



Preface to the Sir William A. Wakeham Festschrift

*Sir William Arnot Wakeham FEng, Molecular Physicist, Fluids Engineer,
and Academic Leader*

This special issue of the *Journal of Chemical and Engineering Data* is published to recognize and celebrate the immense contributions of Bill Wakeham to the science and engineering of fluids. The papers cover many of the topics close to Bill's heart - phase behavior, transport properties, statistical mechanics and kinetic theory, and engineering implications - and their authors include collaborators and former students from over the years, all of whom will have benefitted from the insights and example he brings to his scientific endeavors, from the laboratory bench through to high-level policy.

Of his many outstanding characteristics that have shaped his approach to science and to life, there are six at least that are deserving of special emphasis - his precision, practicality, action, internationalism, service and, perhaps surprisingly, diplomacy - and we will touch on these in turn as we journey through his career. Bill studied at Exeter University from where he emerged in 1969 with a First Class degree in Physics and a PhD working with Kenneth Grew on the measurement of thermal diffusion coefficients, the start of a life-long association with fluid transport properties. He spent the next two years at Brown University in Providence, Rhode Island, working as a postdoctoral research associate with Joseph Kestin on the measurement of the shear viscosity of dilute, simple gases, producing a series of seminal papers that encapsulate many of the qualities that were to characterize his research over the coming decades. He used a technique capable in principle of high precision (the oscillating disk), realized this potential through the combination of precision engineering and the development of an accurate absolute working equation that minimized the need for calibration, and applied it to systems of both theoretical and practical value, over wide ranges of extreme conditions, in this case high temperatures. His preoccupation with precision, both in designing and constructing novel equipment and in the data they produced - something that he inherited from Kestin, the most precise and meticulous of men - has remained at the center of his approach to research throughout his career. His data revealed major errors in much of the existing data in the literature and, as well as being of practical significance in engineering design, turned out to have important consequences for one of the other areas in which he has made a major contribution, the understanding of intermolecular forces. These "Brown" viscosities had a precision of $\pm 0.1\%$ and an accuracy of $\pm 0.2\%$ - pity the poor student who did not grasp the difference!

On the back of this successful experience, Bill returned to the U.K. in 1971 to a Lectureship in the Department of Chemical Engineering and Chemical Technology at Imperial College London. Here he joined the likes of Paul Ubbelohde, John Rowlinson, and Roger Sargent in a department that traditionally mixed chemical engineers with physical scientists to extend the bounds of process engineering and forge strong links between engineering advances and fundamental understanding. It was in this environment that Wakeham built up his own research group on thermophysical properties and began a lifetime penchant for collaboration with scientists, engineers, and mathematicians of all persuasions. He combined his own fluid measurement and modeling work with studies on engineering applications ranging from the implications of data uncertainties for equipment and process design, through adapting transport

property techniques to characterizing mass transfer and adsorption in packed-bed catalyst systems, to the properties of refrigerants and “spider” viscometers for use in the oilfield. The next 30 years were to prove extraordinarily productive and fruitful in addressing some of the fundamental measurement and data prediction needs for the thermophysical properties of fluids of increasing complexity. Over this period, he established himself as the outstanding fluid property engineer of his generation. His laboratory established new and enhanced state-of-the-art techniques for high-precision measurement of thermal conductivity and viscosity through various forms of hot- and vibrating-wire methods, and these have been applied to wide ranges of gases, liquids, and their mixtures over extremes of both temperature and pressure. He is a very practical person, an individual who gets things done, and as an engineer never misses an opportunity to roll up his sleeves and sort out equipment problems himself. Bill is equally at home with mounting 100 μm wires into high-pressure cells as developing perturbation solutions to the Boltzmann equation for the transport coefficients of complex fluid mixtures - his PhD students learn by example and are given the responsibility to devise practical solutions and to implement them. His fertile mind means there has never been a shortage of new ideas; what distinguishes him from many others is his high (some would say workaholic) activity levels and commitment to putting plans into action, as witnessed by his sustained high rate of publications and conference presentations, even when in later years his day job has been running universities - but more of that later. Generations of research students and postdocs have benefitted from this utter professionalism and dedicated work ethic, which he has infectiously passed on to them and can be seen to be propagated across the world as several generations of his scientific family tree have become established as leading academics in their own right.

His research prowess was recognized at Imperial by his promotion to Reader in 1979 and to a Personal Chair of Chemical Physics in 1985. He was elected a Fellow of the Royal Academy of Engineering in 1997, the same year that he was awarded the Touloukian Medal of the American Society of Mechanical Engineers. More international awards followed as the Rossini Lecturer in 2000 and the Ared Cezairliyan Lecturer in 2001. His personal scientific achievements are many and varied but particularly worthy of note, in addition to the development of high accuracy techniques for the measurement of transport and thermodynamic properties under extreme conditions, are his contributions to establishing robust physically based methods for predicting the thermophysical properties of liquids and gases for temperatures, pressures, and mixture compositions way beyond the bounds of existing or practicable experimental measurements and his clear exposition and quantification of the implications of the accuracy of thermophysical property data for equipment and process design, with its obvious engineering impact on cost and efficiency.

