

2

Cape Town

Alexander Bobrow, known to his friends as Alter, grew up in Pinsk, now part of Belarus near the Ukrainian border. He attended the same high school as Chaim Weizmann, and went on to the University at Vilna to study chemistry. After University he took up work as a chemical engineer in a sugar factory.

In 1917 the towns of the Pale of Settlement, already poor, suffered dreadfully from the ebb and flow of the revolutionary and imperial armies. Returning to visit his family in Pinsk, Alter was confronted with appalling scenes of destruction: children could be seen crawling around in the wreckage that had been their homes. Many had watched their entire families butchered before their eyes. Typhus was rife. Alter resolved that these children must be offered succour. He belonged to a Poale Zion Group (Workers of Zion), and on his initiative all the members of the Pinsk group left their jobs to help save the children. They walked from place to place collecting starving children from the rubble. The group commandeered a disused old-age home and converted it into the first Pinsk orphanage. Within two years there were three orphanages in Pinsk alone.

Emigration seemed the only way out of this mess. Fortunately, the influential Jewish Community in Cape Town established an orphanage for children from the Pale of Settlement. In 1921 they accepted 200 children, to include some of the children from Pinsk but with the proviso that Alter should come too. Thus in 1921, via Danzig,

London and Southampton, Alter sailed to Cape Town accompanied by a group of children from Pinsk.

In 1921, Cape Town was still a smallish city. The town is blessed with a congenial Mediterranean climate and one of the world's most dramatic settings. From the waterfront the skyline consists of the spire of Devil's Peak, the flat mesa of Table Mountain – 1000 m high – and the dome of Lion's Head and Signal Hill. The older residential part (referred to as the City Bowl) snuggles in this ring of mountains and looks out to the northeast over the remarkable Table Bay. The Jewish Orphanage was located in the suburb Oranjezicht on the slopes of Table Mountain, but still in the City Bowl. The harbour sits in Table Bay in the cradle of the mountains. The older suburbs snake around the northerly slopes of the Devil's Peak and turn south along the east side of Table Mountain to form a string that eventually reaches False Bay. This beautiful bay, on the eastern side of the peninsula where the sand is soft white, faces the Indian Ocean. Its name stems from the frustration felt by many mariners returning from the Far East who turned into the bay thinking that they had already rounded the Cape of Good Hope.

A spirited young lady, Hannah Gamsu (known as Annie), who originally came from Dvinsk in Latvia, taught sewing and dressmaking at the orphanage. Annie was decidedly left-wing and was the rebel of her family. She had great taste and style for visual things, whether for clothes or house decoration. Annie was introduced to Alter by one of the orphan girls that he had saved. There ensued a meeting and merging of souls, but the pair did not marry for another five years because Alter felt an obligation to send much of the money he earned back to his parents. At the time of their wedding in 1927, they lived in a flat in an old house in Jagersfontein Avenue. When Annie became pregnant, they moved to the beautiful suburb of Muizenberg on False Bay so that the child should benefit from the ozone-rich sea air. On 24th May 1929, Annie gave birth to Liebe Bobrow, who 19 years later would become Liebe Klug.

The 'Southern Line' railway links Muizenberg with the city centre, but the journey took about 45 minutes, so that after three years of living on the seashore the Bobrows decided it was time to move back into town. They purchased a house in the foothills of Table Mountain in a new suburb called Vredehoek, to the east of Oranjezicht. They named the house *Espero* (Esperanto for hope), embodying one of

their dreams: if all were to speak one language then we should have peace. At the time their road, Rugley Road, was still the highest on the mountain. From the back window of the house, young Liebe was able to watch the cable car travelling up and down Table Mountain. The view from the front stoep (veranda) was the wonderful vista of Table Bay. As a child, she would watch the ships rounding the bluff into the bay to dock at the end of Adderley Street. When the wind blew from the southeast, as it sometimes did with great ferocity when bringing the hot summer weather, it covered the mountain with a white cloud known as the 'Table Cloth'.

Despite the Board of Governors' original insistence on his coming from Pinsk, Alter's position at the orphanage was not secure. Perversely, this may have come about because he was very popular with the children. There was envy among the staff. Furthermore, the Bobrows were not at all conventional in their views, being remarkably left-wing and politically active. Annie worked very hard for a Jewish Workers' organisation called 'Geserd'. This decreased Alter's popularity with the management. His contract was not renewed.

