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Ståhle, Per; Barenblatt, G. I.; Rice, J. R.

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LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

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Professor Knut Bertram Broberg was born in Balingsta, west of Uppsala, Sweden on February 4, 1925. After completing secondary school in Uppsala, he attended The Royal Institute of Technology (KTH) in Stockholm, graduating in engineering physics in 1949. The year before graduation he was employed as an engineer at the Royal Swedish Fortifications Administration. In 1952 he was invited to assist Professor Waloddi Weibull, who at that time was working for the Ministry of National Defence. Professor Weibull later developed his well known statistical theory, the Weibull Distribution. In 1952 Professor Weibull led an oceanographic expedition in the Mediterranean to measure the sediment layer thickness by means of acoustic methods, and Bertram worked as his assistant.

In 1956, Bertram became head of the research section of the Royal Swedish Fortifications Administration, where he stayed until 1959. Also in 1956, he defended his TeknD thesis. The Solid Mechanics department was headed at the time by Professor Folke Odqvist, president of the International Union of Theoretical and Applied Mathematics (IUTAM), and renowned for his contributions to creep deformation and fracture. In 1959 he invited Bertram to join the Solid Mechanics department and he became an Associate Professor at KTH. Then in 1961, after only 2 years, he was invited to become the first professor at the Lund Institute of Technology (LTH), as well as its Pro-Rector. In 1965 he served as Rector at LTH, but resigned in 1966 when it was obvious that LTH would lose its autonomy and become a part of Lund University.

Because of his broad competence he was asked to serve as Dean of several schools at LTH. He did so for the School of Engineering Physics during two periods and the schools of Electrical Engineering and Mechanical Engineering. He held the chair of Solid Mechanics at LTH until his retirement in 1989.

He was Vice-Chairman of the Committee for Planning University Premises and Equipment in Southern Sweden, from 1964 to 1979. In 1969 he was appointed by the Swedish government to take part in an international committee, initiated by the Ethiopian government, to review the technical education in Ethiopia. In 1975 he was invited by the Japanese Society for the Promotion of Science to Tohoku University, Sendai and he spent 3 months there. In 1976 he was invited to the California Institute of Technology as the first non-American recipient of a Sherman Fairchild Distinguished Scholarship, and stayed for 6 months. Later he spent 2 years (1979–1981) as Visiting Professor at Brown University, and shorter periods in Poland (Kielce and Wroclaw).

Bertram Broberg was a member of three Royal Academies: the Swedish Royal Academy of Sciences, the Royal Academy of Engineering Sciences, and the Royal Physiographical Society. He was an Honorary Member of the Scanian Engineer's Club and President of the International Association for Ecological Design from 1982 until 1992.

His doctoral thesis, *Shock Waves in Elastic and Elastic-Plastic Media*, which was later translated into both Russian and Chinese, is a mathematical treatise

of stress waves in a half space. To obtain his results for an impulse on a half space he used Cagniard's method from 1939, utilizing the self-similar properties of the problem for inversion of a Laplace transform. He also developed a capacitive method of measuring displacements from a small metallic ball hitting a thick steel plate, taken from the German battleship Tirpitz, which was scrapped after being bombed by the Allied forces during the Second World War.

Among Bertram's many publications the following should be mentioned for their particular impact: In *The Propagation of a Brittle Crack* (1960), the first solution for a dynamically expanding crack was presented; earlier solutions of moving cracks were limited to cracks with constant length. In the publication *Crack Growth Criteria and Non-Linear Fracture Mechanics* (1971), he suggested the use of the J -integral for prediction of onset of crack growth. In this paper he also provided an amendment of the J -integral to consider finite strain. In order to explain the mechanics of sliding contact between two elastic bodies he wrote *On Transient Sliding Motion* (1978). Two kinds of transient sliding motion under dry friction were studied; one concerned uni-directional slip at constant propagation velocity along a strip; the other discussed extensional slip along a strip expanding symmetrically with constant velocity.

