CURRICULUM VITAE

PERSONAL

- Surname: Kalashev
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PROFESSIONAL

- Date and Place of Ph.D: Ph.D. in Theoretical Physics, INR, Russian Academy of Sciences, Moscow, 2003.
- Previous education:
  - M.S. in Physics, Moscow Institute for Physics and Technology, 1999.
  - Post-Graduate school (quantum field theory, cosmology), INR, Russian Academy of Sciences, 1999 -2003.
- Positions held:
  - Research Scientist at the Theory Division (INR RAS, Moscow), May 2003–May 2005.
  - Post-doc research fellow at Physics and Astronomy department (UCLA, Los Angeles), June 2005–August 2006
  - Research Scientist at the Theory Division (INR RAS, Moscow), Sep 2006–now
- Fellowships, honors, etc.:
  - RFFR Grant 97-02-17064A (in group)
  - RFFR Grant 98-02-17493A (in group)
  - INTAS Grant 1A-1065 (in group)
  - INTAS Grant 03-51-5112 (in group)
  - NS Grant 2184.2003.2 (in group)
  - NASA Grant NAG5-13399 (in group)
  - NASA Grant ATP03-0000-0057 (in group)
  - RFFR Grant 07-02-00820-A (in group)
  - RFFR Grant 09-02-09357-MOB-Z (personal)
  - RFFR Grant 09-07-00388-A (in group)
  - RFFR Grant 09-02-92630-KO-A (in group)
  - President of the Russian Federation Grant MK-1966.2008.2 (personal)
  - RFFR Grant 10-02-01406-A (in group)
  - RFFR Grant 11-02-01528-A (in group)
  - RFFR Grant 11-02-09584-MOB-Z (personal)
  - RFFR Grant 13-02-01311 (in group)
  - RFFR Grant 13-02-01293 (in group)

- Teaching:
  - Seminars for undergraduate students on physics of the Early Universe. (Moscow Institute of Physics and Technology, 2000 autumn - 2001 spring).
  - Lectures for undergraduate students on physics of the Early Universe. (Moscow Institute of Physics and Technology, 2003 autumn - 2005 spring).
- Main research fields:
  - Ultra High Energy Cosmic Rays (UHECR). Spectrum and composition study. Standard model particles as UHECR. New particles as UHECR and physics beyond the standard model. The source models of the UHECR.
  - Simulation of UHECR propagation including all relevant standard model interactions of UHECR with universal microwave background as well as radio and infrared background and with random magnetic field.
  - High energy neutrino astrophysics. Theoretical predictions of the diffuse flux of extragalactic neutrinos in various models. Neutrino fluxes from individual sources.
  - Large scale jets in the AGN. Models for jets. Acceleration mechanisms in AGN cores.
  - GeV-TeV gamma astronomy. Secondary photons and neutrinos from cosmic rays produced by distant blazars

- Statement of research interests:

1. Ultra High Energy Cosmic Rays.
The problem of explanation of the UHECR spectrum is one of the most popular and sophisticated problems of today's high energy physics. It includes theoretical estimates of the primary cosmic ray composition and spectra as well as source identifications based on cosmic ray experiments data as well as the existing limits on diffuse gamma-ray and neutrino fluxes. With the numerical code, which I have developed, the detailed analysis of general properties of the models with UHE nuclei, proton, photon and neutrino sources has been done. This investigation was the main point in my PhD thesis.

The two largest today's cosmic ray experiments are Pierre Auger Observatory (PAO) and Telescope Array (TA). As a member PAO and later member of TA collaboration I was involved in the analysis of the energy spectrum and arrival directions of the cosmic rays.

Currently existence of cosmic ray flux cutoff is confirmed experimentally, although it's nature is not yet well understood. Still there is no agreement on the cosmic rays composition at the highest energies. The main observable used for composition study is the depth of the shower maximum X_{max}.