There ensued the Bobrows' 'Wanderjahre'. Being influenced by Buddhism and the Indian poet and mystic Rabindranath Tagore, Alter first tried meditating in a little shack by the sea in a deserted place called Bakhoven. Later he started teaching Hebrew privately and preparing boys for their Bar Mitzvahs. However, with a family to feed, Alter was obliged to seek more permanent employment, which he found in the Johannesburg area. The Bobrows sold their wonderful house and wandered into an economically imposed exile from beautiful Cape Town. Their banishment ended only in 1944 when Annie and Alter were appointed Matron and Principal of Herzlia, a boarding facility (and later school) in Cape Town that enabled children from smaller communities to come to the city and be properly educated in a Jewish environment. In the meantime, Liebe sampled schools in Muizenberg, Johannesburg, Johannesburg Springs and a convent in Benoni, each with its own curriculum. Thus Liebe's schooling became a wide-ranging pedagogic survey of South Africa beginning and ending at the Good Hope Seminary for young ladies.

Liebe played the piano rather well, and after completing school she started a BMus degree at the College of Music in Cape Town. She also loved to dance. Sometimes Alter would play his mandolin to accompany

her. In addition, Alter introduced her to the ideas of modern dance (he somewhat disapproved of classical ballet as being the plaything of the Russian aristocracy). He also encouraged Liebe to improvise. After a year at the College of Music, the siren call of dance became too strong, and Liebe changed to an unconventional dance studio called 'The School of Charm'. The studio earned money by running classes in energetic dancing ('dancercise'). The serious dance students had the freedom to concentrate on developing their own kind of modern dance. It was way outside the South African style, more akin to Isadora Duncan and Martha Graham. Like everything else the Bobrows were involved in, it seemed to be about 30–40 years before its time. Alter was rather proud that Liebe was becoming a dancer.

During 1947, his second year in Cape Town, Aaron Klug went to a performance at which Liebe danced to the music of Vaughan Williams' setting of 'Greensleeves', and he fell in love. Thus the fate of the Bobrows and the Klugs became entwined.

But how had Aaron come to be in Cape Town? At the end of 1945, after four years at Wits, Aaron knew that now he really wanted to study physics. Physics as a discipline was in turmoil. Two atomic bombs had demonstrated, devastatingly, the correctness of Einstein's formula equating mass and energy. This relationship came out of special relativity: there was no 'ether' as had previously been thought, only space. In 1919 Eddington had exploited a total eclipse of the sun to measure the displacement of star images near the sun. The mass of the sun bent the starlight exactly as predicted by Einstein's general theory of relativity: even space could be bent. This was the death knell of Newtonian physics. Perhaps even worse for classical physics was the notion that energy came in packets or 'quanta' of determined size. All this seemed to give modern physics the attributes of Alice's sojourn in Wonderland. Nevertheless, experimental data fitted the new physics with wonderful accuracy. Moreover, quantum mechanics was very good at accounting for the behaviour of electrons. It predicted atomic and even simple molecular structures, thereby turning chemistry into an exact science. The downside was that you needed to understand a lot of mathematics to come to grips with quantum mechanics. Most undergraduate physics courses now had to teach more applied mathematics simply in order to make modern physics accessible. Aaron was a special case. He had taught himself enough of the appropriate

mathematical language to wonder at the power and subtleties of the new physics, and he wanted to know more.

After obtaining his degree in November 1945, Aaron was offered a job at the Department of Scientific and Industrial Research (DSIR) in Johannesburg. It turned out that this was not the new physics he was looking for; rather, it was applied electronics. After six weeks, Aaron resigned.

In a further thread in the story of Aaron's future, in 1943 Baruch Hirson had come to Cape Town to try to convince the Hashomer Hatzair leaders to leave the organisation in order to promote the wider aims of world revolution. In this he was broadly successful: the Cape Town Ken was splintered by the same defections and doctrinaire disputes that had beset the Johannesburg Ken. Thus in 1945 the Johannesburg Ken, noting the disarray of the Cape Town Ken, arranged that a shaliach (youth leader and emissary) should be sent to reorganise the remnants. Blue shirts and neck scarves were reinstated. Study groups were instituted. In addition, the group became renowned for its enthusiastic singing and dancing. The venue for these noisy activities was the Maon or meeting place in rooms above a dentist's practice in Long Street. The long-suffering dentist must have regretted ever having signed a rental agreement with this lively bunch. A great deal of earnest discussion happened both there and in 6 Annadale Street, a student lodging-house belonging to the Bobrows, which turned out to be a second Maon. The courtyard in Annadale Street was a social hub; one could nearly always find someone there. Furthermore, Peter the Greek, who ran a small 'tea room' on the other side of the street, offered welcome opportunities for eating, socializing and dating in an affordable price range. Naturally, the young Hashomer Hatzair members studied the official texts, but they also organised seminars on Marx, Freud and Reich. Poetry readings were interspersed with Israeli dances such as the Hora. They learnt and sang the Hebrew songs of the future state. Although the success rate in terms of promoting Aliyah was modest, this romantic brain-washing brought together a group of young people at an impressionable age: they connected and remained a cohesive group of friends for the rest of their lives.

