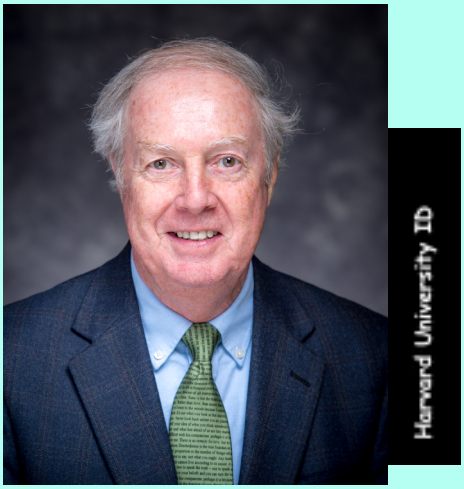
Eric J. Chaisson

curriculum vitae

Dr. Eric J. Chaisson researches physics & astronomy at Harvard-Smithsonian Center for Astrophysics and teaches natural science at Harvard University.

His major interests are currently twofold: His scientific research addresses an interdisciplinary, thermodynamic study of physical, biological, and cultural phenomena, seeking to understand the origin and evolution of galaxies, stars, planets, life, and society, thus devising a unifying cosmic-evolutionary worldview of the Universe and our sense of place within it writ large. His educational work engages master teachers and computer animators to create better methods, technological aids, and novel curricula to enthuse teachers and instruct students in all aspects of natural science. He teaches an annual undergraduate course at Harvard College on the subject of cosmic evolution, which combines both of these research and educational goals.



- **Member, Harvard-Smithsonian Center for Astrophysics, Cambridge MA**
- **Research Associate, Director's Office, Smithsonian Astrophysical Observatory, Smithsonian Institution, Washington DC**
- **Associate, Harvard College Observatory**
- **Faculty of Arts & Sciences, Division of Continuing Education, Harvard Univ.**

Contact Information

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chaisson@fas.harvard.edu
phone: 978.505.2667
internet: http://www.cfa.harvard.edu/~ejchaisson
paper: Harvard College Observatory, Bldg. A, MS-10
60 Garden St., Cambridge, MA 02138 USA

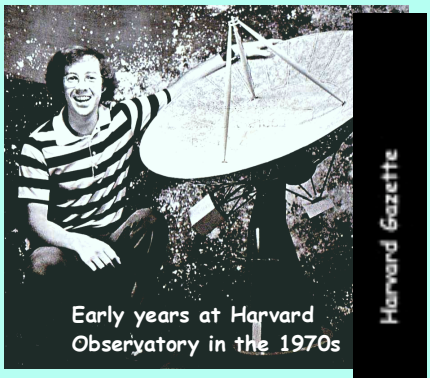
Curriculum Vitae

Education:

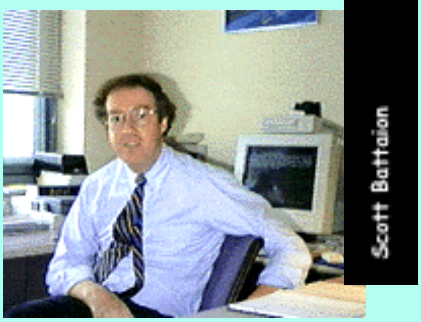
- **B.S. 1968 University of Massachusetts, Lowell (cum laude)**
- **A.M. 1969 Harvard University**
- **Ph.D. 1972 Harvard University**

Professional Experience:

- **1972-74:**
  National Academy of Sciences (NRC) Post-doctoral Fellow, Smithsonian Astrophysical Observatory;
  Research Associate, Harvard College Observatory
- **1974-79:**
  Assistant Professor, Harvard University
  Member, Harvard-Smithsonian Ctr for Astrophysics
  Non-resident Tutor, Mather House, Harvard College
- **1979-82:**
  Associate Professor, Harvard University
  Member, Harvard-Smithsonian Ctr for Astrophysics
  Non-resident Tutor, Mather House, Harvard College
- **1982-86:**
  Professor of Astronomy and Physics, Haverford
- **1986-87 (sabbatical):**
  Research Physicist, Lincoln Laboratory, MIT;
  Associate, Harvard College Observatory;
  Non-resident Tutor, Quincy House, Harvard College
  Adjunct Professor of Physics, Wellesley College
- **1987-92:**
  Scientist and Director of Educational Programs, Space Telescope Science Institute;
  Adjunct Professor of Physics, Johns Hopkins Univ;
  Associate Director, Maryland Space Grant Consortium, Johns Hopkins University;
  Associate, Harvard College Observatory
- **1992-2011:**
  Director, Wright Center for Science Education
  Research Professor of Physics, Astronomy, and Education, Tufts University;
  Associate, Harvard College Observatory;
  Affiliate-director, Space Grant Consortium, MIT
- **2017-18:**
  Visiting Professor and Director's Fellow
  Institute for Advanced Study, Univ. of Notre Dame



Early years at Harvard Observatory in the 1970s



Directing the Wright Center at Tufts in the 1990s

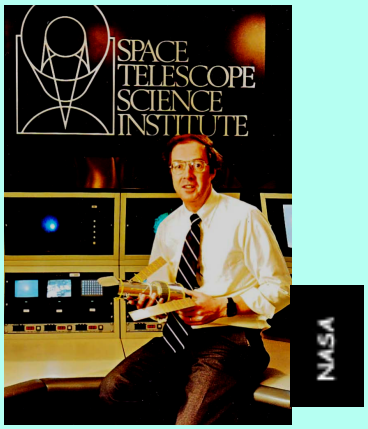
At home, near Walden Pond, in the 2010s

- **Current positions, 2011-**
  Member, Harvard-Smithsonian Center for Astrophysics;
  Associate, Harvard College Observatory;
  Research Associate, Director's Office, Smithsonian Astrophysical Observatory, Smithsonian Institution, Washington DC;
  Faculty of Arts & Sciences, Division of Continuing Education, Harvard Univ.

