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Teaching Astronomy with Science Fiction: A Resource Guide

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Abstract

One of the great challenges of teaching modern astronomy is that many of the concepts seem abstract and removed from everyday experience. One way to make astrophysical ideas become more concrete and easy to visualize is to introduce your students to science fiction stories based on accurate science.

Not All Bug-eyed Monsters

If you have not looked at science fiction writing recently, you may have the impression, reinforced by television and Hollywood, that all science fiction is about bug-eyed monsters, UFOs, or magic unicorns. So it may come as a surprise that, when it comes to written science fiction, the field has become a lot more sophisticated in its portrayal of science than the popular media would have you believe.

Today, more than ever, there is a lot of good science fiction being written by authors who have either advanced degrees or a good background in science. Even a number of well-known authors without science training take their science seriously enough to make their works worth reading. Some of the best stories involve both sensitive, literate writing and reasonable extrapolation from today's scientific discoveries. Many of these stories can actually make astronomical ideas come alive for the reader--whether it is the conditions on the martian surface, the (once-in-a-lifetime) descent toward a black hole, or the dangers of a nearby supernova.

A Subject Index to Useful Stories

To help instructors who are interested in doing more with science fiction in their classes, I have assembled an annotated topical index to science fiction stories and novels that use good astronomy and physics. The listing currently has about 200 entries organized into 40 subject categories, ranging from "anti-matter" to "Venus." It is not designed as a complete index, but highlights stories that teachers have found particularly useful for teaching non-science students. Suggestions of stories to add to the list are most welcome.

The index is now available on the education Web pages of the nonprofit Astronomical Society of the Pacific: <http://www.astrosociety.org/education/resources/scifi.html>.

Note that in the discussion below, I cite a number of stories and novels by author and title only. Full information and a source for each story I cite can be found on the above Web pages.

As someone who teaches large courses in astronomy and physics to non-science students, I find that recounting and recommending an occasional science fiction story in my classes really helps liven up the factual survey of what we have learned about the universe. Many of my students call themselves science fiction fans, but most have, in fact, rarely read what an astronomy instructor might call good science fiction stories. Their experience is often limited to the science fiction on television and the movies, and occasional best-selling fantasy novels. It's as if they called themselves food enthusiasts, but had only been to Burger King when they ate out.

Whether or not students are fans, seeing an astronomical idea or phenomenon played out in a story can be an instructive experience. It is, to take an example, one thing to understand in principle that the day and night on the Moon are about two Earth weeks long, and quite another to read about a future astronaut stranded on the Moon for whom this becomes a life-or-death issue (as in the story "Walk in the Sun" by Geoffrey Landis.)

Science Fiction by Scientists

Landis, who works at NASA's Glenn Research Center near Cleveland, is a good representative of scientists who have written science fiction that is effective in portraying human feelings and foibles, and yet pays scrupulous attention to scientific accuracy. A list of some authors who have degrees in science (together with their Web sites) is in Appendix 1. Let me mention just a few examples of astronomer-authors here, to give you the flavor of what is available.

The late Fred Hoyle, co-developer of both the steady state theory of the universe and our modern ideas of how stars produce the chemical elements, was a prolific science fiction writer. In his first and best-known novel, *The Black Cloud*, an intelligent dust cloud comes to the Earth and astronomers learn to communicate with it. Hoyle used to recount that the idea of molecules or life in interstellar clouds was too radical a notion for the astronomical journals in the 1950s, so he decided to put it into a novel--and a whole sub-career followed. Hoyle's later novel, *October the First Is Too Late*, was one of the first fictional discussions of the many-worlds interpretation of quantum mechanics.

In an interesting example of fiction influencing science, Hoyle told me years ago that one source of the steady state theory (in which the universe has neither beginning nor end) was a 1945 horror film called *Dead of Night*, which also has no beginning or end. Hoyle, Gold, and Bondi saw the film as they were

debating the nature of the universe, and got to thinking whether they could devise a model of the universe that resembled the structure of the movie. You can find the film on video and occasionally on cable channels, such as Turner Classic Movies or AMC.

The late Carl Sagan wrote a novel called *Contact*, which many people still consider the best portrait of how the scientific search for extra-terrestrial radio signals really works. The life of the main character, Ellie Arroway, has some interesting parallels to the life of Jill Tarter, who heads the radio search at the SETI Institute. It was made into a fine film, starring Jodie Foster, that, incidentally, starts with an amazing tour of the universe that some instructors have taken to showing at the beginning of their courses.

