COMPLETE 1–LOOP CALCULATION OF THE T–VIOLATING D–PARAMETER IN NEUTRON DECAY IN THE MSSM

M. Drees (1) and M. Rauch (1)

(1) Physik Department, Technische Universität München, James–Franck–Straße, D–85748 Garching, Germany

Abstract: We investigate the violation of time reversal invariance in the decay of the free neutron in the framework of the Minimal Supersymmetric Standard Model (MSSM). The coefficient of the triple product of the neutron spin and the momenta of electron and neutrino, the so called D parameter, is computed at one loop order including all diagrams. We find that D is mainly sensitive to the trilinear A coupling in the squark sector and to the phase of the coefficient μ which mixes the two Higgs superfields. The maximal MSSM contribution using parameters still allowed by experiment is however at $D \approx 10^{-7}$, while QED final state interactions give a value of $D_{\text{fsi}} = -2.3 \cdot 10^{-5}$. Explicit expressions for all relevant diagrams are given in an Appendix.

Report–no.: hep–ph/0302244.

European Physical Journal C – Particles and Fields 29 (2003), 573.

NEUTRINO MASSES, OSCILLATIONS, AND TESTS WITH FUTURE SUPERBEAMS AND A NEUTRINO FACTORY

M. Lindner (1)

(1) Physik Department, Technische Universität München, D–85748 Garching, Germany

Abstract: Future long baseline neutrino oscillation (LBL) setups are discussed and the remarkable potential for very precise measurements of mass splittings, mixing angles, MSW effects, the sign of Δm^2 and leptonic CP violation is shown. Furthermore we discuss the sensitivity improvements which can be obatined by combining the planned JHF–Superkamiokande and the proposed NuMI off–axis experiment.

Report–no.: TUM–HEP–501/03.

Proccedings of "Neutrinos and Implications for Physics Beyond the Standard Model", Stony Brook, USA, October 11–13, 2002.

ELECTRON CAPTURE RATES ON NUCLEI AND IMPLICATIONS FOR STELLAR CORE COLLAPSE

K. Langanke (1), G. Martínez-Pinedo (2,3), J. M. Sampaio (1), D. J. Dean (4), W. R. Hix (4,5,6), O. E. B. Messer (4,5,6), A. Mezzacappa (4), M. Liebendörfer (7,4,5), H.–T. Janka (8), and M. Rampp (8)

(1) Institute for Physics and Astronomy, University of Århus, DK–8000 Århus C, Denmark
(2) Institut d'Estudis Espacials de Catalunya, Edifici Nexus, Gran Capità 2, E–08034 Barcelona, Spain
(3) Institució Catalana de Recerca i Estudis Avançats, Lluís Companys 23, E–08010 Barcelona, Spain
(4) Physics Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831
(5) Department of Physics and Astronomy, University of Tennessee, Knoxville TN 37996
(6) Joint Institute for Heavy Ion research, Oak Ridge, TN 37831
(7) Canadian Institute for Theoretical Astrophysics, Toronto ON M5S 3H8
(8) Max–Planck–Institut für Astrophysik, D–85741 Garching, Germany

Abstract: Supernova simulations to date have assumed that during core collapse electron captures occur dominantly on free protons, while captures on heavy nuclei are Pauli–blocked and are ignored. We have calculated rates for electron capture on nuclei with mass numbers $A = 65-112$ for the temperatures and densities appropriate for core collapse. We find that these rates are large enough so that, in contrast to previous assumptions, electron capture on nuclei dominates over capture on free protons. This leads to significant changes in core collapse simulations.

Report–no.: astro–ph/0302459.

Physical Review Letters 90 (2003), 241102.

IMPROVED MODELS OF STELLAR CORE COLLAPSE AND STILL NO EXPLOSIONS: WHAT IS MISSING?

R. Buras, M. Rampp, H.–Th. Janka, and K. Kifonidis

(1) Max–Planck–Institut für Astrophysik, Karl–Schwarzschild–Straße 1, D–85741 Garching, Germany

Abstract: Two–dimensional hydrodynamic simulations of stellar core collapse with and without rotation are presented which for the first time were performed by solving the Boltzmann equation for the neutrino transport including a state–of–the-art description of neutrino interactions. Although convection develops below the neutrinosphere and in the neutrino-heated region behind the supernova shock, the models do not explode. This suggests missing physics, possibly with respect to the nuclear equation of state and weak interactions in the subnuclear regime. However, it might also indicate a fundamental problem of the neutrino-driven explosion mechanism.

Report–no.: astro–ph/0303171.

Physical Review Letters 90 (2003), 241101.

SUPERNOVA NEUTRINOS: FLAVOR-DEPENDENT FLUXES AND SPECTRA

G.G. Raffelt (1), M.Th. Keil (1), R. Buras (2), H.–T. Janka (2), and M. Rampp (2)

(1) Max–Planck–Institut für Physik (Werner–Heisenberg–Institut), Föhringer Ring 6, D–80805 München, Germany

(2) Max–Planck–Institut für Astrophysik, Karl–Schwarzschild–Str. 1, D–85741 Garching, Germany

Abstract: Transporting ν_μ and ν_τ in a supernova (SN) core involves several processes that have been neglected in traditional simulations. Based on a Monte Carlo study we find that the flavor-dependent spectral differences are much smaller than is often stated in the literature. A full–scale SN simulation using a Boltzmann solver and including all relevant neutrino reactions confirms these results. The flavor–dependent flux differences are largest during the initial accretion phase.

Report–no.: astro–ph/0303226.

Proceedings of "NOON 03, The 4th Workshop on Neutrino Oscillations and their Origin", Kanazawa, Japan, February 10–14, 2003.

NEUTRINOS IN PHYSICS AND ASTROPHYSICS

G.G. Raffelt

(1) Max–Planck–Institut für Physik (Werner–Heisenberg-Institut), Föhringer Ring 6, D–80805 München, Germany

Abstract: The observed flavor oscillations of solar and atmospheric neutrinos determine several elements of the leptonic mixing matrix, but leave open the small mixing angle Θ_{13}, a possible CP–violating phase, the mass ordering, the absolute mass scale m_ν, and the Dirac vs. Majorana property. Progress will be made by long-baseline, tritium endpoint, and 2β decay experiments. The best constraint on m_ν obtains from cosmological precision observables, implying that neutrinos contribute very little to the dark matter. However, massive Majorana neutrinos may well be responsible for ordinary matter by virtue of the leptogenesis mechanism for creating the baryon asymmetry of the universe. In future, neutrinos could play an important role as astrophysical messengers if point sources are discovered in high-energy neutrino telescopes. In the low-energy range, a high–statistics observation of a galactic supernova would allow one to observe directly the dynamics of stellar collapse and perhaps to discriminate between certain mixing scenarios. An observation of the relic neutrinos from all past supernovae has come within reach.

Report–no.: astro–ph/0302589.

Proceedings of “Texas in Tuscany: XXI Symposium on Relativistic Astrophysics”, Florence, Italy, December, 9–13, 2002.

