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Special Section Editorial: Felicitations to Craig Frederick Bohren on his 70th Birthday

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This Special Section of the *Journal of Nanophotonics* on scattering by nanoparticles and other nanostructures comprises papers written by admirers, friends, colleagues, and former students of Craig Frederick Bohren, distinguished professor emeritus of meteorology at the Pennsylvania State University, to commemorate his 70th birthday.

1 CRAIG BOHREN

Craig Frederick Bohren was born in San Francisco, California on February 24, 1940. Twenty-three years later, he graduated with a B.S. in mechanical engineering from San Jose State University. In 1966, he received an M.S. in nuclear engineering from the University of Arizona, Tucson. The same institution granted him M.S. (1971) and Ph.D. (1975) degrees, both in physics. Between his two M.S. degrees, he worked for General Atomics in San Diego, California.

Fig.1. Nanette and Craig Bohren in University Park, PA, USA in early 2010.

After three years as a postdoctoral researcher at University College, Cardiff, Wales and the next two as a researcher at Llandough Hospital, Llandough, Wales, he returned to Tucson, Arizona to teach meteorology to non-science students. He also began to write his magnum opus—*Absorption and Scattering of Light by Small Particles*—to be published in 1983 to great acclaim. In 1980, he became a faculty member in the department of meteorology at Penn State. Tenured full professorship came in 1985, and in 1990 he became a distinguished professor. He retired formally in 2000, but continues to be an active researcher, a writer of books and articles, a trainer of dogs, a judge at dog shows, and a regular consumer of hot

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foods with average Scoville index around 100,000 and a peak Scoville index exceeding 200,000.

As his 70th birthday approaches, he is busier than ever, revising *Absorption and Scattering* and fielding via the internet an unending stream of questions on matters optical, atmospheric and canine from the curious all over the world. Nanette, his dear wife of more than 45 years, and he are probably the only long-term speakers of Welsh in central Pennsylvania. And his deep intimacy with Spanish, although with an Argentinean veneer, continues to astound visitors from Hispanic countries.

2 AN ILLUMINATING LIFE

When I recently sat down to acknowledge, in a recent book, my debts of gratitude to all those researchers who had helped shaped my understanding of electromagnetic fields during the last three decades and with whom I had been in personal contact, I thought of Craig Bohren before anyone else. We met in early 1985, after the first lecture in a new graduate-level course on multiple scattering. I had recently shed a post-doctoral appointment to become a fixed-term assistant professor in the department of engineering science and mechanics. He asked me what I was then working on. Hearing my lament that no one seemed to have studied electromagnetic fields in isotropic chiral materials, he informed me that his doctoral dissertation was on that very subject. Next day, I received from him copies of four papers he had written as a doctoral student. These four papers set me up on a major theme in my research career.

Over the years, Craig became my friend, philosopher, and guide. Fastidious though I had been as a writer, I learnt from him the virtues of writing simply and unpretentiously, and to carefully weigh every word, every sentence, and every paragraph. A research paper must never be written to show off. Instead, it must be written for the reader to comprehend first the main message quickly and then the details without much labor. All derivations must be transparent and complete. All deductions must be strongly supported by evidence. All explanations must be clear and amply illustrated. Citations must not be frivolous, each one being the most appropriate one for the reader to consult.

As a researcher, Craig's forte is explanation. He is intrigued by a phenomenon. He finds the literature on that phenomenon, and he does not rest until he has mastered it. If at all possible, he personally observes the phenomenon. Then he bores into its totality, constructs the simplest possible explanation for it, and strips away grime from previous explanations to expose their weaknesses and strengths. Why is the sky blue? Why are some icebergs green? Do rainbows have seven colors? Should you wear an orange vest in the woods? Is the chirality of an isotropic chiral composite material really responsible for enhanced absorption of electromagnetic energy? As you examine Craig's answers to these and other questions in his research papers as well as his popular-science articles, you are struck by their simple elegance.

No wonder, Craig became recognized as a wonderful teacher shortly after moving to Penn State. I never sat through a course he taught, but I gathered from his seminars that his classroom teaching style must be imbued with both passion and scientific temper. My graduate students who took his course on meteorological observations confirmed my "suspicions". You learn not by accepting the wisdom of the ancients in textbooks—he teaches—but by questioning it, turning it over in your head, devising models, conducting thought experiments, and possibly conducting actual experiments. And he conveys this relentless spirit of inquiry with a passion that few can match. He thunders in the classroom and he thunders in the corridors—you can hear him from miles away—and he does not let you rest until you have devised a coherent explanation that can be put to test and is.

Craig loves the history of science. He has both a grasp of major scientific trends and an intimacy with the minutiae of reported research on topics of his interest. Endowed with a deep

familiarity with Spanish, a working knowledge of French, a bit of German, and an abiding love for the aroma of musty old volumes in a library, he is able to extract the evolution of thought on a topic, relate it to his own observations and calculations, and distil its essence in a few pages. Since he is blessed with an insatiable appetite for books and journals, and because he never forgets what he reads and thinks, his appreciation of any line of research is multifarious.

No wonder then, that Craig's first book on light scattering became an instant classic. It is written with the same passion for science and engineering and a zest for life that ooze out of his pores the moment you start speaking to him. It is written with the same sense of humor that makes laughter burst out of him at any time of the day. It is written with the same zeal to envelop the totality of any topic that he cares to investigate. And it is written with a simplicity of language that embraces specialists and nonspecialists alike.