In order to strengthen the Cape Town Ken further, the Johannesburg Ken of the Hashomer Hatzair decided that Aaron should be posted to Cape Town as second in command to the shaliach. The idealism of the Hashomer Hatzair was not particularly concerned with mundane

factors such as earning a living – but then Aaron saw an advertisement offering £20 a month to demonstrators in physics at the University of Cape Town (UCT) coupled with the possibility of doing a MSc in physics. It transpired that the UCT had the best physics department in South Africa. Aaron applied and was accepted.

Thus, in January 1946, Aaron moved to Cape Town. Unlike Durban and Johannesburg, Cape Town is an old city with a distinctive history and culture. As an impressionable 19-year-old, Aaron thought it was marvellous. He found lodgings in 6 Annadale Street. In fact, Aaron shared a room with the shaliach Mike Levine, who was originally from Johannesburg and had gone off to Israel in the general exodus, living in the kibbutz Shoal in the Negev. However, Levine had soon returned to South Africa to study medicine and help with organising the Hashomer Hatzair. The Annadale Street house was built around a courtyard, as are many houses in Cape Town. At the back of the courtyard were four rooms in a building that had been the servants' or slaves' quarters. A slave's room was to be Aaron's home. There was a small kitchen, bathroom and shower in the courtyard. A mature Malay woman called Annie ran the place. Very much in the spirit of a Cambridge bedder or an Oxford scout she cleaned the rooms, provided linen and brought everyone an early morning tea, made with sweet condensed milk.

Aaron was befriended by Vivian Rakoff, who lived but two blocks away. An erudite and witty person, Vivian had played a pivotal role in re-establishing the Ken in Cape Town. In the Maon above the dentist's practice, Vivian had painted a mural showing a group dancing the Hora. He was a man of many talents: he could design, paint, write poetry, sing and act. Having recently acted the part of Macbeth in a school play, he was brimming with enthusiasm for the theatre and often in demand in the amateur productions in the town. After studying English at the University of Cape Town he planned to go to Downing College Cambridge to read English with Frank Raymond ('F. R.') Leavis, and then perhaps become an actor. In fact, he was to become a well-known psychiatrist, head of the Clarke Institute and chairman of the Department of Psychiatry at the University of Toronto. Vivian's early literary aspirations overlapped with Aaron's interests, which helped to foster the deep and lasting friendship that developed between them. Moreover, in fulfilment of their support for the Hashomer Hatzair, Aaron and Vivian became involved in a number of slightly risky attempts to help potential

candidates for Aliyah out of the Cape Town Docks and on their way to the Promised Land. On one occasion, an Argentinean member of Hashomer Hatzair was to arrive on a training vessel. The plan was that he would jump ship and should be met and helped on his way to Johannesburg from where he would be translated to Palestine. On the appointed evening, Aaron and Vivian, wearing Hashomer Hatzair blue shirts and carrying Jewish newspapers, proceeded to the docks to await the sailor. They were duly recognised by the candidate, and the group swiftly repaired to Annadale Street. In something of an anticlimax to the event, the arrangements in Johannesburg had not worked out properly, with the effect that the sailor promptly left and returned to his ship. Despite such extramural activities, Aaron's academic career proceeded apace.

The University of Cape Town lies to the east of Devil's Peak, shielded from the setting sun by the mass of the mountain. It was founded in 1829 as the South African College, a hundred years before Wits, and is the oldest university in South Africa. The main teaching campus, known as the Upper Campus, is located on the slopes of the Devil's Peak. It includes the faculties of Science, Engineering, Commerce, and most of the faculty of Humanities. The buildings and layout of Upper Campus were established around 1930. Since that time, many more buildings have been added as the university has grown and the site has extended into the lower or 'Rondebosch' Campus. The journey from Annadale Street to the university entailed walking to the main station in Adderley Street and taking the Southern Line to the sixth stop, Rondebosch. The university could then be reached by an uphill walk through the grounds of the College of Music, which was ensconced in a lovely old Cape House, passing the statue of Cecil Rhodes pointing north, saying 'Your hinterland is there.' Aaron soon discovered a more congenial mode of transport: a lecturer in the physics department, John Walter Faure Juritz, who lived nearby, could pick up Aaron in the mornings in his 'Traction Avant' Citroën car. Juritz too was something of a polymath. He flew small planes, was an accomplished pianist and played the organ in the neighbouring church¹. He also played the bassoon well enough to perform in the Cape Town Orchestra when an extra bassoon was required. He remained a firm friend of Aaron and Liebe until his death in 2007.

