

Born 12th September 1953, Ichapur, India

Secondary education at the Central School, Ambarnath, 1963–69;
All India Higher Secondary School Examination Certificate, 1969

Undergraduate studies at the [Indian Institute of Technology, Kharagpur](#), 1969–74;
B.Sc. in Physical Sciences, 1972; M.Sc. in Physics, 1974

Research at the [Tata Institute of Fundamental Research \(TIFR\), Bombay](#), 1974–82;
Research Associate in Cosmic Rays Group, 1979–84; Ph.D. in Physics, [University of Bombay](#), 1982

Visiting Fellow, [International School of Advanced Studies \(SISSA\), Trieste](#), 1983

Research Associate, [Theory Division, CERN, Geneva](#), 1984–85

Visiting Fellow, [Department of Astrophysics, University of Oxford](#), 1985–86

Research Associate, HEP Theory Group, [Rutherford Appleton Laboratory \(RAL\), Chilton](#), 1987–88

Staff Member of the [Rudolf Peierls Centre for Theoretical Physics, University of Oxford](#), since 1990:
Glasstone Fellow, 1990–92; PPARC Advanced Fellow, 1992–97; Research Fellow, [Wolfson College](#),
1993–97; Departmental Lecturer & Tutor in Physics, [Pembroke College](#), 1997–98; University Lecturer,
Fellow of [Linacre College](#) 1998–; Reader 2000; Professor 2006–; Head, [Particle Theory Group](#) 2011–19



Awards & Honours:

- ▷ [National Science Talent Scholarship](#), 1969–78
- ▷ [George Marx Memorial Lecture](#), 2003
- ▷ [Glasstone Fellowship](#), University of Oxford, 1990–92
- ▷ Advanced Fellowship, [Particle Physics & Astronomy Research Council](#) 1992–97
- ▷ Senior Fellowship, [UK Science & Technology Facilities Council](#) 2006–09
- ▷ [Niels Bohr Professorship, University of Copenhagen](#) 2013–18
- ▷ [IUPAP-TIFR Homi Bhabha Medal and Prize](#), 2017
- ▷ [Bruno Rossi Prize](#) of the American Astronomical Society to the IceCube Collaboration, 2021

Academic Service:

- Member (Astrophysics & Cosmology section), [Particle Data Group](#), 2001–
- [Oxford University](#): Joint Committee on Physics & Philosophy, 2005–07 (Chair 2006–07); Glasstone Committee 2008–12 (Chair 2011–12); India Strategy Working Group, 2006–16; Board, India Oxford Initiative (2019–)
- [Agence d’Evaluation de la Recherche et de l’Enseignement Superieur \(AERES\)](#) Review Panel, 2005–9
- [Astroparticle Physics European Coordination \(ApPEC\)](#), PRC 2005–10, SAC 2010–12
- Steering Committee, [Astroparticle Physics Group, Institute of Physics UK](#), 2006–08
- Science Vision Working Group (Panel A), [ASTRONET](#), 2006–08
- Chair, Astroparticle Physics Panel, [STFC Programmatic Review](#), 2008
- Astroparticle Physics European Research Area Network ([ASPERA](#)): WGs & EC, 2007–19
- International Peer Review Panel, [Danish Council for Independent Research](#), 2010–12
- [Helmholtz Gemeinschaft, Germany](#) Review Panels: Astroparticle Physics, 2011; [DESY](#), 2018
- International Advisory Board, [Helmholtz Alliance on Astroparticle Physics](#), 2012–17
- Editorial Board, [European Physical Journal C](#), 2012–15; [Pramana](#), 2013–; [SciPost](#), 2016–
- Scientific & Technical Advisory Committee, [KM3NeT](#), 2013–20
- Advisory Board, [Gruber Cosmology Prize](#), 2014–20
- IUPAP Working Group 10: [AstroParticle Physics International Committee \(APPIC\)](#), 2014–
- Scientific Advisory Panel, [Institute of Physics, Universiteit Van Amsterdam](#), 2016–
- Scientific Council, [International Center for Theoretical Physics Asia-Pacific, Beijing](#), 2018–
- Steering Committee, [European Centre for Astro Particle Theory](#), 2019–20

Research Experience: My research interests are focussed on particle astrophysics and cosmology. My key contributions have been in cosmic ray phenomenology, in using the early universe as a laboratory for new physics, and in seeking a physical understanding of dark matter and dark energy.

Cosmic Rays & High Energy Astrophysics: Our experimental cosmic ray studies using plastic track detectors flown on balloons and *SKYLAB* showed that heavy nuclei in low energy cosmic rays are not fully ionised, implying a relatively local (Solar System) origin [398]. To investigate this further we designed an experiment (*Anuradha*) flown on *SPACELAB III*, which had a rotating detector to provide time resolved flux measurements, using the Earth’s magnetic field as a momentum filter.

We investigated cosmic ray acceleration by plasma turbulence and the non-thermal radiation which probes such environments. By combining radio, X-ray and γ -ray data on the young supernova remnant (SNR) *Cassiopeia A* we showed that the magnetic field in the radio emitting region has been significantly amplified over the compressed interstellar field [2]. We showed that 2nd-order Fermi acceleration by plasma turbulence generated via the deceleration of the blast wave naturally yields the observed power-law (slightly *convex*) electron spectrum, and explains the rapid rise in synchrotron luminosity (accompanied by spectral flattening) of young SNRs entering the Sedov-Taylor phase [4]. Our analytic solution to the transport equation explains the temporal and spectral evolution of the radio emission from *Cassiopeia A*. We are presently testing the theory using high powered lasers to reproduce a lab-scale version of SNR shocks [370, 371, 372, 105, 374].

I noted [3] that old SNRs in the radiative phase which have expanded to large sizes in the hot interstellar medium can account for the ‘diffuse’ synchrotron radio emission from the Galaxy, thus reconciling the modest magnetic field values inferred from Faraday rotation with the higher values inferred from the synchrotron luminosity. The closest of these stand out as the ‘radio loops’ which extend to high galactic latitudes and we showed that the angular power spectrum of the galactic emission is well matched by the contribution on $\sim (1 - 10)^0$ scales from $\mathcal{O}(10^4)$ such old SNRs [87]. We discovered that one of these, Loop I, is visible in supposedly ‘foreground-cleaned’ maps of the cosmic microwave background (CMB), with its anomalous microwave emission possibly arising from magnetised dust grains [92, 99]. Part of it crosses the sky region from which the BICEP2 experiment recently detected ‘*B-mode*’ polarisation, which was interpreted as due to gravitational waves from inflation but subsequently shown by the *Planck* satellite to arise from dust emission.

A nearby SNR may also be responsible for the positron excess in cosmic rays seen by the *PAMELA* satellite, later confirmed by AMS-02 on the Space Station, which has been widely speculated to be due to dark matter annihilation or decay. The positron secondaries created near the shock wave will themselves be accelerated and naturally acquire a harder spectrum than the primary electrons. By fitting to the $e^- + e^+$ spectrum measured by the *Fermi* satellite, we were able to pick out the most plausible SNR source configuration by doing Monte Carlo simulations [68, 411]. Such nearby SNRs would have a γ -ray brightness consistent with the unidentified extended sources seen by *MILAGRO* and should be detectable by *IceCube* in TeV energy neutrinos. As a corollary B/C and \bar{p}/p should also start flattening (or even rising) with energy [67, 91] — this is currently being checked by AMS-02.

Another context in which 2nd-order Fermi acceleration of electrons is important is the γ -ray emission from the ‘Fermi bubbles’ — the giant bi-lobar structure at the Galactic Centre. We have shown that inverse-Compton scattering of starlight and CMB photons by electrons fits the spectrum and morphology of the bubbles, and that the electrons can be accelerated on the necessary short time scale by plasma turbulence behind the shocks [80, 412].

I was a member of the *Pierre Auger Observatory* [148, 154, 160, 166] which established the suppression of the energy spectrum of ultra-high energy cosmic rays at around the ‘GZK cutoff’ expected for primary protons due to photopion production on the CMB [143, 151] and a weak correlation between their arrival directions and nearby active galactic nuclei [139, 142]. I am also a member of *IceCube* [287, 289] which made the first observation of high energy neutrinos of cosmic origin [235, 243, 250, 259, 266] and has recently identified a flaring blazar as a source [311, 309]. *IceCube* has also made competitive measurements of atmospheric neutrino oscillations [236, 257, 278, 299] and placed strong constraints on a sterile neutrino [277, 291]. It will be possible to measure the neutrino mass hierarchy with the *PINGU* infill [391, 393]. My main contribution to these experiments has

been to provide state-of-the-art theoretical and phenomenological inputs for the science analyses. For example searches for ultrahigh energy neutrinos require knowledge of their deep inelastic scattering cross-section which we have computed using parton distribution functions measured at HERA [61, 81]. A study of neutrino absorption by the Earth confirms our calculation up to PeV energies [304], as does a measurement of the inelasticity distribution [313]. Another key target of *Auger* and *IceCube* is the ‘cosmogenic’ neutrino flux [198, 242, 308] which we have computed by analysing the intergalactic propagation of UHE cosmic protons, and imposing the constraint from *Fermi* on the concomitant γ -ray background [73]. Motivated by the observation that the chemical composition is getting heavier at the highest energies, we studied the intergalactic propagation of UHE heavy nuclei and showed that the cosmogenic neutrino flux is then reduced substantially [50, 57, 60, 63]. I joined the *Cherenkov Telescope Array* collaboration [362, 363] and participated in defining its science requirements and assessing the ‘Key Science Projects’, as well as elaborating on the science case for the measurements to be performed [365, 394, 364, 394].

