Letter of application

Dear Colleagues,

I would like to ask you to consider my application for the post-doctoral position in Theoretical Particle Physics. I have a substantial experience of study of different aspects of phenomenology of the SM and its extensions. I started my career in ITEP (Moscow, Russia) where I read my PhD and worked as a scientific researcher for a few years. Then I spent one year working in DESY. Since 2004 I continued my career in Southampton and Glasgow Universities. In 2009 I joined University of Hawaii as a postdoc. During my time as Research Fellow in Southampton University I interacted a lot with the experimentalists from the Rutherford Appleton Laboratory and contributed to the "CP violation and Non-Standard Higgs Physics" (CPNSH) working group.

The planned research activity of mine concerns in particular Higgs and SUSY phenomenology beyond the standard scenarios at the LHC, and has a strong interplay with cosmology and neutrino physics. My Curriculum Vitae, list of publications and description of current and future research activities are enclosed. You can also find a list of scientists whom I am working with now. They are expected to provide letters of recommendation.

Thank you for your kind consideration of my application.

Sincerely yours,
Roman Nevzorov

CURRICULUM VITAE

Roman Nevzorov

Personal Details

Born:	November, 24, 1971, Mytishi (Moscow region), Russia
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Home address:	Flat 12, 30 Olimpiisky avenue,
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Education

Ph.D.	Institute for Theoretical and Experimental Physics (ITEP),
	Scientific advisers: Prof. M.I.Vysotsky and Prof. K.A.Ter–Martirosyan
	Title of thesis: Singlet scalar bosons in the standard and SUSY models
	Moscow, Russia, April 2001
M. S.	Moscow Institute of Physics and Technology – State University (MIPT),
	Scientific adviser: Prof. M.I.Vysotsky
	Title of thesis: Gauge dependence of the W boson contribution to $\bar{\alpha} = \alpha(M_Z)$
	Moscow, Russia, June 1995

Awards and Fellowships

2001–2002	Alfred Toepfer Stiftung scholarship
2006–2009	SUPA Fellowship

Research Positions

since 2003	Senior Scientific Researcher at the Theory Department of ITEP
2009–2012	Postdoctoral Research Fellow at the High Energy Physics group of Hawaii University
2006–2009	SUPA Fellow in Theoretical Particle Physics at the Theoretical Particle Physics Group of Glasgow University
2004–2006	Post-Doctoral Research Associate (Research Fellow) at the SHEP group of Southampton University
1998–2003	Research Scientist at the Theory Department of ITEP
2001–2002	Alfred Toepfer Stiftung scholarship held at DESY Theory Group
1995–1998	post-graduate student researcher at the Theory Department of ITEP

Teaching Experience

August 2009	course lectures on *Phenomenological aspects of Supersymmetry: SUSY models and electroweak symmetry breaking* given at the Dynasty Foundation, Summer School, Protvino, Moscow region, Russia, 10-20 August, 2009
2006–2008	course lectures for 1st year postgraduate students of Scottish Universities Physics Alliance (SUPA) on *Group Theory*
Spring 2005	course lectures for 1st year postgraduate theory students of SHEP group of Southampton University on *Selected problems of SUSY phenomenology*
Spring 2005	demonstrator, University of Southampton, Physics Skills Workshops
Autumn 2004	demonstrator, University of Southampton, problem classes on Classical Mechanics
1997–2004	assistant professor, MIPT, course lectures on *Introduction in Quantum Field Theory — Quantum electrodynamics*

Area of expertise

Standard Model and beyond: renormalization of masses and coupling constants; supersymmetry; grand unification; orbifold GUTs; supergravity; cosmological constant problem; Higgs boson and neutrino physics.

I act as a referee for Physical Review D, Physics Letters B, Europhysics Letters, International Journal of Modern Physics A and the Journal of Physics G.

