Preface:

Quarks, Spacetime, and the Big Bang

QS&BB is a book designed to accompany a general education course of the same name that I've taught at Michigan State University for a number of years. Why? Well, there's a story there.

The North American approach to university education is nearly unique in the world. Citizen-students come to college in order to become proficient in a focused few areas of study (your "major") but are also broadly educated in many other areas ("general education"). So an English major would dive deeply into literature but also take courses in maybe physics, astronomy, chemistry, biology, geology, history, anthropology, psychology, etc. Likewise a physics major would study physics and mathematics, but also biology, literature, psychology, and so on. Every U.S. campus manages this deep-plus-broad approach to higher education in its own way.[1]

Creating courses for non-specialists in the sciences is especially challenging, but it's important because many of society's big problems are scientific at their roots.[2] An informed citizen needs to understand some scientific facts, while also appreciating the scientific method: all too often, controversy swirls as much around what is or isn't "science" as it does to the details. How best to do this in physics?

There are many physics courses for non-science college students. The traditional course is often called "Physics for Poets," which is a conceptual (less mathematical) version of the otherwise full-physics curriculum taught to science and engineering students. But there are other paths which teach physics by shining a light on particularly interesting topics in accessible presentations.[3]

[1] This approach to higher education is credited to the Harvard University president Abbott Lawrence Lowell who began transforming undergraduate education in 1909. Under him, fields of concentration (majors) were established along with required sampling of courses outside of majors, the distribution requirement. "A well-educated man must know a little bit of everything and one thing well." affected college education across America to this day.

[2] Climate change. Energy production. Evolution and big bang in schools. Nuclear power. Nuclear proliferation. NASA. NIH. Vaccination. Pandemics. Weather. Health effects (or not) of common radiation sources. Peer review. Basic versus applied research. And so on.

[3] Many physics departments will offer astronomy courses (or of course, astronomy departments will when they exist), physics of music, physics of energy issues, physics of light, and so on. Our department is no different in that respect. By the way, 50,000 students take college-credit astronomy every year in the United States!

What QS&BB Isn't

This book is not a comprehensive survey of all of physics. A student will not be expected to solve many of the standard "physics class" problems—QS&BB is, intentionally, mostly conceptual. Many topics which would be in a conventional course are not covered here, or are touched on lightly. For example, there is no chapter on thermodynamics nor on energy production or climate. Motion and forces are only presented for one-dimensional situations and only sufficiently to appreciate relativity. Electricity and magnetism are covered in a descriptive way, with only a few quantitative examples. "How things work" is sometimes covered, but less so than from the usual survey course.

We cut a strategic path through "classical" areas of physics in order to accumulate the concepts, quantities, and vocabulary that would apply to a conceptual appreciation of relativity and quantum mechanics, both of which are the jumping-off points to our two main topics.

The level of scientific literacy among college-educated young adults in the United States always ranks among the top two or three among all nations of the world. This research has been done over decades by Professor Jon Miller of originally, Northwestern University and Michigan State University, and now the University of Michigan. In an article for the Association of American Colleges & Universities ("What Colleges and Universities Need to Do to Advance Civic Scientific Literacy and Preserve American Democracy" `https://www.aacu.org/node/2139`) he explains why U.S. results are so positive: "The answer is college science courses." He goes on to note that "The United States is the only country that requires all college students to take one or more science courses as a part of a general education requirement. In a series of statistical analyses using structural equation analyses of both cross-sectional and longitudinal data, I have shown that exposure to college science courses is a strong predictor of civic scientific literacy in young adults and in adults of all ages (Miller 2010a, 2010c)."

What QS&BB Is

My aim is to help you appreciate two of the more exciting "fundamental" topics in physics: particle physics and cosmology. You'll come to appreciate our current picture of how our universe began and what open questions continue to motivate thousands of us around the world. Once we've passed through a gentle introduction to motion, collisions, electricity, and magnetism, the light-algebraic approach evolves into a more conceptual narrative where we tackle modern-day topics. The Chapter 1 describes how the book—and the Michigan State course—are organized in more detail.

I emphasize biography. We'll meet intellectual giants whom everyone has heard of, but also our professional scientific heroes whose images are *not* on T-shirts. The history of physics and astronomy is full of unusual people—and a lot of just plain folks—and I'm eager for you to think of us without white coats and strange manners. We're regular people who chose career paths that are a little outside of the mainstream. But we're not so special except that we are privileged to be supported by the public in order to do our work.

I'm an experimental particle physicist and I've been teaching physics to physics majors and especially non-science students for more than three decades and I have fun doing it. I'm lucky enough to be continuously supported by you[4] for my research in particle physics for three decades and I'm grateful. In some ways, this book and course are in partial repayment for that support.

[4] The National Science Foundation, specifically.

I've never met anyone who didn't share my curiosity in wanting to know how the universe works. Even after a lifetime immersed in these matters daily, I'm constantly in awe at how beautiful it all is and how lucky we are to know as much as we do. I enjoy talking about it and teaching some of the details.

Figure 1: You can find more about me at `http://www.pa.msu.edu/~brock/`. You'll get to know me as I tell you stories in the pages that follow. Unfortunately, I'll not be able to meet you!

I'm not stuffy. I've tried to write here like I teach, which is informally and hopefully without pretense. I'm deadly serious about the science and passionate about the subject matter. But I also like to have fun and hopefully I'll make you smile every once in a while as we work to grasp complex ideas. Stay with me, and you'll be able to explain Special Relativity at parties just like I can![5]

[5] Wait. That's not necessarily a selling point.