¹ 6 Annadale Street has since been replaced by a community hall attached to the neighbouring Presbyterian Church.

Another friend Aaron made, this time in the English department, was Bernard John Krikler, known as Bunny. Bunny was a couple of years older than Aaron and had served in Burma towards the end of the war. On discharge from the army he was given UCT quarters that were constructed largely out of corrugated iron. These were rather insensitively referred to as 'Belsen'. Later, while the Klugs were in Cambridge, Bunny Krikler and his wife Berenice came to live in London. They also remained life-long friends of the Klugs.

In addition to the MSc course lectures, which were given by Reginald William (R. W.) James, Aaron attended lectures on mathematics, philosophy and poetry. The senior lecturer of ethics and philosophy, Martin Versfeld, was an eccentric Afrikaans intellectual who had converted to Catholicism and was keen to proselytise, particularly while climbing Table Mountain. The brother of one of Aaron's Hashomer Hatzair friends fell in love but was rejected. As a result, he tried to hang himself. Martin Versfeld not only discovered him and cut him down but also converted him to Catholicism. Subsequently the man became Brother Elias (Elijah), a Carmelite monk, and lived the rest of his life on Mount Carmel in Israel under the protection of his biblical namesake. Aaron found himself being urged to turn from agnostic Judaism to Catholicism. Aaron, who is not devoid of spirituality, explored the situation in some detail but decided to remain as he was. Nevertheless, in so doing he learnt more about the early Christian Church than is known to most clerics. He became something of an authority on Origen, an early Christian philosopher from Alexandria who wrote commentaries on the Bible and interpreted the scriptures allegorically. Despite delving into this fascinating topic, Aaron still managed to complete the two-year physics MSc course in one year and to pass with first-class honours. Aaron is a phenomenally fast reader, but even so, one wonders at his ability to come to terms with so much material. Moreover, at the same time, for his MSc under the tutelage of R. W. James, he generated a research paper on the structure of a halogenated benzene molecule by X-ray diffraction. He was still only 19. The next year, this work was published as a short letter to the research journal *Nature*, forming Aaron's first research publication².

² Klug, A. (1947) *Nature* 160, 570.

For his second year in Cape Town, Aaron readily accepted a position as junior lecturer that carried the princely remuneration of £30 per month. His main task was teaching physics to trainee nurses, who were required to know about medical physics including X-rays and dosage. For some reason they were also required to know about negative numbers, which gave some trouble. Aaron was grateful that they did not need to know about imaginary numbers. Nevertheless, Aaron had plenty of time to continue with research, and he became enthusiastic about working with James.

R. W. James came from Paddington and was a Londoner born and bred. He won a scholarship to St John's College Cambridge and after obtaining a double first in Natural Sciences started research at the Cavendish laboratory under J. J. Thomson. Conditions were not good: J. J. Thomson had a mass of students and no funds. Therefore, in 1914 James responded with some alacrity to an invitation to join Ernest Shackleton's Antarctic expedition as the expedition's physicist – with J. Wordie, later to be Master of St John's, as geologist. Shackleton was known as 'the Boss'. One of the questions the Boss put to James was 'Can you sing?', this being considered an important recreational activity in the long polar nights. Until this point, apart from fell walking, James (nicknamed Jimmy by his new colleagues) had led a rather quiet life that contrasted starkly with the rough seafaring manners of his companions. To them, Jimmy was clearly just a landsman but was tolerated. Unfortunately, after a propitious start, the expedition developed into a catastrophe. Their ship, the *Endurance*, became locked in Antarctic ice and crushed. The party escaped in three small boats. Soon the chronometers became unreliable, and they did not know where they were. Here, the unassuming landsman Jimmy made a very important contribution to saving the expedition: he was able to register the lunar occultations of the planets and, with the aid of a nautical almanac, use these observations to calculate the party's longitude. Thus after 400 days at sea, Elephant Island was found, and the party of 30 men had solid ground under their feet. However, Elephant Island was far from any shipping routes, so Shackleton with five colleagues decided to risk a 1200-km open-boat journey to the South Georgia whaling stations to seek help. Shackleton's heroic journey was successful; and somewhat miraculously, in August 1916 all the members of the expedition were rescued and were able to return to England. In January 1917, James was commissioned

into the Royal Engineers and went to work with William Lawrence Bragg on sound ranging methods for detecting gun positions near Ypres. The importance of this meeting went beyond their ensuing accurate location of enemy guns: in 1919 Bragg took up the chair of physics at Manchester University, and James joined him there.

