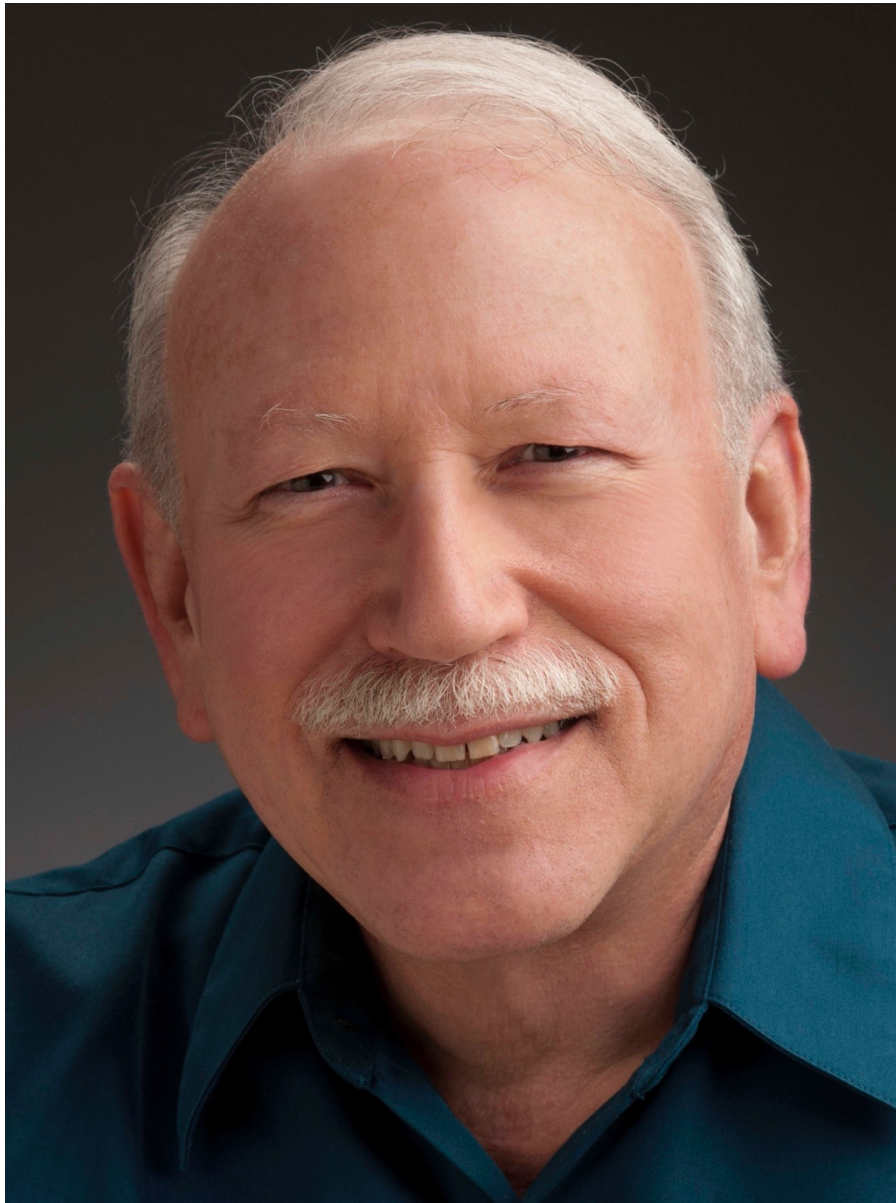




**Professor Joel Primack
Distinguished Professor of Physics Emeritus,
University of California, Santa Cruz
USA**

January 25, 2024

Dear selection committee members:

I am very pleased to nominate Joel Primack for the Albert Einstein World Award of Science. Joel is Distinguished Professor Emeritus of Physics at the University of California, Santa Cruz. He is a theoretical physicist with outstanding scientific accomplishments in several fields including particle physics, astrophysics, and cosmology. Prof. Primack has organized and led efforts to engage scientists in public policy, addressing global challenges with scientific principles and open-mindedness.

Among Prof. Primack's many scientific discoveries in physics and astrophysics, the development of the cosmological cold dark matter model stands out as a decades-long journey of creativity and collaboration. Prof. Primack and collaborators realized that gravitationally-interacting dark matter was responsible for galactic structure formation—the birth of astronomical structures as we see them today. A leap of inspiration led them to postulate that the lightest supersymmetric particles could comprise the bulk of dark matter, and this hypothesis is still being tested with collider experiments at CERN. Through the years, Prof. Primack has deployed all manner of analytical and computational approaches to matching the observed structure with simulated models of galactic evolution. Most recently, high-resolution hydrodynamic simulations have given dramatic visual impact to the cold dark matter model, which has become the modern cosmological standard model.