REACTOR NEUTRINO EXPERIMENTS COMPARED TO SUPERBEAMS

P. Huber (1,2), M. Lindner (1), T. Schwetz (1), and W. Winter (1)

(1) Physik Department T30, Technische Universität München, Germany
(2) Max–Planck–Institut für Physik, Werner Heisenberg Institut, München, Germany

Abstract: We present a detailed quantitative discussion of the measurement of the leptonic mixing angle $\sin^2 2\theta_{13}$ with a future reactor neutrino oscillation experiment consisting of a near and far detector. We perform a thorough analysis of the impact of various systematical errors and compare the resulting physics potential to the one of planned first–generation superbeam experiments. Furthermore, we investigate the complementarity of both types of experiments. We find that, under realistic assumptions, a determination of $\sin^2 2\theta_{13}$ down to 10^{-2} is possible with reactor experiments. They are thus highly competitive to first-generation superbeams and may be able to test $\sin^2 2\theta_{13}$ on shorter timescales. In addition, we find that the combination of a KamLAND–size reactor experiment with one or two superbeams could substantially improve the ability to access the neutrino mass hierarchy or the leptonic CP phase.

Report–no.: hep–ph/0303232.

SEESAW NEUTRINO MASSES WITH LARGE MIXINGS FROM DIMENSIONAL DECONSTRUCTION

K.R.S. Balaji (1), M. Lindner (2), and G. Seidl (2)

(1) Institut für Theoretische Physik, Universität Dortmund, D–44221 Dortmund, Germany

(2) Physik Department, Technische Universität München, D–85757 Garching, Germany

Abstract: We demonstrate how the dimension–five seesaw operator which generates neutrino masses and mixings can have a dynamical origin in dimensional deconstruction models. Light neutrino masses arise in such a scenario from the seesaw scale which corresponds to the inverse lattice spacing. It is shown that the deconstructing limit naturally prefers maximal leptonic mixing. Higher–order corrections which are allowed by gauge invariance can transform the bi-maximal into a bi–large mixing. These terms may appear to be non-renormalizable at scales smaller than the deconstruction scale. We quantitatively outline all relevant features for a few example field theories which accomodate current neutrino data.

Report–no.: hep–ph/0303245.

PARTICLE PHYSICS EXPLANATIONS FOR ULTRA HIGH ENERGY COSMIC RAY EVENTS

M. Drees (1)

(1) Physik Department, Technische Universität München, D–85757 Garching, Germany

Abstract: The origin of cosmic ray events with $E \geq 10^{11}$ GeV remains mysterious. In this talk I briefly summarize several proposed particle physics explanations: a breakdown of Lorentz invariance, the "$Z-$burst" scenario, new hadrons with masses of several GeV as primaries, and magnetic monopoles with mass below 10^{10} GeV as primaries. I then describe in a little more detail the idea that these events are due to the decays of very massive, long–lived exotic particles.

Report–no.: hep–ph/0304030.

TESTING THE STATISTICAL COMPATIBILITY OF INDEPENDENT DATA SETS

M. Maltoni (1) and T. Schwetz (2)

(1) IFIC, Universitat de Valencia, Spain
(2) Physik Department T30d, Technische Universität München, Germany

Abstract: We discuss a goodness–of–fit method which tests the compatibility between statistically independent data sets. The method gives sensible results even in cases where the χ^2–minima of the individual data sets are very low or when several parameters are fitted to a large number of data points. In particular, it avoids the problem that a possible disagreement between data sets becomes diluted by data points which are insensitive to the crucial parameters. A formal derivation of the probability distribution function for the proposed test statistic is given, based on standard theorems of statistics. The application of the method is illustrated on data from neutrino oscillation experiments, and its complementarity to the standard goodness–of–fit is discussed.

Report–no.: hep–ph/0304176.

THE MUNICH NEAR-INFRARED CLUSTER SURVEY – V. THE EVOLUTION OF THE REST–FRAME K– AND J–BAND GALAXY LUMINOSITY FUNCTIONS TO $z \sim 0.7$

G. Feulner (1), R. Bender (1,2), N. Drory (3), U. Hopp (1), J. Snigula (1), and G.J. Hill (3)

(1) Universitäts-Sternwarte München, Scheinerstraße 1, D–81679 München, Germany
(2) Max–Planck–Institut für Extraterrestrische Physik, Giessenbachstraße, D–85748 Garching bei München, Germany
(3) McDonald Observatory, University of Texas at Austin, Austin, Texas 78712

Abstract: We present spectroscopic follow-up observations of galaxies from the Munich Near–Infrared Cluster Survey (MUNICS). MUNICS is a wide–field medium–deep K'–band–selected survey covering 1 deg^2 in the near–infrared K' and J passbands, and 0.35 deg^2 in I, R, V, and, recently completed, B. The spectroscopic sample comprises observations of objects down to a limit of $K' \leq 17.5$ in five survey fields (0.17 deg^2 in total), and a sparsely selected deeper sample ($K' \leq 19.0$) constructed in one of the survey patches (0.03 deg^2). Here we describe the selection procedure of objects for spectroscopic observations, the observations themselves, the data reduction, and the construction of the spectroscopic catalogue containing roughly 500 galaxies with secure redshifts. Furthermore we discuss global properties of the sample like its distribution in colour–redshift space, the accuracy of redshift determination, and the completeness function of the data. We derive the rest-frame K'–band luminosity function of galaxies at median redshifts of $z = 0.2$, 0.4, and 0.7. We find evidence for mild evolution of magnitudes ($\Delta M^*_K \simeq -0.70$ mag) and number densities ($\Delta\Phi^*_K/\Phi^*_K \simeq -0.35$) to a redshift of unity. Furthermore, we present the rest–frame J–band luminosity function of galaxies at these redshifts, the first determination of this quantity at higher redshifts, with a behaviour similar to the K–band luminosity function.

Report–no.: astro–ph/0302517.
MNRAS 342 (2003), 605.

RUNNING NEUTRINO MASSES, MIXINGS AND CP PHASES: ANALYTICAL RESULTS AND PHENOMENOLOGICAL CONSEQUENCES

S. Antusch (1), J. Kersten (1), M. Lindner (1), and M. Ratz (2)

(1) Physik Department T30, Technische Universität München, James–Franck–Straße, D–85748 Garching, Germany
(2) Deutsches Elektronensynchrotron DESY, D–22603 Hamburg, Germany

Abstract: We derive simple analytical formulae for the renormalization group running of neutrino masses, leptonic mixing angles and CP phases, which allow an easy understanding of the running. Particularly for a small angle θ_{13} the expressions become very compact, even when non-vanishing CP phases are present. Using these equations we investigate: (i) the influence of Dirac and Majorana phases on the evolution of all parameters, (ii) the implications of running neutrino parameters for leptogenesis, (iii) changes of the mass bounds from WMAP and neutrinoless double beta decay experiments, relevant for high-energy mass models, (iv) the size of radiative corrections to θ_{13} and θ_{23} and implications for future precision measurements.

Report–no.: hep–ph/0305273.

CAN FOUR NEUTRINOS EXPLAIN GLOBAL OSCILLATION DATA INCLUDING LSND AND COSMOLOGY?