William Lawrence Bragg was born in Adelaide but moved to England when his father was appointed professor in Leeds. Lawrence Bragg entered Trinity College Cambridge at the age of 16. Subsequently he started research under J. J. Thomson at the Cavendish Laboratory. By then, his father had awakened his interest in German physicist Max von Laue's work on the diffraction of X-rays by crystals. Von Laue had shone a beam of X-rays on a crystal of zinc sulphide and recorded the diffraction pattern on a photographic film. X-rays have a wavelength close to the distance between atoms and therefore are strongly diffracted – scattered and diverted into specific directions – by the regular atomic arrays within crystals. On an X-ray film the diffraction pattern consisted of regularly arranged sets of spots, which are known as X-ray 'reflections'. The spots happen as a consequence of the diffraction from a regular crystal lattice. Von Laue produced a set of equations that allowed one to estimate the strength of diffraction in any particular reflection from a crystal of known structure. These equations were not especially intuitive and did not help much with the more interesting problem of working out the crystal structure from the diffraction patterns. Lawrence Bragg's studies of von Laue's diffraction patterns obtained from zinc sulphide crystals led him to postulate that the structure of zinc sulphide crystals was based on a three-dimensional (3D) pattern known as a face-centred cubic lattice, an amazing piece of insight. It also led to the famous Bragg's Law of crystal diffraction. In essence, this says that a beam of X-rays is reflected from planes of atoms in a crystal at an angle that depends inversely on the spacing between the planes: small spacing – large angle; large spacing – small angle. Intuitively much simpler than the von Laue equations, Bragg's law also allows one by inspection of simple crystals to estimate how strong a particular X-ray reflection should be. After demonstrating the power of his law in the analysis of the structure of diamond, Bragg was appointed a Fellow of Trinity College just before the outbreak of the First World War. From 1912 to 1914 he had been working with his father, and the results of their work were published in 1915. It was this

work that earned them jointly the Nobel Prize in Physics in the same year, making William Lawrence Bragg at 25 the youngest-ever Nobel Laureate in science.

When Lawrence Bragg took over the Chair at Manchester University he was neither a skilled lecturer nor a good administrator. It was James who kept the place running and contributed very substantially to the success of the laboratory. On balance, this was a fantastic time: the silicate structures were identified and the optical theory of the diffraction of X-rays was developed. The lab was abuzz with famous visitors. Father Bragg was by then Director of the Royal Institution in London where he had appointed Kathleen Lonsdale and John Desmond Bernal as co-workers. Together they worked out how to do X-ray structure analysis of complex organic molecules. This introduced a whole new world to chemistry: instead of guessing the structure of a molecule on the basis of often tedious chemical synthesis, one could visualise the structure as worked out from X-ray crystallography.

James stayed at Manchester for another 18 years, where his important research includes the demonstration that atoms do not stop vibrating at a temperature of absolute zero (which seems intuitively wrong but is predicted by quantum mechanics). He became Reader in Experimental Physics. In 1936, when everyone had assumed he was a confirmed bachelor, James married. He now had a family to feed. After an unsuccessful application for a chair in Aberdeen he accepted the chair of physics at the University of Cape Town. He moved to Cape Town in 1937 and spent the rest of his life there. He was a fine teacher and founded a successful school. Posthumously, he achieved a distinction earned by few scientists: two of his ex-students from UCT were awarded Nobel Prizes (Allan Cormack, mentioned below, and Aaron Klug).

In the 1930s, James started writing a book entitled *The Optical Principles of the Diffraction of X-rays*. This was an encyclopaedic tome containing all that was known about the diffraction of X-rays. It was finished in 1946, and Aaron was given the spare-time job of checking the page proofs. Since the book was full of equations, this was a demanding task. Because Aaron always remembered everything he had ever read, he ended up knowing a great deal about the diffraction of X-rays. In particular, he came across James's account of Fourier series, which are ways of expressing periodic functions (such as the electron density in a crystal) as the weighted sum of all the sine and cosine waves that will fit

into the crystal. Fourier series are used to work out the electron density in a crystal from the measurements of the strengths of the X-ray reflections. Aaron realised that a Fourier series was a special case of a more general relationship, the Fourier transform, that will also work for non-periodic objects. He was to make much use of Fourier transforms in his subsequent research. Moreover, Fourier transforms have some powerful properties that Aaron later exploited in his Nobel Prize work. James did not know anything about Fourier transforms, but in the next edition of his book there was an appendix featuring them.