Prof. Primack has been recognized with several prestigious prizes for his scientific accomplishments and public communication. He was awarded the 2016 Leo Szilard Lectureship Award from the American Physical Society and the 2020 Lilienfeld Prize for “outstanding contributions to physics by a single individual who also has exceptional skills in lecturing to diverse audiences.” He received the 2024 Philip Hauge Abelson Prize from the American Association for the Advancement of Sciences, a prize awarded for significant contributions to the community through research and policy. In addition, Prof. Primack has given the Benjamin Dean Lecture at the California Academy of Sciences, the Lansdowne Lecture at the University of Victoria, the J. Robert Oppenheimer Memorial Lecture at Los Alamos, the Buhl Lecture at Carnegie Mellon University, and the Terry Lectures at Yale University.

Throughout his career, Prof. Primack initiated and led a number of public policy efforts to address urgent global challenges. He created the U.S. Congressional Science and Technology Fellowship program in 1972 to recruit scientists to serve in legislative offices. This program has been enormously successful in training more than 2000 alumni, some of whom have remained at the highest levels of government. He also organized the first American Physical Society studies of nuclear reactor safety and led the Federation of American Scientists Space Nuclear Power Arms Control project,

which helped to end nuclear-powered satellite programs. Prof. Primack initiated the AAAS Science and Human Rights program and worked with the U.S. Senate to create the National Science Foundation Science for Citizens Program. All of these efforts demonstrate a deep and long-lasting engagement with public policy from a scientific point of view.

Prof. Primack has continued to develop innovative scientific collaborations in a variety of topics. As high-performance computers became a powerful tool for complex simulations, he brought together computational physicists, machine learning experts, and theoretical astrophysicists to test the Λ CDM cold dark matter model. He led the University of California systemwide High-Performance AstroComputing Center and founded the UC Santa Cruz Astronomical Visualization Lab to focus on galaxy morphology. With colleagues from Google and Europe, he used deep learning techniques to enable “face recognition for galaxies,” making it possible to compare simulations with Hubble Space Telescope data. He continues to pursue creative approaches to these important science questions.

As an educator, Prof. Primack mentored more than 50 graduate student researchers and 10 postdoctoral researchers at UC Santa Cruz. Many of those scientists are now scientific leaders in their own right, at prestigious universities and research institutes. He developed public outreach communication programs for museums, planetariums, and television. The popular cosmology books he authored with Nancy Ellen Abrams have thoughtfully embraced the scientific worldview as a starting point for cultural understanding.

The Albert Einstein World Award for Science recognizes a rare blend of scientific achievement and leadership in addressing global challenges. Joel Primack has demonstrated this balance over a career of nearly 60 years, as he proposed creative solutions to particle physics and cosmology while leading a series of public policy science initiatives. He is an outstanding nominee for this award.

Sincerely,



Chancellor Cynthia K Larive
University of California, Santa Cruz

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SANTA CRUZ, CALIFORNIA 95064

SANDRA M. FABER
831 459-2991
faber@ucolick.org

January 22, 2024

To: The World Award of Science Selection Committee

Re: Recommendation letter for Prof. Joel R. Primack

Dear committee members:

I am extraordinarily pleased and honored to write this letter of recommendation on behalf of Prof. Joel R. Primack for the World Award of Science. The prize criteria require that the recipient have made significant contributions to science through ground-breaking, innovative, impactful personal research; leading international and interdisciplinary collaborations; and mentoring and training of the next generation of scientists. And finally, as if the above were not enough, a major contribution to solving the world's problems! What makes Joel Primack so exceptional is that he has in fact contributed strongly to *every one* of these areas.

Prof. Primack is widely regarded as one of the “founding fathers” of the Cold Dark Matter theory of galaxy formation. This theory was born from the convergence of four separate strands of research in the late 1970's and early 1980's. First was the realization that an inflating early Universe would naturally generate a spectrum of initial density fluctuations that could seed the growth of galaxies. Second was the realization (from astronomy) that most of the matter in the Universe is both weakly interacting and invisible (“dark”), a bizarre combination that normal matter does not satisfy. The third strand was that new particle physics theories implied the existence of new particles that would combine these two properties, but the masses of possible different candidates differed greatly. The final strand was the realization that the observed properties of galaxies and clusters of galaxies would depend on – and therefore might reveal – the nature of the dark-matter particle candidate.