I have performed the detailed simulations of cosmic ray spectrum and X_{max} from various astrophysical sources in attempt to fit either PAO or TA data, showing that while TA spectrum and X_{max} measurements can by explained by conventional sources emitting mostly protons, the spectrum and X_{max} observed in PAO require very special kind of astrophysical sources rich with intermediate elements such as silicon and nitrogen.

I have considered the toy model of the population of numerous non-identical extragalactic sources of ultra-high-energy cosmic rays. In the model, cosmic-ray particles are accelerated in magnetospheres of supermassive black holes in galactic nuclei, the key parameter of acceleration being the black-hole mass.

In future I plan to investigate possible influence of new physics on the observational results. The new particles in the non-standard models as candidates for UHECRs can be considered. Another interesting point of investigation is influence of statistical distribution of sources on UHECR spectra characteristics such as small scale flux fluctuations and anisotropy.

2.Propagation of Ultra High Energy Cosmic Rays.
Propagation of UHECR through universal backgrounds was considered theoretically long time ago, but until recent years the complete simulation of this process hasn't been done. Due to growing interest in this area this task has become very important and so I have developed the numerical code for detailed simulation of the UHECR propagation. The simulation is based on Transport

Equations written in the expanding Universe. The code simulates the propagation of nucleons, stable leptons and photons using the standard dominant processes. The propagation of nucleons and electron-photon cascades is calculated self-consistently. Namely, secondary (and higher generation) particles arising in all reactions are propagated alongside with the primaries. The code also simulates several models of UHECR sources including astrophysical sources as well as heavy relic particles and topological defect models.

In the future I plan to investigate both particle propagation and deflection in regular and random magnetic fields. For this purpose I am developing the Monte Carlo code. Currently the part of the code describing electron-photon cascade is completed and successfully tested.

3. High energy neutrino astrophysics.
Detection of ultra-high energy cosmic rays (UHECR) with energies up to 10^{20} eV and above give a chance to detect secondary neutrinos from UHECR protons in the neutrino telescopes and UHECR detectors like IceCube, Pierre Auger Observatory, Telescope Array. Based on my transport code I reconsidered neutrino flux predictions and especially their maxima consistent with all cosmic ray and photon data, for cosmogenic neutrinos produced through pion production of UHECRs during propagation, and for the more speculative Z-burst scenario and top-down scenarios. I have shown that one can easily exceed the Waxman-Bahcall bound and, in the most optimistic cases, even the Mannheim-Protheroe-Rachen bound for cosmogenic neutrinos in scenarios with hard enough cosmic ray injection spectra, and redshift evolution typical for quasars, or stronger. I also have shown that for non-shock AGN acceleration models the AGN neutrino fluxes can reach the photon bound around 10^{16} eV which represents the ultimate limit for all scenarios of photon and neutrino production involving pion production.

4. Large scale jets in the AGN.
The radiative cooling of electrons responsible for the nonthermal synchrotron emission of large scale jets of radiogalaxies and quasars requires almost continuous (in time and space) production of relativistic electrons throughout the jets over the scales exceeding 100 kpc. While in the standard paradigm of large scale jets this implies acceleration of electrons, I have considered a principally different "non-acceleration" origin of these electrons, assuming that they are implemented all over the length of the jet through effective development of electromagnetic cascades initiated by extremely high energy photons injected into the jet from the central object. Development of such cascades is an attractive mechanism for production of ultra-relativistic electrons (with almost 100 percent efficiency) which can be responsible for the observed radio-to-X-ray spectra of jets. This scenario provides a natural and very economic way to power the jets up to distances of 100 kpc and beyond.

5. Active galactic nuclei (AGN) can produce both gamma rays and cosmic rays.

I have shown that under certain conditions the observed high-energy gamma-ray signals from distant blazars may be dominated by secondary gamma rays produced along the line of sight by the interactions of cosmic-ray protons with background photons. This explains the surprisingly low attenuation observed for distant blazars, because the production of secondary gamma rays occurs, on average, much closer to Earth than the distance to the source. Thus the observed spectrum in the TeV range does not depend on the intrinsic gamma-ray spectrum, while it depends on the output of the source in cosmic rays.