Biographical Sketch (cf., also http://en.wikipedia.org/wiki/Eric_Chaisson *Who's Who in America; Who's Who in Science and Engineering; Who's Who in American Education.*)

Dr. Eric J. Chaisson is a member of Harvard-Smithsonian Center for Astrophysics, affiliates with Harvard College Observatory and Smithsonian Astrophysical Observatory, and teaches with the Faculty of Arts & Sciences at Harvard University.

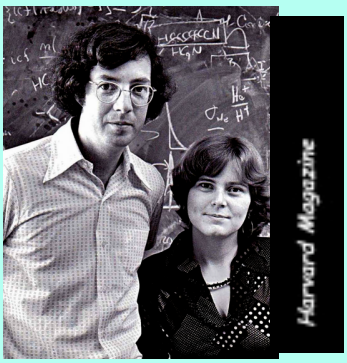
Trained initially in atomic physics, Chaisson obtained his doctorate in astrophysics from Harvard University in 1972. During his early tenure as associate professor at the Harvard-Smithsonian Center for Astrophysics, his research focused largely on radio astronomical studies of interstellar gas clouds. This work won him fellowships from the National Academy of Sciences and the Sloan Foundation, as well as Harvard's BJ Bok Prize for original contributions to astrophysics and Harvard's Smith-Weld Prize for literary merit. He has also held research and teaching positions at MIT, Wellesley, and Johns Hopkins where he was a senior staff scientist and director of educational programs at the (Hubble) Space Telescope Science Institute, and at Tufts University where he was for two decades director of the Wright Center for Science Education and Research Professor of Physics, Astronomy, and Education. He has written nearly 200 publications, most of them in professional journals.



On PBS-TV at Hubble mission control, 1990

Chaisson's major interests are currently twofold: His scientific research addresses an interdisciplinary, thermodynamic study of physical, biological, and cultural phenomena, seeking to understand the origin and evolution of galaxies, stars, planets, life, and society, thus devising a unifying cosmic-evolutionary worldview of the Universe writ large. His educational work engages master teachers and computer animators to create better methods, technological aids, and novel curricula to enthuse teachers and instruct students in all aspects of natural science. He teaches an annual undergraduate course at Harvard College on the subject of cosmic evolution, which combines both of these research and educational goals.

To share the essence of his research and teaching with a wide audience, Chaisson has written a dozen books, including *Cosmic Dawn* that won several literary awards such as the Phi Beta Kappa Prize, the American Institute of Physics Writing Award, and a National Book Award Nomination for distinguished science writing. His other books include two works on relativity, a textbook on cosmic evolution, and a co-authored volume outlining the scientific rationale for the United States' national space policy. The *Hubble Wars* also won the American Institute of Physics Writing Award, and his co-authored textbook *Astronomy Today* (now in 9th edition) is the most widely used college astronomy textbook in the nation. His most recent books, *Cosmic Evolution* and *Epic of Evolution,* were published by Harvard and Columbia University Presses.



This partnership, here with Lola in 1976, produced 3 stars and several books

Chaisson holds membership in numerous American and international scientific organizations, several honor societies, and a host of academic, public, and federal advisory committees. He is an elected Fellow of the American Association for the Advancement of Science.

Professional, Honor Societies

Societies:

- American Institute of Physics
- American Astronomical Society
- American Association of Physics Teachers
- American Assoc. for the Advancement of Science
  - Section B - Physics
  - Section D - Astronomy
  - Section X - Societal Impacts of Science and Engineering
- International Astronomical Union
  - Div F, Planetary Sciences & Bioastronomy
  - Div H, Interstellar Matter & Local Universe
  - Div J, Galaxies and Cosmology
  - Div F, Commission 51, Bio-astronomy
  - Div F, Commission 53, Extrasolar Planets
- International Union of Radio Scientists
- Federation of American Scientists
- Union of Concerned Scientists
- The Authors Guild, Authors League of America
- Emerson and Thoreau Societies

ϕβκ National Lecturer, 1990s

Honors:

- Sigma Xi, Harvard-Radcliffe Chapter (for research)
- Tau Epsilon Sigma (for general science)
- Sigma Pi Sigma (for physics)

Some Named-Lectures Delivered:

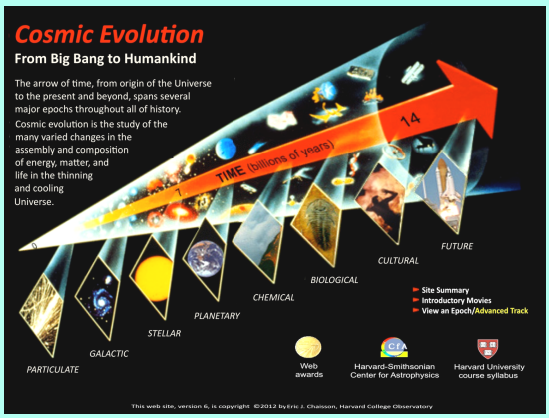
- Birkhead Lectures (St. Paul's)
- Bok Prize Lecture (Harvard)
- Connolly Lecture (Chicago)
- Hume Memorial Lecture (Winsor)
- Wagner Lecture (Penn)
- Cervantes Lectures (Guanajuato and Mexico City)
- Sunoco Lectures (Texas)
- Garvin Lecture (Lancaster)
- Wiegand Lecture (Toronto)
- Phi Beta Kappa Lectures (many U.S. campuses)
- Moore Lectures (University of California)
- Collins Lecture (Harvard Medical School / MGH)
- Donaldson Lecture (Memphis)