By 1984, the astronomical evidence had ruled out light and intermediate-mass particles, leaving only very heavy particles (or alternatively, axions) as possibilities for dark matter. Such particles move slowly – and Joel himself coined the now universally-used term *cold* dark matter (CDM) to describe them. Acting as leader and overall scientific guide, Primack formed a small team which resulted in the paper known as Blumenthal, Faber, Primack, and Rees, *Nature*, 311, 517, 1984 (BFPR). Now cited more than 1500 times, BFPR was the first soup-to-nuts description of how density perturbations born in cosmic inflation and comprised of cold dark matter plus normal matter could explain the masses and sizes of galaxies and clusters of galaxies in the Universe on all scales. The theory quickly became the working paradigm for structure formation in cosmology and remains so today. Joel Primack was the driving force behind writing the original paper, was the one who understood the entire spectrum of necessary physics from inflation to galaxies, and made the lion's share of the intellectual contributions to it.

In leading BFPR, Joel became the sparkplug for a long-lived group of students and collaborators who wrote many of the subsequent fundamental papers on galaxy formation based on Cold Dark Matter. These include foundational papers on the structure of dark-matter haloes (Bullock et al., *Monthly Notices*, 321, 559, 2001, 2061 cites; Wechsler et al., *ApJ*, 2002, 568, 52, 1057 cites), the mass profiles of galaxies (Blumenthal et al., *ApJ*, 301, 27, 1986, 1136 cites; Flores et al., *ApJ*, 427, 1, 804 cites), and the role of mergers in shaping galaxy properties (Lotz et al., *ApJ*, 672, 177, 420 cites). His student Rachel Somerville wrote the Santa Cruz SAM, one of the most widely used semi-analytic codes for modeling galaxies (Somerville, *Monthly Notices*, 320, 504, 2001, 639 cites). With collaborator Klypin, Primack pioneered the Bolshoi-Planck N-body simulations of dark-matter clustering (Klypin et al., *ApJ*, 740, 102, 2011, 842 cites). Presently Joel is leading *Agora*, a collaboration of the world's major galaxy simulators who agreed to test their galaxy-formation codes by modeling the same galaxy starting with the same initial conditions. Senior group leaders were a bit reluctant to have their work put under the microscope this way, but the results – just now emerging – are going to provide invaluable insights into how much these much-used “hydro codes” can really be trusted.

Joel Primack has also been one of the most effective mentors in cosmology, and many of his students and postdocs have become leaders in the field. Advisee Bullock is now Dean of the School of Physical Sciences at UC Irvine, and advisee Wechsler is the director of the Kavli Institute for Particle Astrophysics and Cosmology at Stanford. Advisee Somerville leads the cosmology group at the Flatiron Institute in NYC. Postdoc Lotz was recently director of the Gemini Observatory and is now taking over as director of Space Telescope Science Institute. His most recent advisee Viraj Pandya is a Hubble Fellow at Columbia whose work with Primack on early “pickle-shaped” galaxies was recently featured on the front page of the *NY Times*.

With colleague Avishai Dekel, Primack has also hosted the Santa Cruz Galaxy Workshop at UCSC for the past two decades, which has consistently attracted leading cosmologists and their students from around the world. By providing continuity of focus over many years, this unique annual workshop has generated many of the leading ideas in galaxy evolution theory. Household words such as “galaxy compaction”, “cold streams”, and the “star-forming main sequence” have had their genesis here. The workshop is specifically aimed at junior scientists – the great majority of talks are given by students and postdocs, and many well known scientists got their start in its famously nurturing environment.

Beyond cosmology, Joel Primack has always been mindful of society's larger problems and the role that responsible physicists should play. He co-authored with Frank von Hippel the book *Advice and Dissent: Scientists in the Political Arena* (1974), and he worked with von Hippel and Senator Ted Kennedy to create the NSF Science for Citizens program. He helped initiate the American Physical Society (APS) program of studies on public policy issues in 1974 and co-authored with Freeman Dyson the proposal for the APS Nuclear Reactor Study. Primack helped organize the APS's Forum on Physics and Society, and he shared the 1977 Forum on Physics and Society Award with von Hippel.