M. Maltoni (1), T. Schwetz (2), M.A. Tórtola (1), and J.W.F. Valle (1)

(1) Instituto de Física Corpuscular – C.S.I.C./Universitat de Valencia, Edificio Institutos de Paterna, Apt 22085,E–46071 Valencia, Spain
(2) Institut für Theoretische Physik, Physik Department, Technische Universität München, James–Franck–Straße, D–85748 Garching, Germany

Abstract: We present an analysis of the global neutrino oscillation data in terms of four-neutrino mass schemes. We find that the strong preference of oscillations into active neutrinos implied by solar+KamLAND as well as atmospheric neutrino data allows to rule out (2+2) mass schemes, whereas (3+1) schemes are strongly disfavoured by short-baseline experiments. In addition, we perform an analysis using recent data from cosmology, including CMB data from WMAP and data from 2dFGRS large scale structure surveys. These data lead to further restrictions of the allowed regions for the (3+1) mass scheme.

Report–no.: hep–ph/0305312.

STATUS OF THE CPT VIOLATING INTERPRETATIONS OF THE LSND SIGNAL

M.C. Gonzalez-Garcia (1,2), M. Maltoni (2), and T. Schwetz (3)

(1) Y.I.T.P., SUNY at Stony Brook, Stony Brook, NY 11794–3840, USA
(2) IFIC, Universitat de Valencia - C.S.I.C., Apt 22085, E-46071 Valencia, Spain
(3) Theoretische Physik, Physik Department, Technische Universität München, James–Franck–Straße, D–85748 Garching, Germany

Abstract: We study the status of the CPT violating neutrino mass spectrum which has been proposed to simultaneously accommodate the oscillation data from LSND, KamLAND, atmospheric and solar neutrino experiments, as well as the non–observation of anti–neutrino disappearance in short–baseline reactor experiments. We perform a three–generation analysis of the global data with the aim of elucidating the viability of this solution. We find no compatibility between the results of the oscillation analysis of LSND and all–but–LSND data sets below 3σ CL. Furthermore, the global data without LSND show no evidence for CPT violation: the best fit point of the all–but–LSND analysis occurs very close to a CPT conserving scenario.

Report–no.: hep–ph/0306226.

THE MUNICH NEAR-INFRARED CLUSTER SURVEY (MUNICS) – II. THE K-BAND LUMINOSITY FUNCTION OF FIELD GALAXIES TO $z \sim 1.2$

N. Drory (1), R. Bender (2,3), G. Feulner (3), U. Hopp (3), C. Maraston (2), J. Snigula (3), G.J. Hill (1)

(1) McDonald Observatory, University of Texas at Austin, Austin, Texas 78712
(2) Max–Planck–Institut für extraterrestrische Physik, Giessenbachstraße, D–85748 Garching bei München, Germany
(3) Universitäts–Sternwarte München, Scheinerstraße 1, D–81679 München, Germany

Abstract: We present a measurement of the evolution of the rest–frame K–band luminosity function to $z \sim 1.2$ using a sample of more than 5000 K–selected galaxies drawn from the MUNICS dataset. Distances and absolute K–band magnitudes are derived using photometric redshifts from spectral energy distribution fits to BVRIJK photometry. These are calibrated using >500 spectroscopic redshifts. We obtain redshift estimates having a rms scatter of 0.055 and no mean bias. We use Monte–Carlo simulations to investigate the influence of the errors in distance associated with photometric redshifts on our ability to reconstruct the shape of the luminosity function. Finally, we construct the rest–frame K–band LF in four redshift bins spanning $0.4 < z < 1.2$ and compare our results to the local luminosity function. We discuss and apply two different estimators to derive likely values for the evolution of the number density, Φ^*, and characteristic luminosity, M^*, with redshift. While the first estimator relies on the value of the luminosity function binned in magnitude and redshift, the second estimator uses the individually measured M,z pairs alone. In both cases we obtain a mild decrease in number density by $\sim 25\%$ to $z = 1$ accompanied by brightening of the galaxy population by 0.5 to 0.7 mag. These results are fully consistent with an analogous analysis using only the spectroscopic MUNICS sample. The total K–band luminosity density is found to scale as $\mathrm{dlog}(\rho_L)/\mathrm{dz} = 0.24$. We discuss possible sources of systematic errors and their influence on our parameter estimates.

Report–no.: astro–ph/0306299.

Astrophysical Journal 595 (2003), 698.

THE ROLE OF MATTER DENSITY UNCERTAINTIES IN THE ANALYSIS OF FUTURE NEUTRINO FACTORY EXPERIMENTS

T. Ohlsson (1) and W. Winter (2)

(1) Division of Mathematical Physics, Department of Physics, Royal Institute of Technology (KTH) – Stockholm Center for Physics, Astronomy, and Biotechnology (SCFAB), Roslagstullsbacken 11, 106 91 Stockholm, Sweden

(2) Theoretische Physik, Physik–Department, Technische Universität München (TUM), James–Franck–Straße, 85748 Garching bei München, Germany

Abstract: Matter density uncertainties can affect the measurements of the neutrino oscillation parameters at future neutrino factory experiments, such as the measurements of the mixing parameters θ_{13} and δ_{CP}. We compare different matter density uncertainty models and discuss the possibility to include the matter density uncertainties in a complete statistical analysis. Furthermore, we systematically study in which measurements and where in the parameter space matter density uncertainties are most relevant. We illustrate this discussion with examples that show the effects as functions of different magnitudes of the matter density uncertainties. We find that matter density uncertainties are especially relevant for large $\sin^2 2\theta_{13} \gtrsim 10^{-3}$. Within the KamLAND-allowed range, they are most relevant for the precision measurements of $\sin^2 2\theta_{13}$ and δ_{CP}, but less relevant for "binary" measurements, such as for the sign of Δm^2_{31}, the sensitivity to $\sin^2 2\theta_{13}$, or the sensitivity to maximal CP violation. In addition, we demonstrate that knowing the matter density along a specific baseline better than to about 1% precision means that all measurements will become almost independent of the matter density uncertainties.

Report–no.: hep–ph/0307178.

PULSAR RECOIL BY LARGE-SCALE ANISOTROPIES IN SUPERNOVA EXPLOSIONS

L. Scheck (1), T. Plewa (2,3), H.–Th. Janka (1), K. Kifonidis (1), and E. Müller (1)

(1) Max–Planck–Institut für Astrophysik, Karl–Schwarzschild–Straße 1, D–85741 Garching, Germany
(2) Center for Astrophysical Thermonuclear Flashes, University of Chicago, 5640 S. Ellis Avenue, Chicago, IL 60637, USA
(3) Nicolaus Copernicus Astronomical Center, Bartycka 18, 00716 Warsaw, Poland

Abstract: A systematic study of supernova explosions with two-dimensional hydrodynamic simulations yields evidence that neutrino-driven convection behind the expanding supernova shock can lead to global asymmetries with a dominant contribution of the $l = 1, 2$ modes. Gravitational and hydrodynamic forces by the anisotropically ejected supernova matter can accelerate the remnant neutron star to velocities well above 500 $\mathrm{km\,s^{-1}}$ on a timescale of more than a second. This kick mechanism explains the observed pulsar proper motions without artificial assumptions.

Physical Review Letters 92 (2004), 011103.