Practicing astronomers William Hartmann and Donald Clayton have each written a novel, while NASA astronomer Yoji Kondo has written several novels under the pen name Eric Kotani. Engineer Stephen Baxter has imagined a bold future history for the universe of light and dark matter, in which advanced life-forms made of both kinds of matter vie for supremacy. The late Charles Sheffield, who worked with satellites and space imagery, wrote many novels and stories that scintillate with the latest ideas from astronomy and physics journals.

Among those who have undergraduate degrees in science and math, Arthur Clarke and Larry Niven stand out in my mind as leaders in the field of portraying real science in fictional terms. Clarke, whose short story "The Sentinel" was the basis for the film *2001*, and who was a pioneer in suggesting the use of communications satellites, wrote many novels and stories based on ideas in planetary science. Niven, a very influential figure in modern science fiction, has imagined a whole "known space" universe, with past and future history on a grand scale, where alien races and artifacts interact with and affect the development of humanity (Kitchin 2001). David Brin, a younger author with an advanced degree in science, has a similar *Uplift* series, in which he conceives of a rich universe full of intelligent life, where species must help each other to be admitted to membership in a galactic community.

Perhaps the finest science fiction writer who is also a professional scientist is Gregory Benford, a plasma physicist at the University of California, Irvine (Irion 2001; Taubes 1983). Benford is especially skilled at highlighting the human element, while showcasing the latest ideas in physics and astronomy. Sometimes characters come into his novels who are thinly disguised (or not disguised) versions of real scientists. In a series of six novels, he has envisioned a future in which humans and all organic life-forms are engaged in a vast (and often hopeless) struggle with machine life. Such machines regard us as an infestation, much as we would some mold that grows in our home. The locale of these novels eventually shifts to the center of the Galaxy, and follows the struggle to the neighborhood of the central black hole. Many of his stories use ideas from modern astronomy; a good number are included in the Web subject index I have referred to above.

Using Science Fiction in a Course

Different instructors use science fiction in a variety of ways in their courses. (See, for example, DeGraff 2000; Theison 2000; Schmidt 1980; Dubeck 1994 and 1998; and Lambourne 1990.) Many use films rather than stories, and involve the students in finding correct science and/or science errors in popular films that students may already know. However, to my mind, written stories can have a far greater resonance and depth, and often explore science far more effectively.

Some colleges are now offering an entire introductory science course or seminar based on science learned through science fiction--although these are frequently in biology (Parker 1984), earth science, or social science departments. Both David Theison (U. of Maryland) and Gibor Basri (U.C. Berkeley) have been experimenting in teaching focused astronomy seminars that deal with one small part of astronomy and examine it through science fiction. I am sure there are others doing this as well, and I would be pleased to hear from colleagues whose courses I am not familiar with.

Here are some of the ways that science fiction might be included in an astronomy course:

1. When covering a particular part of science, simply describe a science fiction story that illuminates that topic. For example, whenever I discuss time dilation near a black hole, I talk about Larry Niven's novel, *World Out of Time*, in which the protagonist, having skirted a massive black hole (where time slows down), finds himself three million years in the future.
2. Assign a student or a team of students in advance to read a particularly good story, and then report about it to the class (or a section meeting) just after the science topic that the story involves is covered. For example, after the class studies the planet Mercury, you might have them report on Stephen Baxter's moving and thought-provoking story "Cilia of Gold," about a life form that adapts to the difficult conditions on the innermost planet. You may want to pose a specific set of questions to keep the discussion focused. Some instructors ask the students to concentrate on the science in the story, and to compare those science ideas to what they have been learning in class.
3. Alternatively, pick a science fiction story that is out of date or uses incorrect science, and then have the students discuss what the science problems are. For example, the Mars and Venus stories of Edgar Rice Burroughs (the creator of Tarzan) imagined that humans could live unprotected on the surface of each planet.
4. Assign a short story for homework, ask the students to think about it, and then divide them into small groups to answer some questions about the story. Some of the questions could be specific to what happened in the story, to make sure they all read it, while others might be open-ended and continue with themes or thoughts raised by the story. For example, Brian Aldiss's story "The Difficulties Involved in Photographing Nix Olympica" can lead to a discussion of future tourism, human obsession, or how one deals with planetary features on a scale beyond any Earthly scene. (Alternatively, you can give a short in-class written assignment about the story the students read and ask them to comment about some aspect of it.)
5. Instead of assigning a story, have the students select a story of their choice and do an analysis of the science in it. This could be an oral report or a paper. When I do this as a paper assignment, I ask for a preliminary outline (never more than one page) to make sure that the students are on the right track, have a reasonable story, and are asking the right sorts of questions. (Many are not and appreciate the mid-course correction.) If you want to be familiar with the story they discuss, you may want to limit their choices to a list of stories you have approved in advance. If students want to know more about the author's background, you could also give them the list of author Web sites in Appendix 1.
6. After discussing a number of science fiction stories during the course of a semester, it can be interesting to encourage students (perhaps as an extra-credit assignment) to write one of their own. Even if they don't write a whole story, they could come up with a plot outline and then discuss how good astronomy and physics would play a role in the story they envision.