In 1988, Primack led the Federation of American Scientists program on space nuclear reactor arms control and helped stop the launching of Soviet reactor-powered satellites. Primack started the program on Science and Human Rights at the American Association for the Advancement of Science (AAAS) and chaired the AAAS Committee on Science, Ethics, and Religion from 2000 to 2002. In 1995, he was made a Fellow of the AAAS “for pioneering efforts in the establishment of the AAAS Congressional Science Fellows Program and for dedication to

expanding the use of science in policymaking throughout government”. His role in establishing the Congressional Science and Technology Policy Fellowships was honored with the award of the APS Leo Szilard Lectureship in 2016.

Prof. Primack’s third passion is communicating the importance of cosmology to the general public. These efforts began when Joel teamed up with spouse Nancy Abrams to develop a novel course called “Cosmology and Culture” at UCSC, which they taught for over a decade. This course was the first, to my knowledge, that went beyond the nuts and bolts of modern cosmology to talk about *why this knowledge is important to humanity*. They argued that every culture’s origins story is actually intended as a moral blueprint for how the world “ought” to work. Far from being irrelevant, these stories set the stage for how a culture should behave, in relation to the world and to fellow human beings.

Highlighting the moral nuggets that are latent in modern scientific cosmology became a driving force behind Primack and Abrams’ subsequent work. Their two books *View from the Center of the Universe* and *The New Universe and the Human Future: How a Shared Cosmology Could Transform the World* argue that, far from being insignificant, our beautiful planet Earth may be unique in the Universe, or at least very rare. From that may grow the compulsion to preserve it, which is really the root of the environmental movement. Also important is the notion that we arrived here by the laws of physics and must live by them – no miracles will intervene to save our planet if we destroy it. These books have been extremely well received, and the authors have lectured at Yale, the Hebrew University in Jerusalem, and numerous other academic institutions.

To my knowledge, this body of thought by Primack and Abrams is the first to attempt to draw moral lessons from the laws of physics and astrophysics. Though not yet translated into specific policies, their work argues that modern cosmological knowledge *is in fact the basis of all environmental policy*, and as such needs to be *the* indispensable guide to planning Earth’s future over coming decades.

To summarize, Joel Primack’s remarkable career has touched every base and sounded every note that is mentioned in the criteria for awarding the World Award of Science – originality, impact, interdisciplinary synthesis, leadership, sustained focus, and concern for the most important problems facing humanity. I urge you to recognize his outstanding contributions with this incredibly well deserved award.

Sincerely yours,

A handwritten signature in black ink, appearing to read "SM Faber". The signature is fluid and cursive, with the first letters of the first and last names being capitalized and prominent.

Sandra M. Faber
Professor Emerita of Astronomy and Astrophysics, University of California, Santa Cruz
Astronomer Emerita, University of California Observatories
University Professor, University of California



19 January 2024

Supporting Nomination: Prof. Joel Primack for Albert Einstein World Award of Science

I am not well credentialed to judge Joel Primack's contributions to astrophysics. However, like Albert Einstein, Primack has been engaged with public affairs and I can testify to his impact.

Specifically, a half century ago, Primack initiated the creation of the Science and Technology Policy Fellowships, which today enable hundreds of scientists and engineers each year to spend a year advising the United States Government's Congressional and Executive Branches. Some return to academia and industry but many stay in government, thereby upgrading the US Government's capacity to promote beneficial uses of science and technology and to mitigate adverse impacts.

I am familiar with Primack's impacts because, when he was a physics graduate student and I was an Assistant Professor of physics at Stanford in 1969-70, during the Vietnam War, Primack organized a year-long student workshop of the role of science advising. He invited me to be the faculty advisor for that workshop during the spring of 1970. The workshop inspired me to go into policy myself and later found Princeton University's Program on Science and Global Security, which has had a number of impacts, including working with Gorbachev's science advisors to end the Cold War nuclear arms race. Primack and I also co-authored, *Advice and Dissent: Scientists in The Political Arena* (Basic Books and New American Library, 1974).

The most important impact of the workshop, however, was in proposing Congressional Science Fellowships. Primack took that proposal to the American Physical Society and the American Association for the Advancement of Science (AAAS) and they each created a fellowship. This inspired other societies to do the same, and that inspired the Executive Branch to follow suit. Today [24 US science and engineering societies](#) sponsor Congressional Fellowships and four sponsor Executive Branch Fellowships,. In addition, [Executive Branch agencies sponsor more than 150 fellowships](#) that are administered by the AAAS. A class photo of the 2023-24 fellows may be seen [here](#). In the [timeline](#) for the AAAS program, there is an item at 1972:

"DR. JOEL PRIMACK URGES CREATION OF A FELLOWSHIP PROGRAM. Dr. Joel Primack, a University of California at Santa Cruz physics professor and member of several AAAS committees, played a key role in urging AAAS to establish a congressional fellowship program. During the Stanford Workshops on Political and Social Issues in 1969 and 1970, participants addressed the role of scientists and engineers in advising the government. Along with a questionnaire sent to Congress, Dr. Primack and others recommended the creation of a congressional internship program..."