After completion of his master's degree, Aaron suggested to James that he might carry out an accurate structure determination of triphenylene by X-ray crystallography in order to measure the bond lengths of the various classes of carbon-carbon bond. This would form the basis of a possible doctoral thesis. Triphenylene is a ubiquitous combustion effluent that pollutes the environment. Its structure is actually predictable from its composition: it is a planar molecule with three benzene rings grouped round a central benzene ring, a kind of miniature graphite sheet. Crystals could be made according to a published recipe. Data were obtained on X-ray film using a so-called 'Weissenberg' X-ray camera. The film data (intensities of X-ray reflections) were turned into numbers with the help of a film densitometer that Aaron constructed based on an instrument used for measuring stars at the observatory. Moreover, the work earned the support from the South African Council for Scientific and Industrial Research – Aaron's first research grant.

Diffraction data are three-dimensional: as you rotate the crystal, every view gives a different set of X-ray reflections, and you really need to measure them all. In the days before computers, there was no way of dealing with all these data; instead, one concentrated on measuring the diffraction from two or three views, usually looking along a symmetry axis of the crystal. Feeding these data into a Fourier series yields a map of the electron density in the crystal but projected along the chosen axis (flattened into a two-dimensional view). With an object as symmetrical as triphenylene, two views at right angles give enough data to determine the positions of all the atoms, which show up as separate round objects in the projected electron density. Nevertheless, there is a catch. Diffraction measures intensities, whereas the numbers required for the analysis are the amplitudes, the square roots of the intensities (see Appendix B). One does not know whether these should be positive or negative

(a problem Aaron's student nurses should have been familiar with). An initial model is often used to resolve the ambiguities. One calculates the expected diffraction from the model and takes over the signs. However, if the initial model is wrong, it is easy to be caught in a false solution. Aaron used a sophisticated and original method to obtain a starting model to solve this sign ambiguity. This involved calculating the diffraction pattern of a single molecule (this operation is actually a Fourier transform), and then moving the molecule around in the crystal so as to modify the calculated diffraction data to match the observed diffraction data. He then used the structure that gave the best fit to the observed diffraction data as a starting solution to give the signs to calculate the density from the observed data. These ideas became known by the term 'molecular structure factors', and the method established Aaron's early reputation.

Aaron carried through this analysis for triphenylene, but the answers displayed an unexpected result: some of the distances between the carbon atoms in the molecule itself deviated from the expected values by being rather long; furthermore, some of the distances between atoms in neighbouring molecules were remarkably short. This led Aaron into a ramified wild-goose chase involving calculations of bond lengths by the method of molecular orbitals, which is based on quantum mechanics. At this stage of his life, he was enamoured of quantum mechanics and was perhaps too ready to accept his X-ray crystallographic result as a *raison d'être* for indulging this interest.

A paper published six years later showed that Aaron had placed the molecule in the wrong position in the crystal unit cell. It turned out that a student who had been helping Aaron had made a serious error in copying out lists of intensities of Bragg reflections. With the correct data, the molecule came out in a different position in the unit cell and all the carbon-carbon distances came out in the expected range.

Later, a method very similar to Aaron's became standard in solving protein structures. If a protein has a close relative with known structure, this can be used to predict the signs or phases of the unknown structure. This is known as the method of molecular replacement. It appears that Aaron had published the first paper on molecular replacement. Experience has shown that it is fairly easy to get the correct orientation of the molecule in a crystal but also quite easy to get the position wrong. Here one has to be careful. This was exactly Aaron's problem. It is not

always good to be a pioneer. Fortunately for Aaron's future, no one knew at this time that he was wrong. Aaron's two papers in *Acta Crystallographica* were well received and indeed determined his future.

A spare-time activity that appealed to Aaron was climbing. The first recorded ascent of Table Mountain was by the Portuguese explorer Admiral Antonio de Saldanha, who put into Table Bay in 1488 and then climbed to the top of the mountain in an attempt to find out where he was. Table Mountain offers superb climbing on compact sandstone and the views from the climbing routes are breathtaking, but getting to the climbing pitches is not all that easy. Thus Africa Face and Fountain Ledge are popular climbs because they are situated near the upper



Figure 2.1 Aaron climbing on Table Mountain (courtesy of the Klug family)

station of the cable car. Sometimes the mountain becomes enshrouded in the mist of the 'Table Cloth', which is dangerous unless you know the mountain well. Aaron went climbing at weekends, always riding to Table Mountain on his bicycle.