After-dinner talk at National Academy of Sciences, 2000

Academic Awards

Accepting B.J. Bok Prize, 1977

- **Mingins Award (UMass/Lowell) for excellence in undergraduate research, 1968**
- **National Academy of Sciences/National Research**
- **Council Fellow, 1972-74**
- **Alfred P. Sloan Foundation Research Fellow, 1976-79**
- **Bart J. Bok Prize (Harvard) for original contributions to astrophysics, 1977**
- **Smith-Weld Prize (Harvard) for best general article by Harvard faculty member, 1978**
- **for the book, *Cosmic Dawn*:**
  - **Phi Beta Kappa Award for distinguished science writing, 1981**
  - **American Institute of Physics Science Writing Award, 1981**
  - **National Book Award Nomination (finalist), 1982**
- **NASA Certificate of Merit, Hubble Space Telescope Project, 1993**
- **Phi Beta Kappa Visiting Scholar and National Lecturer, 1995-96**
- **for the book, *The Hubble Wars*:**
  - **American Institute of Physics Science Writing Award, 1995**
  - ***New York Times* "best book of year category," 1995**
- **for the website, *Cosmic Evolution*** http://www.cfa.harvard.edu/~ejchaisson/cosmic_evolution/docs/splash.html
  - **Science & Technology Award (shared with CERN Conseil Europeen pour la Recherche Nucleaire), *Scientific American*, 2004**
  - **Digital Dozen Award, Eisenhower Clearing House, U.S. Dept. of Education, 2005**
  - **Net Watch, *Science,* American Association for Advancement of Science, 2006**
- **for the book, *Epic of Evolution*** http://cup.columbia.edu/book/978-0-231-13560-3/epic-of-evolution
  - **Kistler Award "for increasing understanding of factors shaping the future of humanity," 2007**
- **for the movie, *Arrow of Time* (co-produced with D. Berry)** https://www.cfa.harvard.edu/~ejchaisson/cosmic_evolution/docs/fr_1/fr_1_intro_movies.html
  - **Special Jury Award for Professional Excellence in Visualizing Research, Tufts University, 2011**



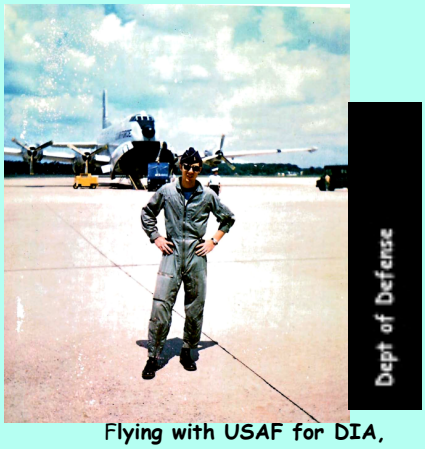
Award-winning web site

. **for the book, *Astronomy: Universe at a Glance***
  - **Most Innovative New Textbook, Textbook Authors Association, 2016**

Award-winning movie

Public Service (partial listing)

- Science Advisory Committee, Hayden Planetarium, Boston Science Museum, 1975-82
- Committee on Academic Studies, Harvard Astronomy Dept., 1975-78; Chair, 1976-78
- Committee on Public Education, Harvard-Smithsonian Ctr for Astrophysics, Chair, 1978-82
- Commissioned officer, U. S. Air Force in conjunction with other government agencies, 1970-
- User's Committee, National Radio Astronomy Observatory, 1978-81
- NASA Science Working Group on Extraterrestrial Intelligence, 1979-90
- Bowdoin Prize (English Literature) Committee, Harvard University, 1979-82
- Harlow Shapley Visiting Professor, American Astronomical Society, 1979-83
- Science Advisor for PBS Television Series, "The Search for Solutions," 1980
- Committee on Public Education and Information, Amer. Institute of Physics, 1981-83
- Editorial Advisory Board, *Zygon: Journal of Religion and Science*, 1982-2004
- Educational Advisory Committee, American Astronomical Society, 1985-89
- Board of Editors, *World Futures: The Journal of General Evolution*, 1986-1998
- National Academy of Sciences Panel, "Benefits to the Nation," 1988-90
- National Science Foundation Advisory Committee, Educational Division, 1989
- Contributing Editor, *Air & Space Magazine*, Smithsonian Institution, 1989-1997
- Co-producer (with PBS's Maryland Public TV) "Starfinder" Television Series, 1990-91
- Science Advisory Board, Merck Inst. for Science Education, Merck & Company, 1992-98
- Host, Wright Lectures on Cosmic Evolution, Boston Museum of Science, 1993-2005
- Visiting Scholar and National Lecturer, Phi Beta Kappa, 1995-96
- Board Member, Foundation For the Future, 1997-2010
- Co-writer (with B. Silleck), "Cosmic Voyage," an IMAX educational film, 1996
- Co-producer (with Jon Palfreman), "Cosmic Origins," educational film, 2000
- Board of Overseers, Boston Science Museum, 2001-07
- Co-producer/writer (with Dana Berry), “Arrow of Time,” an education film, 2007
- Board Member, International Big History Association, 2011-2014
- Thermodynamic, Disequilibrium, & Evolution Focus Group, NASA, 2010-



Flying with USAF for DIA, at Mildenhall RAF, UK, 1970s

Negotiating in the Soviet Union in the 1980s

UNESCO meetings, Paris, early 21st century

Some Recent Videoed Talks

Donaldson Lecture, Memphis, 2016
https://www.youtube.com/watch?v=uLtJyg_f3B0

WGBH Forum, Boston, 2014
http://forum-network.org/lectures/evolution-cosmos

Harvard Faculty Insight, Cambridge, 2014
https://www.youtube.com/watch?v=ChAmeRD3b-I&t=5s

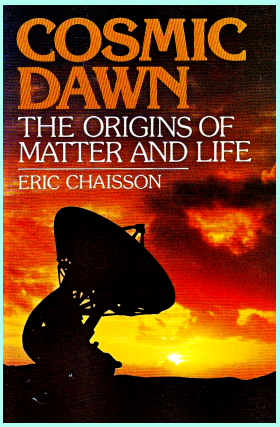
Library of Congress, Washington, 2014 [video excerpt 0:48 – 1:15]
http://www.loc.gov/today/cyberlc/feature_wdesc.php?rec=6578

Global Forum 2045, Moscow, 2014
https://www.youtube.com/watch?v=jbXzmPWCMIM

Typical physics colloquium, Dartmouth College, 2012
https://www.youtube.com/watch?v=NI9W8-DPBag

Typical public talk, Villanova University, 2015
https://youtu.be/Troj1savkLI

Books Published



COSMIC DAWN: The Origins of Matter and Life
302 pgs and 60 figs
Illustrated by Lola Judith Chaisson
Originally published by Atlantic Monthly Press, distributed by Little, Brown, Boston, 1981
Published in paperback by W.W. Norton, New York, 1989
Translated into nine foreign languages
Awards: Phi Beta Kappa Prize, 1982
American Institute Physics Award, 1982
National Book Award Finalist, 1982
Available in paperback from iUniverse.com, 2000
Revised and updated as *Epic of Evolution*, 2006, see below