Particle Physics & the Early Universe: My work has developed and refined the constraints on fundamental physics coming from cosmology and astrophysics. All particles, known or as yet undiscovered, would have been created in the early universe; analysis of their possible effects on the CMB and the light element abundances from Big Bang nucleosynthesis (BBN), enables interesting constraints to be derived on their properties. The production and interactions of particles can also have observable effects in astrophysical objects such as the Sun and supernovae. Such arguments have provided useful guidance on physics beyond the Standard $SU(3) \otimes SU(2) \otimes U(1)$ Model of particle physics [23].

By combining cosmological constraints with laboratory bounds on leptonic mixing, we demonstrated that the ν_τ must be stable against weak decay, hence lighter than $2m_e$ [6]. With the subsequent discovery of large-angle neutrino mixing, stronger mass bounds follow, but these arguments remain relevant to other hypothetical neutral leptons e.g. ‘sterile’ neutrinos. We calculated the ‘thermalisation redshift’ above which a large electromagnetic energy release in the early universe (e.g. from decaying ν_τ s) would be instantly converted into blackbody radiation by radiative Compton scattering, leaving no (Bose-Einstein) distortion in the observed spectrum. We showed that even tiny releases of hydrogen ionising radiation would broaden the last scattering surface and noticeably damp the (then) just discovered ‘acoustic peaks’ in the CMB angular power spectrum [33] — this has proven to be a stringent constraint on late-time annihilations of relic particles, enabling precision data from the *Planck* satellite to rule out such annihilations as the source of the *PAMELA/AMS-02* anomaly

The bounds on leptonic mixing used above came from a search for heavy neutrinos using the *Big European Bubble Chamber* in the WA66 ‘beam dump’ in which I participated [9]. When monojet events seen by the *UA1* experiment were interpreted as due to a light gluino, we proposed a search in WA66 and ruled them out from the absence of any excess of neutral current-like events [8]. We also set a stringent bound on the magnetic moment of tau neutrinos [15].

We showed that the thermal production of massive gravitinos can be disastrous for cosmology, implying a constraint on the temperature to which the universe reheated at the end of inflation [7]. The most restrictive bound comes from consideration of the potential overproduction of D and ^3He through the photodisintegration of ^4He by the radiation cascade triggered in the plasma by high energy photons from gravitino decays. This implies that the baryon asymmetry cannot have been created at the GUT scale and has motivated many theoretical attempts to generate it by alternative means such as ‘leptogenesis’ which is linked to neutrino mass [34]. In subsequent work we further refined these bounds and derived new constraints on high energy neutrinos and cosmic rays produced through the decay of metastable relic particles, which have ruled them out as dark matter [13].

Such arguments have wide application, e.g. the Next-to-Minimal-Supersymmetric Standard Model (NMSSM) which addresses the ‘ μ problem’ due to the mixing of the two Higgs doublets in the MSSM by introducing an additional singlet, is *inconsistent* with cosmology [21]. Unacceptable domain walls form at $SU(2) \otimes U(1)$ symmetry breaking due to the underlying Z_3 symmetry — the wall network can decay through non-renormalisable terms that violate it but these in turn induce tadpole divergences which destabilise the hierarchy and reintroduce the hierarchy problem. This remains an important constraint on variant models of weak scale supersymmetry which are still consistent with LHC data.

We showed that in supergravity-based inflationary models, the Hubble parameter cannot exceed the gravitino mass [20]. Gravitino overproduction is avoided if the inflaton is in a hidden sector and its potential is sufficiently flat if it is a Goldstone mode [27]. Taking non-renormalisable terms into account, inflation can occur as low as the electroweak scale but still generate the required amplitude of density perturbations [41]. Topological inflation can be realised in the ‘racetrack’ model which solves the dilaton runaway problem [56]. Moreover, other scalar fields can undergo symmetry breaking phase transitions *during* inflation, introducing spectral features [28] and associated non-Gaussianity [69]. We developed a robust technique for deconvolving CMB and large-scale structure data [89] and have found marginal evidence for spectral features [97]. This can be encoded in the EFT of inflation [107]

We proposed that quantum gravity effects might be detectable by looking for high energy Lorentz invariance violation (LIV) through e.g. energy-dependent arrival time dispersion in cosmologically distant γ -ray bursts [30]. This demonstration that the Planck scale is not beyond experimental reach has generated considerable interest. Observations by Cherenkov telescopes and *Fermi* have however ruled out a LIV term $\propto E_\gamma^2/M_{\text{Pl}}$ in the dispersion relation. However an even smaller (and theoretically more plausible) term $\propto E_\gamma^3/M_{\text{Pl}}^2$ can decohere oscillations of cosmic neutrinos and alter their flavour ratios away from the large-angle mixing based expectation at a level detectable by *IceCube* [52]

We calculated the error correlation matrix for BBN and highlighted systematic uncertainties in inferring the primordial abundances [31], which allow an additional light neutrino (or equivalent particle) [35]. This imposes constraints on e.g. an additional Z' to which singlet neutrinos are coupled [10], on a ‘time-varying cosmological constant’ [25], on photon mixing [29] and on a light neutralino [85].

Dark Matter & Dark Energy: An attractive particle candidate for dark matter is the lightest supersymmetric state. We have shown that neutralinos in the NMSSM can be significantly lighter than the weak scale [17] — a possibility that has become experimentally interesting recently. Alternatively the dark matter may consist of very massive metastable particles e.g. ‘cryptons’ (bound states from the hidden sector of SUSY breaking). The high energy neutrino flux from their decays is detectable in underground experiments and requires such particles to have lifetimes $> 10^{16}$ yr [16]. When ultrahigh energy cosmic rays were detected beyond the expected ‘GZK cutoff’ we proposed that these arise from the slow decays of such particles clustered in the galactic halo [32] — the observed spectrum is well matched by that expected from QCD fragmentation [43], while the expected small anisotropy in arrival directions should be detectable with forthcoming data [40]. (This model is now disfavoured because *Auger* data show that the trans-GZK flux is indeed suppressed and high energy photons do *not* dominate over nucleons as would be expected from particle decays, however these calculations remain relevant e.g. constraining models of the *IceCube* events as due to decaying dark matter [307].)

We first emphasised that the dwarf spheroidal satellite galaxies of the Milky Way are good search targets for γ -rays from dark matter annihilation, using dynamical arguments to infer their dark matter content [47, 79, 94]. However dark matter may have an asymmetry like baryons and *not* annihilate — we showed that accreted dark matter can then affect heat transport in the Sun and potentially solve the ‘Solar composition problem’ as well as alter Solar neutrino fluxes [70]. Such dark matter arises in models of new strong dynamics [78] and can have different couplings to protons and neutrons, thus potentially reconciling the signal seen in DAMA with upper limits from XENON [82]. However astrophysical uncertainties alone cannot make these results consistent [84]. We discussed collider probes of such new vector interactions [86]. We have studied dark matter self-interactions in colliding clusters [90] and reassessed the recent claim for a signal in A3827 [95].

The breaking of scale-invariance of primordial perturbations due to phase transitions occurring during inflation can dramatically affect cosmological parameter extraction from CMB and other data, in particular doing away with the need for dark energy [39, 46, 59, 65]. Our recent analysis of the Type Ia supernova Hubble diagram also shows that the evidence for cosmic acceleration is *marginal* [96]. Dark energy may thus be just an artifact of interpreting data in an oversimplified model framework. Moreover searches for its dynamic effects, such as the ‘late ISW effect’ using observations of stacked voids, are, we find, inconsistent with the standard Λ CDM cosmological model [83], as is the number of merging galaxy clusters [93]. Our recent work shows that cosmic acceleration is *anisotropic* [106, 112, 113, 111] so cannot be due to a Cosmological Constant, and that the CMB dipole may not be of kinematic origin [101, 109, 104] thus undermining the Cosmological Principle itself.

Invited Talks at Conferences & Workshops:

1. ICHEP 85: International Conference on High Energy Physics, Bari, Jul 1985
2. ISMD 86: XXVI International Symposium on Multiparticle Dynamics, Seewinkel, Jun 1986 [116]
3. UK HEP Theory X'mas Meeting, Rutherford Appleton Laboratory, Chilton, Dec 1987
4. NATO ASI: *Observational Tests of Cosmological Inflation*, Durham, Dec 1990 [117]
5. UK HEP Theory X'mas Meeting, Rutherford Appleton Laboratory, Chilton, Dec 1990
6. UK HEP Cosener's House Forum: *Dark Matter*, Abingdon, Jun 1991
7. UK Institute of Physics Discussion Meeting: *Dark Matter*, London, Jun 1991
8. NORDIC meeting on Theoretical Physics, Copenhagen, Aug 1993
9. XI DAE Symposium on High Energy Physics, Shantiniketan, Jan 1994
10. UK HEP Forum: *New Horizons in Astroparticle Physics*, Abingdon, Feb 1994
11. UK HEP Forum: *Particle Cosmology*, Abingdon, Jun 1994
12. Royal Astronomical Society Discussion Meeting: *Neutron Stars*, London, Jan 1995
13. UK National Astronomy Week, Cardiff, Apr 1995
14. Inaugural Conference of the Asia-Pacific Centre for Theoretical Physics, Seoul, Sep 1996 [119]
15. WHEPP 96: Fourth Workshop on High Energy Physics Phenomenology, Calcutta, Jan 1996
16. DARK 96: *Dark Matter in Astro- & Particle Physics*, Heidelberg, Sep 1996 [118]
17. WIN 07: XVI Intern. Workshop on Weak Interactions & Neutrinos, Capri, Jun 1997 [120]
18. International Workshop on Synthesis of Nuclei in the Early Universe, Trento, Jun 1997
19. ICTP Workshop: *Highlights in Astroparticle Physics*, Trieste, Nov 1997
20. UK Institute of Physics Annual Conference on High Energy Physics, Manchester, Apr 1998
21. CAPP-98: International Workshop on Cosmology & Particle Physics, Geneva, Jun 1998
22. DARK 98: *Dark Matter in Astro- & Particle Physics*, Heidelberg, Jul 1998
23. NOW 98: EPS Neutrino Oscillation Workshop, Amsterdam, Sep 1998 [387]
24. ICTP Workshop: *The Physics of Relic Neutrinos*, Trieste, Sep 1998
25. DESY Theory Workshop: *Directions Beyond the Standard Model*, Hamburg, Oct 1998
26. JENAM'99: Joint European & National Astronomical Meeting, Toulouse, Sep 1999
27. COSMO-99: *Particle Physics & the Early Universe*, Trieste, Oct 1999 [123]
28. Landelijk Seminarium, NIKHEF, Amsterdam, Dec 1999
29. Annual UK HEP Theory Meeting, Rutherford Appleton Laboratory, Chilton, Dec 1999
30. Nordic Workshop: *Neutrino physics & Cosmology*, Copenhagen, Apr 2000
31. Summer Institute: *Dark Matter & Supersymmetry*, Gran Sasso, Jul 2000
32. XIII Recontres des Blois: *Frontiers of the Universe*, Blois, Jun 2001 [129]

33. International Workshop: *The Physics of Extra Dimensions*, Paris, Jun 2001
34. International Conference: *Deuterium in the Universe*, Meudon, Jun 2001
35. ICHEP 01: Intern. Europhysics Conf. on High Energy Physics, Budapest, Jul 2001 [126]
36. COSMO-01: *Particle Physics & the Early Universe*, Rovaniemi, Sep 2001 [127]
37. IUCAA Workshop: *Interface of Gravitational & Quantum Realms*, Pune, Dec 2001 [44]
38. NORDITA Meeting on Astroparticle Physics & Cosmology, Copenhagen, Mar 2002
39. Planck 01: International Conference on Supersymmetry & Brane Worlds, Kazimierz, May 2002
40. Workshop: *Cosmoseismology & Entropy Perturbations*, Portsmouth, Jun 2002
41. International Conference on String/M-theory Phenomenology, Oxford, Jul 2002
42. International Workshop on Branes, Gravity, . . . : *New Interfaces*, London, Sep 2002
43. HEP 2003: Workshop on High Energy Physics and Cosmology, Athens, Apr 2003
44. Planck 03: *From the Planck Scale to the Electroweak Scale*, Madrid, May 2003
45. CAPP-2003: International Workshop on Cosmology & Particle Physics, Geneva, Jun 2003
46. Claude Itzykson meeting: *Which Model(s) for the Early Universe?*, Saclay, Jun 2003
47. Eötvös Graduate Course and Workshop in Physics, Balatonfüred, Jun 2003 [130]
48. ISMD 03: XXXIII International Symposium on Multiparticle Dynamics, Krakow, Sep 2003 [128]
49. International Workshop on Astroparticle & High Energy Physics, Valencia, Oct 2003
50. 315th WE-Heraeus-Seminar: *Dark Matter and Dark Energy*, Bad Honnef, Dec 2003
51. Institute of Physics UK Particle Physics Conference 2004, Birmingham, Apr 2004
52. Planck 04: *From the Planck Scale to the Electroweak Scale*, Bad Honnef, May 2004
53. International Conference: *The density Perturbation in the Universe*, Athens, Jun 2004 [131]
54. *Terrestrial and Cosmic Neutrinos, leptogenesis and Cosmology*, Benasque, Jul 2004
55. ISVHECRI 04: Intern. Symp. on Very High Energy Cosmic Ray Interactions, Pylos, Sep 2004
56. UK High Energy Physics Forum: *Cosmic Particles*, Abingdon, Feb 2005
57. SNS Pisa-UCLA Workshop: *Cosmic Connections*, La Magia, Apr 2005
58. Montpellier-Toulouse meeting: *Dark Energies, Dark matters*, Paris, Apr 2005
59. PASCOS'05: International Conference on Particles, Strings & Cosmology, Gyeongju, Jun 2005
60. COSMO 05: Intern. Workshop on Particle Physics & the Early Universe, Bonn, Sep 2005
61. European Astroparticle Physics Town Meeting, Munich, Nov 2005
62. International Conference: *From Strings to Cosmic Web*, Groningen, Dec 2005
63. Cosmology 2005: *A Reality Check*, Copenhagen, Dec 2005
64. XI IFT-UAM/CSIC Christmas Workshop on Particle Physics, Madrid, Dec 2005
65. Workshop on High Energy Physics Phenomenology, Bhubaneswar, Jan 2006 [388]

66. Sixth National Astroparticle Symposium, Amsterdam, Feb 2006
67. HEP2006: [Recent Developments in High Energy Physics & Cosmology](#), Ioannina, Apr 2006
68. ToK Workshop on Particle Physics & Cosmology, Warsaw, May 2006
69. Institute of Physics UK, Astroparticle Group meeting, Sheffield, May 2006
70. International Workshop: *The Dark Side of the Universe*, Madrid, Jun 2006
71. International Conference: *Quantum ... Gravity and Cosmology*, Barcelona, Jul 2006
72. DESY Theory Workshop: *The Dark Universe*, Hamburg, Sep 2006
73. *Outstanding questions for the standard cosmological model*, London, Mar 2007
74. *From IRAS to Herschel/Planck*, London, Jul 2007
75. ASPERA workshop for the Astroparticle Roadmap, Phase II, Paris, Jul 2007
76. COSMO 07: Intern. Workshop on Particle Physics & the Early Universe, Falmer, Aug 2007
77. TRR-33 Workshop: *The Dark Universe*, Bad Honnef, Oct 2007
78. AMT Workshop: *Questions for the Universe*, Toulouse, Nov 2007
79. ICGC 07: International Conference on Gravitation & Cosmology, Pune, Dec 2007
80. Rencontre des Particules, Annecy, Jan 2008
81. Workshop on *Nu Horizons*, Allahabad, Feb 2008
82. International Workshop: *Quarks in astrophysics and cosmology*, Puri, Feb 2008
83. Nordic Workshop: *Field Theoretical Applications in Cosmology*, Copenhagen, Mar 2008
84. UK HEP Forum Meeting: *Neutrino Horizons in the 21st Century*, Abingdon, Apr 2008
85. International Conference: *Progress on Old and New Themes in Cosmology*, Avignon, Apr 2008
86. Neutrino 08: Intern. Conf. on Neutrino Physics & Astrophysics, Christchurch, May 2008 [[133](#)]
87. International Conference on Quantum Geometry & Quantum Gravity, Nottingham, Jul 2008
88. [International Conference on Dark Energy and Dark Matter](#), Lyon, Jul 2008 [[134](#)]
89. ICTS Workshop: *Cosmology with CMB and LSS*, Pune, Aug 2008
90. ICTS Workshop: *QCD at High Parton Density*, Panjim, Sep 2008
91. ISSI Workshop: *The Nature of Gravity*, Bern, Oct 2008
92. Royal Astronomical Society Discussion Meeting: *Galaxies and the Elements*, London, Nov 2008
93. IoP UK Meeting: *Searching for Dark Matter Underground & at the LHC*, London, Dec 2008
94. WAPP-08: Workshop on Astroparticle Physics, Ootacamund, Dec 2008
95. ToK Workshop on Particle Physics and Cosmology, Warsaw, Feb 2009
96. Eleventh National Astroparticle Symposium, Leiden, March 2009
97. ICTS Workshop: *Neutrinos in Particle Astrophysics & Cosmology*, Mahabalipuram, Apr 2009
98. *Cosmology and astroparticle physics from the LHC to PLANCK*, Copenhagen, Jun 2009