The future Nobel Laureate Allan Cormack, who was a lecturer in the physics department of UCT at that time, was a climbing nut and had a climb named after him. One weekend in the winter of 1947 he invited Aaron to climb. Aaron himself described this adventure³:

I used to be a kind of Sunday climber doing mild climbs on Kloof Nek, B climbs, occasional C climbs, and Allan was an established climber. I didn't know that he had a route named after him, but he said he'd take me up something really interesting. I'd done some climbing with ropes, but only a bit, just for short stretches, so he took me up the Africa Face, which is a D or E climb⁴. About half way up he was leading, above me, just the two of us. Suddenly I slipped off the ledge and swung out into empty space and swung back again, hurting my arm. However, Allan held me, belayed the rope, pulling me back to safety and I was able to climb the rest of the way. I often think: what would have happened if he hadn't been able to hold me.

Two future Nobel Laureates – hanging from one nylon rope.

In the middle of 1947, Aaron suddenly became aware of Liebe. He had known her for a couple of years but somehow, what with the Hashomer Hatzair blue shirts and Girl Guide skirts, he had never really noticed what a remarkable person she was. Besides, Liebe was going steady with Denis Rutowitz, known as Rut, also a UCT student and a keen climber (and apparently very good looking, a bit like James Dean), who courted her enthusiastically. Nevertheless, as mentioned earlier, one evening Aaron saw Liebe dancing and was hooked. Now Aaron's tenacity came to the fore. He courted Liebe with stories, not of danger and moving accidents as Othello to Desdemona, but rather of life's richness and meaning. His suit was successful: despite his being rather unmusical and certainly no dancer, he was accepted by Liebe, the dancer and musician. Alter seems to have been delighted with his daughter's

³ Recorded in *Imagining the Elephant: A Biography of Allan MacLeod Cormack* by Christopher L. Vaughn, UCT Press and Imperial College Press (2008).

⁴ In modern notation, climbs on Africa Face vary between 20 and 32.

choice: his prospective son in law was a scholar knowledgeable in Hebrew and Yiddish. Rut eventually gave up the chase and retreated to Johannesburg to fly planes, later joining the Israeli Air Force.

In the summer on a Saturday evening, the young couple would take the bus and walk to a part of the beach called Saunders Rocks. There, a little out to sea, was a big flat rock warmed by the sun where they could sit and dream. After sunset, they would run to catch the last bus back to Cape Town, and then walk past the Parliament Building through the Great Synagogue Gardens to the corner of Annadale Street. At the parting of the ways they would sit on the pavement chatting, not wanting to separate.

Aliyah beckoned, but immigration to Israel, even after independence, was limited. Those in the older age group such as Ralph and Aaron had the opportunity to go to Israel first. Often pairs married, or married out of convenience, since couples could enter Israel on the same immigration voucher or 'ticket'. By the middle of 1948, Ralph and his first wife had already left. Vivian Rakoff went with them on the mail boat, intending to travel to Cambridge. Somewhat by chance, he finished up on a kibbutz on Mount Tabor, where he stayed for a year. Aaron and Liebe started making plans: he could seek out an appointment at the Weizmann Institute; she could set up a modern dance school in a nearby kibbutz. Aaron had a ticket and by then a passport, but they wanted to stay together. A lively debate ensued over whether they should marry. Liebe felt the case was clear, but Aaron thought that they were too young. He was 22 and Liebe was just 19. Nevertheless, in June 1948 Aaron and Liebe suddenly decided to get married on 8th July, which was just three weeks away. They wanted a very quiet wedding and reasoned that with only three weeks' warning one couldn't generate too much fuss. Also the time chosen, a Thursday at 5 p.m., was selected to minimise interest. They did not reckon with the fact that Liebe's parents were well known figures in the Jewish community. So they had to go and see the Chief Rabbi, who, given the apparently precipitous timing, assumed the worst about Liebe's status but in any case read the banns. Aaron's parents were shocked when he phoned and announced, hesitantly, "Um. . . I'm getting married in three weeks' time!" Their brilliant son! What floozy had got hold of him? And a dancer! Nonetheless, Aaron and Liebe were duly married in the Great Synagogue in the garden at the end of the Avenue. The Synagogue is a grand and beautiful

building, perhaps the most beautiful in Cape Town. Liebe's parents and most of her cousins had been married there. The choirmaster was an old friend of the family and had known Liebe since she was a baby, so there was a full choir. So much for a quiet wedding!