Further Resources for Instructors and Students

If you or your students want to explore further the world of scientifically reasonable science fiction, a number of useful resources are now available to help you. Appendix 2 lists some helpful Web sites. David DeGraff's site is an especially good one, in which he discusses in some detail how he uses science fiction stories in his classes. (The only disadvantage is that he frequently tends to focus on stories that have appeared only in science fiction magazines, and are thus not especially accessible.) Biologist and textbook author Julie Czerneda has published a manual called *No Limits*, which gives many hints about using science fiction in the classroom (Czerneda 1999). It is primarily for the high school level, but many of its suggestions are applicable to lower level college classes as well. Several other useful articles and books are included in the longer list of references below.

For anyone who gets serious about *writing* science fiction, many books are available with suggestions and hints from published writers. Two recent books (Gillett 1996; Schmidt 1995) devote themselves to how one constructs alien worlds and alien beings within the bounds of known science. Another (Bova & Lewis 1997) is a primer on the essentials of space travel.

The Web sites listed in Appendix 2 can also help you and your students learn more. The last two sites we list are Web-based indexes to thousands of science fiction stories and can be helpful when you are trying to track down a particular story or author. Peter Nicholl's book *The Science of Science Fiction* is a mini-encyclopedia of themes, ideas, and authors from science fiction that is (or was) within the bounds of accepted science. There are many published anthologies of such science fiction stories, although such anthologies go out of print rapidly and are not always reprinted. Luckily, the best stories often are revived in another anthology, and many of the ones I recommend on my subject index site have managed to remain in print. A used book site such as <http://www.abebooks.com> can help you find out-of- print books with some ease.

I hope this discussion might whet a few appetites for reading more modern science fiction, and giving it a try in a classroom setting. In a culture that all too often tends to look backwards and envy the past, good science fiction can teach a bit of science, help your students prepare for an uncertain future, and envision the dangers and possibilities that the future brings. Students who develop a long-lasting appreciation of speculative fiction may thank you for adding this new dimension to their lives.

Appendix 1: Science Fiction Authors With Science Degrees

- Poul Anderson (deceased; Physics BA): <http://www.catch22.com/SF/ARB/SFA/Anderson,Poul.php3>
- Isaac Asimov (deceased; Biochemistry PhD): <http://www.asimovonline.com/>
- Stephen Baxter (Engineering PhD): <http://www.cix.co.uk/~sjbradshaw/baxterium/baxterium.html>
- Gergory Benford (Physics Professor, U of California, Irvine): <http://www.authorcafe.com/benford/index.html>
- David Brin (Space Physics PhD): <http://www.kithrup.com/brin/>
- Arthur Clarke (Physics & Math Degree): <http://www.lsi.usp.br/~rbianchi/clarke/>
- Hal Clement (Chemistry MS): <http://hea-www.harvard.edu/~ruiz/hal>
- John Cramer (Physics professor at U. of Washington): <http://faculty.washington.edu/jcramer/>
- Michael Crichton (Medical Doctor): <http://www.crichton-official.com>
- Greg Egan (mathematics BS): <http://netspace.net.au/~gregegan>