Publications and talks

67 papers have been published and submitted in journals and proceedings of international conferences; 30 talks have been given at

- 35th, 34th and 33rd International Conferences on High Energy Physics;
- 2007 Europhysics Conference on High Energy Physics;
- 2011 Meeting of the Division of Particles and Fields of the American Physical Society;
- 19th, 17th, 15th and 13th International Conferences on Supersymmetry and Unification of Fundamental Interactions;
- 11th Conference on the Intersections of Particle and Nuclear Physics;
- 13th and 12th Lomonosov Conferences on Elementary Particle Physics (Moscow, Russia, 2007 and 2005);
- Workshop on CP Studies and Non-Standard Higgs Physics (CERN, Geneva, 2005),
- 19th and 18th International Workshops on High-Energy Physics and Quantum Field Theory (Golitsyno, Moscow region, Russia, 2010 and St. Petersburg, Russia, 2004),
- International Workshops "What Comes beyond the Standard model?" (Bled, Slovenia 2004, 2002 and 2000),
- Nuclear Physics Department of Russian Academy of Science Conferences (Moscow, Russia, 2002 and 2000),
- ITEP International Winter School of Physics (Moscow, Russia, 1997).

These talks cover a broad range of topics in particle physics and cosmology and their associated phenomenology.

Referees

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Colin Froggatt	Professor, Department of Physics and Astronomy, Kelvin Building, University of Glasgow Glasgow, G12 8QQ, Scotland, UK Telephone: +44 (0)141 330 5896 fax: +44 (0)141 330 8600 e-mail: Colin.Froggatt@glasgow.ac.uk
Holger Bech Nielsen	Professor, Theoretical Particle Physics and Cosmology group, Niels Bohr Institute, Blegdamsvej 17, DK-2100 Copenhagen, Denmark Telephone: +45 353 25 259 fax: +45 31 42 10 16 e-mail: hbech@nbi.dk

List of publications of Dr. Roman Nevzorov

1. S. F. King, M. Muhlleitner, R. Nevzorov, K. Walz, Natural NMSSM Higgs Bosons, arXiv:1211.5074 [hep-ph].

2. P. Athron, S. F. King, D. J. Miller, S. Moretti, R. Nevzorov, Constrained Exceptional Supersymmetric Standard Model with a Higgs Near 125 GeV, Phys. Rev. D **86** (2012) 095003; arXiv:1206.5028 [hep-ph].

3. R. Nevzorov, E_6 inspired SUSY models with exact custodial symmetry, arXiv:1205.5967 [hep-ph].

4. S. F. King, M. Muhlleitner, R. Nevzorov, NMSSM Higgs Benchmarks Near 125 GeV, Nucl. Phys. B **860** (2012) 207; arXiv:1201.2671 [hep-ph].

5. R. Nevzorov, Phenomenological aspects of Supersymmetry: SUSY models and electroweak symmetry breaking, Proceedings of the Dynasty Foundation Summer School, p.108-154 (2011); arXiv:1201.0115 [hep-ph].

6. P. Athron, J. P. Hall, S. F. King, S. Moretti, D. J. Miller, R. Nevzorov, S. Pakvasa, M. Sher, Collider phenomenology of the E_6SSM, to be published in the proceedings of the 2011 Meeting of the Division of Particles and Fields of the American Physical Society, Providence, Rhode Island, USA, 9-13 August, 2011; arXiv:1109.6373 [hep-ph].

7. J. P. Hall, S. F. King, R. Nevzorov, S. Pakvasa, M. Sher, Nonstandard Higgs Decays and Dark Matter in the E6SSM, to be published in the proceedings of the 2011 Meeting of the Division of Particles and Fields of the American Physical Society, Providence, Rhode Island, USA, 9-13 August, 2011; arXiv:1109.4972 [hep-ph].

8. R. Nevzorov, Theoretical aspects of electroweak symmetry breaking in SUSY models, PoSQFTHEP **2010** (2010) 015; arXiv:1103.2141 [hep-ph].