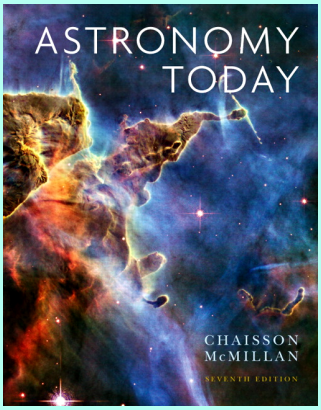
LA RELATIVITA
64 pgs and 80 figs; Gruppo Editoriale Fabbri, Milan, 1983

***THE INVISIBLE UNIVERSE: Probing the Frontiers of Astrophysics* (with G.B. Field)**
220 pgs and 52 figs
Illustrated by Thomas Stephenson
Originally published by Birkhauser-Boston, 1985
Translated into three foreign languages
Available in paperback from Vintage Press, distributed by Random House, 1987

THE LIFE ERA: Cosmic Selection and Conscious Evolution
261 pgs and 42 figs
Illustrated by Lola Judith Chaisson
Originally published by Atlantic Monthly Press, New York, 1987
Published in paperback by W.W. Norton, New York, 1989
Available in paperback from iUniverse.com, 2000

RELATIVELY SPEAKING: Black Holes, Relativity, and Fate of the Universe
255 pgs and 86 figs
Illustrated by Lola Judith Chaisson
Originally published by W.W. Norton, New York, 1988
Translated into three foreign languages
Available in paperback from W.W. Norton, New York, 1989

UNIVERSE: An Evolutionary Approach to Astronomy
604 pgs and 520 figs, Prentice-Hall, Englewood Cliffs, 1988



***ASTRONOMY TODAY* (co-authored with Steve McMillan)**
704 pgs and 950 figs (1st edition, 1993)
623 pgs and 920 figs (2nd edition, 1996)
660 pgs and 760 figs (3rd edition, 1999)
757 pgs and 810 figs (4th edition, 2002)
764 pgs and 820 figs (5th edition, 2005)
812 pgs and 834 figs (6th edition, 2008)
727 pgs and 790 figs (7th edition, 2011)
749 pgs and 805 figs (8th edition, 2014)
767 pgs and 844 figs (9th edition, 2018)

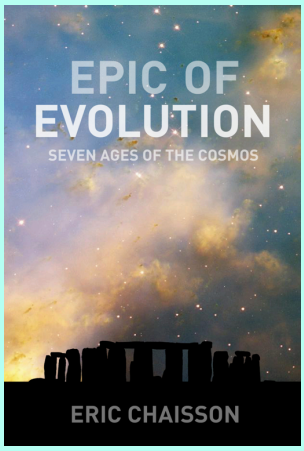
Pearson Education, London / Addison-Wesley, San Francisco

ASTRONOMY: A Beginner's Guide to the Universe **(co-authored with S. McMillan)**
478 pgs and 740 figs (1st edition, 1995)
404 pgs and 722 figs (2nd edition, 1998)
470 pgs and 735 figs (3rd edition, 2001)
487 pgs and 730 figs (4th edition, 2004)
498 pgs and 742 figs (5th edition, 2007)
502 pgs and 745 figs (6th edition, 2010)
492 pgs and 737 figs (7th edition, 2013)
521 pgs and 740 figs (8th edition, 2017)
Pearson Education, London / Addison-Wesley, San Francisco

THE HUBBLE WARS: Astrophysics Meets Astropolitics in the Two-Billion Dollar Struggle over the Hubble Space Telescope
408 pgs and 132 figs
Originally published by HarperCollins, New York, 1994 (paperback, 1995)
Awards: American Institute of Physics Science Writing Award, 1995
New York Times **"best book of the year" category, 1995**
Available, updated and in paperback, Harvard Univ. Press, Cambridge, 1998

THE 13th LABOR: Improving Science Education**: A collection of essays from a workshop at the American Academy of Arts & Sciences (co-edited with Tae-Chang Kim), 182 pgs, Gordon & Breach Publishers, New York, Amsterdam, 1999**

COSMIC EVOLUTION: The Rise of Complexity in Nature
http://www.hup.harvard.edu/catalog.php?recid=27447
280 pgs and 32 figs
Illustrated by Lola Judith Chaisson
Harvard University Press, Cambridge, London, 2001
Available in paperback, Harvard University Press, 2003



EPIC of EVOLUTION: Seven Ages of the Cosmos
http://cup.columbia.edu/book/978-0-231-13560-3/epic-of-evolution
520 pgs and 74 figs
Illustrated by Lola Judith Chaisson
Columbia University Press, New York, 2006
Translated into several foreign languages
Award: Kistler Book Award, 2007
Available in paperback, Columbia University Press, 2007

ASTRONOMY: The Universe at a Glance **(co-authored with S. McMillan)**
306 pgs, 480 figs
Pearson Education, London, San Francisco, 2016
Award: Textbook Authors Assoc. Most Innovative New Textbook, 2016

Journal, General Articles

Chaisson, E. J. "Detection of an Unidentified Emission Feature in the Microwave Spectrum of W3A," *Astrophysical Journal*, 167, L61, 1971.

Chaisson, E. J. and Ball, J., "Radiofrequency Detection of an Anomalous Interstellar Recombination Line," *Astrophysical Journal*, 169, 495, 1971.

Dickinson, D. F. and Chaisson, E. J., "Search for Extragalactic Water Vapor," *Astrophysical Journal*, 169, 207, 1971.

Chaisson, E. J., "High Frequency Confirmation of a Radio Recombination Line from an HI Region," *Astrophysical Journal*, 170, 81, 1971.

Chaisson, E. J., "Atomic Hydrogen Observations toward W3," *Astronomy & Astrophysics*, 18, 149, 1972.

Chaisson, E. J. and Goad, L. E., "Measurement of Fractional Ionization of Interstellar Hydrogen toward K3-50," read at 136th AAS Meeting, San Juan, Dec. 1971; *Bulletin American Astronomical Society*, 3, 471, 1971.

