

The Structure, Stability, and Dynamics of Self-Gravitating Systems



The purpose of Joel Tohline's online textbook, "The Structure, Stability, and Dynamics of Self-Gravitating Systems," is twofold. The textbook aims "to document in an electronically accessible format many of the key physical principles that underlie modern discussions of the structure, stability, and dynamical evolution of astrophysical fluid systems." The second purpose is "to take advantage of the added dimensions offered by the hypertext medium—particularly color, animation, and text linkage—to effectively illustrate many of these physical principles."

Tohline, professor of physics at Louisiana State University and a member of *CIP*'s Advisory Committee, is a thorough believer in the superiority of hypertext and multimedia materials over conventional printed matter for teaching science and presenting scientific research. His textbook, which is currently under development, may be found at http://www.phys.lsu.edu/astro/H_Book.current/H_Book.shtml.

According to Tohline, hypermedia documents are particularly valuable in presenting scientific results that involve visualization. It seems illogical to reduce a computer-generated animation sequence to a still image (or even a set of still images) for publication, when the animation itself could be distributed electronically over the Internet. Tohline cites his work on computational-fluid-dynamics (CFD) simulations using a

heterogeneous computing environment as an instance in which hypermedia should be used to present a visualization that is an integral part of a simulation experiment. The heterogeneous environment couples a massively parallel Cray T3E supercomputer with an SGI workstation in order to animate the CFD results. Tohline's research group has developed an efficient CFD algorithm, but to make the results understandable, they must be visualized. Accordingly, the Cray supercomputer pauses at intervals and dumps out a data set that the SGI renders as an image. This image is stored as one animation frame. Eight hours' worth of computation on the Cray yields around 30 frames of an animation that may eventually contain up to 2000 frames. The animation is produced as a natural byproduct of the simulation.

An animation of this sort is best presented in the form in which it was originally created, rather than through the artificial and information-squandering process of reducing it to a still image. "When we are doing a large-scale numerical simulation," Tohline says, "it is difficult to put the results down on the printed page. Look at any page [in a magazine like *CIP*] and you'll see, for example, a color figure that is one frame out of an animation sequence. It took the authors more effort to make the figure than it did to make the animation, and the printed journal cannot show the animation!" For this reason,

Tohline believes that hypermedia will ultimately supplant print as the preferred form for presenting scientific research. With his online textbook, Tohline hopes to participate in and suggest the future directions of this process. "A printed journal is just a small subset of the kind of information that most scientists would like to make available on a regular basis," Tohline says. "We shouldn't abandon the printed page, but I believe that the printed page will be like a readers' digest, with short excerpts of what is available online."

Visitors to Tohline's Web site will find animations in plenty, presented as Java applets, MPEG movies, VRML simulations, and visualizations of data generated by Mathematica. These animations are integrated into the presentation of the course material but are also offered to the visitor independently, with the invitation to "Try a Java (or movie, VRML, or Mathematica, or HSCF [Hachisu Self-Consistent-Field Technique]) example!" Tables show which sections of the textbook are accompanied by animations, which are not, and which areas of the text are still being written.

Tohline wrote some of the animation programs himself and has involved students in writing others. (Peter Nelson, an LSU undergraduate, has been instrumental in helping Tohline to manage the layout of the textbook as it has grown in size.) Visitors to the site can also read brief explanations of the principal partial-

differential equations that govern self-gravitating systems, with variables and constants in the equations hyperlinked to their definitions in a glossary. Students can test their understanding by doing sample problems and check their work by exploring the hyperlinked answers.

The open-endedness of hypermedia documents and the collaborative possibilities they invite are among their most important advantages of online publication for Tohline. In a recent semester he taught a course using the online textbook, in which he would assign students specific projects in areas not yet covered in the text. These projects involved designing small problems, writing chapters in HTML that presented the solutions, and putting the work online for viewing by other students. These assignments opened up the possibility of including the students' chapters in the text and crediting the students for their work.

Likewise, according to Tohline, experts in particular fields could contribute hypertext chapters in what has the potential to become far more of a collaborative than an individual project. The ability to update hypermedia documents continually and convenient multi-author collaboration imply the possibility of creating a textbook that resists becoming obsolete.

Tohline hopes to be ready by the end of August to advertise his textbook's existence to the astrophysics community, along with an invitation to others to participate in the book's evolution. "The material is sufficiently complete that it could appear in a book, though it never will," Tohline says. "Virtually everyone who sees what I am doing asks when I will publish it [in print], but there are many features that would be lost if I did." In Tohline's view, hypermedia and not print is the best form in which his work can appear: "I strongly feel that this will be the medium of all scholarly publication, not just that aimed at students."

Mark Becker