However, what makes Wakeham's contributions to fluids physics and engineering particularly outstanding is not just what he has achieved as a researcher but the way he has carried this out. He recognized fairly early in his career that to be really useful to industry and users of thermophysical properties of all sorts - from F1 designers to weather forecasters - data needed scrutiny and benchmarking so that information from different sources, obtained using different techniques and under different physical conditions, could be combined to give a unified description of pure fluids and their mixtures, with known bounds of accuracy and precision over the widest possible range of conditions and compositions. So it was that, on the retirement of Selby Angus in 1983, Bill took over as Director of the IUPAC Project Centres for Thermodynamic Tables and Transport Properties and created the Imperial College Thermophysical Properties Data Centre. With great energy, he expanded its staffing and scope to embark on an extremely productive period of critical data evaluation and the production of a classical series of data publications which are likely to remain standards indefinitely. This activity exploited well his meticulous attention to detail and gave an early example of his abilities to manage and motivate bigger academic teams. It also demonstrates Bill's commitment to look to the needs of the broader technical community and be prepared to give his time and talents to serve that community. Many would look down on the time-consuming activity of analyzing other people's data, preferring to focus on the higher personal kudos from publishing new measurements. Bill did both, and the community owes him a significant debt that he, alongside Yeram Touloukian and a relatively small band of others, was prepared to continue and stimulate this activity, bringing to it his characteristic brand of quality and precision.

Having started international collaboration with Kestin early in his career, this became the natural *modus operandi* as the energetic young Wakeham grew his research group and built up research collaborations all over the world. Some of this arose from the migration to his increasingly respected research team by hosts of overseas students and academic visitors. Many of these later returned to their native countries to academic and other influential positions, continuing to collaborate with Bill as their own activities and influence grew. Particularly notable was the close association with Jorge Calado and the Instituto Superior Técnico, Lisbon, in the 1980s who, in the days when their own research base was in its infancy, encouraged several

aspiring young lecturers to move to Wakeham's laboratory to learn about research and work for a PhD. As these people - among them Carlos Nieto de Castro, Joao Fareleira, and later, to Aberta, Carla Oliveira - returned to Portugal to establish a strong research presence and produce their own PhD students (and take major roles in government to expand the higher education system), the academic scientific prowess of the country grew to the levels we take for granted today. His encouragement and promotion of outstanding young talent is one of the hallmarks of his generous approach to the research process and his training of successive generations of students and young academics. Bill has maintained close interaction with scientists, engineers, and educationalists in Portugal to this day, and his influence and contribution to the expansion and growth of the higher education system there has been very significant. Of course, Bill also likes to visit interesting locations and combine his science with good vacations and convivial dinners (if not 'fado'), so his travel and times abroad have given him the time and excuse to relax (occasionally) and build up a host of long-standing friendships closely linked to his love of research. Researchers and institutions in Japan, Germany, Greece, New Zealand, and elsewhere have all experienced the Wakeham presence for extended visits and long-standing interactions that have spawned further networking. So Bill's influence and reputation can be said to be truly international, and in the nature of these interactions we can see that element of generous giving back to the community, through both individuals and institutions.

We should not lose sight of the fact that, as well as being a world-leading researcher, Bill is a first-rate teacher. He has the ability to explain the most complex of concepts in understandable terms, always applying his characteristic rigor to both preparation and presentation and finding time, in always crowded days, to listen and explain to interested and inquisitive students. The same is true of his scholarship - having written several books with him, I can testify to the meticulous detail with which he ensures not only that his own expositions are logical, consistent, and clear but also that those of his coauthors are too.

This combination of high capacity for action, multitasking, and sense of service - as well as an appreciation by others of his ability to apply the same skills of organized thinking and care for people, that so characterize his research style, to solving organizational problems and motivating large teams - pulled Bill more and more into academic management and the bigger stage. Not that he gave up research - far from it, he just added the management and administration and exploited his organizational and delegating skills to do more and more. In 1988, he started an extremely successful period as Head of Department of Chemical Engineering, completely restructuring the department both in terms of the way it was organized through shared responsibilities and persuading industry to help refurbish some aging facilities. He brought it through a period of unprecedented expansion of its research income and championed the department to become one of the jewels in the crown of Imperial's impressive array. While leading from the front at the highest levels, the technicians in the workshop and the support and service staff remained just as important to Bill as the highest academic flyers - understanding how a team works and remaining faithful to his roots and the common touch has stood him in good stead.

