A *NUCLEAR NEWS* INTERVIEW

Nichita: On *Problems in Elementary Reactor Physics, with Solutions*

This book is a collection of problems intended primarily for undergraduate students studying reactor physics and for those interested in reviewing fundamental reactor physics concepts.

The book *Problems in Elementary Reactor Physics, with Solutions* was recently published by the American Nuclear Society. The book's authors, Eleodor Nichita, of the University of Ontario Institute of Technology, and Benjamin Rouben, retired from Atomic Energy of Canada Limited (AECL) and currently an adjunct professor at McMaster University and the University of Ontario Institute of Technology, found that students lacked enthusiasm for working on physics problems that past generations had already solved. The authors wanted to present something new.

Nichita: "This is first and foremost a collection of problems meant to be used in addition to a textbook when teaching a reactor physics course."

What the authors produced is a collection of problems intended primarily for undergraduate students studying reactor physics, with the secondary audience being graduate students and nuclear industry professionals interested in reviewing fundamental reactor physics concepts.

Nichita was born in Romania in the small city of Buzău. His interest in physics developed while he was attending the historic B.P. Hasdeu high school, founded in 1867 and counting among its graduates George E. Palade, who in 1974 was awarded the Nobel Prize in Physiology or Medicine jointly with Albert Claude and Christian de Duve.

After winning a silver medal at the 1982 International Physics Olympiad, held in Malente, Germany, Nichita went on to study at the University of Bucharest, where in 1988 he received a bachelor's degree in engineering physics with a thesis titled "Three-Dimensional Response-Matrix Code for Neutronic Modelling of Nuclear Reactors." After graduation, he worked for five years at Romania's Institute for Nuclear Research in Pitesti, and then went on to pursue a Ph.D. in nuclear engineering at the Georgia Institute of Technology.

Upon obtaining his Ph.D. in 1997, Nichita joined the Reactor Physics branch of AECL in Toronto, Ontario, as a developer of the CANDU-core neutronics simulator, RFSP. It is there that he met Benjamin Rouben, co-author of the book, who was leading AECL's Reactor Physics branch at the time.

After a few years with AECL, Nichita joined the Faculty of Energy Systems and Nuclear Science at the newly established University of Ontario Institute of Technology, where he is currently an associate professor and director of the nuclear engineering graduate program. An ANS member since 1994, Nichita is a fellow and past president (2009–2010) of the Canadian Nuclear Society.

Rick Michal, director of ANS's Department of Scientific Publications and Standards, spoke with Nichita about his newly published book.

Problems in Elementary Reactor Physics, with Solutions is available through ANS at <ans.org/store> and at Amazon.com.

How did you come up with the idea for a book of problems?

For the past decade or so, I have been teaching reactor physics courses to second-year undergraduate nuclear engineering students. I found that when assigning problems from established textbooks, students sometimes got a feeling of "old hat"—that they were solving problems that countless generations had solved before them and that the best they could hope for was to reproduce the "official" solution, which was very likely already available in some corner of the internet.

To counter that sense of monotony and to keep their enthusiasm alive, I often presented them with new problems, developed specially for them. These were problems that nobody had solved before and for which no "official" solution existed. The students found that much more exciting.

Such new problems also offered me additional flexibility in choosing important ideas and points that I wanted to emphasize. Since I wanted a problem to illustrate a specific point, I tried to make it such that the mathematics involved was at the lowest necessary level, so as not to obscure the main concept.

I later found such problems very useful when teaching reactor physics to graduate students with backgrounds other than physics or nuclear engineering.

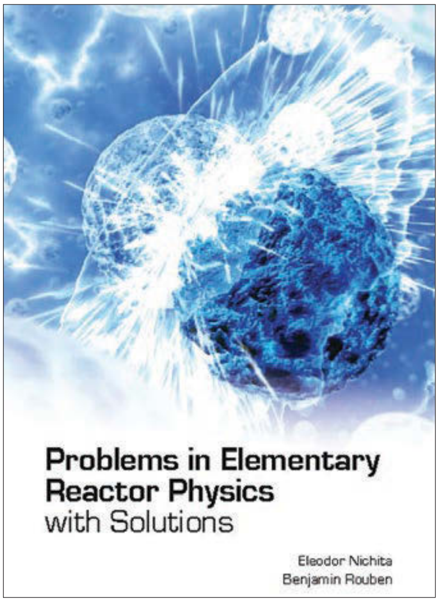
How did your coauthor, Ben Rouben, get involved with the book?