List of Publications

1. **"Search for correlations of the arrival directions of ultra-high energy cosmic ray with extragalactic objects as observed by the telescope array experiment"**
   T. Abu-Zayyad, R. Aida, M. Allen, R. Anderson, R. Azuma, E. Barcikowski, J. W. Belz and D. R. Bergman *et al.*.
   arXiv:1306.5808 [astro-ph.HE]

2. **"Energy Spectrum of Ultra-High Energy Cosmic Rays Observed with the Telescope Array Using a Hybrid Technique"**
   T. Abu-Zayyad, R. Aida, M. Allen, R. Anderson, R. Azuma, E. Barcikowski, J. W. Belz and D. R. Bergman *et al.*.
   arXiv:1305.7273 [astro-ph.HE]

3. **"The Energy Spectrum of Ultra-High-Energy Cosmic Rays Measured by the Telescope Array FADC Fluorescence Detectors in Monocular Mode"**
   T. Abu-Zayyad *et al.* [The Telescope Array Collaboration].
   arXiv:1305.6079 [astro-ph.HE]

4. **"Upper limit on the flux of photons with energies above 10^{19} eV using Telescope Array surface detector"**
   T. Abu-Zayyad *et al.* [Telescope Array Collaboration].
   arXiv:1304.5614 [astro-ph.HE]

5. **"PeV neutrinos from intergalactic interactions of cosmic rays emitted by active galactic nuclei"**
   O. E. Kalashev, A. Kusenko and W. Essey.
   arXiv:1303.0300 [astro-ph.HE]

6. **"Secondary neutrinos and multi-TeV photons from distant blazars"**
   O. E. Kalashev.
   Proceedings of 16th International Seminar on High Energy Physics (QUARKS 2010)

7. **"Restrictions on cosmogenic neutrinos and UHECR from Fermi 3 years data"**
   G. B. Gelmini, O. Kalashev and D. V. Semikoz.
   10.1088/1742-6596/375/1/052012
   J. Phys. Conf. Ser. **375**, 052012 (2012).

8. **"Towards a model of population of astrophysical sources of ultra-high-energy cosmic rays"**
   O. E. Kalashev, K. V. Ptitsyna and S. V. Troitsky.
   arXiv:1207.2859 [astro-ph.HE]
   10.1103/PhysRevD.86.063005
   Phys. Rev. D **86**, 063005 (2012)

9. **"Search for Anisotropy of Ultra-High Energy Cosmic Rays with the Telescope Array Experiment"**
   T. Abu-Zayyad, R. Aida, M. Allen, R. Anderson, R. Azuma, E. Barcikowski, J. W. Belz and D. R. Bergman *et al.*.
   arXiv:1205.5984 [astro-ph.HE]
   10.1088/0004-637X/757/1/26
   Astrophys. J. **757**, 26 (2012)

10. **“The Cosmic Ray Energy Spectrum Observed with the Surface Detector of the Telescope Array Experiment”**
T. Abu-Zayyad, R. Aida, M. Allen, R. Anderson, R. Azuma, E. Barcikowski, J. W. Belz and D. R. Bergman *et al.*.
arXiv:1205.5067 [astro-ph.HE]

11. **“The Energy Spectrum of Telescope Array’s Middle Drum Detector and the Direct Comparison to the High Resolution Fly’s Eye Experiment”**
T. Abu-Zayyad, R. Aida, M. Allen, R. Anderson, R. Azuma, E. Barcikowski, J. W. Belz and D. R. Bergman *et al.*.
arXiv:1202.5141 [astro-ph.IM]
10.1016/j.astropartphys.2012.05.012
Astropart. Phys. **39-40**, 109 (2012)