Sincerely yours,

Frank N. von Hippel, Professor of Public and International Affairs and Senior Research emeritus, Princeton University, fvhippel@princeton.edu

**Joel R. Primack, Distinguished Professor of Physics Emeritus
University of California, Santa Cruz**

Scientific contributions

- First modern theory of **nuclear fission** (Primack, PRL 1966)
- First calculation of the **mass of the charmed quark** (1973),
- Creation of the modern cosmological standard model, **Λ CDM** (1983)
- Analysis of **dark matter halo assembly history** in structure formation (2002)
- Comparison of high-resolution ***Bolshoi* cosmological simulations** with observations (2011)
- **“Face recognition for galaxies”** - using deep learning to compare simulations with Hubble Space Telescope observations (2018)
- Effect of varying **radiogenic heating of rocky planets** on planetary habitability (2020)

Contributions to solving global challenges

- Founder of **Congressional Science and Technology Fellowship Program** for the American Association for the Advancement of Science and the American Physical Society (1973). More than 2000 scientists have passed through this program and engaged with complex policy issues in the U.S. government.
- Initiated APS studies on public policy: **nuclear reactor safety** (1972)
- Initiated **AAAS Science and Human Rights program** (1976)
- Founded **NSF Science for Citizens Program** (1977)
- Federation of American Scientists **Space Nuclear Power Arms Control project** (1987-89)

International recognition

- Senior Award of the Alexander von Humboldt Foundation, 1999
- 2016 APS Leo Szilard Lectureship Award
- 2020 APS Julius Edgar Lilienfeld Prize
- 2024 AAAS Philip Hauge Abelson Prize

Leadership in the scientific community through collaboration

- President of **Sigma Xi scientific honorary** (2018-2019)
- Director of University of California High-Performance AstroComputing Center (**UC-HiPACC**) (2010-2015)
- Initiated and leads **Assembling Galaxies of Resolved Anatomy** (AGORA) project (2014-)
- Founder and host of the annual **Santa Cruz Galaxy Workshop**
- Chair, **APS Forum on Physics and Society** (2005 and 2019)

Educational contributions

- Mentored **50 graduate student researchers** and **10 postdoctoral researchers**
- **Public lectures and multimedia presentations on modern cosmology and its implications for society and the environment**

Joel Primack

Distinguished Professor of Physics Emeritus, University of California, Santa Cruz

Cell: (831) 345-8960; Office Phone: (831) 459-2580, Fax: -3043; Home (831) 425-1194; Email: joel@ucsc.edu

Education: Princeton University A.B. 1966 Physics (Summa cum Laude, Valedictorian); Stanford University PhD 1970 Physics

Academic Positions: Junior Fellow, Society of Fellows, Harvard University 1970-73. Assistant Professor of Physics, UCSC 1973-1977; Associate Professor of Physics, UCSC, 1977-1983; Professor of Physics, UCSC 1983-present; Distinguished Professor 2007-; Emeritus 2014-. Chair, UCSC Committee on Educational Policy, 1992-94; Chair, UCSC Committee on Computing and Telecommunications, 2008- 2011; Chair, University Committee on Computing and Communications, 2010-12; Director, University of California systemwide High-Performance Astro-Computing Center (UC-HiPACC), 2010-2015, including organizing annual AstroComputing Summer Schools. Hosting the annual **Santa Cruz Galaxy Workshop**, a major international meeting.

Honors (partial list): A. P. Sloan Foundation Research Fellowship, 1974-1978
American Physical Society Forum on Physics and Society Award, 1977; APS Fellow, 1988
American Association for the Advancement of Science (AAAS), Fellow, 1995
Senior Award of the Alexander von Humboldt Foundation, 1999
California Academy of Sciences, Fellow, 2009
Spirit of Rustum Roy Award, Chopra Foundation, 2012
Leo Szilard Lectureship Award of the American Physical Society, 2016
President, Sigma Xi (Scientific Research Honor Society), 2018-19
American Physical Society Julius Edgar Lilienfeld Prize, 2020
AAAS Philip Hauge Abelson Prize, 2024

Advice (partial list): SAGENAP advisory panel to DOE/NSF 2000-2001; NSF Astronomy Theory Review Panel 2000; DOE Lehman Review of SNAP Proposal 2001; Chair, NASA Cosmology panel on LTSA and ADP 2001; Cosmology Panel, Hubble Space Telescope Time Allocation Committee 2003, 2017; National Academy Beyond Einstein panel, 2006-07; National Academy Review of NASA Technology Roadmap, 2010-11.