99. CHIPP Workshop: *Astroparticle Physics*, Lausanne, Jun 2009
100. PPAP Meeting: *Neutrino & Non-accelerator Physics*, Birmingham, Jul 2009
101. *Universe in a Box : LHC, Cosmology & Lattice Field Theory*, Leiden, Aug 2009
102. Workshop on *Origin of mass*, Odense, Nov 2009
103. HEAP 2009: *Cosmic Particles, Jets and Accelerator Science*, Tsukuba, Nov 2009
104. WAPP-09: Workshop on Astroparticle Physics, Darjeeling, Dec 2009
105. [Workshop on the New, the Rare and the Beautiful](#), Zurich, Jan 2010
106. DISCOVERY Centre inauguration, Copenhagen, Jan 2010
107. [ToK Workshop: Particle Physics & Cosmology](#), Warsaw, Feb 2010
108. [Workshop: Frontiers of Cosmology](#), Heraklion, Apr 2010
109. [Cosmology and astroparticle physics from the LHC to PLANCK](#), Copenhagen, Jun 2010
110. [NEB14: Recent developments in gravity](#), Ioannina, Jun 2010
111. [PPC 2010: Workshop on interconnection between particle physics & cosmology](#), Torino, Jul 2010
112. [TeVPA-10: International conf. on TeV Particle Astrophysics](#), Paris, Jul 2010
113. [Darkness visible: Workshop on Dark Matter in Astro- & Particle Physics](#), Cambridge, Aug 2010
114. [UniverseNet Workshop: Confronting Theory with Observations](#), Copenhagen, Aug 2010
115. [SUSY10: Supersymmetry & Unification of Fundamental Interactions](#), Bonn, Aug 2010
116. WAPP-10: Workshop on Astroparticle Physics, Ootacamund, Dec 2010
117. Workshop on *Dark Matter in the LHC Era: Direct and Indirect Searches*, Kolkata, Jan 2011
118. [XIV International Workshop on Neutrino Telescopes](#), Venice, Mar 2011
119. [IoP Nuclear & Particle Physics Divisional Conf.](#), Glasgow, Apr 2011
120. [Workshop on Cosmology & astroparticle physics from LHC to PLANCK](#), Copenhagen, Jun 2011
121. [NuSky2011: International Workshop on Cosmic Rays & Cosmic Neutrinos](#), Trieste, Jun 2011
122. [TeVPA-11: Workshop on TeV Particle Astrophysics](#), Stockholm, Aug 2011
123. [ICRC2011: 32nd International Cosmic Ray Conference](#), Beijing, Aug 2011
124. [XXV International Symposium on Lepton Photon Interactions](#), Mumbai, Aug 2011
125. RAS Specialist Discussion Meeting, [Exploring the Non-Thermal Universe](#), London, Nov 2011
126. HEAP 2011: [Gamma-ray universe: Fermi to CTA](#), Tsukuba, Nov 2011
127. [OPERA versus Maxwell and Einstein' event](#), King's College London, Nov 2011
128. [CTA Consortium Meeting](#), Univ Complutense Madrid, Nov 2011
129. [Amazing Particles & Light: Horizons in Accelerators and Enabled Sciences](#), Bangalore, Dec 2011
130. Advances in Astroparticle Physics & Cosmology, Darjeeling, Mar 2012
131. [National Symposium on Particles, Detectors and Instrumentation](#), Mumbai, Mar 2012

132. HEP2012: *Recent Developments in High Energy Physics and Cosmology*, Ioannina, Apr 2012
133. Planck 2012: *From the Planck Scale to the Electroweak Scale*, Warsaw, May 2012
134. NORDITA Workshop on *Origin of Mass 2012*, Stockholm, Jun 2012
135. *darkattack2012*, Ascona, Jul 2012
136. *International Symposium on Very High Energy Cosmic Ray Interactions*, Berlin, Aug 2012
137. IAU XXVIII General Assembly: *The Highest-Energy Gamma-ray Universe*, Beijing, Aug 2012
138. Workshop on *Physics of De Sitter Space-time*, Hannover, Sep 2012
139. John Ellis Day, *Outlook in Particle Physics*, London, Oct 2012
140. *IMAPP Jubilee Colloquium*, Nijmegen, Nov 2012
141. *Partikeldagarna*, Stockholm, Nov 2012
142. *ASPERA ad futurum*, Brussels, Nov 2012
143. V F Hess Centenary Symposium, Mumbai, Dec 2012
144. *Time & Matter*, Venice, Mar 2013
145. Nordic CTA Meeting, Stockholm, Mar 2013
146. 47th ESLAB Symposium: *The Universe as seen by PLANCK*, Noordwijk, Apr 2013
147. Latsis Symposium: *Nature at the Energy Frontier*, Zurich, Jun 2013
148. *KSETA Plenary Workshop*, Bad Herrenalb, Feb 2014
149. *New Frontiers in Theoretical Physics*, Cortona, May 2014
150. *Strategy Workshop on Astroparticle in Switzerland*, Geneva, Jun 2014
151. *Frontiers of Fundamental Physics*, Marseille, Jul 2014
152. *DISCRETE 2014*, London, Dec 2014
153. *NuPhys2014*, London, Dec 2014
154. *LahanasFest*, Athens, Jan 2015
155. *Measuring B-mode polarization from Greenland*, Copenhagen, Feb 2015
156. *AMS Days at CERN: The Future of Cosmic Ray Physics*, Geneva, Apr 2015
157. *WylerFest*, Zurich, May 2015
158. *5th Iberian Gravitational-Wave Meeting*, Barcelona, May 2015
159. Workshop on *Alternative matter & alternative gravity*, Heraklion, May 2015
160. *TamavakisFest*, Ioannina, May 2015
161. *Planck 2015*, Ioannina, May 2015
162. *2015: The Spacetime Odyssey Continues*, Stockholm, Jun 2015
163. *Current Themes in High Energy Physics & Cosmology*, Copenhagen, Aug 2015
164. *European Nuclear Physics Conference*, Groningen, Sep 2015

165. [Sixth Quantum Universe Symposium](#), Groningen, Mar 2016
166. [APPEC Town Meeting](#), Paris, April 2016
167. [Axion-like Particles: Theory & Experiment](#), Durham, April 2016
168. [CMB Spectral Distortions](#), Bangalore, Jul 2016
169. [Relativistic astrophysics & gravitational waves](#), Copenhagen, Jul 2016
170. [Current Themes in High Energy Physics & Cosmology](#), Copenhagen, Aug 2016
171. [LHC Days in Split](#), Split, Sep 2016
172. [Danish Astroparticle Physics Meeting](#), Odense, Oct 2016
173. [Dark matter from aeV to ZeV](#), Lumley Castle, Nov 2016
174. [Landelijk Seminarium](#), NIKHEF, Mar 2017
175. [DIS 2017](#), Birmingham, Apr 2017
176. [The future of WIMP dark matter](#), Chicheley Hall, May 2017
177. [Messengers: Astroparticles and Gravitational Waves](#), Stockholm, Jul 2017
178. [DAVCo: DArk matter, neutrinos and their Connections](#), Odense, Sep 2017
179. [Galileo Institute Conference: Collider Physics & the Cosmos](#), Florence, Oct 2017
180. [Probing Fundamental Physics with CMB Spectral Distortions](#), Geneva, Mar 2018
181. [New Probes for Physics Beyond the Standard Model](#), Santa Barbara, Apr 2018
182. [The small-scale structure of cold\(?\) dark matter](#), Santa Barbara, Apr 2018
183. [Symposium on Particle, Astroparticle & Cosmology](#), Tallin, Jun 2018
184. [NORDITA Workshop: Cosmology & Gravitational Physics with Lambda](#), Stockholm, Jul 2018
185. [Current themes in High Energy Physics and Cosmology](#), Copenhagen, Aug 2018
186. [Workshop on The Standard Model & Beyond](#), Corfu, Sep 2018
187. [Hillas Symposium](#), Heidelberg, Dec 2018
188. [XVIII International Workshop on Neutrino Telescopes](#), Venice, Mar 2019 [talk]
189. [International Conference on High-Energy-Density Physics](#), Oxford, Apr 2019
190. [Ninth Quantum Universe Symposium](#), Groningen, Apr 2019
191. [1st CTA Science Symposium](#), Bologna, May 2019
192. [ICTP-AP International Conference on Frontiers of Fundamental Physics](#), Beijing, May 2019
193. [36th International Cosmic Ray Conference](#), Madison, Jul 2019
194. [International Conf. on Fundamental Physics](#), Hyderabad, Sep 2019
195. [15th Central European Seminar on Particle Physics & Quantum Field Theory](#), Vienna, Nov 2019
196. [Multimessengers, compact objects and fundamental physics](#), Prague, Dec 2019
197. [Chitre Memorial Symposium: Frontiers in Astrophysics & Fluid Dynamics](#), Mumbai, May 2021

198. [Cosmological Frontiers in Fundamental Physics](#), Paris, May 2021

199. [Recent Developments in High Energy Physics & Cosmology](#), Thessaloniki, Jun 2021

Invited Lectures at Schools:

1. ICTP Summer School in High Energy Physics & Cosmology, Trieste, Jul 1985 [[115](#)]
2. Scuola Internazionale Superiore Studi Avanzati (SISSA) Graduate School, Trieste, Jul 1986
3. GIFT School in Theoretical Physics, Peniscóla, Aug 1986
4. Adriatic School on High Energy Physics, Split, Jun 1987
5. Centro Fundamental Materia Condensada (CFMC) Graduate School, Lisbon, Mar 1992
6. Spring School in High Energy Physics & Cosmology, Tenerife, May 1992
7. Tata Institute of Fundamental Research (TIFR) Graduate School, Bombay, Aug 1993
8. Indian Institute of Astrophysics (IoA) Graduate School, Bangalore, Dec 1994,
9. BCSPIN/ICTP Summer School in Physics, Kathmandu, May 1997
10. Autumn School on Theoretical Physics, Santiago de Compostela, Sep 1997
11. XIX UK Institute for Theoretical High Energy Physicists, Oxford, Aug 1998
12. Graduiertenkolleg on Cosmology & Statistical Physics, Heidelberg, Nov 1998
13. IPM School on Large-scale structure formation, Kish, Jan 1999 [[122](#)]
14. Bruno Pontecorvo School on Elementary Particles, Capri, May 1999
15. Finnish Particle Cosmology School, Kiljavanranta, Aug 1999
16. NATO Advanced Study Institute: Particle Physics & Cosmology, Cascais, Jul 2000 [[124](#)]
17. British Universities Summer School in Elementary Particle Physics, Oxford, Sep 2000
18. British Universities Summer School in Elementary Particle Physics, Manchester, Sep 2001
19. International Graduate School in Mathematics & Physics, Bonn, Jan 2002
20. ICTP Summer School on Particle Physics & Cosmology, Trieste, Jul 2002
21. Second Crete School on String Theory, Kolymbari, June 2003
22. Second Aegean School on the Physics of the Early Universe, Syros, Sep 2003
23. CERN Summer Student Programme: *Introduction to Cosmology*, Geneva, Aug 2004
24. Third Aegean School on the Physics of the Early Universe, Chios, Sep 2005
25. CERN Summer Student Programme: *Introduction to Cosmology*, Geneva, Jul 2006
26. Nordic Winter School in Particle Physics & Cosmology, Gausdal, Jan 2007
27. CERN Summer Student Programme: *Introduction to Cosmology*, Geneva, Jul 2007
28. CERN Summer Student Programme: *Introduction to Cosmology*, Geneva, Jul 2008
29. ICTS School: *Cosmology with CMB and LSS*, Pune, Aug 2008
30. ICTS School: *QCD at High Parton Density*, Dona Paula, Sep 2008