- John Gribbin (Physics PhD): http://www.biols.susx.ac.uk/home/John_Gribbin/
- Joe Haldeman (BS in Physics & Astronomy): <http://home.earthlink.net/~haldeman>
- William Hartmann (Astronomy PhD; planetary astronomer): <http://www.psi.edu/hartmann>
- Fred Hoyle (deceased; noted astrophysicist): <http://members.tripod.com/~gwillick/hoyle.html>
- Eric Kotani (Yoji Kondo) (astrophysicist at NASA): <http://www.sfw.org/members/kotani>
- Geoffrey Landis (NASA Planetary Astronomer): <http://www.sff.net/people/geoffrey.landis>
- Philip Latham (deceased; was the pen name of Robert Richardson) (Astronomy PhD): http://www.isfdb.org/cgi-bin/ea.cgi?R._S._Richardson
- Mark O. Martin (Professor of Biology at Occidental College): <http://employees.oxy.edu/momartin>
- Paul McAuley (PhD in botany): <http://www.omegacom.demon.co.uk>
- Larry Niven (BA in Math): <http://www.larryniven.org>
- G. David Nordley (MS in Engineering): <http://www.sfw.org/members/Nordley/>
- William Rossow (NASA Planetary Scientist): <http://www.giss.nasa.gov/staff/wrossow.html>
- Tony Rothman (Professor of Physics at Bryn Mawr): <http://godel.ph.utexas.edu/~tonyr>
- Carl Sagan (deceased; Professor of Astronomy, Cornell U): <http://www.carlsagan.com>
- Stanley Schmidt (Physics PhD): <http://www.bucconeer.worldcon.org/goh/schmidt.html>
- Charles Sheffield (deceased; Physics PhD): <http://www.sff.net/people/Sheffield>
- Joan Slonczewski (Prof. of Biology, Kenyon College): <http://www2.kenyon.edu/depts/biology/slonc/slonc.htm>
- Vernor Vinge (Math Professor at San Diego State): <http://www.ugcs.caltech.edu/~phoenix/vinge/>

A Few Others Writing Science Fiction with Strong Science

- Michael Capobianco (amateur astronomer): <http://www.geocities.com/michaelcapobianco/>
- Fred Pohl: http://www.fantasticfiction.co.uk/authors/Frederik_Pohl.htm
- Robert Sawyer (an active amateur astronomer): <http://www.sfwriter.com>
- John Stith: <http://www.neverend.com>
- John Varley: <http://www.geocities.com/Area51/Rampart/3870>

Appendix 2: A Few Key Web Resources on Science Fiction for Instructors

- Subject Index of Science Fiction Stories with Good Astronomy: <http://www.astrosociety.org/education/resources/scifi.html>
- Science Fiction Resource Guide (rich compilation of information and links): <http://www.astrosociety.org/education/resources/scifi.html>
- David DeGraff's "Using Science Fiction to Teach Astronomy": <http://www.astrosociety.org/education/resources/scifi.html>
- Gibor Basri's Seminar at Berkeley: <http://astron.berkeley.edu/~basri/astro39/>
- CONTACT (An Annual Conference about Building Realistic Worlds in Science Fiction): <http://www.cabrillo.cc.ca.us/contact/index.html>
- Locus Magazine's Index to Science Fiction after 1984: <http://www.locusmag.com/index/>
- William Contento's Index of Science Fiction Stories and Anthologies Before 1984: <http://users.ev1.net/~homeville/isfac/0start.htm>

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- Guthke, K. 1990, *The Last Frontier: Imagining Other Worlds from the Copernican Revolution to Modern Science Fiction*, Ithaca, NY: Cornell University Press. A scholarly study of the theme of extraterrestrial life in literature, philosophy, and science.
- Irion, R. 2001, Frozen Species, Deep Time, and Marauding Black Holes, *Science*, 239, 1984. A profile of physicist and science fiction writer Gregory Benford.
- Kitchin, C. 2001, The Man Who Wrote a Universe, *Astronomy Now*, May, 58. An introduction to the science in the science fiction of Larry Niven.
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- Nahin, P. 1997, *Time Travel: A Writer's Guide to the Real Science of Plausible Time Travel*, Writer's Digest Books.

Nicholls, P., et al. 1983, *The Science in Science Fiction*, Westminster, MD: Alfred A. Knopf. An encyclopedic reference book on science themes in modern science fiction.

Parker, H. 1984, *Biological Themes in Modern Science Fiction*, Ann Arbor, MI: UMI Research Press.

Plait, P. 1998, Hollywood: A Full Moon in Every Plot, *Astronomy*, April, 49. On problems with science in many films about space. (See also his book *Bad Astronomy*).

Preiss, B., & Fraknoi, A., Editors. 1987, *The Universe*, New York: Bantam. A further collection of essays by leading astronomers and science fiction stories with good science; deals with the realms outside our solar system.

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