CURRICULUM VITAE

EDWARDS, PROFESSOR SIR SAMUEL FREDERICK
(SIR SAM EDWARDS).

KT 1975, FRS 1966.

DATE OF BIRTH: 1 Feb 1928

MARRIED: 1953, Merriell E M Bland, 1 son, 3 daughters.

EDUCATION
Swansea Grammar School,
Gonville and Caius College, Cambridge.
Harvard University.

CAREER
Member of Institute for Advanced Study, Princeton 1952.
Posts at Birmingham University 1953-58.
Manchester University 1958-72.
Professor of Theoretical Physics 1963-72.
Fellow of Caius and Plummer Professor at Cambridge 1972,
Cavendish Professor of Physics 1984-95
Pro-Vice Chancellor 1992-95

GOVERNMENTAL POSITIONS
Chairman, Science Research Council 1973-77.
Chairman, Defence Scientific Council 1977-80.
Chief Scientific Adviser, Department of Energy 1983-88.
Member of Council AFRC 1991-1994.

EUROPE
Member of Council for Research and Development (CERD) 1976-80.
Member of the Fachbeirat of the MPI fur Polymerforchung 1989-95. Chairman 1996-01
Chaired Report of EC 'Science' programme.

PROFESSIONAL AND INSTITUTIONAL BODIES
Vice-President, Royal Society 1982-83.
Vice-President, Institute of Physics 1970-73.
President, Institute of Mathematics 1980-81.
Foreign member of the Academie des Sciences 1989.
Foreign Member of the National Academy of Sciences, USA 1996
Honorary Fellow of the French Physical Society 1996

INDUSTRIAL CONNECTIONS
Was Senior Consultant to several companies.

HONOURS AND DEGREES
MA, PhD.
Fellowship of Institute of Physics, Royal Society of Chemistry,
Institute of Maths, Royal Society 1966.
Honorary Degrees from Loughborough 1975, Salford 1976,
Edinburgh 1976, Bath 1978, Birmingham 1986, Strasbourg 1986, Wales 1987,
Sheffield 1989, Dublin 1991, Leeds 1994, Swansea 1994, East Anglia 1995,
Cambridge 2001, Mainz 2002, Tel Aviv 2006.
Maxwell Medal for Theoretical Physics, Institute of Physics.
Ford High Polymer Prize, American Physical Society 1982.
Davy Medal for Chemistry, Royal Society 1984.
Gold Medal, Institute of Maths 1986.
Guthrie Medal, Institute of Physics 1987.
Gold Medal, British Society of Rheology 1990.
LVMH Science pour l'Art Prize (Paris) 1993.
Boltzmann Medal, International Union of Pure and Applied Physics (IUPAP) 1995.
Hon. Fellow, Institute of Physics 1997.
Hon. Fellow, French Physical Society 1997.
Hon. Member, European Physical Society 1997.
Royal Medal, Royal Society 2001.
Dirac Medal, International Center for Theoretical Physics (ICTP), Trieste 2005.

PUBLICATIONS
Technological Risk (with others) 1980.
Theory of Polymer Dynamics (with M Doi) OUP 1986.
Networks of Liquid Crystal Polymers (with S Aharoni) Springer (1994).
250 contributions to learned journals,
Several reports including: UFC/UGC report on Future of British Physics
(HMSO) 1988.
European Community Report on Science Stimulation programme 1990.

SCIENTIFIC WORK
Sam Edwards did his thesis under Julian Schwinger on the structure of the electron, and subsequently developed the functional integral form of field theory. Professor Edwards' work in condensed matter physics started in 1958 with a paper which showed that disordered systems (glasses, gels etc) could be described by the methods invented in quantum field theory. This paper has started a new way of looking at complex matter which is now all pervading. During the following 35 years Professor Edwards has worked in the theoretical study of complex materials such as polymers, gels, colloids and similar systems.

In the period 1958-64 he extended his work mainly to liquid metals, and semiconductors with new mathematical techniques, notably with Gulyaev, and to descriptions of turbulent flow which led to the first direct calculation of Kolmogoroffs constant, with D McComb. These new methods were applied to quantum many body problems, work done with D Sherrington, which produced a new formalism now known as mode-mode coupling. In 1965 there started a series of papers which revolutionised the theoretical basis of polymer physics in particular the introduction of quantum mechanical techniques in the 'Edwards Hamiltonian' followed in 1966 by the discovery of polymer screening. The concept of polymer entanglements followed in 1967 and 1968.