9. C. Froggatt, R. Nevzorov, H. B. Nielsen, Dark Energy density in models with Split Supersymmetry and degenerate vacua, submitted to Int. J. Mod. Phys.; arXiv:1103.2146 [hep-ph].

10. P. Athron, S. F. King, D. J. Miller, S. Moretti, R. Nevzorov, LHC Signatures of the Constrained Exceptional Supersymmetric Standard Model, Phys. Rev. D **84** (2011) 055006; arXiv:1102.4363 [hep-ph].

11. J. P. Hall, S. F. King, R. Nevzorov, S. Pakvasa, M. Sher, Nonstandard Higgs decays in the E_6SSM, PoSQFTHEP **2010** (2010) 069; arXiv:1012.5365 [hep-ph].

12. J. P. Hall, S. F. King, R. Nevzorov, S. Pakvasa, M. Sher, Novel Higgs Decays and Dark Matter in the E_6SSM, Phys. Rev. D **83** (2011) 075013; arXiv:1012.5114 [hep-ph].

13. C. Froggatt, R. Nevzorov, H. B. Nielsen, Dark Energy density in Split SUSY models inspired by degenerate vacua, PoSICHEP **2010** (2010) 442; arXiv:1012.5121 [hep-ph].

14. P. Athron, J. P. Hall, R. Howl, S. F. King, D. J. Miller, S. Moretti, R. Nevzorov, Aspects of the exceptional supersymmetric standard model, Nucl. Phys. Proc. Suppl. **200-202** (2010) 120.

15. P. Athron, S. F. King, D. J. Miller, S. Moretti, R. Nevzorov, The constrained E_6SSM, PoSEPS **-HEP2009** (2009) 249; arXiv:0910.0705 [hep-ph].

16. P. Athron, S. F. King, D. J. Miller, S. Moretti, R. Nevzorov, Phenomenological Consequences of the Constrained Exceptional Supersymmetric Standard Model, AIP Conf. Proc. **1200** (2010) 454; arXiv:0909.5336 [hep-ph].

17. C. D. Froggatt, R. Nevzorov, H. B. Nielsen, On the Smallness of the Cosmological Constant in SUGRA Models Inspired by Degenerate Vacua, AIP Conf. Proc. **1200** (2010) 1093; arXiv:0909.4703 [hep-ph].

18. P. Athron, S. F. King, R. Luo, D. J. Miller, S. Moretti, R. Nevzorov, Unification of Gauge Couplings in the E_6SSM, AIP Conf. Proc. **1200** (2010) 466; arXiv:0909.4530 [hep-ph].

19. P. Athron, S. F. King, D. J. Miller, S. Moretti, R. Nevzorov, The Constrained Exceptional Supersymmetric Standard Model, Phys. Rev. D **80** (2009) 035009; arXiv:0904.2169 [hep-ph].

20. P. Athron, S. F. King, D. J. Miller, S. Moretti, R. Nevzorov, Predictions of the Constrained Exceptional Supersymmetric Standard Model, Phys. Lett. B **681** (2009) 448; arXiv:0901.1192 [hep-ph].

21. P. Athron, S. F. King, D. J. Miller, S. Moretti, R. Nevzorov, The Constrained E_6SSM, to be published in the proceedings of the 34th International Conference on High Energy Physics, Philadelphia, USA, 29th July – 5th August, 2008; arXiv:0810.0617 [hep-ph].

22. C. D. Froggatt, R. Nevzorov, H. B. Nielsen, Cosmological Constant in SUGRA Models Inspired by Degenerate Vacua, to be published in the proceedings of the 34th International Conference on High Energy Physics, Philadelphia, USA, 29th July – 5th August, 2008; arXiv:0810.0524 [hep-th].

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27. S. F. King, R. Luo, D. J. Miller, R. Nevzorov, Leptogenesis in the Exceptional Supersymmetric Standard Model: flavour dependent lepton asymmetries, JHEP **0812** (2008) 042; arXiv:0806.0330 [hep-ph].