Ben Rouben is a kindred spirit with respect to the importance of problems. As head of AECL's Reactor Physics branch, he used to periodically regale us coworkers with math or physics "puzzles" that, while requiring minimal background knowledge, made for some serious brain workouts. One evening in 2014, toward the end of the annual meeting of the Canadian Nuclear Society and after discussing our similar teaching experiences and approaches, we decided to write this book.

The book includes what you call "official" solutions. Why did you include them?

Ben and I found that today's engineering students were very much focused on numerical results, sometimes at the expense of a full analytical solution. In our opinion, analytical solutions offer much better insight than a simple numerical value. We therefore felt that presenting full analytical solutions, and making all the important points in the process, would encourage students to take such an approach when attempting to solve problems.

We do caution readers in the preface that just because solutions are provided, they should not be treated as "official," and so readers should also try to find alternative solutions.



A special appendix in the book shows only the final numerical answers so that readers can do a quick check of their final results. Of course, now that the book has been published, we will have to come up with new problems for our students, and possibly cover additional concepts. Resonance absorption and heterogeneous lattices are topics that come to mind.

Who is the intended audience for the book?

The book is intended primarily for beginning undergraduate students, but we think it will be useful to graduate students as well, especially those with backgrounds other than physics or nuclear engineering.

The book is also meant for professionals who wish to brush up on reactor physics and who want to be able to perform "back-of-the-envelope" calculations to check computer-code results. It may seem counterintuitive, but computer-generated results should always be checked for plausibility using an approximate model and "hand" calculations.

When a computer-generated result is correct, it is likely correct to several decimal places, but when it is wrong, it can be wrong by an order of magnitude or more. There is no substitute for "hand" calculations.

The problems in the book are divided into three areas: Preliminary Concepts, Reactor Statics, and Reactor Dynamics. Why these three sections?

The material division follows the one used in most reactor physics textbooks. This makes it easy for students to refer to the appropriate chapter when looking for additional problems to solve.

You mention solving problems just for the numerical answer versus working through a full analytical solution. Can you expound on the difference? Related to that, you mention alternative solutions. Is there more than one way to correctly solve every problem?

After figuring out the logical solution steps, one has two options: to go through each step by performing numerical calculations, starting from the given numerical data and arriving, after all the steps, at the final numerical result; or to go through each step by deriving analytical formulas and arriving at a final analytical solution, whose numerical value can subsequently be found by substituting the given numerical data in one fell swoop.

I find that the analytical approach offers better insight than the numerical one. It is also easier to verify and correct if the initial answer turns out to be incorrect.

In most cases, there is more than one way of correctly solving a problem. All correct ways of solving a problem will normally yield the same result, or demonstrably equivalent results.

Would this text make a good backbone for teaching a full course in reactor physics? Or would it perhaps make a good scaffold for writing a textbook? If so, do you foresee pursuing such developments?

This is first and foremost a collection of problems meant to be used in addition to a textbook when teaching a reactor physics course. Appendix B is meant to be a summary of the usual concepts that one would become familiar with after taking an introductory reactor physics course.

I have been thinking about writing a reactor physics textbook at a beginning undergraduate level, one that would be suitable for nonnuclear engineering students.

What is the feeling you get from your undergraduate nuclear engineering students about the state of the nuclear industry? Are they planning to find employment in the industry, and if so, in which areas (i.e., waste management, new reactor design, regulation and rulemaking)?

Twenty operating power reactors are located within a 150-mile radius of our campus, and so, not surprisingly, a majority of our students plan to work in the industry, primarily for utilities. Most of them expect to work in the area of operations, life extension, or decommissioning. Some are looking to work on special projects within utilities, such as special radionuclide production for medical and space applications.

There is also an increasing fraction of students who are looking to work for small startup companies developing Generation IV small and modular reactor concepts.

Will there be a companion volume or volumes to your book?

At this point, we are not anticipating a companion volume, but we may consider an expanded edition to include additional topics. NN