VARIATIONS ON KAMLAND: LIKELIHOOD ANALYSIS AND FREQUENTIST CONFIDENCE REGIONS

T. Schwetz (1)

(1) Physik Department, Technische Universität München, James–Franck–Straße, D–85748 Garching bei München, Germany

Abstract: In this letter the robustness of the first results from the KamLAND reactor neutrino experiment with respect to variations in the statistical analysis is considered. It is shown that an event-by-event based likelhood analysis provides a more powerful tool to extract information from the currently available data sample than a least–squares method based on energy binned data. Furthermore, a frequentist analysis of KamLAND data is performed. Confidence regions with correct coverage in the plane of the oscillation parameters are calculated by means of a Monte Carlo simulation. I find that the results of the usually adopted χ^2– cut approximation are in reasonable agreement with the exact confidence regions, however, quantitative differences are detected. Finally, although the current data is consistent with an energy independent flux suppression, a $\sim 2\sigma$ indication in favour of oscillations can be stated, implying quantum mechanical interference over distances of the order of 200 km.

Report–no.: hep–ph/0308003.

RESOLVING DEGENERACIES FOR DIFFERENT VALUES OF θ_{13}

W. Winter (1)

(1) Physik Department, Technische Universität München, James–Franck–Straße, D–85748 Garching bei München, Germany

Abstract: We discuss options to resolve correlations and degeneracies with combinations of future neutrino long-baseline experiments. We use a logarithmic scale of $\sin^2 2\theta_{13}$ as a representation for a systematical classification of the experiments.

Report–no.: hep–ph/0308227.

STATUS OF THREE–NEUTRINO OSCILLATIONS AFTER THE SNO–SALT DATA

M. Maltoni (1), T. Schwetz (2), M.A. Tortola (1), and J.W.F. Valle (1)

(1) IFIC, Universitat de Valencia, Edificio Institudos de Paterna, Apt. 22085, E–46071 Valencia, Spain
(2) Theoretische Physik, Physik Department, Technische Universität München, D–85748 Garching, Germany

Abstract: We perform a global analysis of neutrino oscillation data in the framework of three neutrinos, including the recent improved measurement of the neutral current events at SNO. In addition to all current solar oscillation neutrino data we take into account the reactor neutrino data from KamLAND and CHOOZ, the atmospheric neutrino data from Super–Kamiokande and MACRO, as well as the first spectral data from the K2K long baseline accelerator experiment. The up- to-date best fit values and allowed ranges of the three–flavour oscillation parameters are determined from these data. Furthermore, we discuss in detail the status of the small parameters $\alpha \equiv \Delta m^2_{sol}/\Delta m^2_{ATM}$ and $\sin^2\theta_{13}$, which fix the possible strength of CP violating effects in neutrino oscillations.

Report–no.: hep–ph/0309130.

CASIMIR ENERGY IN DECONSTRUCTION AND THE COSMOLOGICAL CONSTANT

F. Bauer (1), M. Lindner (1), and G. Seidl (2)

(1) Physik–Department, Technische Universität München, James–Franck–Strasse, D–85748 Garching, Germany
(2) Department of Physics, Oklahoma State University, Stillwater, OK 74078, USA

Abstract: We demonstrate that by employing the correspondence between gauge theories in geometric and in deconstructed extra dimensions, it is possible to transfer the methods for calculating finite Casimir energy densities in higher dimensions to the four–dimensional deconstruction setup. By this means, one obtains an unambiguous and well-defined prescription to determine finite vacuum energy contributions of four–dimensional quantum fields which have a higher–dimensional correspondence. Thereby, large kink masses lead to an exponentially suppressed Casimir effect. For a specific model we hence arrive at a small and positive contribution to the cosmological constant in agreement with observations.

Report–no.: hep–th/0309200.

SUPERNOVA SIMULATIONS WITH BOLTZMANN NEUTRINO TRANSPORT: A COMPARISON OF METHODS

M. Liebendörfer (1,2,3), M. Rampp (4), H.-Th. Janka (4), and A. Mezzacappa (2)

(1) CITA, University of Toronto, Toronto, Ontario M5S 3H8, Canada
(2) Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831–6354
(3) Department of Physics and Astronomy, University of Tennessee, Knoxville, Tennessee 37996–1200
(4) Max–Planck–Institut für Astrophysik, Karl–Schwarzschild–Straße 1, D–85741 Garching, Germany

Abstract: Accurate neutrino transport has been built into spherically symmetric simulations of stellar core collapse and postbounce evolution. The results of such simulations agree that spherically symmetric models with standard microphysical input fail to explode by the delayed, neutrino-driven mechanism. Independent groups implemented fundamentally different numerical methods to tackle the Boltzmann neutrino transport equation. Here we present a direct and detailed comparison of such neutrino radiation–hydrodynamical simulations for two codes, AGILE–BOLTZTRAN of the Oak Ridge–Basel group and VERTEX of the Garching group. The former solves the Boltzmann equation directly by an implicit, general relativistic discrete angle method on the adaptive grid of a hydrodynamics code with conservative first–order finite differencing. In contrast, the latter couples a variable Eddington factor technique with an explicit, moving–grid, conservative high-order Riemann solver with important relativistic effects treated by an effective gravitational potential. The presented study is meant to test both neutrino radiation-hydrodynamics implementations and to provide a data basis for comparisons and verifications of supernova codes to be developed in the future. The results are investigated in simulations of the core collapse and post–bounce evolution of a 13 $M_\odot$ star with Newtonian gravity and a 15 $M_\odot$ star with relativistic gravity.

Report–no.: astro–ph/0310662, J–MPA1581e.

Astrophysical Journal, submitted.

UNDERSTANDING CP PHASE–DEPENDENT MEASUREMENTS AT NEUTRINO SUPERBEAMS IN TERMS OF BI–RATE GRAPHS

W. Winter (1)

(1) Physik Department, Technische Universität München, D–85748 Garching, Germany

Abstract: We discuss the impact of the true value of the CP phase on the mass hierarchy, CP violation, and CP precision measurements at neutrino superbeams. Useful tools to investigate this impact semi–quantitatively are bi–rate graphs. Unlike bi–probability graphs, which use oscillation probabilities, bi–rate graphs show the total event rates of two measurements simultaneously as a function of the CP phase. Since they allow error bars for direct quantitative estimates, we use bi–rate graphs for a direct comparison with a complete statistical experiment simulation including spectral information, systematics, correlations, and degeneracies. We find that one can describe the CP phase dependencies of the mentioned measurements as well as one can understand the role of the sgn(Δm^2_{31})–degeneracy. As one of the most interesting results, we discuss the dependence of the CP precision measurement as a function of the CP phase itself, which leads to "CP patterns". It turns out that this dependence is rather strong, which means that one has to be careful when one is comparing the CP precisions of different experiments. In addition, we demonstrate that alternative options for a NuMI off–axis antineutrino running, a larger detector size, or a different baseline can also be understood in terms of bi–rate graphs, and we investigate the potential of the first–generation superbeams with respect to the mass hierarchy and CP measurements.

Report–no.: hep–ph/0310307.

