A Tribute to Leon Knopoff *May 5, 2011*

by David D. Jackson, Professor of Geophysics, UCLA

Leon Knopoff met me and my wife Kathy in 1968. He then hired me (I should say us) to come to UCLA in 1969. He was a superb mentor and I owe him much for enabling my professional life. I surely wouldn't be here if he hadn't supported and inspired me.

When I first entered his office we talked about our common research interests and plans. At that time I couldn't help notice a large coil of half-inch rope hanging on his coat rack, where one might hang a necktie. That stimulated a conversation about his interest in mountain climbing, musicology, reading, and many other things beyond seismology. It was a great beginning.

He set a wonderful example for a young scientist. He published prolifically, he invited great scholars to visit UCLA, and he supported me to travel to some of the most inspiring international meetings on challenging new ideas. He searched for the hidden assumptions in presentations and publications, and he would frequently repeat calculations of others to see for himself. Leon often used computer simulations to test complex ideas, and on several occasions he discovered logical flaws that way. He was just as demanding of his own ideas as those of others.

His attitude towards retirement has also been a model for me as I approach my own. He continued to write, to teach, and to work with students long past his formal retirement. He would still have students if he were alive today. Soon after Leon died, Jerry Wasserburg of Caltech called me to say "You've lost a giant". In the next few weeks other people used essentially the same phrase. Given his importance in geophysics and seismology, it was an almost irresistible description. When Isaac Newton attributed his vision to standing on the shoulders of giants, he was surely referring to people like Leon Knopoff. Leon developed many of the fundamental theories of seismology, including an important formulation of the seismic waves caused by propagating rupture, the response of rocks with interacting cracks to being squeezed, and the huge stresses at the tip of a propagating crack. Some time ago Paul Davis and I were writing a proposal on seismic wave diffraction when we confronted a mathematical problem we did not know how to solve. We went to the library and found that Leon had published the solution years ago. OF COURSE!

Leon was not just a giant. He was intensely curious, unable to contain his boyish excitement at discoveries large and small. Dorothy Parker said it well: "The cure for boredom is curiosity. There is no cure for curiosity." Even as he was fighting cancer, Leon was intently interested in its biological aspects. He established a nearly academic relationship with his doctor, returning from medical visits with amazing stories of how the body works. He loved conundrums: many times the questions were as stimulating as the answers. Niels Bohr said "Every sentence I utter must be understood not as an affirmation, but as a question." Leon would agree.

Leon loved to reduce complex problems to their simplest elements. In the 1960s he developed with Bob Burridge what was essentially toy: a sequence of blocks, held together by springs, dragged across a tabletop. When one block slipped, the energy stored in its adjacent springs could push or pull the next block to slip, etc., simulating the propagation of earthquake rupture. He then developed a quantitative theory that described very elegantly many phenomena of earthquake complexity. The paper describing that model was his most frequently cited publication. Knopoff had great wit, and he loved to play with language. He wrote

the paper with shortest title ever: "Q", which is a commonly used abbreviation related to seismic wave attenuation. Paul Davis will later describe to you Leon's paper with the shortest abstract on record.

Leon loved the yearly "Ig Nobel Prize" announcements, which were of course parodies of the Nobel prizes. For example, in 2010 three New Zealand physicists won for demonstrating that, on icy footpaths in wintertime, people slip and fall less often if they wear socks on the outside of their shoes. The Chemistry prize went for proving that oil and water do mix, and the Peace prize for confirming the widely held belief that swearing relieves pain.

So here we had the two Leon Knopoffs: the giant who could tackle the most challenging problems, and the kid who was tickled by curious observations. The intellectual David and Goliath, rolled into one, if you can imagine the gentle, good Goliath.

Leon had a great heart, full of kindness. He listened intently to his students' and colleagues' progress, as well as to their personal stories. He would visit his assistants in hospital when appropriate. Curiously, some people found Leon intimidating, which was certainly not his intention. Maybe some people were awed by the rope in his office? Students look for the opportunity to inform their mentors with new insights. This was difficult with Leon, because he knew so much about nearly everything. Perhaps some were awed by the incisive questions he was sure to raise. I loved his questions and miss them dearly.

When I first came to UCLA, Leon posed several questions that are still fundamental today. Earthquake aftershocks decay in frequency according to well described patterns, but what happens in the times between the aftershocks? Those times are way too short to accumulate stress in the normal way. What happens at the tip of a crack, where theory says the stress is nearly infinite, but the strength of rock is too weak to resist that stress? What causes earthquake rupture to stop? Are there some barriers that can resist the highest stresses? If so, how can we find them? And finally the broadest question: what can we measure that will help us test our ideas about earthquakes, which occur miles below ground?

The larger the island of knowledge, the longer the shoreline of wonder, wrote Ralph Sockman, A Methodist pastor. Leon's island was huge, as was his heart. We will all miss him greatly.