, i.e. in May/June of 1940, the dates of their releases varied widely. Fuchs, Kellermann, Weiss and Perutz were released upon arrival in Liverpool mid January 1941, Buneman late April 1941, and Bondi and Gold several months later.

Support and sponsorship

Buneman's scientific career was facilitated by the patronage of various persons and institutions. When he left school, his school granted him a grant for being the '*Primus Omnium'*. After his father lost his position because of the diffcult economic situation in 1932, the University of Hamburg waived about half of his semester fees.

When Oscar and several friends were arrested in April 1934 for their anti-Nazi activities, his father together with the lawyer (Dr. h.c.) Hans Harder succeeded in moving all of them from the concentration camp located in a building formerly used by the Fuhlsbüttel prison to a regular pre-trial custody in the neighbouring prison. They then had a `regular' trial, based on a law from 1933 that was declared null and void in the fall of 1945. While he was arrested, his family and several friends gave him compassionate support. Upon his arrival in England in October 1935, he was welcomed by Mr Joseph William Ison of London, a friend of the Bünemann family who had made himself responsible for OB to the Immigration Officer, thus securing a permit of stay for the young student.[25] Mr Ison, who had visited the Bünemanns in Hamburg in 1933, also paid for tuition and university fees for the first two years of study at the University of Manchester. One might say that Oscar left Germany in the traditional Bünemann style, benefiting from the social network of his mercantile family.

[23] Perutz' account of the incident implies that his fellow-prisoner was Hermann Alexander Brück CBE FRSE FRIA, a German-born astronomer who later became Astronomer Royal for Scotland.

[24] Stanford University News Service (01/26/93): Oscar Buneman, pioneer of computer simulation of space, dies at 79; archived release, http://news.stanford.edu/pr/93/930126Arc3435.html

[25] Alien's Certificate 51754

From the summer of 1940 onwards however, while interned in Canada as an enemy alien, Oscar Buneman needed support and sponsorship beyond the reach of family connections. The Society for the Protection of Science and Learning, on the other hand, was actively involved in appealing to the Home Office for the release of interned academics who were registered with them. Our knowledge of their correspondence with OB in internment starts with MS SPSL 474/3 folio 356, which is not dated, but obviously stems from July 1940: it contains answers to some questions, apparently written by OB under difficult conditions: `Research can be carried out wherever postal communication with some university and library is possible.' - `Research carried out at the moment concerns the problem of airscrew noise and was suggested by the Aircraft Establishment, Farnborough. Applicant would like to get permission for speedy correspondence with Mr H. B. Squire of Farnborough and opportunity to publish papers which are being completed at the moment'. It seems that no such permission and opportunity was given.

In August 1940, Professor Blackett wrote a confidential and personal letter to Ms Simpson of the SPSL, praising Bünemann's mathematical abilities, character and personality.

> `I consider Bünemann a most valuable man in the eventualities that we all hope will occur. He is Aryan or whatever is the official title for a non-non-Aryan, and is definitely a political refugee.' . . . `In general he is I think one of the ablest & sanest political refugees I have met'.

But he also wrote[26]

> `Prof. D. R. Hartree of Manchester could tell you more than I can about his mathematical work. I know he has been doing some applied mathematics connected to aeronautics, in collaboration with Dr. Squire, now at the Royal Aircraft Establishment, Farnborough. I could collect details of all this for you if you would think it worth while.' . . . `As to possible employment, I would have to consult Hartree.'

Ms Simpson wrote back for more information:[27]

> `what interests the Home Office is his scientific value (which the Royal Society tribunal will assess) and his personal integrity and loyalty, for which you, and

[26] MS SPSL 474/3 folio 357
[27] MS SPSL 474/3 folio 358

> perhaps Professor Hartree also, vouch.' … `I shall certainly prepare an application for his release'

but since neither Hartree nor Blackett gave any statement about OB's scientific merit, no early release was forthcoming. It may have expedited his transport back to England while some others remained interned in Canada until 1943.[28] He arrived back in Liverpool in January 1941, at the same time as Fuchs, Kellermann, Weiss and Perutz. Those were officially released during their stay in Canada in the fall of 1940, but had to wait for a transport back to England.