12. **“The surface detector array of the Telescope Array experiment”**
T. Abu-Zayyad, R. Aida, M. Allen, R. Anderson, R. Azuma, E. Barcikowski, J. W. Belz and D. R. Bergman *et al.*.
arXiv:1201.4964 [astro-ph.IM]
10.1016/j.nima.2012.05.079
Nucl. Instrum. Meth. A **689**, 87 (2012)

13. **“New air fluorescence detectors employed in the Telescope Array experiment”**
H. Tokuno, Y. Tameda, M. Takeda, K. Kadota, D. Ikeda, M. Chikawa, T. Fujii and M. Fukushima *et al.*.
arXiv:1201.0002 [astro-ph.IM]
10.1016/j.nima.2012.02.044
Nucl. Instrum. Meth. A **676**, 54 (2012)

14. **“Gamma-Ray Constraints on Maximum Cosmogenic Neutrino Fluxes and UHECR Source Evolution Models”**
G. B. Gelmini, O. Kalashev and D. V. Semikoz.
arXiv:1107.1672 [astro-ph.CO]
10.1088/1475-7516/2012/01/044
JCAP **1201**, 044 (2012)

15. **“The status of the Telescope Array experiment”**
H. Tokuno, T. Abu-Zayyad, R. Aida, M. Allen, R. Azuma, E. Barcikowski, J. W. Belz and T. Benno *et al.*.
10.1088/1742-6596/293/1/012035
J. Phys. Conf. Ser. **293**, 012035 (2011).

16. **“The theoretical predictions of ultra-high energy neutrino fluxes”**
O. E. Kalashev.
Proceedings of 12th International Seminar on High-Energy Physics (QUARKS 2002)

17. **“Role of line-of-sight cosmic ray interactions in forming the spectra of distant blazars in TeV gamma rays and high-energy neutrinos”**
W. Essey, O. Kalashev, A. Kusenko and J. F. Beacom.
arXiv:1011.6340 [astro-ph.HE]
10.1088/0004-637X/731/1/51
Astrophys. J. **731**, 51 (2011)

18. **“The telescope array experiment: Status and prospects”**
H. Tokuno, T. Abu-Zayyad, R. Aida, M. Allen, R. Azuma, E. Barcikowski, J. W. Belz and T. Benno *et al.*.
10.1063/1.3455968
AIP Conf. Proc. **1238**, 365 (2010).

19. **“Secondary photons and neutrinos from cosmic rays produced by distant blazars”**
W. Essey, O. E. Kalashev, A. Kusenko and J. F. Beacom.

arXiv:0912.3976 [astro-ph.HE]
10.1103/PhysRevLett.104.141102
Phys. Rev. Lett. **104**, 141102 (2010)

20. **“Sensitivity of cosmic-ray experiments to ultra-high-energy photons: reconstruction of the spectrum and limits on the superheavy dark matter”**
O. E. Kalashev, G. I. Rubtsov and S. V. Troitsky.
arXiv:0812.1020 [astro-ph]
10.1103/PhysRevD.80.103006
Phys. Rev. D **80**, 103006 (2009)

21. **“Double Pair Production by Ultra High Energy Cosmic Ray Photons”**
S. V. Demidov and O. E. Kalashev.
arXiv:0812.0859 [astro-ph]
10.1134/S1063776109050057
J. Exp. Theor. Phys. **108**, 764 (2009)

22. **“Global anisotropy of arrival directions of ultrahigh-energy cosmic rays: capabilities of space-based detectors”**
O. E. Kalashev, B. A. Khrenov, P. Klimov, S. Sharakin and S. V. Troitsky.
arXiv:0710.1382 [astro-ph]
10.1088/1475-7516/2008/03/003
JCAP **0803**, 003 (2008)