THE WENDELSTEIN CALAR ALTO PIXELLENSING PROJECT (WECAPP): FIRST MACHO CANDIDATES

A. Riffeser (1), J. Fliri (1), R. Bender (1,2), S. Seitz (1), and C.A. Gössl (1)

(1) Universitäts–Sternwarte München, Scheinerstr. 1, D–81679 München, Germany

(2) Max–Planck–Institut für extraterrestrische Physik, Giessenbachstraße, D–85748 Garching bei München, Germany

Abstract: We report the detection of the first 2 microlensing candidates from the Wendelstein Calar Alto Pixellensing Project (WeCAPP). Both are detected with a high signal-to-noise-ratio and were filtered out from 4.5 mill. pixel light curves using a variety of selection criteria. Here we only consider well–sampled events with timescales of $1\,\mathrm{d} < t_{\mathrm{fwhm}} < 20\,\mathrm{d}$, high amplitude, and low χ^2 of the microlensing fit. The two–color photometry (R, I) shows that the events are achromatic and that giant stars with colors of $(R-I) \sim 1.1\,\mathrm{mag}$ in the bulge of M31 have been lensed. The magnification factors are 64 and 10 which are obtained for typical giant luminosities of $M_I = -2.5\,\mathrm{mag}$. Both lensing events lasted for only a few days ($t_{\mathrm{fwhm}}^{\mathrm{GL1}} = 1.7\,\mathrm{d}$ and $t_{\mathrm{fwhm}}^{\mathrm{GL2}} = 5.4\,\mathrm{d}$). The event GL1 is likely identical with PA-00-S3 reported by the POINT–AGAPE project. Our calculations favor in both cases the possibility that MACHOs in the halo of M31 caused the lensing events. The most probable masses, $0.08\,M_\odot$ for GL1 and $0.02\,M_\odot$ for GL2, are in the range of the brown dwarf limit of hydrogen burning. Solar mass objects are a factor of two less likely.

Report–no.: astro–ph/0311135

Astrophysical Journal Letters 599 (2003), 17.

STATUS OF NEUTRINO OSCILLATIONS II: HOW TO RECONCILE THE LSND RESULT?

T. Schwetz (1)

(1) Theoretische Physik, Physik Department, Technische Universität München, James–Franck–Straße, D–85748 Garching, Germany

Abstract: We present an analysis of the global neutrino oscillation data including the LSND result in terms of four–neutrino mass schemes and a CPT violating three–neutrino framework. We find that the strong preference of oscillations into active neutrinos implied by recent solar+KamLAND as well as atmospheric neutrino data allows to rule out (2+2) mass schemes at 5.8σ, whereas (3+1) schemes are disfavoured at the 3.2σ level by short–baseline experiments. The CPT violating scenario is disfavoured at 3.4σ by KamLAND and atmospheric anti–neutrino data. We conclude that currently no convincing explanation for the LSND signal exists, and it remains a puzzle how to reconcile it with the other evidences for neutrino oscillations.

Report–no.: hep–ph/0311217.

FINDING STRUCTURES IN PHOTOMETRIC REDSHIFT GALAXY SURVEYS: AN EXTENDED FRIENDS–OF–FRIENDS ALGORITHM

C. S. Botzler (1), J. Snigula (2), R. Bender (1,2), and U. Hopp (1)

(1) Universitäts–Sternwarte München, Scheinerstr. 1, D–81679 München, Germany

(2) Max–Planck–Institut für extraterrestrische Physik, Giessenbachstraße, D–85748 Garching, Germany

Abstract: We present a modified version of the friends–of–friends (FOF) structure finding algorithm (Huchra & Geller, 1982), designed specifically to locate groups or clusters of galaxies in photometric redshift datasets. The main objective of this paper is to show that this extended friends–of–friends (hereafter EXT–FOF) algorithm yields results almost identical to the original FOF, if applied to a spectroscopic redshift dataset, and a rather conservative catalogue of structures, in case of a dataset with simulated photometric redshifts. Therefore, we create group catalogues for the first Center for Astrophysics Redshift Survey (CFA1; Huchra et al., 1983), as well as for the Las Campanas Redshift Survey (LCRS; Shectman et al., 1996), both of which being spectroscopic surveys, using FOF-algorithms. We then apply our new algorithm to said surveys and compare the resulting structure catalogue. Furthermore, we bestow simulated photometric redshifts on the LCRS galaxies, and use the EXT-FOF to detect structures, that we compare in size and composition to the ones found in the original, spectroscopic dataset. We will show that the properties of this modified algorithm are well understood and that it is suited for finding structures in photometric datasets. This is the first paper in a series of papers, dealing with the application of our new cluster finding algorithm to various photometric redshift galaxy surveys.

Report–no.: astro–ph/0312018.

MNRAS, accepted.

ON THE SMALL–SCALE STABILITY OF THERMONUCLEAR FLAMES IN TYPE IA SUPERNOVAE

F.K. Röpke (1), J. C. Niemeyer (1), and W. Hillebrandt (1)

(1) Max–Planck–Institut für Astrophysik, Karl–Schwarzschild–Straße 1, D–85741 Garching, Germany

Abstract: We present a numerical model which allows us to investigate thermonuclear flames in Type Ia supernova explosions. The model is based on a finite–volume explicit hydrodynamics solver employing PPM. Using the level–set technique combined with in-cell reconstruction and flux–splitting schemes we are able to describe the flame in the discontinuity approximation. We apply our implementation to flame propagation in Chandrasekhar–mass Type Ia supernova models. In particular we concentrate on intermediate scales between the flame width and the Gibson scale, where the burning front is subject to the Landau–Darrieus instability. We are able to reproduce the theoretical prediction on the growth rates of perturbations in the linear regime and observe the stabilization of the flame in a cellular shape. The increase of the mean burning velocity due to the enlarged flame surface is measured. Results of our simulation are in agreement with semianalytical studies.

Astrophysical Journal 588 (2003), 952.

SMALL STEPS TOWARD REALISTIC EXPLOSION MODELS OF TYPE IA SUPERNOVAE

J. C. Niemeyer (1), M. Reinecke (1), C. Travaglio (1), and W. Hillebrandt (1)

(1) Max–Planck–Institut für Astrophysik, Karl–Schwarzschild–Straße 1, D–85748 Garching, Germany

Abstract: We describe recent progress in multidimensional simulations of exploding Chandrasekhar mass white dwarfs, interpreted as the canonical model for type Ia supernovae. We particularly stress the importance of the initial ignition surface, chosen here as a distribution of 30 spherical, randomly located bubbles near the center of the star. In addition, we present the first results for nucleosynthetic yields obtained by post-processing a multidimensional explosion model.

Proccedings of "From Twilight to Highlight: The Physics of Supernovae. ESO/MPA/MPE Workshop, Garching, Germany", Eds. W. Hillebrandt, B. Leibundgut, Springer (2003), 151.

THE PHYSICS AND ASTROPHYSICS OF TYPE IA SUPERNOVA EXPLOSIONS

W.Hillebrandt (1), J. C. Niemeyer (1), M. Reinecke (1), and C. Travaglio (1)

(1) Max–Planck–Institut für Astrophysik, Karl–Schwarzschild-Straße 1, D–85741 Garching, Germany

Abstract: Because calibrated light curves of type Ia supernovae have become a major tool to determine the local expansion rate of the Universe, considerable attention has been given to models of these events over the past couple of years. Recent progress in modeling type Ia supernovae as well as several of the still open questions are addressed in this article. Although the main emphasis will be on studies of the explosion mechanism itself and on the related physical processes, including the physics of turbulent nuclear combustion in degenerate stars, observational implications and constraints will also be discussed.