31. Les Houches School: *Searching for Dark Matter*, Les Houches, Mar 2009
32. Corfu Summer School: *The Standard Model & Beyond*, Corfu, Sep 2009
33. DPG Physics School: *Astroparticle Physics*, Bad Honnef, Sep 2009
34. Winter School in Astroparticle Physics, Darjeeling, Dec 2009
35. YETI School in Astroparticle Physics, Durham, Jan 2009
36. Taller de Altas Energias: *Astroparticle Physics*, Barcelona, Sep 2010
37. CORSIKA Winter School in Astroparticle Physics, Ooty, Dec 2010
38. Corfu Summer Institute: *Unification in the LHC Era*, Corfu, Sep 2011
39. Intern. School of Cosmic Ray Astrophysics: *A new era in particle astrophysics*, Erice, Jul 2012
40. 4th International Summer School on Astroparticle Physics, Nijmegen, Aug 2012
41. Nordic Winter School on Particle Physics and Cosmology, Gausdal, Jan 2013
42. International School for AstroParticle Physics (ISAPP) 2013, Djurönäset, Aug 2013
43. Corfu Summer School: *The Standard Model & Beyond*, Sep 2013
44. Corfu Summer School *The Standard Model & Beyond*, Sep 2014
45. ICTP Summer School on Particle Physics, Jun 2015
46. Taller de Altas Energias, Benasque, Sep 2016
47. Nordic Winter School on Particle Physics and Cosmology, Skeikampen, Jan 2017
48. GIAN School: *Dark Matter: The Astroparticle Connection*, New Delhi, Dec 2017
49. International School of Cosmic Ray Astrophysics, Erice, Aug 2018
50. Cracow School of Theoretical Physics, Zakopane, Jun 2019
51. Summer Research School: *Quantum to Cosmos: Ideas and Applications*, Gebze, Jul 2019

D.Phil Theses Supervised:

1. [Kevin C. Benson](#), Wadham College, Oxford, 1991–93
(Thesis: ‘*Aspects of the electroweak phase transition & baryogenesis*’)
2. [Jennifer A. Adams](#), Magdalen College, Oxford, 1992–95
(Thesis: ‘*Cosmological phase transitions: techniques & applications*’)
3. [Sebastian E. Larsson](#), Christ Church College, Oxford, 1993–98
(Thesis: ‘*Topological defects from cosmological phase transitions*’)
4. [Michael Birkel](#), Linacre College, Oxford, 1994–97
(Thesis: ‘*Astroparticle physics beyond the Standard Model*’)
5. [Fermin Viniegra](#), Worcester College, Oxford, 1997–2001
(Thesis: ‘*Reheating in inflationary cosmology*’) — with B Bassett
6. [Mario Santos](#), Wadham College, Oxford, 1999–2003
(Thesis: ‘*Primordial effects in the CMB*’) — with P Ferreira
7. [David Skinner](#), Linacre College, Oxford, 1999–2003
(Thesis: ‘*Cosmology of heterotic M-theory*’)

8. [Paul Hunt](#), St John's College, Oxford, 2000–06
(Thesis: '*The cosmological implications of inflation*')
9. [Andrew Taylor](#), Linacre College, Oxford, 2003–06
(Thesis: '*The intergalactic propagation of ultrahigh energy cosmic rays*')
10. [Francesco Riva](#), Merton College, Oxford, 2004–08
(Thesis: '*Cosmological consequences of supersymmetric flat directions*') — with J March-Russell
11. [Shaun Hotchkiss](#), Balliol College, Oxford, 2006–10
(Thesis: '*Inflation: beyond the scalar fluctuation power spectrum*')
12. [Philipp Mertsch](#), Balliol College, Oxford, 2007–10
(Thesis: '*Cosmic ray backgrounds for dark matter indirect detection*')
13. [Seshadri Nadathur](#), Merton College, Oxford, 2007–11
(Thesis: '*Inflation, large-scale structure & inhomogeneous cosmologies*')
14. [Felix Kahlhoefer](#), St Catherine's College, Oxford, 2011–14
(Thesis: '*Complementarity of searches for dark matter*')
15. [Kyle Allison](#), Balliol College, Oxford, 2010–14
(Thesis: '*The Standard Model to the Planck scale*') — with G Ross
16. [Jim Talbert](#), Hertford College, Oxford, 2012–16
(Thesis: '*From the LHC to IceCube, a melange of particle phenomenology*') — with G Bell
17. [David Kraljic](#), Balliol College, Oxford, 2012–16
(Thesis: '*Inhomogeneities in Cosmology*')
18. [Jeppe Trøst Nielsen](#), Niels Bohr Institute, Copenhagen, 2013–17
(Thesis: '*Testing cosmological models*')
19. [Amel Durakovic](#), Niels Bohr Institute, Copenhagen, 2014–18
(Thesis: '*On the likely structure and origin of primordial fluctuations*')
20. [Konstantin Beyer](#), Merton College, Oxford, 2017–
(working on axion plasma physics) — with G Gregori
21. [Rudin Petrossian-Byrne](#), Balliol College, Oxford, 2017–
(working on BSM physics) — with J March-Russell
22. [Giacomo Marocco](#), Balliol College, Oxford, 2018–
(working on non-accelerator physics) — with J Wheeler

Refereeing

Appointments & Promotions: CERN, Geneva; Demokritos, Athens; DESY, Zeuthen; Fermilab, Batavia; HRI, Allahabad; IISER, Bhopal; IISc, Chennai; ICTP, Trieste; ICTS, Bengaluru; IUCAA Pune; King's College, London; LAPTH, Annecy; Michigan State University; MPIK Heidelberg; National Technical University Athens; NISER, Jatni; NORDITA Stockholm; Penn State University; RRI, Bangalore, Royal Holloway, University of London; SINP Kolkata; SISSA Trieste; TIFR Mumbai; Tufts University; Universität Aachen; University of Athens; University of Bath; University of California, Berkeley; University of California, Los Angeles; University of California, Riverside; University of Cambridge; University of Crete; Universität Dortmund; University of Durham; University of Edinburgh; University of Geneva; Universität Göttingen; Universität Hamburg; Universität Karlsruhe; University of Lancaster; University of Lyon; University of Massachusetts, Amherst; University of Montpellier 2; University of New Mexico; University of Nottingham; Universität Potsdam; University of Southampton; Universität Wuppertal; Universität Zurich

Grant applications: Academy of Finland; Agence Nationale de la Recherche, France; Alexander von Humboldt Stiftung, Germany; Australian Research Council; Department of Atomic Energy, India; Department of Energy, USA; Department of Science & Technology, India; Deutsche Forschungsgemeinschaft, Germany; Engineering & Physical Sciences Research Council, UK; European Commission; European Research Council; European Space Agency; Fondazione Cariparo, Italy; Fundamenteel Onderzoek der Materie, Netherlands; International Centre for Theoretical Physics, Trieste; Istituto Nazionale di Fisica Nucleare, Italy; Leverhulme Foundation, UK; Ministero dell'Istruzione, Italy; Ministry of Education, Greece; National Research Foundation, South Africa; National Science Foundation, USA; Natural Sciences and Engineering Research Council, Canada; Nederlandse Organisatie voor Wetenschappelijk Onderzoek; Newton Institute, Cambridge; RANNIS Iceland; Royal Society of New Zealand; The Royal Society, UK; Science & Technology Facilities Council, UK; Swiss National Science Foundation; Tata Institute of Fundamental Research, Mumbai

Book proposals: Cambridge University Press, Oxford University Press

Journals: Astronomy & Astrophysics, Astrophysical Journal, Astroparticle Physics, Astrophysics & Space Science, Classical & Quantum Gravity, Computer Physics Communications, European Physical Journal C, Europhysics Letters, Journal of Cosmology & Astroparticle Physics, Journal of High Energy Physics, International Journal of Modern Physics A, Modern Physics Letters, Monthly Notices of the Royal Astronomical Society, Nature, Nuclear Physics B, Physics Letters B, Physical Review D, Physical Review Letters, Pramana, Reports on Progress in Physics, Science

Organisation of Conferences, Schools & Workshops:

▷ Main Organiser:

- UK Theoretical Cosmology Network meeting, Oxford, 15 May 1996, 26 Mar 1997, 20 May 1998
- EU Research & Training School: *Supersymmetry & the Early Universe*, Oxford, 26–29 Sep 2002
- IceCube collaboration meeting, Oxford, 21–24 Sep 2005
- ASPERA Workshop: *Theory and Astroparticle Physics*, Oxford, 17 Mar 2008
- EU Research & Training School: *Fundamental Physics & Cosmology*, Oxford, 22–26 Sep 2008
- First LINK Workshop: *Probing Physics beyond the SM with CTA*, Abingdon, 12 Nov 2010
- GrahamFest, Oxford, 30 Sep 2011
- IoP/IPPP Workshop: *New paths to particle dark matter*, Oxford, 29–30 Mar 2012
- NBIA PhD School: *Neutrinos underground and in the heavens*, Copenhagen, 23–27 Jun 2014
- 2nd NBIA-APCTP Workshop: *Cosmology & Astroparticle Physics*, Copenhagen, 18–22 Aug 2012
- NBIA-Oxford Colloquium, Copenhagen, 13–15 Apr 2015
- NBIA PhD School: *Neutrinos underground and in the heavens II*, Copenhagen, 1–5 Aug 2016
- NBIA Workshop: *Self-interacting dark matter*, Copenhagen, 1–5 Aug 2017

▷ Local Organising/Advisory Committee:

- SUSY 98, Oxford, 11–17 Jul 1998
- Kogan Memorial Meeting: *From Fields to Strings*, Oxford, 8–10 Jan 2004
- First International Conference on *String/M-theory Phenomenology*, Oxford, 6–11 Jul 2002
- UK Neutrino Network meeting, Oxford, 29 Nov 2006
- Astroparticle Physics UK meeting, Oxford, 18–20 Jun 2008
- Rudolf Peierls Symposium on Theoretical Physics, Oxford, 5–6 Jul 2018
- British Univ. Summer School in Theoretical Elementary Particle Physics, Oxford, 20–31 Aug 2018
- *Higgs Couplings 2019*, Oxford, 30 Sep–4 Oct 2019

▷ Organising Committee:

- UK Institute for Theoretical High Energy Physics, Cambridge, 1–7 Sep 1991
- UK HEP Forum: *Cosmology after COBE*, Abingdon, 20–21 Jun 1992
- International Europhysics Conference on High Energy Physics, Brussels, 28 Jul–3 Aug 1995
- 28th International Conference on High Energy Physics, Warsaw, 25–31 Jul 1996
- UK HEP Forum: *New Horizons in Neutrino Physics*, Abingdon, 8–9 May 1999
- EU Network School: *The Early Universe*, CERN, 19–22 Apr 2001
- IPPP Workshop: *Phenomenology of Ultra-high-energy Cosmic Rays*, Durham, 21 June 2002

- UK HEP Forum: *The World according to WMAP*, Abingdon, 7–8 Jun 2003
 - Astrophysics/Cosmology Session, SUSY'05, Durham, 18–23 Jul 2005
 - Dalitz Memorial Meeting, Oxford, 3 Jun 2006
 - EU Network School: *The Origin of the Universe*, Mytilene, 24–29 Sep 2007
 - IoP/RAS meeting: *The Search for Dark Matter*, London, 26 Nov 2007
 - International Workshop: *Cosmology with the CMB & LSS*, Pune, 18–31 Aug 2008
 - PPAP Community Meeting: *Neutrino & Non-accelerator Physics*, Birmingham, 15 July 2009
 - 9th Hellenic School of Elementary Particle Physics & Gravity, Corfu, 30 Aug–20 Sep 2009
 - EU Network School: *Particle Physics & Cosmology*, Barcelona, 28 Sep–2 Oct 2009
 - 10th Hellenic School of Elementary Particle Physics & Gravity, Corfu, 29 Aug–5 Sep 2010
 - EU Network School: *Frontiers of Particle Cosmology*, Lecce, 13–18 Sep 2010
 - ICATPP Conference: *Cosmic Rays for Particle and Astroparticle Physics*, Como, 7–8 Oct 2010
 - Cherenkov Telescope Array Collaboration Meeting, Rutherford Lab, 8–11 Nov 2010
 - Astroparticle Physics session: RAS National Astronomy Meeting, Llandudno, 17–21 Apr 2011
 - ICTP Workshop: *Looking at the Neutrino Sky*, Trieste, 20–24 Jun 2011
 - CERN Theory Institute: *Dark Matter Underground and in the Heavens*, Geneva, 18–29 Jul 2011
 - 11th Hellenic School of Elementary Particle Physics & Gravity, Corfu, 4–18 Sep 2011
 - XII Workshop on High Energy Physics Phenomenology, Mahabaleshwar, 2–8 Jan 2012
 - 12th Hellenic School of Elementary Particle Physics & Gravity, Corfu, 8–27 Sep 2012
 - Danish National Astronomy Meeting, Sandbjerg Estate, 18–19 Jun 2013
 - 13th Hellenic School of Elementary Particle Physics & Gravity, Corfu, 31 Aug–27 Sep 2013
 - 1st APCTP-NBIA joint workshop on Cosmology and Astroparticle Physics, Pohang, 21–25 Oct 2013
 - 14th Hellenic School of Elementary Particle Physics & Gravity, Corfu, 3–21 Sep 2014
 - *Dark Matter@LHC*, Oxford, 25–27 Sep 2014
 - 15th Hellenic School of Elementary Particle Physics & Gravity, Corfu, 1–27 Sep 2015
 - 16th Hellenic School of Elementary Particle Physics & Gravity, Corfu, 31 Aug–23 Sep 2016
 - Nordic Winter School: *Cosmology and Particle Physics*, Skeikampen, 2–7 Jan 2017
 - Corfu Summer Institute, Corfu, 2–28 Sep 2017
 - Current themes in high energy physics & cosmology, Copenhagen, 13–17 Aug 2018
 - Workshop on the Standard Model and Beyond, Corfu, 31 Aug–9 Sep 2018
 - 36th International Cosmic Ray Conference, Madison, 24 Jul–1 Aug 2019
 - 21st International Symposium on Very High Energy Cosmic Ray Interactions, Ooty, 4–8 Jun 2020
 - International Workshop on Laboratory Astrophysics with Intense Lasers (remote), 7–8 Dec 2020
 - 37th International Cosmic Ray Conference, Berlin, 12–23 Jul 2021
- ▷ **International Scientific/Advisory Committee:**
- *Trends in Astroparticle Physics*, Stockholm, 22–25 Sep 1994
 - *Beyond the Desert*, Castle Ringberg, 6–12 June 1999
 - COSMO-01, Rovaniemi, 30 Aug–4 Sep 2001
 - WIN'02, Canterbury, 21–26 Jan 2002
 - COSMO-03, Ambleside, 24–30 Aug 2003
 - *Quantum gravity phenomenology*, Ladek Zdroj, 4–14 Feb 2004
 - 3rd International workshop on Ultra High Energy Cosmic Rays, Leeds, 22–24 Jul 2004
 - WIN'05, Delphi, 6–11 Jun 2005
 - WIN'07, Kolkata, 15–20 Jan 2007
 - ICGC'07, Pune, 17–21 Dec 2007
 - DISCRETE'08, Valencia, 11–16 Dec 2008
 - *Radiation Matter Interaction Under Extreme Conditions*, Varanasi, 19–20 Dec 2008
 - *Dark Matter in Astrophysics & Particle Physics*, Cambridge, 2–6 Aug 2010
 - DISCRETE'10, Rome, 6–11 Dec 2010
 - *Primordial Features and Non-Gaussianities*, Allahabad, 14–18 Dec 2010
 - TAUP 2011, Munich, 5–9 Sep 2011
 - Lepton-Photon Conference, Mumbai, 22–27 Aug 2011
 - VLVnT11 – Very Large Volume Neutrino Telescopes, Erlangen, 12–14 Oct 2011
 - WHEPP12: Workshop on High Energy Physics Phenomenology, Mahabaleshwar, 2–15 Jan 2012

- COSGRAV12: *Modern Perspectives of Cosmology & Gravitation*, Kolkata, 7–11 Feb 2012
- ICHEP2012: *36th International Conf. on High Energy Physics*, Melbourne, 4–11 Jul, 2012
- *Darkattack2012*, Ascona, 15–20 Jul 2012
- TeVPA 2012, Mumbai, 11–15 Dec 2012
- 33rd ICRC 2013, Rio de Janeiro, 2-9 Jul 2013
- TeVPA 2013, Irvine, 26–29 Aug 2013
- TeVPA 2014, Amsterdam, 23–28 Jun 2014
- Cosmo Cruise 2015, 2–9 Sep 2015
- VLVnT–2015: *Very Large Volume Neutrino Telescopes*, Rome, 2–16 Sep 2016
- TeVPA 2016, Geneva, 12–16 Sep 2016
- *Winter School on AstroParticle Physics*, Ootacamund, 21–29 Dec 2016
- DISCRETE 2016, Warsaw, 28 Nov–3 Dec 2016
- *International Neutrino Summer School*, Fermilab, 7-18 Aug 2017
- TeVPA 2017, Columbus, 7–11 Aug 2017
- *International Neutrino Summer School*, Mainz, 21 May–1 Jun 2018
- TeVPA 2018, Berlin, 27–31 Aug 2018
- PPNT19, Uppsala, 7–9 Oct 2019
- TeVPA 2019, Sydney, 2–12 Dec 2019

Participation in Experiments:

- *Big European Bubble Chamber WA66 Beam Dump Collaboration* (Data analysis 1985)
- *Pierre Auger Observatory* (Institutional Representative, 2003–13; Publications Committee)
- *IceCube* (Collaboration Board Member, 2004–; Editor, Yellow Book ; Publications Committee)
- *Cherenkov telescope Array* (Collaboration Member, 2010–; Requirements Review Committee; Co-editor of Special Issue; Review of Key Science Projects)
- *Laboratory Astroparticle Physics with High Powered Lasers* (Participant, 2016–)
- *Quantum Sensors for the Hidden Sector* (co-I, 2020–)

Research Grants:

1. SERC AF Starter Research Grant (*‘Cosmological Probes of Physics Beyond the SM’*)
PI, 1993–98 [GR/H90162] – £10,000
2. EU Third Framework Programme (*‘Theoretical Astroparticle’* network)
(Annecy + Barcelona, Copenhagen, Geneva, Gran Sasso, Munich, Oxford, Paris, Stockholm)
UK Scientist-in-Charge, 1993–97 [CHRX-CT93-0120] — €57,140
3. EU 4th Framework Programme (*‘Beyond the Standard Model’* TMR network)
(Paris + Bonn, Geneva, Lisbon, Madrid, Oxford, Pisa, Thessaloniki, Trieste, Valencia)
Co-I with G Ross (PI) *et al*, 1996–00 [FMRX-CT96-0090] — €132,000
4. British Council ‘Acciones Integradas’ Programme (*‘Large-scale Structure’* network)
(Barcelona, Cambridge, Durham, Oxford)
Co-I with G Efstathiou (PI) *et al*, 1997–98 — £2,900
5. PPARC Rolling Grant (*‘Theoretical Studies of Elementary Particles’*)
Co-I with G Ross (PI) *et al*, 1999–03 [PPA/G/O/2000/00469]; — £360,692
6. PPARC Special Program Grant (*‘Neutrino Mass’*)
Co-I with G Ross (PI), 2000–02 [PPA/G/S/1998/00561] — £87,287
7. EU 5th Framework Programme (Marie Curie training site *‘Particle Astrophysics’*)
Co-I with J Binney and J Silk (PI), 2000–03 — €158,400
8. EU 5th Framework Programme (*‘Physics Across the Present Energy Frontier’* TMR network)
(Paris + Bonn, Geneva, Lisbon, Madrid, Oxford, Pisa, Thessaloniki, Trieste, Valencia)
Co-I with G Ross (PI) *et al*, 2000–04 [HPRN-CT-2000-00148] — €145,000

9. EU 5th Framework Programme (*'Supersymmetry and the Early Universe'* TMR network)
Network Coordinator, 2000–04 [HPRN-CT-2000-00152] — €1.49 M
10. Leverhulme Foundation Major Grant (*'Dark Matter'*)
Co-I with J Binney and J Silk (PI), 2000–05 [F/08776A] — £433,134
11. EU Marie Curie fellowship (*'Cosmic Ray Probe of Physics beyond the SM'*)
Scientist-in charge (awarded to R Toldra), 2000–02 [MCFI-1999-00465] — €107,072
12. Joint Research Equipment Initiative (*'Beowulf Supercomputer'*)
Co-I with J Silk (PI) *et al*, 2000–05 — £127,151
13. EU Marie Curie fellowship (*'Non-Baryonic Dark Matter'*)
Scientist-in charge (awarded to F Ferrer), 2001–03 [MCFI-2001-00645] — €107,072
14. PPARC Rolling Grant (*'Theoretical Studies of Elementary Particles'*)
Co-I with G Ross (PI) *et al*, 2003–08 [PPA/G/O/2002/00479] — £562,204
15. PPARC Special Program Grant (*'Neutrino Physics'*)
Co-I with G Ross (PI), 2004–06 [PPA/G/S/2003/00138] — £72,919
16. PPARC Research Grant (*'Operation of the Pierre Auger Observatory ...'*)
Co-applicant with A Watson (PI) *et al*, 2004–07 [PPA/G/S/2003/00073] — £475,495.68
17. PPARC Senior Fellowship (*'Auger & IceCube: Probes of the high energy universe'*)
PI, 2006–09 [PPA/C506205/1] — £118,692
18. EU 6th Framework Programme Marie Curie RTN (*'The Origin of the Universe'*)
Network Coordinator, 2006–10 [MRTN-CT-2006-035863] — €3.53 M
19. John Fell Fund *Strengthening Oxford-India Research Links in Theoretical Physical Sciences*)
PI (with J. Cardy *et al*) 2006–12 — £25,313
20. STFC Research Grant (*'UHE cosmic ray research with the Pierre Auger Observatory'*)
PI, 2008–11 [PPA/E007007/1] — £42,428
21. PPARC Rolling Grant (*'Theoretical Studies of Elementary Particles'*)
Co-I with G Ross (PI) *et al*, 2008–11 [ST/G000492/1] — £1,900,748
22. UKIERI grant (*'Interdisciplinary Oxford-India Research Network in Theoretical Physics'*)
Co-I (with J. Cardy *et al*), 2008–11 — £67,372
23. STFC Consolidated Grant (*'Theoretical Particle Physics Research'*)
PI, 2011–14 [ST/J000507/1] — £989,201
24. IPPP Associateship (*'Phenomenology of Dark Matter'*)
PI, 2011–12 — £4,000
25. DNRF Niels Bohr Professorship (*'Connecting Inner Space & Outer Space'*)
PI, 2013–18 [506600-50-36547] — DKK 29,000,000
26. STFC Consolidated Grant (*'Theoretical Particle Physics Research'*)
PI, 2014–17 [ST/L000474/1] — £1,107,542
27. STFC Grant (*'Parton Distributions with Electroweak corrections'*)
co-PI (with J. Rojo), 2015–18 [ST/M003787/1] — £173,570
28. EPSRC grant (*'Particle acceleration in magnetised shocks'*)
Co-I (with G. Gregori (PI) & A. Bell), 2016–19 — £566,043
29. SPARC (*'India-UK partnership in laboratory astro-particle physics'*)
Co-I (with G. Gregori *et al*), 2016–20
30. STFC Consolidated Grant (*'Theoretical Studies of Elementary Particles'*)
PI, 2017–20 [ST/P000770/1] — £721,571
31. STFC Consolidated Grant (*'Theoretical Studies of Particles & Strings'*)
Co-I (with G. Salam *et al*), 2020–23 [ST/T000864/1] — £1,141,212

32. STFC Grant (*‘Quantum Sensing for the Hidden Sector’*)
Co-I (with P.J. Leek *et al*), 2020–24 [ST/T000864/1] — £838,605

Participation in Networks:

- ▷ Scientist-in-Charge @ Oxford, EU network on *‘Theoretical Astroparticle Physics’*, 1993–97
(Annecy + Barcelona, Copenhagen, Geneva, Gran Sasso, Munich, Oxford, Paris, Stockholm)
- ▷ Member, Oxford node of EU network on *‘Beyond the Standard Model’*, 1996–00
(Paris + Bonn, Geneva, Lisbon, Madrid, Oxford, Pisa, Thessaloniki, Trieste, Valencia)
- ▷ Co-ordinator, EU network on *‘Supersymmetry and the Early Universe’*, 2000–04
(Oxford/Lancaster/King’s College + Bonn, Geneva, Helsinki, Ioannina/Thessaloniki, Madrid/Barcelona/Granada, Orsay/Annecy/Marseilles, Trieste, Warsaw)
- ▷ Member, Oxford node of [European Network of Theoretical Astroparticle Physics](#), 2004–
- ▷ Member, [UK Neutrino Network](#), 2004–
- ▷ Member, Oxford node of EU network on *‘Quest for Unification’*, 2004–08
(Paris + Salonicki, Lisbon, Madrid, Bonn, Oxford, Pisa, Trieste, Valencia, Geneva)
- ▷ Co-ordinator, EU network on *‘Origin of the Universe’*, 2006–10
(Oxford + Lancaster, King’s College London, Annecy, Barcelona, Bonn, Copenhagen, Geneva, Helsinki, Ioannina, Munich, Padova, Paris, Seoul, Warsaw)
- ▷ Co-ordinator, [Oxford-India network on Theoretical Physical Sciences](#), 2006–12
- ▷ Oxford representative, UK-India Education & Research Initiative Network on *‘Neutrino & the Fundamental Laws of Nature’*, 2007–10
- ▷ Member, UKIERI Network on *‘Theoretical Physical Sciences’*, 2008–11
- ▷ Member, Oxford node of EU network on *‘Unification in the LHC era’*, 2009–13
(Paris + Salonicki, Lisbon, Madrid, Bonn, Oxford, Pisa, Trieste, Valencia, Geneva)
- ▷ Associate Member, DFG Research Training Group on *‘Models of Gravity’*, 2013–21

External Appointments:

- ▷ Maxwell Visiting Fellow, [King’s College, London](#), 2000–05
- ▷ Adjunct Professor, [Tata Institute of Fundamental Research](#), Mumbai, 2006–09
- ▷ Adjunct Professor, [Saha Institute of Nuclear Physics](#), Kolkata, 2008–13
- ▷ Scientific Associate, [Discovery Center, Niels Bohr Institute](#), Copenhagen, 2010–20
- ▷ Scientific Associate, [Institute of Particle Physics Phenomenology](#), Durham, 2011–12
- ▷ Niels Bohr Professor, [Niels Bohr International Academy](#), Copenhagen, 2013–18
- ▷ Affiliate Professor, [Niels Bohr Institute](#), Copenhagen, 2018–23
- ▷ Adjunct Professor, [Raman Research Institute](#), Bangalore, 2019–22

Public Understanding of Science

I worked (1988-89) with [Eklavya](#), a NGO in Bhopal concerned with science teaching and outreach. My main task was to launch a monthly newsletter on science and technology ([Srote](#)) for regional vernacular newspapers. We set up the supporting library and desktop publishing facility and wrote a number of articles for the newsletter.

