

# Sergei Bashinsky

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Discoveries at the forefront of physics that have influenced understanding and the direction of studies of the universe on the largest and sub-proton scales. Experience with leading and managing a team.

## EDUCATION

<b>Massachusetts Institute of Technology (MIT)</b>	Cambridge, MA
Ph.D. in Physics, 2001	GPA: all subjects 4.9/5.0, science-related (H-level) subjects 5.0/5.0
Theoretical Particle Physics, Center for Theoretical Physics	1995–1999
Cosmology and Physics of the Early Universe, Center for Astrophysics and Space Research	1999–2001
<b>Moscow Institute of Physics and Technology</b>	Dolgoprudnyi, Moscow region, Russia
B.S. <i>summa cum laude</i> in Physics, 1995	
Department of General and Applied Physics (FOPF)	1991–1995
Specialized in Particle Theory at the Institute for Theoretical and Experimental Physics (ITEP)	1994–1995

## EXPERIENCE, SCIENCE

<b>Princeton University</b>	Princeton, NJ
R. H. Dicke Postdoctoral Fellowship (Honorific postdoctoral fellowship at the Princeton Physics Department awarded to one person in theory and one in experiment among contenders from all physics fields.)	2001–2004

- Developed a [formalism](#) for analyzing inhomogeneous cosmological evolution that, unlike the earlier methods, manifestly reveals which properties of dark species (dark matter/energy/radiation) affect which observables. Its equations are substantially [simpler](#) the traditional ones and are analytically solvable for realistic systems.
- Continued to develop my novel for cosmology formalism of [plane-parallel Green's functions](#), initiated in my Ph.D. thesis research with E. Bertschinger at MIT.
- Applying both formalisms, discovered a clean and the only non-degenerate signature of streaming relic neutrinos — the second most abundant particles in the universe. The signature is an additive [shift of the CMB peaks<sup>\[1\]</sup>](#). In 2015 it was observed<sup>[2,3]</sup> by ESA's Planck satellite, reporting agreement with my theoretical prediction. In 2018 it was also [detected<sup>\[4\]</sup>](#) in baryon acoustic oscillations.
- First correctly [identified](#) microphysics behind the intermediate-scale angular spectrum of the Cosmic Microwave Background (no resonant "[radiation driving](#)" on small scales; about six times stronger than thought – by incorrect interpretation suggested by a misleading description – [suppression](#) of the spectrum by dark matter on large scales).
- First [calculated](#) analytically the coupled evolution of the relic neutrinos and primordial gravitational waves.
- Proved [new conservation laws](#) for dynamics on the largest, "superhorizon" scales.
- In collaboration with C. Hirata and U. Seljak, worked on a book on cosmological evolution, gravitation, and the CMB.
- Participated in regular intra-group and Princeton-area discussions, journal clubs, and seminars.

<b>Los Alamos National Laboratory (LANL)</b>	Los Alamos, NM
Research Associate, Elementary Particles and Field Theory Group	2005–2008
<ul style="list-style-type: none"><li>• Co-investigator in a LANL Grand Challenge project "Dark Energy and the Cosmic Web." Explored the <a href="#">prospects and optimal strategy</a> for observations to probe the properties of dark energy.</li><li>• Participated in a 5-person project on the formation of dark matter halos. Advocated and performed the analysis of simulation box effects, reversing the project's <a href="#">main result</a> to the now frequently cited approximate "universality."</li><li>• Initiated a 3-person project that explored cosmological constraints on models of neutrino mass and interactions. Numerically calculated the <a href="#">expected constraints</a> for the Planck satellite and ground experiment ACT.</li><li>• First suggested in a paper definitive <a href="#">methods to distinguish</a> dark energy from its possible alternative—modified gravity. The results are <a href="#">nontrivial</a> and are now accepted.</li><li>• Discovered the first stable mechanism for dark energy density growth, which is somewhat preferred by observations and can "restart" the Big Bang. This study stopped at LANL by administrative action. The mechanism was soon after <a href="#">described</a> by other researchers, attracting attention (300+ citations).</li></ul>	

- One of the three co-applicants for a LANL grant “Precision Cosmology and the Neutrino Sector,” following my postdoctoral proposal. The application was selected among 5% of LANL proposals to be funded. Granted \$1 M.
- Led weekly Los Alamos Cosmology Discussion Group meetings, 2007–2008. Invited LANL and external speakers and chaired the discussions.