Memorie della Societa Astronomica Italiana 74 (2003), 942.

THE CELLULAR BURNING REGIME IN TYPE IA SUPERNOVA EXPLOSIONS – I. FLAME PROPAGATION INTO QUIESCENT FUEL

F. K. Röpke (1), W. Hillebrandt (1), and J. C. Niemeyer (2)

(1) Max–Planck–Institut für Astrophysik, Karl–Schwarzschild–Straße 1, D–85748 Garching, Germany

(2) Institut für Astronomie und Astrophysik, Universität Würzburg, Würzburg, Germany

Abstract: We present a numerical investigation of the cellular burning regime in Type Ia supernova explosions. This regime holds at small scales (i.e. below the Gibson scale), which are unresolved in large–scale Type Ia supernova simulations. The fundamental effects that dominate the flame evolution here are the Landau–Darrieus instability and its nonlinear stabilization, leading to a stabilization of the flame in a cellular shape. The flame propagation into quiescent fuel is investigated addressing the dependence of the simulation results on the specific parameters of the numerical setup. Furthermore, we investigate the flame stability at a range of fuel densities. This is directly connected to the questions of active turbulent combustion (a mechanism of flame destabilization and subsequent self-turbulization) and a deflagration–to–detonation transition of the flame. In our simulations we find no substantial destabilization of the flame when propagating into quiescent fuels of densities down to $\sim 10^7$ g/cm^3, corroborating fundamental assumptions of large–scale SN Ia explosion models. For these models, however, we suggest an increased lower cutoff for the flame propagation velocity to take the cellular burning regime into account.

Report–no.: astro–ph/0312092.

THE CELLULAR BURNING REGIME IN TYPE IA SUPERNOVA EXPLOSIONS – II. FLAME PROPAGATION INTO VORTICAL FUEL

F. K. Röpke (1), W. Hillebrandt (1), and J. C. Niemeyer (2)

(1) Max–Planck–Institut für Astrophysik, Karl–Schwarzschild–Straße 1, D–85748 Garching, Germany

(2) Institut für Astronomie und Astrophysik, Universität Würzburg, Würzburg, Germany

Abstract: We investigate the interaction of thermonuclear flames in Type Ia supernova explosions with vortical flows by means of numerical simulations. In our study, we focus on small scales, where the flame propagation is no longer dominated by the turbulent cascade originating from large–scale effects. Here, the flame propagation proceeds in the cellular burning regime, resulting from a balance between the Landau–Darrieus instability and its nonlinear stabilization. The interaction of a cellularly stabilized flame front with a vortical fuel flow is explored applying a variety of fuel densities and strengths of the velocity fluctuations. We find that the vortical flow can break up the cellular flame structure if it is sufficiently strong. In this case the flame structure adapts to the imprinted flow field. The transition from the cellularly stabilized front to the flame structure dominated by vortices of the flow proceeds in a smooth way. The implications of the results of our simulations for Type Ia Supernova explosion models are discussed.

Report–no.: astro–ph/0312203.

SEARCHING FOR STARS IN COMPACT HIGH–VELOCITY CLOUDS. I. FIRST RESULTS FROM VLT AND 2MASS

U. Hopp (1), R.E. Schulte-Ladbeck (2), and J. Kerp (3)

(1) Universitäts–Sternwarte München, Scheinerstraße 1, D–81679 München
(2) University of Pittsburgh, Department of Physics & Astronomy, Pittsburgh, PA 12260
(3) Radioastronomisches Institut der Universität Bonn, Auf dem Hügel 71, D–53121 Bonn

Abstract: We investigate the hypothesis that compact high–velocity clouds (CHVC) are the missing dwarf galaxies of the Local Group, by searching them for populations of resolved stars. To this end we conducted two distinct tests based on optical and near–infrared single–star photometry. The optical and the near–infrared experiments complement one another; the optical data help us to rule out distant populations but they are restricted to the central regions of the gas distributions, whereas the near–infrared photometry allows us to set limits on nearby populations spread over the typical cloud size. First, we discuss deep optical single–star photometry of five CHVCs in the V and I filters, obtained with the FORS instrument at the Very Large Telecope (VLT). We find that their optical colour–magnitude diagrams are indistinguishable from that of a population of Galactic stars, and attribute all of the resolved stars to Galactic foreground. We present simulations which address the question of how much of a normal dwarf–galaxy type population we might hide in the data. A Kolmogorov–Smirnov test allows us to set very stringent limits on the absence of a resolved stellar population in CHVCs. Second, we also culled near infrared single–star photometry in the J, H, and K_S bands for four of the CHVCs from the Two Micron All Sky Survey (2MASS). The infrared data do not reveal any stellar contents in the CHVCs which resembles that of nearby dwarf galaxies either, and are explained with Galactic foreground as well. We interpret our null detections to indicate that the five CHVCs investigated by us do not host an associated stellar content which is similar to that of the known dwarf galaxies of the Local Group. These CHVCs are very likely pure hydrogen clouds in which no star formation has taken place over cosmic time.

MNRAS 339 (2003), 33.

NEW LIMIT ON T VIOLATION IN FREE NEUTRON DECAY

T. Soldner (1), L. Beck (2), C. Plonka (3), K. Schreckenbach (3), and O. Zimmer (4)

(1) Institut Laue Langevin, BP156, F–38042 Grenoble Cedex 9, France
(2) Beschleunigerlabor von LMU und TU München, Am Coulombwall, D–85747 Garching, Germany
(3) Physik–Department E21, TU München, James–Franck–Straße, D–85747 Garching, Germany
(4) Physik–Department E18, TU München, James–Franck–Straße, D–85747 Garching, Germany

Abstract: Time reversal invariance violation beyond the Standard model mechanism can be tested in free neutron beta decay. The triple correlation between neutron spin and the momenta of electron and antineutrino (D coefficient) tests T violating phases in non-standard couplings.
We present a new preliminary limit for this correlation which was obtained by the Trine experiment: $D_{\mathrm{preliminary}} = (-3.1 \pm 6.2^{\mathrm{stat}} \pm 4.7^{\mathrm{syst}} \pm 4.7^{\mathrm{syststat}}) \cdot 10^{-4}$.

Nuclear Physics A 721 (2003), 469c.

MINKOWSKI FUNCTIONALS OF SDSS GALAXIES I : ANALYSIS OF EXCURSION SETS

C. Hikage (1), J. Schmalzing (2), T. Buchert (1,2,3), Y. Suto (1), I. Kayo (1), A. Taruya (1), M. S. Vogeley (4), F. Hoyle (4), J. R. Gott III (5), and J. Brinkmann (6)

(1) Department of Physics, School of Science, University of Tokyo, Tokyo 113–0033, Japan
(2) Theoretische Physik, Ludwig–Maximilians–Universität, Theresienstraße 37, D–80333 München, Germany
(3) Research Center for the Early Universe (RESCEU), School of Science, University of Tokyo, Tokyo 113–0033, Japan
(4) Department of Physics, Drexel University, 3141 Chestnut Street, Philadelphia, PA 19104, U.S.A.
(5) Princeton University Observatory, Peyton Hall, Princeton, NJ 08544, U.S.A.
(6) Apache Point Observatory, P.O.Box 59, Sunspot NM 88349–0059, U.S.A.