28. S. F. King, R. Luo, D. J. Miller, R. Nevzorov, Leptogenesis in the E_6SSM, J. Phys. Conf. Ser. **110** (2008) 082009.

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31. S. Hesselbach, D. J. Miller, G. Moortgat-Pick, R. Nevzorov, M. Trusov, The lightest neutralino

in the MNSSM, Proceedings of the 15th International Conference on Supersymmetry and the Unification of Fundamental Interactions (SUSY07), Karlsruhe, Germany, p.918; arXiv:0710.2550 [hep-ph].

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33. P. Athron, S. F. King, D. J. Miller, S. Moretti, R. Nevzorov, Electroweak Symmetry Breaking in the E_6SSM, J. Phys. Conf. Ser. **110** (2008) 072001; arXiv:0708.3248 [hep-ph].

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35. C. D. Froggatt, R. Nevzorov, H. B. Nielsen, Enhanced Higgs boson production and avoidance of CP-violation and FCNC in the MPP inspired 2HDM, J. Phys. Conf. Ser. **110** (2008) 062010; arXiv:0708.2905 [hep-ph].

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37. S. F. King, S. Moretti, R. Nevzorov, Gauge Coupling Unification in the Exceptional Supersymmetric Standard Model, Phys. Lett. B **650** (2007) 57; arXiv:hep-ph/0701064.

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43. S. F. King, S. Moretti, R. Nevzorov, Theory and Phenomenology of an Exceptional Supersymmetric Standard Model, Phys. Rev. D **73** (2006) 035009; hep-ph/0510419.

44. S. F. King, S. Moretti, R. Nevzorov, Exceptional Supersymmetric Standard Model, Phys. Lett. B **634** (2006) 278; hep-ph/0511256 .

45. C. Froggatt, R. Nevzorov, H. B. Nielsen, On the smallness of the cosmological constant in SUGRA models, Nucl. Phys. B **743** (2006) 133; hep-ph/0511259 .

46. D. J. Miller, S. Moretti, R. Nevzorov, Higgs bosons in the NMSSM with exact and slightly broken PQ-symmetry, Proceedings of the 18th International Workshop on High-Energy Physics and Quantum Field Theory (QFTHEP 2004), St. Petersburg, Russia, p.212; hep-ph/0501139.

47. C. D. Froggatt, L. V. Laperashvili, R. B. Nevzorov, H. B. Nielsen, M. Sher, The Two Higgs Doublet Model and the Multiple Point Principle, Proceedings to the 7th workshops "What Comes beyond the Standard model?", Bled, Slovenia (DMFA – ZALOZNISTVO, Ljubljana, 2004) p.28; hep-ph/0412333.

48. R. Nevzorov, D. J. Miller, Approximate solutions for the Higgs masses and couplings in the NMSSM, Proceedings to the 7th workshops "What Comes beyond the Standard model?", Bled, Slovenia (DMFA – ZALOZNISTVO, Ljubljana, 2004) p.107; hep-ph/0411275.

49. C. Froggatt, L. Laperashvili, R. Nevzorov, H. B. Nielsen, No–scale supergravity and the Multiple Point Principle, Proceedings to the 7th workshops "What Comes beyond the Standard model?", Bled, Slovenia (DMFA – ZALOZNISTVO, Ljubljana, 2004) p.17; hep-ph/0411273.

50. C. Froggatt, L. Laperashvili, R. Nevzorov, H. B. Nielsen, Cosmological constant in SUGRA models and the multiple point principle, Phys. Atom. Nucl. **67** (2004) 582; hep-ph/0310127.

51. D. J. Miller, R. Nevzorov, The Peccei-Quinn Axion in the Next-to-Minimal Supersymmetric Standard Model, hep-ph/0309143.

52. D. J. Miller, R. Nevzorov, P. M. Zerwas, The Higgs Sector of the Next-to-Minimal Supersymmetric Standard Model, Nucl. Phys. B **681** (2004) 3; hep-ph/0304049.

