

Commentary

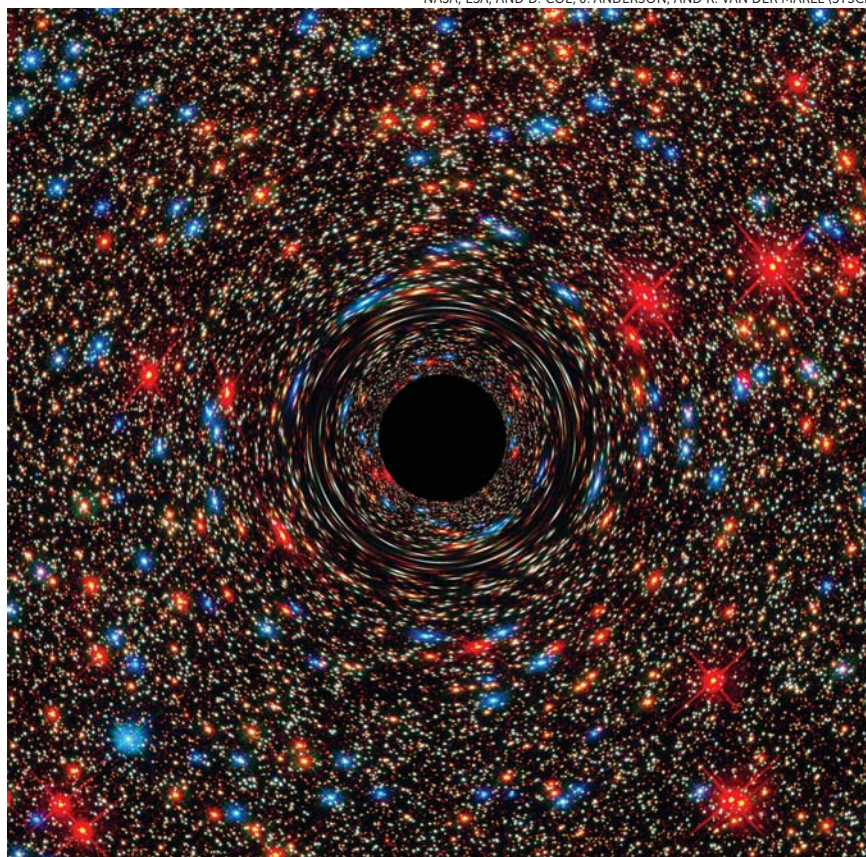
How killer black holes saved astronomy

As a physics professor at a small college, I teach a variety of courses to a student body that is diverse in both preparedness and interests. My courses range from general-education physics and astronomy to upper-level courses on advanced physics topics. In each setting, I have found that integrating popular and historical readings into the curriculum has a substantive and positive effect on the student learning experience.

When I started my career, I quickly realized that curriculum design should be much more thoughtful and nuanced than simply choosing a textbook. Despite the time and effort publishers spend to produce accessible and engaging astronomy textbooks, I found that my students struggled with the voluminous texts and their formal tone.

Evidence of that struggle emerged when I assigned open-book quizzes that consisted of basic questions addressed in the text—from simple definitions to foundational concepts in physics and astronomy. The majority of my students have performed poorly on those quizzes, with class averages typically in the C range, even though all the answers came directly from the textbook. Whether students weren't reading or they were reading without any substantive comprehension, the reality was that they arrived in class without the necessary background to review examples, collaborate in groups, or contribute to class discussions. If I didn't find a way to engage and motivate my students, the astronomy course was destined to become an experience that neither instructor nor students enjoyed.

While researching different textbook options, I came to realize that the majority of introductory astronomy textbooks have similar writing, content, and design elements. Therefore, adopting a new



textbook would not solve the problems my students were having. My experience in teaching the general astronomy course was what first motivated me to explore and develop my curriculum.

After several years of exploration, I have arrived at an approach that allows for the technical treatment of physics and astronomy topics within their historical, cultural, and social contexts. I complement the technical content of a textbook with reading and writing assignments derived from popular and historical science publications. I have found that approach to be successful at engaging students regardless of grade level, major, or interests.

I had read Neil deGrasse Tyson's *Death by Black Hole*¹ and had noted its breadth of topics. A compilation of short essays written for *Natural History* magazine, it spans subjects from science and numerical literacy to the history and fundamental physics of various astronomy phenomena. I decided to use it in my general-education astronomy course to complement the technical assignments

of a standard textbook. I emphasized reading and writing assignments. The idea wasn't to replace the textbook but to drive student interest and motivate learning. The textbook, then, would be a resource that expands on topics covered in the readings.

My astronomy course meets for three 50-minute lectures and one 3-hour lab each week. Students typically read two chapters—roughly 20 pages—from *Death by Black Hole* each week and write a 1- or 2-page response. I set aside 20 minutes of weekly class time to discuss the reading and the students' responses. It is important that they not simply summarize a reading; a thoughtful response allows the student to consider what the reading means and to connect it to personal experiences and anecdotes. In the lab, we expand on problem solving and the quantitative aspects of the course. Without such an arrangement, adopting the reading-and-writing approach may require a reduction in course topics or content.