I have mentioned "totality" twice because Craig embodies the Renaissance ideal. Had he been an Arab intellectual around 1000 AD, he would have surely written a *muqaddimah* comprising all knowledge. Had he been born in 18th-century France, he would surely have compiled an *encyclopédie* after personally verifying the truth of every entry. I do not doubt for a moment that, had he lived in the same century in either today's United States or the United Kingdom, later-day historians would have edited several volumes of his correspondence with Benjamin Franklin. Born in the 20th century, he took degrees in mechanical engineering, nuclear engineering, and physics, became a professor of meteorology, and served as a topical editor of *Applied Optics*.

Today, as nanotechnology is making technoscientific cross-disciplinarity fashionable once again, Craig Bohren has been a shining example for several decades. Instead of meteorology, he should have been offered a faculty position in my department, which is a miniature college of science and engineering.

3 A SPOUSAL PERSPECTIVE

While Craig's passion for science and engineering in general and for optics in particular is well known among scattering circles, details of his personal life may not be—even though he is not a very private person. Craig kindly wrote a biographical article for this Special Section. For a different perspective on Craig's personality, I requested his dear wife Nanette to describe their lives together. She wrote the following passage.

> "I can say, without fear of contradiction, that the last 45 years and a half have been an adventure.
>
> "It started with our first summer, spent near Chicago, Illinois, at an Argonne National Laboratory summer institute. Craig's fellow-students and professors were a new experience for me, a 19-year-old from California. Especially memorable was a professor who said that his house was asymptotically approaching completion.
>
> "Then back to Tucson, Arizona, and first steps with Craig in hiking on Wasson Peak, west of the city, graduating to hiking by myself in the Catalina Mountains north of Tucson and on Mt. Wrightson to the south. One reason why it took so long to finish his Ph.D. was all the hiking and backpacking we did in Arizona, New Mexico, Colorado, Utah, and Nevada. Two-week trips were fitted in whenever possible. Occasionally we would go without a tent or a stove to see what we could improvise if necessary. After we were introduced to cross-country skiing and snow-shoeing, we would sometimes go to Flagstaff, Arizona, during the winter for a weekend of fun in snow.
>
> "Three years in Wales, post-Ph.D. (Craig's), led to trips to Iceland and Scotland with George Greaves, who became our partner in climbing, cycling, and hiking. Cycling to Stonehenge from Cardiff was great fun. We came back through Bath, taking time to see the Roman ruins and have lunch at a lovely old wood-paneled pub. History was much

more immediate in Wales that I would have thought. We hiked on Roman roads almost two-thousand years old. Churches and other buildings often dated back to 1250 AD or so. The Welsh-language chapel that we attended was a century old.

"Hiking, climbing, and snow-shoeing have also taken us to Canada. We first went to the Canadian Rockies in the early 1970s to climb Mt. Athabaska with Rudy, a Swiss guide from Banff, Alberta. He was familiar with the Bohren name as the family has produced climbing guides. In fact, Craig mentioned to Rudy that a person named C. Bohren had been the first to climb Mt. Assiniboine, also in the Canadian Rockies. 'Oh, yes,' replied Rudy unhesitatingly. 'That would have been Christian Bohren.' We made two more trips to continue the family tradition.

"Another adventure was snow-shoeing in Ontario Provincial Park, after Craig delivered a lecture at the University of Guelph. Getting to Guelph was an adventure in itself, as an icestorm went through southern Ontario while we were driving through New York state. After we crossed the international bridge from Buffalo, New York, into Ontario, our old Dodge pickup truck had the highway to itself all the way to Guelph. Everyone else had either crashed or gotten off the highway.

"Trips to Australia, Turkey, and Sweden have been sprinkled across the years, partly for business—mainly conferences and lectures—and partly for pleasure. In Australia, our honorary nieces from Sri Lanka and I have driven from Adelaide to Sydney along the southern edge of the outback. I have swum in the wine-dark Aegean Sea. Our second trip to Sweden took us north of the Arctic Circle. There were lectures on light scattering in the mornings and hiking in the afternoons, and even a daytrip to Norway. Great fun! On the flight back to Uppsala, Sweden, we saw a subsun—an ice-crystal phenomenon—and managed to shift many of the passengers to our side of the aeroplane to see it. The captain complained!

"Books have also been part of my adventures with Craig. Starting in Tucson, I discovered a collection of novels of H. Rider Haggard at the University of Arizona Library, *She* and *King Solomon's Mines* being the best known of the lot. What treasures they were! Other books leapt off the shelves at me. This relationship with books continued in Wales at the Cardiff Public Library with, among others, a three-volume set entitled *God is an Englishman* by Ronald Delderfield. As Craig and I learnt the Welsh language, various books in that language began to be acquired or borrowed. Many of the books that I have read belong to us, others are borrowed from the libraries of Penn State, still more from the library of State College, the town surrounding Penn State's main campus called University Park. Sometimes I'll pick up a book that Crag has finished reading. Sometimes I will take up a book that he suggests I read. When we lived in Tucson, I began to keep a record of the books read by me. Forty years later, I am still adding titles to that record: from Boris Pasternak to J. Frank Dobie, Martin Gardner, H. Rider Haggard, Daniel Boorstin, James/Jan Morris, Umberto Eco, Colleen McCullough, David Halberstam, and many, many others.

"Adventures with Craig continue."

4 PRINCIPAL PUBLICATIONS OF CRAIG BOHREN

The range of topics covered in Craig's books, research papers, and popular-science articles is large but not surprising, given his diverse academic experiences and because both of his twin loves—optics and thermodynamics—are widely applicable sciences. Even though the majority of his research covers optical phenomenons, particularly of the visible kind, it is always thermodynamically informed. And his doctorate in physics has not obscured Craig's engineering roots—which are always in evidence in the form of plausibility estimates and back-of-the-envelope calculations.

Following is a list of his principal publications.

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