Chaisson, E. J. and Goad, L. E. "Low-Energy X-rays Ruled Out as Interstellar Ionizing Mechanism toward K3-50," *Astrophysical Journal*, 171, L61, 1972.

Papadopoulous, G., Lo, K. Y., Rosencranz, P., and Chaisson, E. J., "Observations of Recombination Lines at Ku Band," *Astrophysical Letters*, 10, 89, 1972.

Chaisson, E. J., Black, J. H., Dupree, A. K., and Cesarsky, D., "Detection of Interstellar Recombination Lines from Emitters of Intermediate Mass," *Astrophysical Journal*, 173, L131, 1972.

Chaisson, E. J., "Microwave Observations of a Partially Ionized Interstellar Cloud," *Nature Physical Science*, 239, 83, 1972.

Goad, L. E. and Chaisson, E. J., "Observations of Radio Recombination Lines in Planetary Nebulae," *Eighteenth International Astrophysical Symposium*, Liege, Belgium, V, 115, 1973.

Chaisson, E. J., "Microwave Spectroscopic Mapping of Gaseous Nebulae; I. Excited Hydrogen, Helium and Carbon in Orion B," *Astrophysical Journal*, 182, 767, 1973.

Lada, C. J. and Chaisson. E. J., "Microwave Spectroscopic Mapping of Gaseous Nebulae; II. Observations of Hydrogen in NGC 7538," *Astrophysical Journal* , 183, 479. 1973.

Chaisson, E. J., "Microwave Spectroscopic Mapping of Gaseous Nebulae; III. Hydrogen, Helium and Carbon in Orion A," *Astrophysical Journal*, 186, 545, 1973.

Chaisson, E. J., "Microwave Spectroscopic Mapping of Gaseous Nebulae; IV. Excited Hydrogen in Sagittarius B2," *Astrophysical Journal*, 186, 555, 1973.

Chaisson, E. J. and Dickinson, D. F., "OH in the Hoffman Infrared Sources," *Astrophysical Letters*, 12, 119, 1972.

Chaisson, E. J., "A Recombination-Line Study of the Sagittarius B2 Radio Complex," read at 138th AAS Meeting, East Lansing, Aug. 1972; *Bulletin Amer. Astr. Soc.*, 4, 317, 1972.

Lada, C. J., and Chaisson, E. J., "Microwave Spectroscopic Mapping of NGC 7538," read at 138th AAS Meeting, East Lansing, Aug. 1972; *Bulletin Amer. Astr. Soc.*, 4, 319, 1972.

Dent, W., Kapitzky, J., Leslie, B., Kojoian, G., Meeks, L. M., Danforth, H., Kollasch, J. J., Chaisson, E. J., Dickinson, D. F., Goad, L. E., and Lada, C. J., "15.5-GHz Observation at the Haystack Observatory of the Cygnus X-3 Outburst," *Nature Physical Science*, 239, 126, 1972

Dickinson, D. F. and Chaisson, E. J., "Long-Period Variables: Correlation of Stellar Period with OH Radial Velocity Pattern," *Astrophysical Journal*, 181, L135, 1973.

Chaisson, E. J., "A Correlation Study of Carbon Emission Lines and Hydroxyl Absorption Lines Toward Galactic Nebulae," read at 139th AAS Meeting, Las Cruces, Jan 1973; *Bulletin American Astronomical Society*, 5, 22,1973.

Chaisson, E. J., "On the Recombination-Line Observations toward Supernova 3C391," *Astrophysical Journal*, 189, 69, 1974.

Chaisson E. J., "Correlation Study of Carbon Ions and Hydroxyl Molecules toward Galactic Nebulae," *Astronomical Journal*, 79, 555, 1974.

Chaisson. E. J. and Lada, C. J., "Recombination Lines from HI Gas toward Orion A," *Astrophysical Journal*, 189, 227, 1974.

Sistla. G., Kojoian, G., and Chaisson. E. J., "Radio Continuum Measurements of Planetary Nebulae at 15.5 GHz," *Astrophysical Journal*, 192, 165, 1974.

Chaisson. E. J., "High-Frequency Observations of Possible 'Heavy Element' Recombination Lines," *Astrophysical Journal*, 191, 411, 1974.

Chaisson. E. J., "Heavy-Element Recombination Lines," read at 141st AAS Meeting, Tucson, Dec. 1973; *Bulletin American Astronomical Society*, 5, 451, 1973.

Sistla, G., Kojoian, G. and Chaisson, E. J. "Microwave Measurements of Planetary Nebulae," read at 141st AAS Meeting, Tucson, Dec. 1973; *Bulletin American Astronomical Society*, 5, 424, 1973.

Black, J. H., Chaisson, E. J., Ball, J. A., Penfield, H. and Lilley, A. E., "Radiofrequency Emission from CH in Comet Kohoutek (1973f)," Int. Astr. Union Circ. No. 2621, 18 Jan 1974; *Astrophysical Journal*, 191, L45 1974.

Beichman, C. A. and Chaisson, E. J., "Possible Evidence for a Large Magnetic Field in the Orion Infrared Nebula," *Astrophysical Journal*, 190, L21, 1974.

Lada, C. J. and Chaisson, E. J., "Observations of Formaldehyde toward M17," *Astrophysical Journal*, 195, 367, 1975.

Dickinson, D. F. and Chaisson, E. J., "An OH Survey of the Hoffmann λ100-micron Sources," *Astronomical Journal*, 79, 938, 1974.

Chaisson, E. J., Ingalls, R. I., Rogers, A.E.E., and Shapiro, I.I., "An Upper Limit on the Radar Cross-Section of Comet Kohoutek," *NASA-MSFC Proceedings of Comet Kohoutek Workshop*, NASA SP-355, p.I89, 1975; *Icarus*, 24, 188, 1975.

Black, J. H., Chaisson. E. J., Ball, J. H., Penfield, H. and Lilley, A. E., "λ 9-cm CH Emission in Comet Kohoutek (1973f)," *NASA-MSFC Proceedings of Comet Kohoutek Workshop*, NASA SP-355, p.I35, 1975.