American Physical Society activities (partial list): Executive Committee, APS Division of Astrophysics, 2000-2002; APS Panel on Public Affairs (POPA) 2002-2004; Chair, POPA Task Force on Moon-Mars Program and Funding for Astrophysics 2004; Chair, APS Forum on Physics and Society 2005 and 2019; Chair, APS Sakharov Prize committee 2009

Outreach (partial list): Smithsonian National Air and Space Museum, Advisory Committee on *Cosmic Voyage* IMAX film, 1994-1996. Co-organizer, "Cosmic Questions" Conference, Smithsonian Museum of Natural History, Washington, DC, April 14-16, 1999. Over 100 public lectures on galaxies and cosmology, including Lansdowne Lecture, University of Victoria (September 2004); Halliday Lecture, UCSC (March 2006, with Nancy Abrams); Frontiers of Science Lecture, University of Utah (April 2006, with Nancy Abrams); Sackler Lecture, UC Berkeley (May 2006, with Nancy Abrams); NASA Ames Directors Colloquium (October 2006, with Nancy Abrams); J. Robert Oppenheimer Memorial Lecture, Los Alamos (July 2007); Banquet Lecture, APS Division of Plasma Physics, Orlando, FL (November 2007); APS Annual Meeting Public Lecture, St. Louis Science Center (April 2008, with Nancy Abrams); Buhl Lecture, Carnegie-Mellon University (April 2008); Banquet Lecture, U. S. Army Science Conference, Orlando, FL (December 2007, with Nancy Abrams); Dwight H. Terry Lectureship, Yale University (four lectures over two weeks in October 2009, with Nancy Abrams); Supercomputing the Universe (Keynote talk, Vail Computer Elements Conference, June 2013); Distinguished Lecture, Scientific Computing and Imaging (SCI) Institute, University of Utah (April 2016); Talks at Google: New Insights on Galaxy Formation (May 2017); UCSC Emeriti Research Lecture (November 2020); Golden Webinar in Astrophysics (April 2021). TV documentaries including [Inside the Milky Way](#). Help with Adler, Hayden, and Morrison Planetarium Shows.

Books

- Joel R. Primack and Frank von Hippel, *Advice and Dissent: Scientists in the Political Arena* (New York: Basic Books, 1974; New American Library, 1976) http://physics.ucsc.edu/~joel/Advice_and_Dissent.pdf
- Joel R. Primack and Nancy Ellen Abrams, *The View from the Center of the Universe: Discovering Our Extraordinary Place in the Cosmos* (New York: Riverhead/Penguin, 2006; London: HarperCollins, 2006; Paris: Laffont, 2008; and other foreign editions) <http://viewfromthecenter.com/>
- Nancy Ellen Abrams and Joel R. Primack, *The New Universe and the Human Future: How a Shared Cosmology Could Transform the World* (Yale University Press, 2011; Barcelona: Antoni Bosch, 2013) <http://new-universe.org/>; <http://www.el-nuevo-universo.com/>

Papers Over 500 scientific papers, >56,000 citations, h-index = 104 (Google Scholar); plus many popular articles in *American Scientist*, *IEEE Spectrum*, *Scientific American*, *Science*, *Sky & Telescope*, etc.

Primack's undergraduate senior thesis first applied modern nuclear physics theory to nuclear fission (Primack 1966). His graduate and post-graduate research was on particle physics, including papers with Brodsky on composite particles, and papers on what is now known as the standard model of particle physics. Lee, Primack, and Treiman 1972 calculated the mass of the charm quark, in agreement with the discovery of the J/ψ in 1974.