Lazar, Rose and Aaron's half-siblings came over from Durban. Aaron was taken to buy his first suit. As a reception, Annie had arranged a simple late afternoon cocktail party and invited as few people as possible. There was an announcement in the paper, and, since the Herzlia School, where the Bobrows lived, was just a stone's throw from town, the wedding party was well attended. Aaron's brother Bennie was best man, but was not enthusiastic at having been dragged all the way from Johannesburg in such a hurry. Liebe's dress was made by a parent of one of the children at the Jewish boarding school. The dress was ice blue in heavy taffeta, and the style, appropriately, was Christian Dior's New Look. Liebe herself designed a silver hat with a pale blue and silver threaded veil. With her beautiful dark hair and lovely dress, the bride looked wonderful. Nevertheless, it seemed that many thought this was an ill-assorted match, including Vivian, who wrote a letter to Aaron explaining why it shouldn't happen, and Ralph, who expressed rather muted enthusiasm. Nor were any of the Hashomer Hatzair in evidence. Aaron's family stayed for a few days, and were warmly entertained by the Bobrows. However, when Aaron and Liebe went to Durban a few weeks later the family reception remained cool: Liebe was not wealthy, did not have a degree, and went on the stage.

There was no honeymoon, nor did the Klugs have a married home in any formal sense. Liebe just moved in with Aaron in his room in Annadale Street, and everything continued as before. Each morning, Aaron was fetched by John Juritz and they drove together to the University. Liebe taught at a local nursery school.

One morning in early 1949, Aaron, in a rather confused state, phoned Liebe from the University. He had applied for an 1851 British Empire Fellowship and for a Trinity College Rouse Ball Scholarship. On account of his *Acta Crystallographica* papers, he had been awarded both. The prospect of doing his PhD in Cambridge, particularly in Lawrence Bragg's laboratory, looked too good to turn down, but their life's plan was to go to Israel. After some debate, it was decided that Aliyah had to take a rain check until Aaron had a Cambridge PhD. Liebe could use the time to study modern dance at the Contemporary Dance School in



Figure 2.2 Aaron and Liebe, 8th July 1948 (courtesy of the Klug family)

London with Sigurd Leeder. Liebe's mother packed their voluminous luggage, cabin trunks, suitcases and two enormous crates, with linen, blankets, pots, pans, crockery – all the basics to start a home – and of course Liebe's clothes for three years and all seasons, plus a large square box just for Liebe's hats.

On 26th August 1949 Aaron and Liebe set sail on the S.S. *Edinburgh Castle* for England. Leaving on the mail ship was always a big occasion.

The Klugs' large circle of friends and relatives sent flowers, chocolates and fruit that were duly delivered to their cabin. Neither felt sad at leaving; it was the beginning of a huge adventure. Naturally, Liebe's parents were downcast at losing their only daughter, but they kept their feelings under control, not wanting to upset the young pair.

Getting out of Cape Town Harbour takes time. It takes a while for the big ship to be slowly towed out to sea. The Klugs stood on the deck watching the figures on the quayside slowly getting smaller. Once the ship reached the open sea, it was hit by the infamous Cape rollers and pitched and rolled to the sound of creaking timbers. The 1851 Fellowship entitled Aaron to a first-class ticket, but Liebe's parents could only afford a cabin-class ticket for Liebe, and Aaron had to downgrade. Nevertheless, they had a big cabin with a porthole. The stewards drew one's bath – salt water and very hot – and brought tea to the cabin first thing in the morning. The routine of the ship was much like that in the movies: hot beef tea on deck at 11.00 in the morning; deck games; officers in dark Navy uniforms. At 23° S, the officers changed into white uniform. That was when Aaron and Liebe saw flying fish and dolphins following the ship. The 'crossing the line' ceremony was done in style, with Father Neptune coming aboard and passengers being dunked in the pool. On the voyage they were befriended by Max Gordon, a well-known left-wing activist, who led the first strike of black workers in Soweto. He was an experienced traveller and knew the ropes.

At length, after 11 days, the ship stopped at Madeira to give Aaron and Liebe their first experience of continental ambience and food. The passengers disembarked into small ships to get to the harbour. Gordon showed Aaron and Liebe around and took them to a typical restaurant: fish Spanish style in olive oil. After a few hours in Madeira, it was back to the ship and on to England.