53. R. B. Nevzorov, K. A. Ter-Martirosyan, M. A. Trusov, Renormalization of coupling constants in the minimal SUSY models, Proceedings to the workshops "What Comes beyond the Standard model?", Bled, Slovenia (DMFA – ZALOZNISTVO, Ljubljana, 2002) p.106.

54. R. B. Nevzorov, M. A. Trusov, Quasi fixed point scenario in a modified nonminimal supersymmetric standard model, Phys. Atom. Nucl. **65** (2002) 335.

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58. R. B. Nevzorov, M. A. Trusov, Renormalization of the soft SUSY breaking terms in the strong Yukawa coupling limit in the NMSSM, Phys. Atom. Nucl. **64** (2001) 1513.

59. R. B. Nevzorov, M. A. Trusov, Infrared quasi fixed solutions in the NMSSM, Phys. Atom. Nucl. **64** (2001) 1299.

60. R. B. Nevzorov, M. A. Trusov, Particle spectrum in the modified NMSSM in the strong Yukawa coupling limit, J. Exp. Theor. Phys. **91** (2000) 1079.

61. R. B. Nevzorov, Stimulated neutrino conversion and bounds on neutrino magnetic moments, Surveys High Energ.Phys. **13** (1998) 241.

62. P. A. Kovalenko, R. B. Nevzorov, K. A. Ter-Martirosian, Masses of Higgs bosons in supersymmetric theories, Phys. Atom. Nucl. **61** (1998) 812.

63. J. M. Frere, R. B. Nevzorov, V. A. Novikov, M. I. Vysotsky, Neutrino magnetic moment behavior in a renormalizable model, Phys. Atom. Nucl. **60** (1997) 1662.

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65. R. B. Nevzorov, A. V. Novikov, Gauge dependence of the W boson contribution to $\bar{\alpha} = \alpha(M_Z)$, Phys. Atom. Nucl. **59** (1996) 511.

66. R. B. Nevzorov, A. V. Novikov, M. I. Vysotsky, Simple analytic formula for the hadronic contribution to the photonic vacuum polarization, Phys. Atom. Nucl. **59** (1996) 688.

67. R. B. Nevzorov, A. V. Novikov, M. I. Vysotsky, A simple way to estimate the value of $\bar{\alpha} = \alpha(M_Z)$, JETP. Lett. **60** (1994) 399.

Highly cited papers:

1. S. F. King, S. Moretti, R. Nevzorov, Higgs spectrum in the exceptional supersymmetric standard model, Workshop on CP Studies and Non-Standard Higgs Physics, Geneva, 2006, p.284; CERN–2006–009; hep-ph/0608079.

2. D. J. Miller, R. Nevzorov, P. M. Zerwas, The Higgs Sector of the Next-to-Minimal Supersymmetric Standard Model, Nucl. Phys. B **681** (2004) 3; hep-ph/0304049.

3. S. F. King, S. Moretti, R. Nevzorov, Theory and Phenomenology of an Exceptional Supersymmetric Standard Model, Phys. Rev. D **73** (2006) 035009; hep-ph/0510419.

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5. S. F. King, M. Muhlleitner, R. Nevzorov, NMSSM Higgs Benchmarks Near 125 GeV, Nucl. Phys. B **860** (2012) 207; arXiv:1201.2671 [hep-ph].

Current and future research activity of Dr. Roman Nevzorov

My current research concerns different aspects of the physics beyond the Standard Model (SM). Despite the Standard Model describing perfectly the major part of experimental data in high energy experiments, there are serious reasons to believe that new particles and interactions might exist at the TeV scale. One of the strongest pieces of evidence for physics beyond the SM arises from cosmology. The analysis of fluctuations in the cosmic microwave background (CMB) and other measurements, indicate that about 25% of the energy density of the Universe exists in the form of stable non–baryonic, non–luminous matter, the so–called dark matter. Although the microscopic composition of dark matter remains a mystery it is clear that it cannot consist of any elementary particles which have been discovered so far.