Models of the continuum surrounding cracks have been developed for a large variety of material models. However in many situations such as at large scale yielding, initiations of cracks, crack tips approaching material interfaces, dynamic initiation of crack growth, etc., the linear extent of the process region cannot be ignored. The fracture processes involve micro-structural events in which an intrinsic material length parameter plays a significant part. This is usually identified as the distance between the sources of the dominant micro-separation processes. The existence of such a significant material length parameter motivates the cell model of materials introduced by Bertram in the paper *On the Behaviour of the Process Region at a Fast Running Crack Tip* (1979). The cell is the smallest material unit that contains information about the fracture processes in the material. He used the model in a number of papers during the 80's and 90's (cf. *The Cell Model of Materials*, 1997). The cell model is used for dynamic crack growth in the paper *Significance of Morphology changes at a Propagating Crack Edge* (2004) where Bertram found that there exists a continuous spectrum

of velocities for steady dynamic cracks. A conclusion is that the velocity of propagation and the amplitude of such cracks are determined by the conditions preceding the asymptotic steady state. The discovered phenomenon is similar to the solitons given by the Korteweg-de Vries equation. It is interesting that the phenomenon is in an intermediate regime, contrary to KdV, the Rayleigh wave velocity is a natural limit for the crack speed, whereas for KdV there are no bounds for the amplitude and the velocity. In fact, in this case the situation is even more complex, because the solutions corresponding to the velocities larger than around 1/3 of the Rayleigh speed are unstable.

Considering self-similar descriptions of shear crack propagation in that 2004 paper, Bertram also explored loosely analogous effects for turbulent wall-bounded shear flows. He noted that an alternative description to the classical von Karman-Prandtl logarithmic law could be provided by a matched pair of power laws, like that proposed by Barenblatt, Chorin and Prostokishin, for connecting the inner region, beyond the viscous sub-layer, with the outer velocity-defect region adjoining the lightly shearing mid-region of the flow channel. Motivated by the feeling that the fluid mechanics community may have given insufficient attention to this possibility, Bertram continued with characteristic public-spiritedness to replot a large experimental data set generated in 1999 by Österlund et al. at KTH in terms of matched power laws, showing that a close fit to observations in the transition region could be obtained, including a region of small but relatively abrupt increase in the velocity gradient. While there is disagreement as to whether the location of the gradient transitions fits within what is normally considered the "overlap" layer, his description contributes to continuing discussion of the possibility that not just the wall shear stress controls the near-wall velocity distribution, as in the classical view, but that there may also be a modest dependence on the overall Reynolds number.

Bertram also made several contributions to biomechanics. The publications *On the Mechanical Behaviour of Intervertebral Discs* (1983) and *Slow Deformation of Intervertebral Disks* (1993) are examples of this, where he explains the mechanics behind the shrinking of the spinal column during the day making us about one centimeter shorter in the evening. He co-wrote a paper on methods of finding wave distributions: *Cycle Range Amplitude Distributions for Gauss-*

ian Processes—Exact and Approximate Results (2004). Also illustrating his versatility was his 1995 paper entitled *Blisters—A Wallpapering Problem*.

In addition, Bertram made many fundamental and original contributions to the theory of fracture mechanics (see the bibliographic list in the next section). In 1999, he published a monumental treatise on the foundations of fracture mechanics, *Cracks and Fracture*.

He once spoke of an incident during the oceanographic Mediterranean expedition, where he and Professor Weibull used explosives to examine the properties of the bottom sediments out at sea. Electric wires were attached to the explosives, a technique that they later abandoned. At the occasion a large part of the wire was tangled and the explosives ended up hanging just under the water line, close to the hull of the ship. The mistake was discovered just before Professor Weibull discharged the explosive. A fortunate ending for what could have been a tragic loss for science, as this was at the beginning of Bertram Broberg's career and before Professor Weibull had presented his general statistical theory.