Back in England, OB was very disappointed to stay interned while many of his companions were released, mostly thanks to the help of SPSL. When he complained about this in a very polite letter to Ms Simpson, she answered with a warm, understanding letter making clear what was needed: a detailed statement from an authoritative British scientist - preferably more than one - concerning his scientific work, together with assurances of his personal integrity and loyalty to Britain.[29] OB provided further information on his scientific work, most of which was unpublished because of internment. He also provided the addresses of Mr Ison and two other personal contacts, and informed about his political activities before internment.[30] Ms Simpson wrote to all three personal contacts, as well as Professors Hartree, Blackett and Mordell and tried to contact Dr Squire, with whom Buneman had tried to get in touch in the early stages of internment, and to whom Professor Blackett had referred in the letter quoted above.

Professor Hartree replied this time, but there was never any response from Dr Squire. An answer from him might very well have been conducive to Buneman's early release. It seems that he was the only (other) person who knew the `further developments of which I' [Hartree] 'am not aware', and who probably had obtained OB's letters and at least one of OB's manuscripts. But in spite of every attempt to contact him, Dr Squire never replied. We may find a clue to Dr Squire's reticence in the Biographical Memoirs of Fellows of the Royal Society (Gates &al 1962), according to which he had `something of the iron of the self-reliant nonconformist'. As a professor at Imperial College later on, he `was always approachable - up to a point. When he had had enough of a conversation he would unobtrusively cease to listen.' Squire's research on rotary-winged aircraft (and thus on airscrews) was not considered important for the war at Farnborough. It was delayed to later years.

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[28] Virtual Museum of Canada, "Enemy Aliens", The Internment of Jewish Refugees in Canada 1940-43; www.enemyaliens.ca

[29] MS SPSL 474/3 folios 361-2

[30] MS SPSL 474/3 fols 366-7

Notwithstanding the conspicuous lack of support from one of Buneman's main scientific contacts, the SPSL lodged their appeal for his release from internment on January 30, 1941. This appeal needed some time to be passed on to the Home Office by the Royal Society with their recommendation - how fast was a question of the frequency of the meetings of their special tribunal. The letter from the Home Office authorising his release is dated April 22, 1941, and Oscar Bunemann's letter of thanks to Ms Simpson of the SPSL is dated May 5, 1941: [31]

> `I not only appreciate the fact that you have collected all the material and launched the actual application, but also that you have done so with a promptness and speed which was so reassuring after the grave difficulties which we had to overcome in all official matters.
>
> In the various camps I have met nothing but praise for the Society's work, effciency and sympathy. The many delays with which our applications were confronted, we were sure, were never due to the Society. We were under the impression that the energetic and businesslike manner in which the Society pushed the applications compensated for the many stoppages in the proverbial "bottle-necks".
>
> Allow me to conclude by offering you my humble thanks for the freedom which I owe to you and the fact that I can now do my small part for the British cause.'

Scientific career

After release from internment, Bunemann joined the magnetron group of Professor Hartree working for the British Admiralty. The task was to achieve a better understanding of the generation of microwaves in a cavity magnetron, to design a device for efficient production of radar waves (i.e. special microwaves) of wave lengths which the German *Luftwaffe* could not jam because they did not know how to produce them. Mathematically speaking, they computed the paths of many charged particles (an electron beam) in a given electro-magnetic field of a cavity magnetron, taking into account that the moving charged particles generate fields themselves. The resulting field is called a self-consistent field. One of the equations to be solved again and again was the Poisson equation. By observing the particles timestep by timestep, he

[31] MS SPSL 474/3 folio 387

discovered the `threshold' criterion for magnetron operation, later on an important design tool. During this time Hartree, Oscar Buneman, Phyllis Lockett (later Nicolson) and David Copley closely cooperated. At a history meeting many years later, Buneman described this in modern language: Hartree wrote a `computer program' (with loops and goto statements), and the other three acted as human CPUs (sometimes in parallel), doing their computations on mechanical desk calculators and keeping track of the positions of the particles on a plastic sheet. During this time a close friendship between Hartree and Buneman developed, which lasted as long as Hartree was alive.