At the moment my efforts are concentrated on the investigation of supersymmetric (SUSY) models which are the best motivated extensions of the SM. Although the theoretical arguments for low energy SUSY are quite compelling, the simplest candidate for such a low energy effective theory, the minimal supersymmetric standard model (MSSM), suffers from the μ problem. Because of this problem the MSSM looks intrinsically unsatisfactory and it is essential to consider extended SUSY models. It is especially interesting to study non–minimal SUSY models in which the μ term of the required size is automatically generated as a result of the electroweak (EW) symmetry breaking (EWSB). I plan to consider the implications of these models for Higgs and neutrino physics, dark matter, inflation, CP–violation, baryogenesis and leptogenesis, flavour violating processes and the $g-2$ anomalous magnetic dipole moment of the muon. In addition I will address the cosmological constant problem in supersymmetric models using the Multiple Point Principle (MPP).

Natural SUSY and NMSSM

The recent discovery of a new particle with a mass around $\sim 125\,\text{GeV}$ is consistent not only with the Standard Model Higgs boson but also with the SM-like Higgs state in SUSY models. Nevertheless naturalness arguments disfavour the MSSM because large stop masses are needed to raise the Higgs boson mass to $125-126\,\text{GeV}$ that typically requires a tuning at least of order 1% in the MSSM. The fine-tuning of the MSSM can be ameliorated in the Next-to-Minimal Supersymmetric Standard Model (NMSSM), which contains only one extra SM singlet superfield S. In this model a Z_3 discrete symmetry forbids any bilinear terms in the superpotential but allows the interaction of S with the Higgs doublets H_u and H_d: $\lambda S(H_d\epsilon H_u)$. At the EW scale the superfield S gets a non-zero vacuum expectation value (VEV) ($\langle S\rangle = s/\sqrt{2}$) generating an effective μ term ($\mu_{eff}=\lambda s/\sqrt{2}$).

During my scientific career I have written several papers in which different aspects of the phenomenology of the NMSSM and its modifications (Minimal Non–minimal Supersymmetric Standard Model (MNSSM) etc.) were studied. In particular, in the case, when CP is conserved, D. Miller, P. Zerwas and I argued that the qualitative features of the Higgs boson masses and couplings were dependent on how strongly the Peccei-Quinn (PQ) symmetry was broken in the NMSSM. S. Hesselbach, D. Miller, G. Moortgat-Pick, M. Trusov and I found that the allowed range of the mass of the lightest neutralino in the MNSSM is limited and established a theoretical upper bound on the mass of this particle. More recently S. F. King, M. Mühlleitner, K. Walz and I considered the phenomenology of Higgs bosons within the NMSSM with and without extra matter, focusing on the regions of parameter space favoured by low fine-tuning considerations and associated with the SM-like Higgs boson near 125 GeV. We showed that the $\gamma\gamma$ signal strength may be enhanced up to a factor of about two not only due to the effect of singlet-doublet mixing, but also due to loop corrections induced by stops, chargino and charged Higgs states which are assumed to be relatively light to satisfy naturalness requirements (all first and second family sfermion masses were taken to be substantially heavier). In a non-negligible part of the parameter range the increase in the $\gamma\gamma$ rate can be due to the superposition of rates from nearly degenerate

Higgs bosons. We also argued that there may be smaller enhancements in the Higgs decay channels into WW, ZZ, correlated with the $\gamma\gamma$ enhancement. In the considered case the requirement of having perturbative couplings up to the grand unification (GUT) scale favours the interpretation of the 126 GeV Higgs boson as being the second lightest NMSSM CP-even state, which can decay into pairs of lighter neutralinos, CP-even or CP-odd Higgs bosons.

Our study of the natural SUSY extensions of the SM will be continued. In the future our analysis can be extended to the NMSSM with explicit CP–violating interactions and various modifications of this model. The spectrum of the Higgs bosons and neutralinos will be examined and the direct processes for the production of these particles at the LHC and other future colliders will be explored. The nonstandard decays of the SM–like Higgs state will be analysed and the contribution of the lightest neutralino to the dark matter density will be studied. The processes of electroweak baryogenesis and spontaneous CP–violation will separately be reexamined.

