

obituaries

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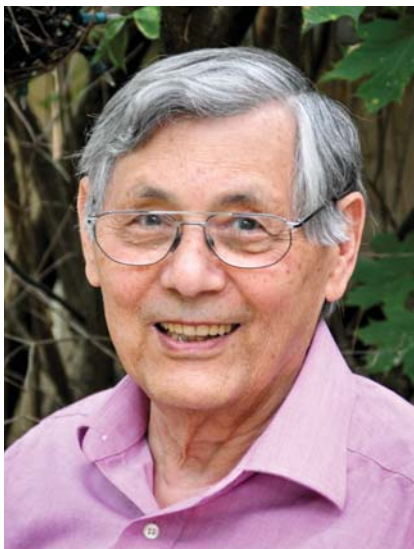
Richard Ernest Azuma

Richard Ernest Azuma, professor emeritus at the University of Toronto and adjunct professor at the University of Notre Dame, died on 19 September 2013 in Toronto after fighting cancer for many years. Dick was a leading figure in low-energy nuclear physics and nuclear astrophysics; among his most notable contributions were to the identification of the nuclear halo in neutron-rich nuclei and the solution of the $^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$ reaction-rate problem.

Dick was born in Regina, Saskatchewan, on 18 April 1930. In the early years of World War II, his Japanese-born father lost his job and was interned for several years in a Canadian work camp. Dick remembered vividly the difficulties he had with his classmates during his early years: "Every second day, I got beaten up. . . . They used to form a circle around us and call us chinky Japs. I can still remember my father tending my blackened eyes and bloody nose, clenching his fist in anger because he could not do anything." In 1942 Dick was kicked out of high school; he worked as a logger until 1944, when he was readmitted to high school in Vancouver, British Columbia. While there, he finished second in the provincial competitive exams.

Admitted to the University of British Columbia, Dick received his BA degree in 1951 in physics and MA degree on a research project in nuclear physics in 1953. He then went to the University of Glasgow in Scotland and in 1959 received his PhD on lifetime measurements of excited states in nuclei, with Philip Ivor Dee as his adviser.

After spending two more years at Glasgow, first as a postdoc then as a lecturer, Dick returned to Canada in 1961 to be an assistant professor of physics at the University of Toronto. Initially, he extended his research into the properties of excited states of nuclei and radiative capture reactions with a 3-MV Van de Graaff generator and an eager group of other young faculty members and graduate students. Following the timely arrival of Claus Rolfs as a post-



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doc in 1972, that effort developed quickly into a new program of measuring reactions of significance for stellar hydrogen burning. Dick was one of the first to apply *R*-matrix theory to simulate the reaction cross section of low-energy nuclear reactions, an effort that became a lifelong passion.

During a sabbatical at CERN's ISOLDE radioactive ion-beam facility in 1978, Dick was a leading participant in a groundbreaking study of beta-delayed neutron emission from lithium-11. That study opened a new field in nuclear structure and radioactive-beam physics involving neutron halos. Dick's insight helped identify the multineutron component of the decay.

Dick also recognized new research opportunities at Chalk River Laboratories and later at TRIUMF in Vancouver. At Chalk River he and his students worked with John Hardy on aspects of weak interactions, including a precise measurement of beta-neutrino angular correlations via beta-delayed particle decay, not to mention *Q*-value and half-life measurements to unprecedented precision for superallowed beta.

From 1982 to 1987, while serving as chair of Toronto's physics department, Dick helped establish at TRIUMF a strong experimental group that included faculty members, postdocs, and

students from the university. The group concentrated on intermediate-energy proton-scattering experiments as a new probe for nuclear structure, complemented by (p,n) reaction studies to determine the Gamow-Teller strength of the weak interaction. On the basis of the group's work, by the end of 1988 the University of Toronto had become an associate member of TRIUMF, an early step in the evolution of TRIUMF from a joint venture of four local universities to a national facility.

A sabbatical at Caltech brought Dick back to nuclear astrophysics; he focused on the $^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$ reaction rate, which William Fowler had called the field's holy grail. The reaction determines the carbon-oxygen ratio in our universe, the fate of stars, and the explosion of supernovae. Many groups have tried for decades to solve the enigma of the complex interference pattern that determines the $^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$ reaction rate. Dick and his collaborators pursued two fundamental measurements to cut the Gordian knot: At TRIUMF, they measured the beta-delayed alpha decay of ^{16}N and identified the E1 contribution; at the University of Notre Dame, they made the precision measurement of the $\alpha + ^{12}\text{C}$ elastic scattering pattern and set limits on the reaction's E2 component.

After retiring from the University of Toronto in 1998, Dick accepted an adjunct faculty position at Notre Dame, where, with the help of many students, he focused on analyzing all $^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$ reaction contributions. He developed a novel *R*-matrix approach capable of simultaneously fitting all reaction channels. His computational code, AZURE, provides a meaningful description for the $^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$ reaction rate and finds ready application in other questions in nuclear astrophysics. Dick did not live to see the final result published, but those who work in the field know and recognize his contributions to the understanding of the more than 50-year-old problem that now seems solved.

Dick was a great mentor and friend; an excellent teacher with infectious enthusiasm, he was a strong supporter of his students. The community will miss him greatly.

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