In June 1942 he married Mary Frances Behrens (*1921) of the well-known mercantile family Behrens of Manchester. They had two sons: Oscar Peter (*1943 in Manchester, now FRS) and Michael (*1945 in Berkeley).

The scientific expertise he gathered in the magnetron group had a deep impact on all of his subsequent scientific life. When the work of the magnetron group came to an end, Professor Mark Oliphant invited him to join his group in Berkeley to work on `ion optics', i.e. on the electro-magnetic separation of uranium isotopes with the CALUTRON (California University cyclotron). In a cyclotron, charged particles move in circles, the radii of which depend on isotopical mass; different isotopes describe different paths. The work at Berkeley entailed computing paths of charged particles (ions) in their self-consistent fields.

When the Manhattan Project came to an end in the summer of 1945, it seemed clear to OB that he would continue to work in the field of nuclear research. He and his wife considered several different job offers, in the US and in the UK. The offer from Professors Peierls and Oliphant to work with their team at the University of Birmingham was turned down by the couple: the salary seemed too low to support a family with two children. He accepted another offer from the UK and joined the team led by Professors Cockroft and Chadwick for the Canadian and British Atomic Energy Projects.

This project was started in the late thirties in England, moved to Montreal during the war, but was not intensely pursued during the Manhattan project. After the war it was intensified in Montreal, and its return to England was planned during the Montreal phase. It was clear that it would be too dangerous to do this work at a university in the middle of a city, so a new site, AERE Harwell, was found in the countryside between Oxford and Reading, far enough away from population centers, but close enough to a university for using their facilities (library, lecture halls, hospitals etc.) and to a military airport.

According to the public records in The National Archives, while at Harwell Buneman did

(secret, military) research on nuclear energy, fission and fusion, analytic and computational, and shared his knowledge in internal reports (two of which were declassified and published as articles in scientific journals later on) and in two series of lectures: four lectures on pile theory (1946) and seven lectures on `Scientific and engineering problems of nuclear power' (1949). In his reports he mostly dealt with pile theory, i.e. with devices for gaining energy from fission of heavy nuclei like uranium. But he also dealt with magnetron theory again (1948) and with `The use of large-scale computing facilities in the theoretical analysis of light nuclei' like the hydrogen isotopes which are important for fusion (1950).

In 1948 Bunemann was unhappy about his working conditions and about the topics of his work. He felt that . . . `the possibility of making "fundamental contributions" in pile work and the scientific appeal of the work (limited in any case by the continued security restrictions) is decreasing rapidly' . . . . He would have preferred to fully concentrate on the newly evolving field of plasma research and fusion.[32] Also, the private life of families at Harwell was uncomfortable and very much restricted by the military: they had to live in prefabricated houses, `tiny tin boxes', which gave the place `the general appearance of a penal colony.' His wife Mary had a massive re-entry culture shock and remembered later: `Never before had I felt so humiliated nor so homesick for the wonderful, convenient United States'. The couple separated during their Harwell time and were divorced in September 1951. They both remarried shortly afterwards: she in October 1951 to Brian Flowers, Baron Flowers, FRS (1924 - 2010) and he to Ruth Eades (*1929) in April 1952. The children of his first marriage lived with their mother and stepfather in England, but stayed in contact with their father. The children of his second marriage are Kevin (*1953) and Paul (*1956), both born in Cambridge.

The head of his department in Harwell was Klaus Fuchs, who in 1950 was convicted as a spy. Security regulations at AERE were then greatly increased, and several people, including Oscar Buneman, were advised to leave. Buneman then became a university lecturer for mathematics at the University of Cambridge and a member of Cambridge's oldest college Peterhouse. His scientific interests, however, stayed in theoretical physics, especially in fundamental and cosmical electro-dynamics and the newly evolving field of plasma physics (cosmic plasmas, fusion plasmas).