Having demonstrated his strategic and leadership qualities at departmental level, it was inevitable that Bill would be "invited" to play a larger role in the management of Imperial College as a whole. In 1996, he was appointed Pro-Rector (Research), combining this role with the position of Deputy Rector to Lord (Ron) Oxburgh the following year, and with the third hat of Pro-Rector (Resources) in 1999. He oversaw the College's merger with a series of medical schools and stimulated its activities in entrepreneurship. With the Rector playing an increasingly outward-looking role, much of the day-to-day running of the College was left to his right-hand man. This was a period of great change and expansion for the College, and Bill's astuteness and good business sense, still well-connected into the academic grass-roots of the College, was admired both within and outside Imperial as its academic standing and influence continued to grow on the world stage. Yet through all this period, Bill continued to be active in his research and to make strong contributions to the thermophysical properties community through scholarship, chairing international committees such as the International Association for Transport Properties, attending major meetings, and even organizing some of them, and serving as Editor and on the editorial board of the *Journal of Chemical Thermodynamics*. He sees university leadership not as a substitute for a research career but as a means to share his skill and experience for the greater good, fueled by his continuing direct engagement in the core activities for which universities exist. Research is in his blood - cut him and a high-temperature, high-pressure fluid pours out...along with another paper.

And so in October 2001, he moved to Southampton as Vice-Chancellor. Bill has always been a man of boats, and now he had his own ship. He has steered his university through calm (pre-eminent engineering) and choppy (a major fire which destroyed £50M of research laboratories) waters with the same skill and continuing contact with the grass roots that have characterized all his endeavors. He has maintained its position as one of the U.K.'s top research

universities and has transferred his Imperial experience of exploiting research through spin-out companies to make Southampton one of the leading entrepreneurial universities in the U.K. Under him, engineering in particular was featured very strongly, with the University joining Imperial College and Cambridge in a “golden triangle” of engineering research excellence as the top three institutions in the country for their range and quality of engineering. Bill has continued to train and nurture people at the highest level - just as his ex-research students populate universities as academics all over the world, so in Southampton at least three of his pro-Vice Chancellor team have been appointed to head universities of their own during his time there.

During this period, Bill also had an increasing influence on science and engineering policy and funding. He is a member of the Engineering and Physical Science Research Council, the major U.K. research funding body, and chaired the most comprehensive review of the state of U.K. Physics for a generation, issued in 2008 as The Wakeham Report. It says much for Bill’s political and diplomatic skills that the report, while not holding back in making strong comments and firm recommendations for change, has been widely welcomed by both those seeking condemnation of funding cuts and deficiencies in the facilities provision and by those seeking confirmation of a clean bill of health. It is interesting that key recommendations for greater consultation with the scientific community reflect Bill’s career-long insistence on listening to and informing everyone in the wider team affected by any decisions and retaining connections with the grass roots.

Throughout all this time, Bill has been strongly supported by Sylvie and their sons Russ and Nick. The scientific community should be grateful to them for enabling Bill to focus so much of his efforts on his research and his quest to make universities better and more far-reaching and for ensuring that from time to time he recharges his batteries on the seas or behind a speed boat or carrying out the next building project.

I first met Bill in 1971 just after he had moved to Imperial College. I remember him now as he arrived to meet me - flared trousers, shoulder-length hair, you could almost hear Genesis in the background, and you knew from a brief conversation that here was something of a rebel who spoke his mind and was very sharp. Some 38 years later, you could say that Bill Wakeham is an enigma: he remains a rebel, in many ways a nonestablishment figure, yet is perfectly able to operate within the system and make changes from within; a rigorous scientist with painstaking attention to detail who does not suffer fools gladly, yet who listens and is sympathetic and sensitive to the human condition. Our community, in particular, and the science and engineering research community at large has much to thank him for in his ability and willingness to exploit these seeming contradictions to such good effect in benefitting both individuals and the academic arena in general.

It came as little surprise, therefore, when Bill’s major and broad contributions were recognized in the Queen’s Birthday Honors List of June 2009 with the award of a Knighthood “for services to Chemical Engineering and to Higher Education”. Sir William Wakeham - there could be no more timely or deserving recognition of his achievements as he brings to an end the latest chapter of his career.

So with this special issue we mark his retirement from his position as Vice-Chancellor of Southampton University and celebrate him reaching his 65th birthday. It is also an opportunity to celebrate Bill’s enormous contributions to many fields, particularly the Thermophysics of Fluids. However, this landmark does not of course signify his retirement from research and strong engagement with the fluids community. In many ways it marks a new beginning, with more time for research and scholarship as well as more time (at least his family hopes so) to enjoy his water sports, boating, cycling, and many pursuits. He and Sylvie will have more time to spend at their home in Portugal, and Bill will have more formal association with Instituto Superior Técnico, as well as with Imperial College London, to continue his research in both old and new surroundings. So in many ways, the wheel turns full circle - both institutions await the arrival of the whirlwind with bated breath!

This Festschrift is a testament to the work and influence of Bill Wakeham *so far*...for further action watch this space. It is dedicated to him with thanks and affection from the many colleagues, students, and friends who have had the privilege of working with him over the first 45 years of his career.

Geoff Maitland

Imperial College London

JE9004728