In Tyson's broad-ranging book I have

found appropriate reading assignments to complement every textbook chapter covered throughout the semester. For example, in the chapter that gives the book its title, Tyson describes what would happen as you fall into a black hole (he uses the term “spaghettification”). Students read this chapter as the course begins to explore extreme environments in the universe, including black holes, quasars, and gamma-ray bursts.

I implemented this approach in my astronomy course in 2013, and since 2015 I have included a question on the midterm exam that asks students to discuss the value of reading *Death by Black Hole* and whether they would recommend the book to a friend interested in learning about astronomy. The feedback has been overwhelmingly positive, and the learning environment and level of student engagement are the healthiest I have ever experienced.

I have used the same approach with much success in my advanced courses. Mark Kidger’s *Cosmological Enigmas*² and *Death by Black Hole* have made wonderful companion texts in a mid-level astrophysics course. The approach works well for exploring the people behind paradigm shifts throughout the history of physics. In that context, I use *Faraday, Maxwell, and the Electromagnetic Field* by Nancy Forbes and Basil Mahon³ in my upper-level electricity and magnetism course, and I use *Thirty Years That Shook Physics* by George Gamow⁴ and *Quantum* by Manjit Kumar⁵ in my modern physics course to enhance a learning experience that is often focused on technical and abstract content.

I highly recommend the above titles for your courses, but I am nearly convinced that the specific readings used are irrelevant. I am constantly searching for new books and texts to incorporate into my reading lists and am working to expand the courses for which I use this curriculum design. What makes this approach so compelling for students is the opportunity to explore the historical, cultural, and social contexts of the subjects found in textbooks. If your readings address those topics, I am confident they will have the same effect on your courses.

Perhaps it is hyperbole to say killer black holes saved my astronomy course, but the reality is difficult to ignore. By using popular and historical readings to complement technical content, I have

seen dramatic improvement in student participation and learning in all my courses. I highly recommend using popular and historical science writings in the ways I’ve outlined here.

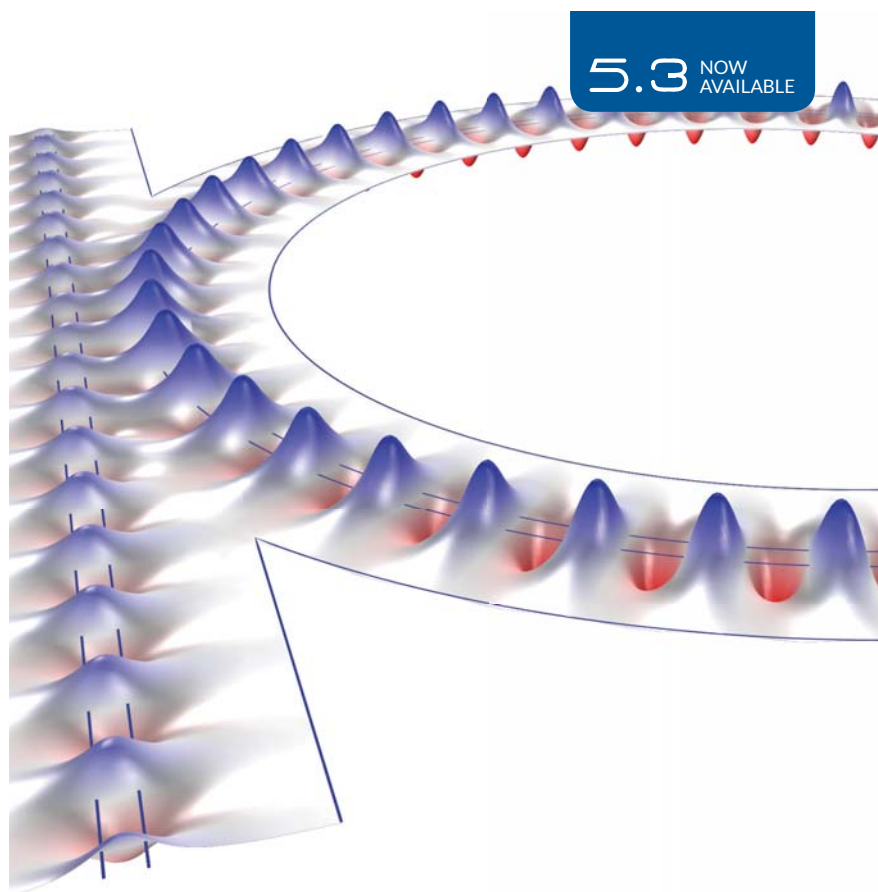
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1. N. D. Tyson, *Death by Black Hole: And Other Cosmic Quandaries*, W. W. Norton (2007).
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