I have engaged in the following science outreach activities in the UK:

- ▷ Oxford Physics: Publicity Committee (1995–96); Participation in Open Days; Science, Engineering & Technology Weeks; Assessment Panel, Undergraduate Speaking Competition (2001–04)

- ▷ Continuing Education, Oxford: Summer School: ‘*Blowing up the universe*’, 15–22 Jul 1995; School: ‘*Cosmic antimatter*’, 23 Jan 1999; Summer School: ‘*Constructing the Universe*’, 24–31 Jul 1999
- ▷ Consultant to BBC science programme makers on several occasions
- ▷ Radio interviews, e.g. BBC Thames Valley, 12 Jan 2000, LBC, London, 27 Apr 2000
- ▷ Assisted the [Royal Institution, London](#) to organise topical exhibition
- ▷ Filmed interview for new [Space Galleries at Royal Greenwich Observatory](#) (Dec 2007)
- ▷ Debate: *The fate of the universe: Does dark energy exist?*, Imperial College, London, July 2009
- ▷ Popular level talks:
 - ‘*Why do science?*’, Kingsway Camden’s College, London, 10 May 1993
 - ‘*A magical mystery tour of the universe*’
 - St Phillip & James Primary School, Oxford, 9 Oct 1997
 - St Barnabas Primary School, Oxford, 14 Jun 2004
 - ‘*Why is the sky dark at night?*’
 - SET’95 Public Lecture, Oxford, 17 Mar 1995
 - Cherwell School, Oxford, 26 Mar 1996
 - SET’97 ‘Frontier Physics for Teachers’, Cosener’s House, Abingdon, 15 Mar 1997
 - Oxford Space & Astronomical Society, Oxford, 9 Feb 1998
 - ‘*Seeing the edge of the universe*’
 - Linacre College Seminar, Oxford, 12 Oct 1999
 - ‘Oxford Festival of Science’ Programme, Peers School, Oxford, 26 Jan 2000
 - Charterhouse School, Godalming, 6 Mar 2001
 - IOP Lecture, Shrewsbury School, 28 Sep 2001
 - New College ‘Discovery Evening’, Oxford, 15 Nov 2001
 - St Edward’s School, Oxford, 13 Mar 2002
 - Taunton School, 10 May 2002
 - Georgia Tech Summer School, Oxford, 17 Jul 2002
 - Linacre Lecture at King’s School, Canterbury, 18 Sep 2003
 - National AimHigher Masterclass for Sixth Form students, Oxford, 6 Dec 2004
 - Jadavpur University, Kolkata, 5 Jan 2005
 - British Council, Kolkata, 7 Jan 2005
 - Dudley Residential Masterclass, Oxford, 21 Mar 2005
 - Open Day talk, Department of Physics, Oxford, 30 Jun 2005
 - Headington School, Oxford, 28 Nov 2005
 - Admissions talk, Department of Physics, Oxford, 13 Dec 2005
 - AVM School Bandra, Mumbai, 20 Dec 2006
 - Cherwell School, Oxford, 17 Jan 2007
 - InfoSys lecture, [Homi Bhabha Centre for Science Education, Mumbai](#), 22 Dec 2008
 - [International Year of Astronomy lecture](#), Green Templeton College, Oxford, 3 Mar 2009
 - [Chipping Norton Amateur Astronomical Society](#), 21 Mar 2011
 - [Folkeuniversitet i København](#), 5 & 7 Dec 2017
 - [Jawaharlal Nehru University, New Delhi](#), 19 Dec 2017
 - [Manthan, Hyderabad](#), 3 Sep 2019
 - ‘*The road to quantum gravity*’
 - ‘Frontier Physics for Teachers’ Workshop, Cosener’s House, Abingdon, 4 Mar 2000
 - ‘Oxford Access Scheme’ Summer School, Dept of Physics, Oxford, 23 Aug 2000
 - Georgia Tech Summer School, Oxford, 9 Jul 2001
 - IOP ‘Young Physicist’s Conference’, Dept of Physics, Oxford, 25 Nov 2001
 - [Linacre Seminar](#), Oxford, 12 Feb 2002
 - A K Raychoudhury Symposium, Scottish Church College, Kolkata, 5 Jan 2005
 - [Oxford University Physics Society](#), 26 Apr 2012

- *‘Discovering brane-world’*
 - Meeting of Heads of Physics, Rugby Group, Cheltenham College, 24 Feb 2001
 - ‘Oxford Access Scheme’ Summer School, Dept of Physics, Oxford, 22 Aug 2001
- *‘Cosmology in wonderland’*, IOP ‘Physics Update’ Meeting, Oxford, 10 Dec 2004
- *‘Dark matter vs. modified gravity’*
 - [Oxford Space & Astronomical Society](#), 1 Nov 2010
 - Oxford Undergraduate Student Conference, St Catherine’s College, 16 Apr 2013
- *‘Darkness visible: the search for the missing mass of the universe’*
 - [Public talk at Lepton Photon 2011](#), TIFR, Mumbai, 27 Aug 2011
 - Larsen & Toubro “GuruSpeak” Forum, Mumbai, 30 Aug 2011
 - [Cambridge University Scientific Society](#), 11 Oct 2011
 - [Folkeuniversitetet](#), NBI, Copenhagen, 8 Dec 2014
- ▷ Articles & letters in scientific/academic magazines:
 - *‘Lifetime significance’*, Physics World, 1987
 - *‘Shadow of a star: the neutrino story of Supernova 1987a’*, THES, Sep 1997 (book review)
 - *‘Could the end be in sight for high energy cosmic rays?’*, Physics World, Sep 2002, p.23
 - *‘The solution to Olbers’ paradox’*, Physics World, Oct 2002, p.17
 - *‘Does dark energy really exist?’*, Physics World, Jul 2004
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- ▷ My work was reported on in:
 - Astronomy: *‘Skeptics of dark energy raise concerns, but remain outnumbered’*, Jan 2020
 - Astronomy Today: *‘Quantum Gravity - revealed by gamma ray bursts?’*, 2001
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 - CERN Bulletin: *‘Astroparticle Physics Gets Organized’*, Dec 2008
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 - Daily Express: *‘The expansion of the universe is NOT accelerating’*, Oct 2016
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 - De Morgen: *‘Zijn de kreukels in de oerknal nu al een illusie?’*, Apr 2014; *‘Deze onderzoeken kunnen ons begrip van de werkelijkheid op zn kop zetten (als ze kloppen)’*, Apr 2020
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 - Frontline: *Chasing supernovae*, Nov 2011; *‘New window to the universe’*, Jun 2014; *The dark side of the universe*, Apr 2017
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 - Kijk: *‘Dijt ons heelal toch niet steeds sneller uit?’*, 27 Oct 2016
 - Nature: *‘Cosmic rays without end’*, 3 Sep 1998; *‘Quantum gravity: Testing time for theories’*, 18 Mar 1999; *‘Relativity: Special treatment’*, 4 Jul 2002; *‘Quantum gravity: an astrophysical constraint’*, 28 Aug 2003; *‘Physicists question model of the universe’*, 12 Apr 2007; *‘Bursting dark energy’s bubble’*, 2 Nov 2007; *‘Cosmology: Out of the darkness’*, 10 Oct 2012
 - Newsweek: *‘There’s a huge void in space and we are living inside it, scientists say’*, 7 June 2017; *‘Dark energy: Mystery force driving expansion of universe might not exist at all’*, 9 Sep 2018

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- Science News: *'A little mass goes a long way'*, Jan 1999, p.76
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- [2] [A lower limit to the magnetic Field in Cassiopeia-A](#)
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- [3] [Does the galactic synchrotron background originate in old supernova remnants?](#)
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- [4] [The evolution of supernova remnants as radio sources](#) * ADS:50+ CITES¹
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- [5] [Astrophysical consequences of \$n - \bar{n}\$ oscillations](#)
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- [7] [The cosmology of decaying gravitinos](#) * TOPCITE 250+
Nuclear Physics B259 (1985) 175–188
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- [8] [Bounds on light gluinos from the BEBC beam dump experiment](#)
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- [10] [Primordial nucleosynthesis, additional neutrinos & neutral currents from the superstring](#)
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- [11] [Neutron oscillations & the primordial magnetic field](#)
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(with P. Gondolo & G.B. Gelmini)
- [17] [Neutralino dark matter in a class of unified theories](#)
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- [18] [Cosmological constraints on perturbative supersymmetry breaking](#)
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- [21] [On the cosmological domain wall problem for the minimally extended supersymmetric standard model](#) * Nuclear Physics B454 (1995) 663–681 [hep-ph/9506359] TOPCITE 100+
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- [22] [A supersymmetric resolution of the KARMEN anomaly](#)
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ArXiv: 404 articles; GOOGLE SCHOLAR: 134,601 cites, h =126; SCOPUS: 374 documents, 74,788 cites, h =95
²INSPIRE: 338 papers/104,979 cites, h_{HEP} =114 (328 papers/42,153 cites, h_{HEP} =110 — excluding *RPP*)
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