In the academic year 1957/58 he spent a sabbatical at Stanford University. During this stay he

[32] Oscar Buneman Papers (SC 0450). Department of Special Collections and University Archives, Stanford University Libraries. Original and copy of a typewritten letter.

had access to the biggest and fastest computer of the time, a Univac 1103AF. Extending the numerical methods employed earlier, he did a first numerical simulation of a plasma, computing paths of the same number (256) of positively and negatively charged particles in a self-consistent field. Thus he discovered an electron-ion instability, today called the Buneman Instability, and he showed how anomalous resistivity comes about. The publication of these results roused a great deal of attention and was frequently cited (Buneman 1959). This work probably also helped him to attain a full professorship at Stanford University. Later on he remembered: . . . `the publication of two pages of graphic computer output in Physical Reviews, showing electron and ion space-time orbits made quite a stir' (Buneman 1990). This paper is still frequently cited; in the ISI Web of Science citation index there are 424 citations in the first 25 years (1959 - 1984), 194 citations in the next 25 years (1985-2010), with new citations being recorded every year.

In the years 1960 - 1984 Buneman was Professor of Electrical Engineering at Stanford University and head of SUIPR, cooperating with colleagues at Berkeley, Livermore and elsewhere. Besides his other work he continued research in numerical simulation of plasmas (laboratory plasmas and cosmic plasmas), not only in one spatial dimension as in the 'citation classic' paper, but later on also in two and three spatial dimensions, with growing numbers of particles. Treating as realistic mathematical models of plasmas as possible, it was - and is - necessary to use the biggest and fastest computers (which were available in the Bay Area) and to develop new and more efficient computational methods.

His main interest was in investigating plasmas. But whenever necessary, he dealt with many different problems of computer science and numerical analysis. Thus, for instance, he also dealt with fast and multi-dimensional Hartley transforms, certain types of finite elements, and he replaced certain functions of Cray software by his own, more efficient routines. In the 1960s he and his PhD student Roger Willis Hockney were strongly involved in the development of numerical methods closely related to the Fast Fourier Transform, together with Gene Golub (Hockney 1966a). Buneman became well-known among numerical analysts for his Fast Poisson Solver, the 'Buneman algorithm' (Buneman 1969; Buzbee &al. 1970, 4; Henrici 1986; Stoer &al 1983).

At the time when it still was cumbersome and time-consuming to generate computed pictures using plotters, i.e. programmable machines for drawing lines with ink-filled pens, Buneman produced computer-generated pictures on printers as well, by using digits and letters as pixels. It seems that Roger Hockney was the first to produce a film of moving plasma particles

(Hockney 1966b). After Hockney left SUIPR, Buneman himself started to run Fortran codes and showed movies of his numerical simulations during his talks at international meetings and summer schools. Soon other plasma physicists around the world started to display their numerical results in movies. And then this technique spread to other fields, as did the particle methods.

In 1984 Buneman became Stanford emeritus. He joined Stanford's STARLab and continued his research as before. He died on January 24, 1993. His plenum talk planned for the IEEE 1993 plasma meeting was replaced by a memorial session for him, with a talk by his colleague Bruce Langdon (Langdon 1993).

Honours

Oscar Buneman was elected Fellow of the American Physical Society (1948) and Fellow of the Cambridge Philosophical Society (1950). His name is tied to the 'Buneman Instability', a property first introduced in his most frequently cited paper (Buneman 1959), and the 'Buneman Algorithm' (Buneman 1969) which is still cited in numerical analysis papers and used in plasma codes ('Buneman trees' and the 'Buneman-Levy algorithm' are named in honor of his son Oscar Peter.) The dedication of the first text book on computer simulation using particles (Hockney &al 1981) reads: 'To Oscar, Founder of the subject'. His achievements about communicating computed numbers in meaningful computer-drawn pictures, still or animated, are commemorated in the Oscar Buneman Awards for the most insightful visualisation of plasmas, with one prize in the still category and one in the animation category. They are presented at the International Conferences on Numerical Simulation of Plasmas since 1998.

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