Primack is best known for helping to create the modern cosmological standard model, Λ CDM. He was the first to propose that the lightest supersymmetric partner particle is a natural candidate for the dark matter particle (Pagels & Primack 1982), which led to warm dark matter (Blumenthal, Pagels, Primack 1982) and then **cold dark matter** (Primack & Blumenthal 1983; Blumenthal, Faber, Primack, Rees 1984; Primack 1984). Subsequent work:

- **baryonic contraction of dark matter galactic halos** (Blumenthal, Faber, Flores, & Primack 1986)
- **how to discover dark matter** (Primack, Seckel, & Sadoulet, Annual Rev. Nuclear & Particle Science 1988)
- calculations of **linear power spectra for many CDM variants** (John Holtzman's 1989 dissertation based on Blumenthal & Primack 1983 code, and comparison with observations Holtzman & Primack 1993)
- **dynamical effects of a cosmological constant**, including on the growth rate of structure (Lahav, Lilje, Primack, & Rees 1991)
- **cosmological structure formation simulations** on CDM variants Cold + Hot Dark Matter (Klypin et al. 1993, Primack et al. 1995) and LCDM (Klypin, Primack, & Holtzman 1996) **compared with observations**
- **conflicts between steep central dark matter halo profiles in dark matter simulations vs. observations** of dwarf galaxies and galaxy clusters (Flores & Primack 1994, based on Flores dissertation research with Primack)
- improvements in **semi-analytic modeling of the galaxy population** (Rachel Somerville's thesis paper Somerville & Primack 1999; also Somerville, Primack & Faber 2001 and many subsequent papers including Somerville et al. 2012, Gilmore et al. 2012, Porter et al. 2014ab, Brennan et al. 2015, Pandya et al. 2017)
- **semi-analytic modeling of damped Ly α systems** (Ari Maller's dissertation papers with Prochaska, Somerville, and Primack 2000-2002)
- **dark matter halo concentration evolution and angular momentum distribution** (Primack's grad student James Bullock's dissertation papers with Avishai Dekel, Anatoly Klypin, and Primack 2001)
- **dark matter halo assembly history and angular momentum evolution** (Primack's grad student Risa Wechsler's dissertation papers with Avishai Dekel, Anatoly Klypin, and Primack 2002)
- **halo occupation distribution and predicted evolution of the galaxy two-point correlation function** (Kravtsov et al. 2004), subsequently shown to have correctly predicted observed galaxy correlations
- **Gini-M20 non-parametric classification of galaxy images** (Lotz, Primack, & Madau 2004 and many subsequent papers, including observability timescales for indications of galaxy mergers (Lotz, Jonsson, Cox, and Primack 2008, 2011ab) used for measurement of **galaxy merger rates** compared with theory (Lotz et al. 2011)
- **shapes of dark matter halos** (Brandon Allgood's dissertation paper with Primack, 2006)
- the **Sunrise code for producing images from galaxy simulations** including the effects of stellar evolution and dust scattering, absorption, and re-emission of light (Patrik Jonsson's dissertation and postdoc research with Primack, 2002-2010; papers and MAST mock images with Greg Snyder and Raymond Simons, 2015-2024)

- comparing **extragalactic background light** from calculations with observations (Rudy Gilmore and Alberto Dominguez dissertation papers with Primack 2010, and many subsequent papers including Dominguez+2024)
- high-resolution ***Bolshoi* cosmological simulations compared with observations** (Klypin, Trujillo-Gomez, & Primack 2011, Trujillo-Gomez, Klypin, Primack, Romanowsky 2011, Prada et al. 2012, with analyses by Peter Behroozi, Mike Busha, Risa Wechsler et al. 2012, and the Klypin-Primack *Bolshoi-Planck* simulations 2016, Halo Demographics Rodriguez-Puebla et al. 2016, Galaxy-Halo Connection Rodriguez-Puebla et al. 2017)
- **high-resolution hydrodynamic cosmological galaxy simulations**, including roles of cold streams and violent disk instabilities, compared with HST CANDELS survey (papers with Daniel Ceverino, Avishai Dekel, Sandra Faber, Anatoly Klypin, Nir Mandelker, Sandro Tacchella, Matteo Tomassetti, Adi Zolotov, et al. 2010-)
- leadership of **AGORA** comparison of high-resolution cosmological galaxy simulations by leading codes
- discovery of and explanation for **prolate** (pickle-shaped) early-stage galaxies (Ceverino, Primack, Dekel 2015)
- **effect of varying radiogenic heating of rocky planets** on volcanic activity, magnetic field generation, and plate tectonics -- and therefore of planetary habitability (Nimmo, Primack+2020)
- **deep learning for galaxies**, papers published & in preparation in collaboration with Marc Huertas-Company, Dekel, and others comparing many features of simulated and observed galaxies, including **galaxy morphological evolution, compaction, and giant clumps** in star-forming galaxies