Abstract: We present a first morphometric investigation of a preliminary sample from the SDSS of 154287 galaxies with apparent magnitude $14.5 < m_{\rm r} < 17.5$ and redshift $0.001 < z < 0.4$. We measure the Minkowski Functionals, which are a complete set of morphological descriptors. To account for the complicated wedge–like geometry of the present survey data, we construct isodensity contour surfaces from the galaxy positions in redshift space and employ two complementary methods of computing the Minkowski Functionals. We find that the observed Minkowski Functionals for SDSS galaxies are consistent with the prediction of a Λ–dominated spatially–flat Cold Dark Matter model with random–Gaussian initial conditions, within the cosmic variance estimated from the corresponding mock catalogue. We expect that future releases of the SDSS survey will allow us to distinguish morphological differences in the galaxy distribution with regard to different morphological type and luminosity ranges.

Report–no.: astro–ph/0304455.

Publications of the Astronomical Society of Japan 55 (2003), 911.

UNIVERSALITY IN THE DISTRIBUTION OF CAUSTICS IN THE EXPANDING UNIVERSE

T. Yano (1), H. Koyama (1), T. Buchert (1,2,3), and N. Gouda (1)

(1) National Astronomical Observatory, Mitaka, Tokyo 181–8588, Japan
(2) Department of Physics and Research Center for the Early Universe, School of Science, The University of Tokyo, Bunkyo–ku, Tokyo 113–0033, Japan
(3) Theoretische Physik, Ludwig–Maximilians–Universität, Theresienstraße 37, D–80333 München, Germany

Abstract: We numerically investigate the long–time evolution of density perturbations after the first appearance of caustics in an expanding cosmological model with one–dimensional "single–wave" initial conditions. Focussing on the time–intervals of caustic appearances and the spatial distribution of caustics at subsequent times, we find that the time–intervals of caustic appearances approach a constant, i.e., their time–subsequent ratio converges to 1; it is also found that the spatial distribution of caustics at a given time features some universality rules, e.g., the ratio between the position of the nearest caustic from the center and that of the second nearest caustic from the center approaches a constant. Furthermore we find some rules for the mass distribution for each caustic. Using these universality constants we are in the position to predict the spatial distribution of caustics at an arbitrary time in order to give an estimate for the power spectral index in the fully–developed non–dissipative turbulent ("virialized") regime.

Report–no.: astro–ph/0306487.

Astrophysical Journal Supplement, in press.

DETECTING THE NEUTRINO MASS HIERARCHY WITH A SUPERNOVA AT ICECUBE

A.S. Dighe, M.T. Keil, and G.G. Raffelt

(1) Max–Planck–Institut für Physik, Föhringer Ring 6, D–80805 München, Germany

Abstract: IceCube, a future km^3 antarctic ice Cherenkov neutrino telescope, is highly sensitive to a galactic supernova (SN) neutrino burst. The Cherenkov light corresponding to the total energy deposited by the SN neutrinos in the ice can be measured relative to background fluctuations with a statistical precision much better than 1%. If the SN is viewed through the Earth, the matter effect on neutrino oscillations can change the signal by more than 5%, depending on the flavor-dependent source spectra and the neutrino mixing parameters. Therefore, IceCube together with another high–statistics experiment like Hyper–Kamiokande can detect the Earth effect, an observation that would identify specific neutrino mixing scenarios that are difficult to pin down with long-baseline experiments. In particular, the normal mass hierarchy can be clearly detected if the third mixing angle is not too small, $\sin^2\theta_{13} \gtrsim 10^{-3}$. The small flavor-dependent differences of the SN neutrino fluxes and spectra that are found in state–of–the–art simulations suffice for this purpose. Although the absolute calibration uncertainty at IceCube may exceed 5%, the Earth effect would typically vary by a large amount over the duration of the SN signal, obviating the need for a precise calibration. Therefore, IceCube with its unique geographic location and expected longevity can play a decisive role as a "co-detector" to measure SN neutrino oscillations. It is also a powerful stand-alone SN detector that can verify the delayed-explosion scenario.

Report–no.: hep–ph/0303210.

Journal of Cosmology and Astroparticle Physics 0306 (2003), 005.

IDENTIFYING EARTH MATTER EFFECTS ON SUPERNOVA NEUTRINOS AT A SINGLE DETECTOR

A.S. Dighe, M.T. Keil, and G.G. Raffelt

(1) Max–Planck–Institut für Physik, Föhringer Ring 6, D–80805 München, Germany

Abstract: The neutrino oscillations in Earth matter introduce modulations in the supernova neutrino spectra. These modulations can be exploited to identify the presence of Earth effects on the spectra, which would enable us to put a limit on the value of the neutrino mixing angle θ_{13} and to identify whether the mass hierarchy is normal or inverted. We demonstrate how the Earth effects can be identified at a single detector without prior assumptions about the flavor–dependent source spectra, using the Fourier transform of the "inverse-energy" spectrum of the signal. We explore the factors affecting the efficiency of this method, and find that the energy resolution of the detector is the most crucial one. In particular, whereas water Cherenkov detectors may need a few ten thousand events to identify the Earth effects, a few thousand may be enough at scintillation detectors, which generically have a much better energy resolution. A successful identification of the Earth effects through this method can also provide $\Delta m^2_\odot$ to a good accuracy. The relative strength of the detected Earth effects as a function of time provides a test for supernova models.

Report–no.: hep–ph/0304150.

Journal of Cosmology and Astroparticle Physics 0306 (2003), 006.

SUPERNOVA POINTING WITH LOW– AND HIGH–ENERGY NEUTRINO DETECTORS

R. Tomàs, D. Semikoz, G.G. Raffelt, M. Kachelriess, and A.S. Dighe

(1) Max–Planck–Institut für Physik, Föhringer Ring 6, D–80805 München, Germany

Abstract: A future galactic SN can be located several hours before the optical explosion through the MeV-neutrino burst, exploiting the directionality of ν–e–scattering in a water Cherenkov detector such as Super–Kamiokande. We study the statistical efficiency of different methods for extracting the SN direction and identify a simple approach that is nearly optimal, yet independent of the exact SN neutrino spectra. We use this method to quantify the increase in the pointing accuracy by the addition of gadolinium to water, which tags neutrons from the inverse beta decay background. We also study the dependence of the pointing accuracy on neutrino mixing scenarios and initial spectra. We find that in the "worst case" scenario the pointing accuracy is 8° at 95% C.L. in the absence of tagging, which improves to 3° with a tagging efficiency of 95%. At a megaton detector, this accuracy can be as good as 0.6°. A TeV–neutrino burst is also expected to be emitted contemporaneously with the SN optical explosion, which may locate the SN to within a few tenths of a degree at a future km^2 high–energy neutrino telescope. If the SN is not seen in the electromagnetic spectrum, locating it in the sky through neutrinos is crucial for identifying the Earth matter effects on SN neutrino oscillations.

Report–no.: hep–ph/0307050.
Physical Review D 68 (2003), 093013.