Chaisson, E. J. and Beichman, C. A., "Magnetism In Dense Interstellar Clouds," read at 143rd AAS Meeting, Rochester, June 1974; *Bulletin American Astronomical Society*, 6, 336, 1974.

Willson, R. F. and Chaisson, E. J., "Radiofrequency Observations of the Trifid Nebula," read at 143rd AAS Meeting, Rochester, June 1974; *Bulletin American Astronomical Society*, 6, 350, 1974.

Chaisson, E. J. and Beichman, C. A., "Further Evidence for Magnetism in the Orion Region," *Astrophysical Journal*, 199, L39, 1975.

Chaisson, E. J. and Willson, R. F., "A Microwave Investigation of the Trifid Nebula and Its Surrounding Environment," *Astrophysical Journal*, 199, 647, 1975.

Chaisson, E. J., "On Nebular Non-equilibrium Thermodynamics," read at Union of International Radio Scientists Meeting, Boulder, 1974.

Chaisson, E. J., Review of *Molecules in the Galactic Environment*, M.A.Gordon & L.E.Snyder (eds.), 475 pp, Wiley, 1973; appeared in *Physics Today*, pg 74, January, 1975.

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**Chaisson, E.J., "The Natural Science Underlying Big History,"
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Current Teaching

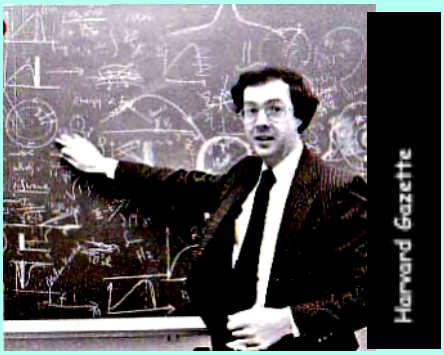
This is the syllabus of the course that Eric Chaisson is teaching at Harvard (spring term):

Astro E-8 COSMIC EVOLUTION: Origins of Matter and Life

Instructor: Dr. Eric J. Chaisson, Harvard-Smithsonian Center for Astrophysics

Meets Wednesdays, 7:45 - 9:45pm, Harvard College Observatory, 60 Garden St., Phillips Auditorium, Bldg D, across from Radcliffe Quad.

***Course Abstract*: Evolution of the Universe, from its beginning in a cosmic expansion to the emergence of life on Earth and possibly other planets. Big-bang cosmology, origin and evolution of galaxies, stars, planets, life, and society. Scientific discussion of Nature writ large, from quarks to quasars, microbes to minds. Materials largely descriptive, based on insights from physics, astronomy, geology, chemistry, biology, and anthropology.**



***Course Description*: This broad survey course combines the essential ingredients of astrophysics and biochemistry to create an interdisciplinary synthesis called "cosmic evolution." Directed mainly toward non-science students, the course addresses, from a scientific viewpoint, some of the time-honored philosophical issues including who we are, whence we've come, and how we fit into the cosmic scheme of things. Our primary goal is to gain an appreciation for the origin of matter and the origin of life, while seeking unification throughout the natural sciences.**

The course divides into three segments:

- **Part I (~10% of the course) introduces some basic concepts, notably those scientific principles needed for the remainder of the course.**
- **Part II (~ 40%) is heavily astronomical, using the concept of space to describe the many varied objects populating the Universe, from nearby planets to distant galaxies; this *spatial theme* serves as an inventory, explicating known material systems throughout the cosmos.**
- **Part III (~ 50%) uses the concept of time to sketch the central ideas of cosmic evolution—including physical, biological, and cultural evolution—employing a *temporal theme* to describe how matter and life have changed throughout eternity. Indeed, change—*i.e.*, evolution generally—is the hallmark for the emergence of all things, including galaxies, stars, planets, life, and society.**

Throughout the course, we shall concentrate on the formation, maintenance, and destiny of all types of known objects—large and small, near and far, past and future. We shall study in some

depth, among other things, the early Universe, active galaxies, black holes, relativity theory, 4-dimensional cosmology, the origin and evolution of stars and planets, as well as the onset of life, intelligence, and civilization, including prospects for extraterrestrial life on alien worlds. These and other related topics are probed to the extent needed to sketch the broadest view of the biggest picture: the newly emerging scientific philosophy of cosmic evolution.

***Course Prerequisite*: Persistent curiosity. (High-school mathematics also useful.)**

***Course Requirements*:**

- **A mid-term exam and a final exam, both generally requiring short paragraph answers. Each exam counts toward $^1/_3$ of the final grade.**

- **An 8-page (10-page maximum) term paper, typewritten, double-spaced, counts toward $^1/_3$ of the final grade. This paper should not be a book review or technical rehash of some known scientific topic. Rather, it should be a concise, high-quality, analytical, yet non-mathematical treatment of any of the wide-ranging, preferably unsolved, subjects addressed in this course. Once a topic has been chosen, students should read carefully and evaluate critically competing arguments in the literature. *Come to your own conclusion and support it.* Paper topics not covered in the course must be approved by the instructor. Papers are due on the penultimate day of class. There will be no extensions. Late papers will be penalized one letter grade per 24-hour interval beyond the deadline.**

***Section Meeting*: An optional period—"the third hour"—for discussion and clarification of course material will be held after each class, 9:45 -- 10:30 pm.**

***Web Sites*: Three Web sites are specifically relevant to this course:**

- **This web site pertains to the course per se and includes a copy of this syllabus, course assignments, and other information pertinent to the administration of the course:** https://canvas.harvard.edu/courses/8131

- **This web site is closely tied to the main textbook for this course, offering much additional material not found in the printed text—images, animations, software, and self-help sections. Access to this site, *which is optional in this course*, may cost money depending upon when/where/how you purchased your textbook; follow the instructions at the front of your textbook to find or purchase an access code, then browse:** http://www.masteringastronomy.com

- **This web site contains material directly related to the interdisciplinary subject of cosmic evolution; it is *required* for Part III of the course and free of charge:** https://www.cfa.harvard.edu/~ejchaisson/cosmic_evolution/docs/splash.html