#### SELECTED VISITS

<b>International Centre for Theoretical Physics (ICTP)</b> High Energy, Cosmology and Astroparticle Physics Section, 1-year visitor and research fellow	Trieste, Italy 2004–2005
<b>Canadian Institute for Theoretical Astrophysics (CITA)</b> 1-month research visitor	Toronto, Canada 2000
<b>Brookhaven National Laboratory (BNL)</b> RIKEN-BNL Research Center, 1-month research visitor	Upton, NY 1998
<b>Les Houches Centre for Physics</b> LXVIII Summer School “Probing the Standard Model of Electroweak Interactions,” 6 weeks	Les Houches, France 1997

Participation and talks at **international conferences** in Canada, France, Germany, Italy, Switzerland, USA.

**Invited talks** in the world’s leading scientific institutions, including **BNL, Caltech, CITA, Fermilab, ICTP, LANL, MIT, Princeton University, Princeton Institute for Advanced Studies.**

#### TEACHING EXPERIENCE

- **International Centre for Theoretical Physics (ICTP)**  
ICTP Diploma Programme: Two lectures on *General Relativity* 2005
- **Princeton University**  
Assistance in a graduate course *Introduction to Theoretical Cosmology*: 2003  
Several lectures and texts on Cosmological Dynamics, Cosmic Microwave Background, Cosmological Inflation, and Gravitodynamics in General Relativity.
- **MIT**  
Teaching assistant assignments:  
Weekly seminars in *Relativistic Quantum Field Theory II*; Fall 1998  
Coaching students, grading, and writing solutions in *Quantum Theory, Quantum Physics, Electromagnetic Theory I and II.* 1995–2000

#### HIGHLIGHTS OF SCIENTIFIC RESULTS

- Discovered the first and only known [non-degenerate observed signature of free-streaming of relic neutrinos](#), invisible directly yet composing **40% of the early universe**.  
(In 2001 Prof. P. Schechter at his MIT astrophysics class stated that whoever would figure out how to observe the relic neutrinos would win the Nobel Prize.)
- In particular, my result is [cited as the motivation](#) to start constraining the neutrino density by NASA’s WMAP satellite collaboration and by ESA’s Planck satellite collaboration ([The Scientific Programme of Planck](#)).
- [Developed](#) a Green’s function method to analyze cosmological evolution. Green’s functions are now applied to baryonic oscillations—one of the primary cosmological probes.
- [Discovered a sharp feature](#) in the CMB correlation function at  $1.2^\circ$  that is a distinctive objective evidence of the acoustic waves in the early universe and is the most sensitive probe of the geometry of the universe.
- Discovered that the phase of the relic gravitational waves should be [locked to zero](#) unless superluminality exists.
- Established and first [described in a paper](#) key general nontrivial and now accepted results on distinguishing dark energy from modified gravity.
- [Predicted measurable signatures](#) of the doubly strange H dibaryon —  $(uudds)_\text{singlet}$  — if it decays strongly.  
(Graduate project with R. Jaffe.) A described signature was later [observed by KEK-PS E224](#) and [E522](#) collaborations.
- First [constructed](#) gauge-invariant operators for quark and gluon orbital angular momentum distributions, which were required for **completing theoretical description of proton spin**. (Graduate project with R. Jaffe.)
- Results are described and cited by several modern textbooks, including [Cosmology](#) (2008) by the Nobel Prize laureate Steven Weinberg.

## EXPERIENCE, IT DEVELOPMENT

### Startup MiKey

Moscow, Russia

supported by System Integration of Business

Founder and General Manager

2009–2010

- Invented a new method of typing without moving fingers. Received funding to investigate the idea.
- Supervised a team of two developers and a designer. Managed and fully participated in development cycles. Organized and conducted testing by independent users.
- Created four conceptually distinct implementations of the method.
- Developed a training course to facilitate user's mastering of the new typing method.
- Arranged and conducted medical tests of a prototype at a clinical hospital.
- Prepared and submitted a US patent application with Harness, Dickey & Pierce, an IP law firm.

## GRANTS AND AWARDS

Private grant to explore and publish my [original results](#) on identifying probability-related wave functions of realistic physical universes composed of gauge and gravitationally interacting bosonic and fermionic fields with closed, finite evolution and inflationary past as objective entities that emerge in the generic static structure, Moscow, 2012–2016.

Exploratory Research grant (successful co-applicant): *Precision Cosmology and the Neutrino Sector*, LANL, 2008.

Directed Research grant (recipient): *Dark Energy and the Cosmic Web*, LANL, 2007–2008.

R. H. Dicke Postdoctoral Fellowship, Princeton University, 2001–2004.

George Soros International Science Foundation Fellowship, 1994–1995.

Lenin Highest Honor Stipend, MIPT, 1994–1995.

Placed 1st, 2nd, and 1st in the inter-departmental MIPT Physics Competition in each eligible year, 1992–1994.

Gold Medal, XXII International Physics Olympiad, Havana, 1991.