Supersymmetric models with extra $U(1)$ gauge symmetries

The electromagnetic, weak and strong interactions may not be the whole story. For example, at high energies the E_6 symmetry in the superstring inspired models can be broken down to a rank–5 subgroup $SU(3)_C \times SU(2)_W \times U(1)_Y \times U(1)'$ where $U(1)' = U(1)_\chi \cos\theta + U(1)_\psi \sin\theta$. Two anomaly-free $U(1)_\psi$ and $U(1)_\chi$ symmetries originate from the breakdown of E_6 and $SO(10)$ respectively, i.e. $E_6 \to SO(10) \times U(1)_\psi$, $SO(10) \to SU(5) \times U(1)_\chi$. In previous work S. F. King, S. Moretti and I proposed a self–consistent E_6 inspired supersymmetric model with an additional $U(1)_N$ gauge symmetry that corresponds to $\theta = \arctan\sqrt{15}$. Only in this exceptional supersymmetric standard model (E$_6$SSM) the right–handed neutrinos do not participate in gauge interactions and therefore they may be superheavy. The extra $U(1)_N$ gauge symmetry forbids a bilinear term $\mu H_d H_u$ in the superpotential of the considered model but allows the interaction $\lambda S H_d H_u$. At low energies the SM singlet superfield S acquires a non-zero VEV, breaking $U(1)_N$ gauge symmetry and giving rise to an effective μ term. Thus the μ problem is solved in the E$_6$SSM in a similar way to that in the NMSSM, but without the accompanying problems of singlet tadpoles or domain walls.

To ensure anomaly cancellation and gauge coupling unification the low energy matter content of the E$_6$SSM involve three 27 representations of E_6 and a pair of $SU(2)$ doublets from additional 27 and $\overline{27}$. Thus E$_6$SSM predicts a Z' boson and extra matter beyond the MSSM that forms three $5 + 5^*$ representations of $SU(5)$ plus three $SU(5)$ singlets which carry $U(1)_N$ charges. The presence of light exotic quarks and Z' boson may lead to spectacular LHC signals. The Z' boson can be discovered in the Drell-Yan process $pp \to \ell\bar{\ell} + X$. Relatively light exotic quarks result in the enhancement of the cross section of either $pp \to t\bar{t}b\bar{b} + E_T^{\rm miss} + X$ (if diquarks) or $pp \to t\bar{t}\tau\bar{\tau} + E_T^{\rm miss} + X$ (if leptoquarks). The discovery at future colliders of the exotic particles and extra Z' boson predicted by the E$_6$SSM would represent a possible indirect signature of an underlying E_6 gauge structure at high energies. In our previous articles S. F. King, S. Moretti and I explored the renormalization group (RG) flow of gauge and Yukawa couplings, studied EWSB, established the qualitative pattern of the spectrum of the Higgs bosons, neutralinos and charginos as well as calculated the two–loop upper bound on the lightest Higgs boson mass within the E$_6$SSM. In particular, our analysis revealed that the unification of the gauge couplings in the E$_6$SSM can be achieved for any phenomenologically acceptable value of $\alpha_3(M_Z)$, consistent with the central measured low energy value. Although this study was performed in the framework of a particular $U(1)_N$ gauge extension of the MSSM, our analysis can be easily generalized to other SUSY models with additional $U(1)$ gauge symmetry.