A key advance in 1967 was the introduction of the tube concept by which macromolecule in a melt or rubber or concentrated solution is considered to be enclosed by a tube formed by its neighbours. This simple concept has had many consequences, the most important being the discovery by de Gennes that the 'reptation', ie, wriggling of the polymer down the tube can provide a basis for understanding the flow of polymers.

In 1970 he and Karl Freed introduced field descriptions of polymeric gels which again has had much consequence in that the brilliant extension of this work, again by de Gennes, allowed modern renormalisation group theories to enter polymer science.

A new mathematical departure appeared in 1971 when he invented the Replica Formalism which allowed closed formulae for the description of rubber networks to be written down. This finally settled various quarrels over the stress-strain relationship of simple networks. It was this work which enabled him, with Anderson, to give the first solution of the disordered magnet problem, the spin glass, in 1975.

A computational advance appeared in 1972 when he discovered a method (the Edwards-Lees boundary condition) enabling computational simulations of liquids, including subsequently polymers and colloids, to be extended to describe the flowing state.

In 1974 he produced the first dynamical treatment of a polymer network; in this year he also discovered hydrodynamic screening of polymers which developed into further collaboration with Karl Freed. Also in 1974, with his student Dolan, he did the first calculation of the stabilisation of colloid suspensions by polymers, work which has led to many investigations central to problems of food science.

In 1977 he quantified in detail the structure of the tube enclosing a polymer in the melt. With Masao Doi from Japan, he was able to use this concept coupled to de Gennes' reptation theory to produce the first comprehensive theory of polymer flow. In addition to flexible polymers they were able to solve the problem of the flow of rod molecules also. Doi returned to Cambridge in 1985 and their work was written up into a book.

In 1980 he became interested in stereology, *i.e.* the science of deducing three dimensional structures from information in a two dimensional section. The problem was solved with his student Wilkinson for the case of spheres. (Subsequently with another student Oakeshott, this problem was solved for other shapes in 1990). Also with Wilkinson he initiated the modern theory of the deposition of powders in 1982, work now referred to as the Edwards-Wilkinson fixed point. They also solved the problem of a fine powder percolating through a rough powder.

In 1982 he continued work on liquid crystal (i.e. rod-like) polymers with his student Evans and derived the first structure of the glass transition of macromolecules. With Evans also he studied the diffusion of macromolecules by computer simulation giving the first direct computational confirmation of de Gennes reptation diffusion law.

In the period 1983-87 many applications of polymer theory were made, notably in the theory of solution viscosity where he and M Muthukumar produced the first extrapolation formula from dilute to concentrated solutions. The problem of the strength of fibre reinforced materials was solved with his student Mike Cates.

In 1986 and 87 with co-worker T Vilgis he was able to give the first derivation of the Vogel-Fulcher-Williams-Landel-Ferry law of glassification thermodynamics. With Vilgis also he was able to improve earlier work on the influence of entanglements on rubber elasticity.

In 1988 he developed a new form of quantum field theory to handle the problems of the kind encountered in polysaccharide networks. Also with co-worker M Schwartz produced closed equations for colloid flow.

An interesting departure in food structure came in a paper in 1988 with Mark Warner where it was shown that the laws could be derived to explain the expulsion of liquids from cellular materials, e.g. vegetables under pressure. Also in 1988 he and co-workers Muthukumar and Chen established the theory of the localisation of polymers when they encounter a rough surface, an effect discovered in computational work by Muthukumar and Baumgartner.

In 1989 he turned his attention to powders and related jammed systems and initiated a new approach based on entropy ideas which had not been previously discussed. Several new concepts appeared and problems like the conditions for the separation of powder mixtures were resolved. This work has attracted much attention and is on-going with collaborators at present.

The dissolution of polymers into solution was studied in 1990 with his co-worker Herman, and also in 1990 the fractal nature of liquid crystal network synthesis was studied with Shaul Aharoni's new syntheses. Some new ideas on the ordering of polysaccharide molecules had led to a general theory of the phase changes of stiff molecules with A Gupta. Some proposals to make negative poisson ratio materials have been published (with G Wei) and the work on deposition started in the eighties has been successfully extended to deposition where the particles stick together (with M Schwartz) where critical indices have been directly calculated for the first time for the KPZ equation. The same mathematics works well in turbulence at the Kolmogoroff level.

Work on jammed entropy is being extended to glasses.