***Instructor's Coordinates*: Eric Chaisson can be reached via any of these routes:**

email: ejchaisson@cfa.harvard.edu
chaisson@fas.harvard.edu
phone (cell): 978.505.2667
internet: http://www.cfa.harvard.edu/~ejchaisson
paper: Harvard College Observatory, Bldg. A, MS-10
60 Garden St., Cambridge, MA 02138 USA

Calendar of Course Events

Date	Topic	Readings
27 January	Course Overview: An Interdisciplinary Approach	1 AG; (Pro CE)
I. The Introductory Part: The Essentials		
03 February	Radiation and Spectroscopy: Basic Physics	2 AG
10	Telescopes and Geometry: Basic Tools	2 AG
II. The Descriptive Part: A Spatial Theme		
17	The Solar System: Our Home in Space	3,4,5,6 AG
24	Sun: Our Parent Star	8 AG
02 March	Stars: Red Giants and White Dwarfs	9 AG
09	Galaxies: The Grand Assemblages	13,14 AG
16	--- Spring Break ---	
23	--- Mid-term Exam ---	
III. The Evolutionary Part: A Temporal Theme		
30	Universe: Relativity and Cosmology	15 AG; (Pro EE)
06 April	Particulate, Galactic, & Stellar Evolution	10,11 AG; 1,2 W (1,2 CE; 1-3 EE)
13	Planetary Evolution: Birth of Elements & Earth	7,12 AG; 3,4 W (Intro CE; 4 EE)
20	Chemical Evolution: Origin of Life	5 W (3 CE; 5 EE)
27	Biological & Cultural Evolution: Onset of Humans	6,7 W (Discn CE; 6,7 EE)
04 May	Future Evolution: Extraterrestrial Life	8 W; Epi AG (Epi CE; Epi EE)
11	--- Final Exam ---	

Required readings are taken from:

AG = Chaisson & McMillan, *ASTRONOMY: The Universe at a Glance*, Pearson, 2016
W = web site, version 7, *Cosmic Evolution: From Big Bang to Humankind*, 2013
https://www.cfa.harvard.edu/~ejchaisson/cosmic_evolution/docs/splash.html

Optional readings (in parentheses above and only recommended) are taken from:
EE = Chaisson, *EPIC of EVOLUTION: Seven Ages of the Cosmos*, Columbia Univ. Pr., 2006

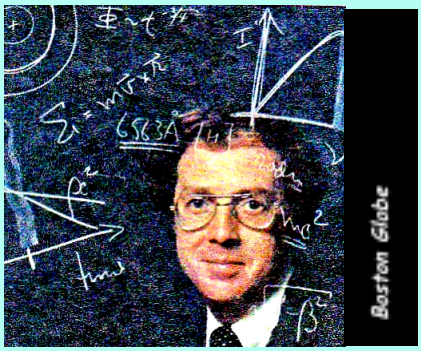
More technical readings (in parentheses above and meant for students who want to go beyond the level of this course) are taken from:
CE = Chaisson, *COSMIC EVOLUTION: Rise of Complexity in Nature*, Harvard Univ. Pr., 2001

Books AG, EE, and CE can be purchase in the Harvard Coop or elsewhere in the Square. All of them are also on reserve at Grossman Library in Harvard Yard.

Web site W is open access without password, free of charge.

Current Research

Eric Chaisson's current scientific research concerns the interdisciplinary subject of cosmic evolution—a grand synthesis of many varied changes from the big bang in the early Universe to humankind on Earth. He strives to use aspects of non-equilibrium thermodynamics to construct an all-inclusive scenario of evolution, broadly conceived, indeed applied to all known complex systems—physical, biological, and cultural. Some representative articles published during the past couple of decades along these lines include:



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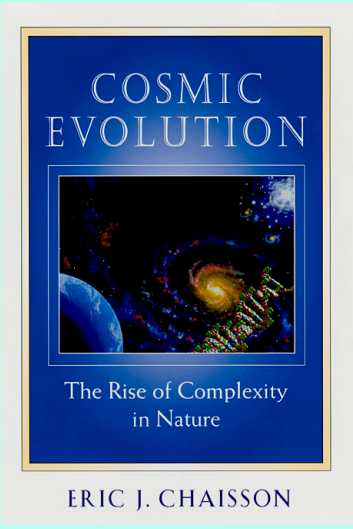
In addition, the interdisciplinary subject of cosmic evolution is addressed in a monograph, *COSMIC EVOLUTION: The Rise of Complexity in Nature* written under contract with Harvard University Press. What follows, by way of a brief description, is the book's reface (© President and Fellows of Harvard College):



www.hup.harvard.edu/catalog.php?isbn=9780674009875&content=reviews

Using astronomical telescopes and biological microscopes, among a virtual arsenal of other tools of high technology, modern scientists are weaving a thread of understanding spanning the origin, existence, and destiny of all things. Now emerging is a unified scenario of the cosmos, including ourselves as sentient beings, based on the time-honored concept of change. From galaxies to snowflakes, from stars and planets to life itself, we are beginning to identify an underlying, ubiquitous pattern penetrating the fabric of all the natural sciences—a sweepingly encompassing view of the order and structure of every known class of object in our richly endowed Universe. We call this subject "cosmic evolution."

Recent advances throughout the sciences suggest that all organized systems share generic phenomena characterizing their emergence, development and evolution. Whether they are physical, biological or cultural systems, certain similarities and homologies pervade evolving entities throughout an amazingly diverse Universe. How strong are the apparent continuities among Nature's historical epochs and how realistic is the quest for unification? To what extent might we broaden conventional evolutionary thinking, into both the pre-biological and post-biological domains? Is such an extension valid, merely metaphorical, or just plain confusing?

