Sergei Bulanov

- Russian theoretical physicist
- studied theoretical physics and astrophysics at the Moscow Institute of Physics and Technology
- distinguished Research Fellow at the National Institute for Quantum Science and Technology in Kyoto, Japan
- Head of the Department of Radiation Physics and Electron Acceleration at ELI Beamlines, Czech Republic

Awards: State Prize of the USSR (1982)
Hannes Alfvén Prize (2016)
Order of Rising Sun with Gold Rays and Rosette (2020)

Publications (for the end of 2021): 2 monographs and 500 papers in refereed journals; according to the Web of Science the citation index and the h-index are equal to 19000 and 66,

Hightlights of his career

Sergei Bulanov is an author of a number of results on charged particle acceleration in space including the theory of charged particle acceleration during reconnection of the magnetic field lines in plasmas. This theory is widely used in the Earth magnetosphere physics, in solar flare physics, and in the physics of plasma pinch discharges. During his work on the problems of cosmic ray physics and radio astronomy, he was involved in the studies of the transport of ultrarelativistic charged particles in Galactic magnetic fields doing calculations on the electromagnetic radiation emitted by the cosmic ray electrons, and was developing cosmic ray acceleration theory during supernova explosions. The results of these studies are summarized in the monograph: "Astrophysics of Cosmic Rays", which currently is a desktop book for experts in astroparticle physics and in high-energy astrophysics.

He was involved in the studies of the magnetic confinement of thermonuclear plasmas and in the physics of the plasma pinch discharges. He pioneered the capillary discharge theory and computer simulations important in applications of capillary discharge plasmas for X-ray lasers, for guiding high intensity laser pulses, and for active lensing of charged particle beams.

He has contributions in the theory and computer simulation of microwave radiation interaction with plasmas addressing the nonlinear processes and electron and ion acceleration in the plasma resonance region. He has formulated a theoretical approach describing the nonlinear wave behavior in unstable media described by a family of exact analytical solutions connected to the mathematically ill posed initial problems.

In the late 80's, his scientific interests have extended over problems of relativistically intense laser radiation interaction with matter, where are distinctly seen the characteristic features of his scientific style which combine the methods of theoretical physics with extensive computer simulations in direct connection with the experimental studies. Several notable results were achieved in this area.

The ultrarelativistic limit of the laser wake-field accelerator has been thoroughly described. For the first time he brought into the scientific community attention the wake wave breaking as a mechanism of the charged particle injection into the acceleration phase, including the idea of the transverse wake wave breaking. Nowadays this is a commonly used injection mechanism in laser wake-field accelerators.

Sergei Bulanov has attracted attention to the key role of the magnetic field self-generated in the laser plasmas during the interaction of laser radiation with various targets. The magnetic field line reconnection in relativistic laser plasmas has also been foreseen, which is the key importance result in "laboratory astrophysics". He and his colleagues found the relativistic electron vortices associated with the magnetic field generated by the laser pulse. They described analytically their properties, extending the theory of the von Karman vortex row stability to the case of vortex rows in dispersive media.

The relativistic electromagnetic solitons have been shown theoretically and observed in their laser-plasma experiments. He has proposed using the solitons as sources of long lasting low and high frequency electromagnetic radiation in laser plasmas.
He has formulated the "relativistic oscillating mirror" model explaining the high order harmonic generation: this model currently provides the widely used concept for the high order harmonic radiation in relativistic laser plasma interaction.

Studying various regimes of the laser ion acceleration he has proposed the tailored targets for ion beam focusing and for high quality ion beam generation. In particular, such the targets are proposed for the applications of the laser ion accelerators to the hadron therapy in the oncology and in controlled nuclear fusion within the framework of the Fast Ignition Concept.

He is a co-author of the idea of hadron therapy with the laser accelerated ions as well as of the idea of the fast ignition of thermonuclear fusion with the laser accelerated ions. He found the highly efficient mechanisms for laser ion acceleration and proposed using them in the experiments on the high-energy physics and in connection with astrophysical problems. At present, the acceleration mechanism, called the "radiation pressure dominated acceleration" is considered as the main ion acceleration mechanism for the next generation of high power lasers.

He has formulated an approach to generate super-intense electromagnetic pulses, up to the limit where the nonlinear quantum electrodynamics effects come into play. This approach uses two counter-propagating laser pulses interacting with plasmas. The proof of principle of this mechanism, called the "relativistic flying mirror", has been achieved in experiments conducted under his leadership at the KPSI-QST center in Japan. Current studies of his team at the ELI BL extends over the physics of nonlinear QED vacuum. It is worth mentioning the results recently obtained by them on nonlinear electromagnetic waves, high order harmonics, and synergic Compton-Cherenkov scattering in the ultrarelativistic electron-laser collision in the quantum vacuum.

What are you most proud of?

"I have had turning points in my career related to external circumstances such as recognition or non-recognition of my scientific results by others, and to my own subjective assessments of my work, but all the scientific results I received are of almost equal value to me, because they are part of my life and part of me."

What research projects are you currently working on?

"In our department at the ELI Beamlines center we have a team of strongly motivated high level experts in the theory and experiments. We aim at the formulating and developing the flagship scientific program for ultra-high power lasers. By synthesizing the knowledge in the relativistic astrophysics and in theoretical physics, I am working on relativistic laboratory astrophysics with high power lasers and on a new state of matter: lepton-gamma plasma in extreme power laser field, on the probing nonlinear quantum vacuum properties, etc. At the same time, with my colleagues I continue studying scientific problems related to the optimization of the laser accelerators of charged particles for various applications ranging from the hard electromagnetic radiation sources and radiotherapy to modelling astrophysical processes."

A SCIENTIFIC DREAM

"Instead of dreaming, I am making plans to accomplish the research program outlined above at the world high standard level to see the ELI as the world's leading research center."

Living in the Czech Republic

"My wife and I really enjoy being in the Czech Republic. It is a beautiful country in the very heart of Europe with beautiful nature and many cultural and historical sites. We often travel across the Czech Republic. Having a rich history, the Czech Republic plays an important role in the modern world. Here we do not feel cut off from our friends and relatives in Russia. Here we have good Czech friends who introduce us to local life and customs. We often have a good time with them. The ELI-BL has a collegiate and friendly atmosphere. Working together with my Czech / international colleagues is an important and pleasing part of my life in the Czech Republic."