Recently P. Athron, S. F. King, D. J. Miller, S. Moretti and I examined the EWSB, the particle spectrum and collider signatures within the constrained version of the E$_6$SSM (cE$_6$SSM). We studied the parameter space of the cE$_6$SSM consistent with a Higgs signal near 125 GeV and the LHC searches for squarks, gluinos and Z'. We found that a 125 GeV Higgs mass only arises for a sufficiently large Z' mass, mostly above current limits, and for particular regions of squark and gluino masses corresponding to multi-TeV squark masses, but with lighter gluinos typically

within reach of the LHC 8 TeV or forthcoming 14 TeV runs. We also argued that the successful dark matter relic abundance may be achieved over all the parameter space. In the nearest time I plan to examine the sparticle spectrum within the E_6SSM and other E_6 inspired SUSY models in the framework of different models of SUSY breaking, like gravity, gauge and anomaly mediated scenarios of SUSY breaking and split supersymmetry. The study of production and decay rates of Z' and exotic particles at the LHC will be continued.

In the E_6SSM the usual SM-like Higgs boson could decay more than 95% of the time into either lightest or next-to-lightest SUSY particles. J. Hall, S. F. King, S. Pakvasa, M. Sher and I carried out a detailed study of this scenario. The evidence for the Higgs boson recently presented by ATLAS and CMS indicates that the corresponding scenario is basically ruled out. At the moment my collaborators and I are continuing to explore other scenarios that leads to the novel Higgs decays within the E_6SSM. The implications of the E_6SSM and other E_6 inspired SUSY models for dark matter and the anomalous magnetic dipole moment of the muon will also be explored.

As in any other SUSY model the gauge symmetry in the E_6SSM does not automatically forbid lepton and baryon number violating operators that result in the rapid proton decay. Moreover, exotic particles in the E_6 inspired SUSY models give rise to new Yukawa interactions that induce unacceptably large non–diagonal flavour transitions. In this context my collaborators and I are examining E_6 inspired SUSY models in which exact discrete symmetry simultaneously forbids non–diagonal flavour transitions as well as rapid proton decay. We are exploring both cosmological as well as collider implications of this symmetry. The considered E_6 inspired SUSY models contain at least two dark-matter candidates. We are also considering five–dimensional and six–dimensional orbifold GUT models based on the E_6 or its subgroup that can lead to the E_6 inspired SUSY models of this type.

Since in the E_6SSM right–handed neutrinos do not participate in gauge interactions they may be superheavy, shedding light on the origin of the mass hierarchy in the lepton sector and providing a mechanism for the generation of lepton and baryon asymmetry of the Universe. In our previous work S. King, R. Luo, D. Miller and I studied the generation of flavour dependent lepton asymmetries within the E_6SSM. Our analysis revealed that the substantial lepton CP asymmetries can be induced even if the right–handed neutrino mass scale is relatively low $\sim 10^6$ GeV. This suggests that in the E_6SSM successful thermal leptogenesis can be achieved without encountering gravitino problem. In the near future we plan to derive and analyse a complete set of Boltzmann equations in the considered model. Also my collaborators and I are going to investigate the possible relationships between the Yukawa couplings of ordinary and exotic particles that arise in superstring and orbifold grand unified theories. These relations can lead to new theoretical bounds for the neutrino masses and mixing angles.

Cosmological constant problem

The problem of the cosmological constant will be addressed on the basis of the Multiple Point Principle (MPP). The MPP postulates that Nature chooses values of coupling constants to ensure the coexistence of many phases of the underlying theory. The vacuum energy densities of these different phases are degenerate. Recently C. D. Froggatt, H. B. Nielsen and I argued that the MPP ensures CP-invariance and the absence of flavour changing neutral currents in the two Higgs doublet extension of the SM. Using the MPP assumption, C. D. Froggatt, H. B. Nielsen and I also obtained a rather reasonable estimation for the value of the cosmological constant in $N = 1$ supergravity (SUGRA) models. The idea of MPP will be further applied to the string inspired SUGRA models. In this context the gaugino condensation scenario of local SUSY breakdown will be analysed. A realistic string inspired SUGRA model, where MPP is realized, will be constructed. The predictions for the soft SUSY breaking terms will be obtained and the cosmological constant problem will be re-examined. The impact of new phases and phase transitions, caused by new vacua arising out of the MPP, on the evolution of the Universe will be investigated.