For many years at Harvard University, starting in the 1970s and continuing to the present, I have taught, initially with George B. Field, an introductory course on cosmic evolution that explores common denominators bridging a wide variety of specialized science subjects—physics, astronomy, geology, chemistry, biology, anthropology, among others. The principal aim of this interdisciplinary course creates a universal framework against which to address some of the most basic issues ever contemplated: the origin of matter and the origin of life, as well as how radiation, matter, and life interact and change with time. Our intention was to help sketch a grand evolutionary synthesis that would better enable us to understand who we are, whence we came, and how we fit into the overall scheme of things. In doing so, my students and I gained a broader, integrated knowledge of stars and galaxies, plants and animals, air, land, and sea. Of paramount import, we learned how the evident order and increasing complexity of the many varied, localized structures within the Universe in no way violate the principles of modern physics, which, prima facie, maintain that the Universe itself, globally and necessarily, becomes irreversibly and increasingly disordered.

Beginning in the late 1980s while on sabbatical leave at MIT, and continuing for several years thereafter while on the faculty of the Space Telescope Science Institute at Johns Hopkins University, I occasionally offered an advanced version of the introductory course. This senior seminar attempted to raise substantially the quantitative aspects of the earlier course, to develop even deeper insights into the nature and role of change in Nature, and thus to elevate the subject of cosmic evolution to a level that colleague scientists and intelligent lay persons alike might better appreciate. This brief and broadly brushed monograph—written mostly in the late 1990s during a stint as Phi Beta Kappa National Lecturer, and polished while resuming the teaching at Harvard of my original course on cosmic evolution--is an intentionally lean synopsis of the salient features of that more advanced effort.

Some will see this work as reductionistic, with its analytical approach to understand all material things. Others will regard it as holistic, with its overarching theme of the whole exceeding the sum of Nature's many fragmented parts. In the spirit of complementarity, I offer this work as an evolutionary synthesis of both these methodologies, integrating the deconstructionism of the former and the constructivist tendencies of the latter. Openly admitted, my inspiration for writing this book has been Erwin Schroedinger's seminal little tract of a half-century ago, *What is Life?,* yet herein to straighten and extend the analysis to include all known manifestations of order and complexity in the Universe. No attempt is made to be comprehensive in so far as details are concerned; much meat has been left off the bones. Nor is this work meant to be technically rigorous; that will be addressed in a forthcoming opus. Rather, the intent here is to articulate a skeletal précis—a lengthy essay, really—of a truly voluminous subject in a distilled and readable manner. To bend a hackneyed cliché, although the individual trees are most assuredly an integral part of the forest, in this particular work the forest is of greater import. My aim is to avoid diverting the reader from the main lines of argument, to stay focused on target regarding the grand sweep of change from big bang to humankind.

Of special note, this is not a New Age book with mystical overtones however embraced or vulgarized by past scholars, nor one about the history and philosophy of antiquated views of Nature. It grants no speculation on the pseudo-science fringe about morphic fields or quantum vitalism or interfering dieties all mysteriously affecting the ways and means of evolution; nor do

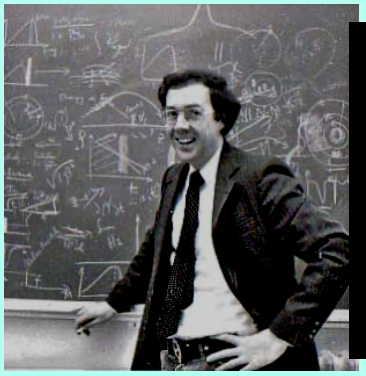
we entertain epistemological discussions about the limits of human knowledge or post-modernist opinions about the sociological implications of science writ large. This is a book about mainstream science, pure and simple, outlining the essence of an ongoing research program admittedly multidisciplinary in character and colored by the modern scientific method's unavoidable mix of short-term subjectivity and long-term objectivity.

In writing this book, I have assumed an undergraduate knowledge of natural science, especially statistical and deterministic physics, since as we shall see, much as for classical biological evolution, both chance and necessity have roles to play in all evolving systems. The mathematical level includes that of integral calculus and differential equations, with a smattering of symbolism throughout; the units are those of the centimeter-gram-second (cgs) system, those most widely used by practitioners in the field, editorial conventions notwithstanding. And although a degree of pedagogy has been included when these prerequisites are exceeded, some scientific language has been assumed. "The book of Nature is written in the language of mathematics," said one of my two intellectual heroes, Galileo Galilei, and so are parts of this one. Readers with unalterable math phobia will benefit from the unorthodox design of this work, wherein the "bookends" of Prologue-Introduction and Discussion-Epilogue, comprising more than half of the book, can be mastered without encountering much mathematics at all.

What is presented here, then, is merely a sketch of a developing research agenda, itself evolving, ordering and complexifying—an abstract of scholarship-in-progress incorporating much data and many ideas from the entire spectrum of natural science, yet which attempts to surpass scientific popularizations (including some of my own) that avoid technical lingo, most numbers, and all mathematics. As such, this book should be of interest to most thinking people—active researchers receptive to an uncommonly broad view of science, sagacious students of many disciplines within and beyond science, the erudite public in search of themselves and a credible worldview—in short, anyone having a panoramic, persistent curiosity about the nature of the Universe and of our existence in it.

Summary Abstract of This Work

The essence of this book outlines the grand scenario of cosmic evolution by qualitatively and quantitatively examining the natural changes among radiation, matter and life within the context of big-bang cosmology. The early Universe is shown to have been flooded with pure energy whose radiation energy density was initially so high as to preclude the existence of any appreciable structure. As the Universe cooled and thinned, a preeminent phase change occurred a few hundred centuries after the origin of all things, at which time matter's energy density overthrew the earlier primacy of radiation. Only with the onset of technologically manipulative beings (on Earth and perhaps elsewhere) has the energy density contained within matter become, in turn, locally dominated by the rate of free energy density flowing through open organic structures.



At ease at a blackboard, either researching or teaching . . . .

Using non-equilibrium thermodynamics at the crux, especially energy flow considerations, we argue that it is the contrasting temporal behavior of various energy densities that have given rise to the environments needed for the emergence of galaxies, stars, planets, and life forms. We furthermore maintain that a necessary (though perhaps not sufficient) condition—a veritable prime mover—for the emergence of such ordered structures of rising complexity is the expansion of the Universe itself. Neither demonstrably new science nor appeals to non-science are needed to explain the impressive hierarchy of the cosmic-evolutionary scenario, from quark to quasar, from microbe to mind.

Eric J. Chaisson, Concord, Massachusetts