23. **“Composition of UHECR and the Pierre Auger Observatory Spectrum”**
K. Arisaka, G. B. Gelmini, M. D. Healy, O. E. Kalashev and J. Lee.
arXiv:0709.3390 [astro-ph]
10.1088/1475-7516/2007/12/002
JCAP **0712**, 002 (2007)

24. **“Constraints on secondary 10-100 EeV gamma ray flux in the minimal bottom-up model of Ultrahigh Energy Cosmic Rays”**
O. E. Kalashev, G. Gelmini and D. Semikoz.
arXiv:0706.3847 [astro-ph]

25. **“GZK Photons Above 10-EeV”**
G. BGelmini, O. E. Kalashev and D. V. Semikoz.
arXiv:0706.2181 [astro-ph]
10.1088/1475-7516/2007/11/002
JCAP **0711**, 002 (2007)

26. **“Ultra-High Energy Cosmic Rays and the GeV-TeV Diffuse Gamma-Ray Flux”**
O. E. Kalashev, D. V. Semikoz and G. Sigl.
arXiv:0704.2463 [astro-ph]
10.1103/PhysRevD.79.063005
Phys. Rev. D **79**, 063005 (2009)

27. **“GZK Photons in the Minimal Ultrahigh Energy Cosmic Rays Model”**
G. Gelmini, O. E. Kalashev and D. V. Semikoz.
astro-ph/0702464
10.1016/j.astropartphys.2007.08.006
Astropart. Phys. **28**, 390 (2007)

28. **“Anisotropy studies around the Galactic Centre at EeV energies with the Auger Observatory”**
M. Aglietta *et al.* [Pierre Auger Collaboration].
astro-ph/0607382
10.1016/j.astropartphys.2006.11.002
Astropart. Phys. **27**, 244 (2007)

29. **“An upper limit to the photon fraction in cosmic rays above 10^{19}-eV from the Pierre Auger Observatory”**
J. Abraham *et al.* [Pierre Auger Collaboration].
astro-ph/0606619
10.1016/j.astropartphys.2006.10.004
Astropart. Phys. **27**, 155 (2007)

30. **“GZK photons as ultra high energy cosmic rays”**
G. Gelmini, O. E. Kalashev and D. V. Semikoz.
astro-ph/0506128
10.1134/S106377610806006X
J. Exp. Theor. Phys. **106**, 1061 (2008)

31. **“Ultrahigh-energy neutrino fluxes and their constraints”**
O. E. Kalashev, V. A. Kuzmin, D. V. Semikoz and G. Sigl.
hep-ph/0205050
10.1103/PhysRevD.66.063004
Phys. Rev. D **66**, 063004 (2002)

32. **“Large scale extragalactic jets powered by very high-energy gamma-rays”**
A. Neronov, D. Semikoz, F. Aharonian and O. E. Kalashev.
astro-ph/0201410
10.1103/PhysRevLett.89.051101
Phys. Rev. Lett. **89**, 051101 (2002)

33. **“Ultrahigh-energy cosmic rays from neutrino emitting acceleration sources?”**
O. E. Kalashev, V. A. Kuzmin, D. V. Semikoz and G. Sigl.
hep-ph/0112351
10.1103/PhysRevD.65.103003
Phys. Rev. D **65**, 103003 (2002)

34. **“Photons as ultrahigh-energy cosmic rays?”**
O. E. Kalashev, V. A. Kuzmin, D. V. Semikoz and I. I. Tkachev.
astro-ph/0107130

35. **“Ultrahigh-energy cosmic rays. Propagation in the galaxy and anisotropy”**
O. E. Kalashev, V. A. Kuzmin and D. V. Semikoz.
astro-ph/0006349
10.1142/S0217732301005990
Mod. Phys. Lett. A **16**, 2505 (2001)

36. **“Top down models and extremely high-energy cosmic rays”**
O. E. Kalashev, V. A. Kuzmin and D. V. Semikoz.
astro-ph/9911035