Leadership in creating new institutions Primack co-organized Stanford Workshops on Political and Social Issues (SWOPSI) in 1969, courses for credit that aim to change the world, a program that continued at Stanford for twenty years. Primack played the main role in starting the Congressional Science and Technology Fellowship Program of the American Physical Society (APS) and the American Association for the Advancement of Science (AAAS) in 1973, through which over 2000 scientists have now served on Congressional staffs. This has evolved into the AAAS Science and Technology Fellowship Program, which now places about 300 scientists each year in government internships. Primack co-organized the APS Forum on Physics and Society in 1972. In 1972, Primack proposed that APS conduct studies on public policy issues, including writing with Freeman Dyson the proposal for the first study, on nuclear reactor safety, and raising the funding for it. Primack initiated the AAAS Science and Human Rights program in 1976, including the Coalition on Science and Human Rights. Primack and Frank von Hippel worked with Senator Ted Kennedy to draft the legislation and organize the Congressional hearings for the NSF Science for Citizens Program, which was signed into law in 1977. In 1987-89 Primack initiated and led the Federation of American Scientists Space Nuclear Power Arms Control project, which helped to end the USSR's nuclear reactor powered ROSAT satellite program. Primack proposed the University of California High-Performance Astrocomputing Center (UC-HiPACC) and directed it 2010-2015, including organizing annual conferences and summer schools. In 2017 Primack was thanked by Space Telescope Science Institute (STScI) for proposing anonymous review of Hubble Space Telescope (HST) proposals, which led to anonymized proposals for STScI programs including HST and James Webb Space Telescope. This resulted in a higher fraction of successful proposals by women and young scientists, and proposals are now anonymous for many other NASA programs.

Innovations at UCSC For more than a decade Primack co-taught with Nancy Ellen Abrams the UCSC course Cosmology and Culture, which developed a new visual language for modern cosmology that provided the basis for our co-authored books and many public lectures. In teaching elementary physics, Primack pioneered at UCSC Harvard physicist Eric Mazur's *Peer Instruction*, also known as active learning and the flipped classroom. As chair of the UCSC and then the UC systemwide computer committee, Primack helped UC negotiate free access to non-advertising Gmail and Google documents for current students and faculty.

Joel R. Primack (with Google Scholar citation numbers, h-index: 104)

Ten Selected Papers (in chronological order)

Formation of galaxies and large-scale structure with cold dark matter 1984, *Nature* **311**, 517. Blumenthal, G. R., Faber, S. M., **Primack, J. R.**, Rees, M. J. (2446 citations as of January 2024)

Contraction of dark matter galactic halos due to baryonic infall 1986, *ApJ* **301**, 27. Blumenthal, G. R., Faber, S. M., Flores, R., **Primack, J. R.** (1515)

Dynamical effects of the cosmological constant 1991, *MNRAS* **251**, 128. Lahav, Ofer, Lilje, Per B., **Primack, Joel R.**, Rees, Martin J. (1010)

Observational and theoretical constraints on singular dark matter halos 1994, *ApJ* 427, 1. Flores, Ricardo A., **Primack, Joel R.** (1094) *

Semi-analytic modeling of galaxy formation: the local Universe 1999, *MNRAS* **310**, 1087. Somerville, Rachel S., **Primack, Joel R.** (1452) *

Profiles of dark haloes: evolution, scatter and environment 2001, *MNRAS* **321**, 559. Bullock, J. S., Kolatt, T. S., Sigad, Y., Somerville, R. S., Kravtsov, A. V., Klypin, A. A., **Primack, J. R.**, Dekel, A. (2624) *

A Universal Angular Momentum Profile for Galactic Haloes 2001, *ApJ* **555**, 240. Bullock, J. S., Dekel, A. Kolatt, T. S., Kravtsov, A. V., Klypin, A. A., Porciani, C., **Primack, J. R.** (1062) *

Concentrations of dark halos from their assembly histories 2002, *ApJ* **568**, 52. Wechsler, R. H., Bullock, J. S., **Primack, J. R.**, Kravtsov, A. V., Dekel, A. (1366) *

Extragalactic background light inferred from AEGIS galaxy-SED-type fractions 2011, *MNRAS* **410**, 2556, A. Dominguez, **J. R. Primack**, et al. (1005) *

Halos and galaxies in the standard cosmological model: results from the Bolshoi simulation 2011, *ApJ* **740**, 102. A. Klypin, S. Trujillo-Gomez, **J. Primack** (1166)

* These papers are based on PhD dissertation research supervised by **Joel Primack**

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