Bertram's love of books should be mentioned. Guests that were offered to sleep in his library both in Lund and Dublin could observe that the library was very rich, reflecting a sincere cultural interest and a refined taste. A quick look at the books clearly showed that they were in frequent use. His cultural interest was not limited to books and reading. He also had a strong interest in art and theatre. When asked by a free theatre group if he wanted to be an actor, he agreed, seemingly out of pure curiosity. He stayed with them as an amateur actor for two seasons. He played the main character in Gogol's "The Government Inspector". The Russian-American actor Mihail Chekhov became famous after his first performance in this role. How Bertram with his handsome tall stature was able to incarnate the tiny incompetent character Khlestakov who became successful only because the people around him were even more incompetent than himself is a mystery. He also played one of the main roles in Werner Aspenström's Swedish play "Vågspel" ("Playing Waves"), the title referring to both the rising and falling of liquid waves and a shaky situation with unknown outcome. The main character takes a boat across the river to propose to his fiancée. On the boat he meets a very unpleasant woman who makes him change his mind. Taking the returning boat back, he meets an offensive old bachelor and suddenly he is unable to decide. The mad

captain, played by Bertram, helps him make a final decision.

He himself lived a large part of his life as a bachelor. A morning newspaper in the early 1970's called him the most attractive bachelor in Lund. Finally, in 1979, he married Anne Buttimer, who at the time was a Visiting Professor of Geography at Lund University. She was his wife and companion for the rest of his life. In 1992 she became Professor at the University College of Dublin, and Bertram was offered a position as a Visiting Professor of Mathematical Physics, which he accepted and held until his death.

In an interview from 2001 he was asked about his hobbies and answered: "I have none. My job as a scientist is so interesting. I never had any need for hobbies." Later in the same interview however he said that he went hiking in the Swedish Alps every year. Physical exercise for Bertram was not a hobby, it was his natural state. He was also an excellent skier, and participated for 17 years in the Vasaloppet, a 90 km ski race. The last time was in 1995. He practiced skiing in the Swedish Alps and later on roller skis in the streets of Dublin.

The summer before the Vasaloppet in 1995 Bertram was skiing on a high plateau near Riksgränsen in northern Sweden. This was during a conference, just before midsummer with 24 h of daylight leaving ample time for skiing. A former Ph.D. student, now a professor, together with four Ph.D. students of his own, spotted Bertram on the edge of a blacklisted off-piste area, called the Branten. This was a nearly 100-m very steep slope, intimidating many good slalom skiers because there was no way to stop if you fall. Proof was given of Bertram's great athletic ability when, with a feeling of some discomfort, they watched the 69-year-old professor take a short-cut straight down the blacklisted off-piste on cross-country skis!

Professor Broberg was a true athlete all his life. He ran the original Marathon distance of 42 km between Marathon and Athens in Greece. In his mid 70-ties he climbed Mount Fuji. And at the age of 79, after having had two knee surgery operations the previous year, after a conference on motion of tectonic plates where he was a keynote speaker, he went on a bus journey over the roof of the world and visited Lhasa in Tibet.

Professor Broberg kept close relationships throughout his life with his Ph.D. students, friends and colleagues from as early as the 1940's. Now these friends eagerly support the Bertram Broberg Memorial Fund,

set up by his widow, Anne, and already sponsoring symposia, lectures in his honour, and an annual memorial medal for the best doctoral thesis completed in fields where he conducted pioneering research (www.bertrambroberg.eu). One of his oldest and dearest friends, Kalle Hjerpe, a school mate from 1946, wrote a letter to Bertram's widow in which he talked of a phone call shortly before Bertram died. They were speaking of an upcoming event and at one point he and Bertram agreed that the years were going by more quickly now, but they themselves were going more slowly. Bertram noted that this relationship is exactly the same as the one Einstein expressed in 1905 in his work on special relativity, concerning our perception of time when passing by a fixed clock. He concluded that as we walk more slowly with advancing age we perceive that the fixed clock is moving faster.

P. Ståhle

Lund University
Lund
Sweden

G. I. Barenblatt

University of California
Berkeley, California
USA

J. R. Rice

Harvard University
Cambridge, Massachusetts
USA



Bertram Broberg and Anne Buttimer (1980)

List of Publications by Bertram Broberg

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