SIGNATURES OF SUPERNOVA NEUTRINO OSCILLATIONS IN THE EARTH MANTLE AND CORE

A.S. Dighe, M. Kachelriess, G.G. Raffelt, and R. Tomàs

(1) Max–Planck–Institut für Physik, Föhringer Ring 6, D–80805 München, Germany

Abstract: The Earth matter effects on supernova (SN) neutrinos can be identified at a single detector through peaks in the Fourier transform of their "inverse energy" spectrum. The positions of these peaks are independent of the SN models and therefore the peaks can be used as a robust signature of the Earth matter effects, which in turn can distinguish between different neutrino mixing scenarios. Whereas only one genuine peak is observable when the neutrinos traverse only the Earth mantle, traversing also the core gives rise to multiple peaks. We calculate the strengths and positions of these peaks analytically and explore their features at a large scintillation detector as well as at a megaton water Cherenkov detector through Monte Carlo simulations. We propose a simple algorithm to identify the peaks in the actual data and quantify the chances of a peak identification as a function of the location of the SN in the sky.

Report–no.: hep–ph/0311172.

Journal of Cosmology and Astroparticle Physics 01 (2004), 004.

COSMOLOGICAL MASS LIMITS ON NEUTRINOS, AXIONS, AND OTHER LIGHT PARTICLES

S. Hannestad and G.G. Raffelt

(1) Max–Planck–Institut für Physik, Föhringer Ring 6, D–80805 München, Germany

(2) University of Southern Denmark, 5230 Odense, Denmark

Abstract: The small–scale power spectrum of the cosmological matter distribution together with other cosmological data provides a sensitive measure of the hot dark matter fraction, leading to restrictive neutrino mass limits. We extend this argument to generic cases of low-mass thermal relics. We vary the cosmic epoch of thermal decoupling, the radiation content of the universe, and the new particle's spin degrees of freedom. Our treatment covers various scenarios of active plus sterile neutrinos or axion–like particles. For three degenerate massive neutrinos, we reproduce the well-known limit of $m_\nu < 0.34$ eV. In a 3+1 scenario of 3 massless and 1 fully thermalized sterile neutrino we find $m_\nu < 1.0$ eV. Thermally produced QCD axions must obey $m_a < 3.0$ eV, superseding limits from a direct telescope search, but leaving room for solar eV-mass axions to be discovered by the CAST experiment.

Report–no.: hep–ph/0312154.

Journal of Cosmology and Astroparticle Physics, submitted.

INFORMATION ENTROPY IN COSMOLOGY

A. Hosoya (1), T. Buchert (1,2,3), and M. Morita (4,5)

(1) Department of Physics, Tokyo Institute of Technology, Oh–Okayama, Meguro–ku, Tokyo 152–0033, Japan
(2) Theoretische Physik, Ludwig–Maximilians–Universität, Theresienstr. 37, D–80333 München, Germany
(3) Department of Physics and Research Center for the Early Universe (RESCEU), School of Science, The University of Tokyo, Tokyo 113–0033, Japan
(4) Department of Physics, Ochanomizu University, Ohtsuka, Bunkyo–ku, Tokyo 112–8610, Japan
(5) Advanced Research Institute for Science and Engineering, Waseda University, Ohkubo, Shinjuku–ku, Tokyo 169–8555, Japan

Abstract: The effective evolution of an inhomogeneous cosmological model may be described in terms of spatially averaged variables. We point out that in this context, quite naturally, a measure arises which is identical to a fluid model of the “Kullback–Leibler Relative Information Entropy”, expressing the distinguishability of the local inhomogeneous mass density field from its spatial average on arbitrary compact domains. We discuss the time–evolution of ‘effective information’ and explore some implications. We conjecture that the information content of the Universe – measured by Relative Information Entropy of a cosmological model containing dust matter – is increasing.

Report–no.: gr–qc/0402076.
Physical Review Letters, in press.

SPATIALLY RESOLVED SPECTROSCOPY OF COMA CLUSTER EARLY – TYPEGALAXIES: III. THE STELLAR POPULATION GRADIENTS

D. Mehlert (1), D. Thomas (2), R. P.Saglia (3), R. Bender (2,3), and G. Wegner (4)

(1) Landessternwarte Heidelberg, Königstuhl, D–69117 Heidelberg, Germany
(2) Max–Planck–Institut für extraterrestrische Physik, Giessenbachstraße, D–85748 Garching, Germany
(3) Universitäts-Sternwarte München, Scheinerstraße 1, D–81679 München, Germany
(4) Department of Physics and Astronomy, 6127 Wilder Laboratory, Dartmouth College, Hanover, NH 03755–3528, USA

Abstract: Based on Paper I of this series (Mehlert et al. 2000), we derive central values and logarithmic gradients for the Hβ, Mg and Fe indices of 35 early–type galaxies in the Coma cluster. We find that pure elliptical galaxies have on average slightly higher velocity dispersions, lower Hβ, and higher metallic line-strengths than galaxies with disks (S0). The latter form two families, one comparable to the ellipticals and a second one with significantly higher Hβ, and weaker metallic lines. Our measured logarithmic gradients within the effective radius are $\langle\triangle\mathrm{Mg}\,b\rangle \approx -0.037$, $\langle\triangle\langle\mathrm{Fe}\rangle\rangle \approx -0.029$, $\langle\triangle\mathrm{H}\beta\rangle \approx +0.017$ and $\langle\triangle\sigma\rangle \approx -0.063$. The gradients strongly correlate with the gradients of σ, but only weakly with the central index values and galaxy velocity dispersion.
Using stellar population models with variable element abundance ratios from Thomas, Maraston & Bender (2003a) we derive average ages, metallicities and [α/Fe] ratios in the center and at the effective radius.
We find that the α/Fe ratio correlates with velocity dispersion and drives 30% of the Mg-σ relation, the remaining 70% being caused by metallicity variations.We confirm previous findings that part of the lenticular galaxies in the Coma cluster host very young (~ 2 Gyr) stellar populations, hence must have experienced relatively recent star formation episodes. Again in accordance with previous work we derive negative metallicity gradients (~ -0.16 dex per decade) that are significantly flatter than what is expected from gaseous monolithic collapse models, pointing to the importance of mergers in the galaxy formation history. Moreover, the metallicity gradients correlate

with the velocity dispersion gradients, confirming empirically earlier suggestions that the metallicity gradient in ellipticals is produced by the local potential well. The gradients in age are negligible, implying that no significant residual star formation has occurred either in the center or in the outer parts of the galaxies, and that the stellar populations at different radii must have formed at a common epoch. For the first time we derive the gradients of the α/Fe ratio and find them very small on the mean. Hence, α/Fe enhancement is not restricted to galaxy centers but it is a global phenomenon. Our results imply that the Mg-σ local relation inside a galaxy, unlike the global Mg-σ relation, must be primarily driven by metallicity variations alone. Finally we note that none of the stellar population parameters or their gradients depend on the density profile of the Coma cluster, even though it spans 3 dex in density.

Astronomy and Astrophysics 407 (2003), 423.

INTEGRATED SPECTROSCOPY OF BULGE GLOBULAR CLUSTERS AND FIELDS. II. IMPLICATIONS FOR POPULATION SYNTHESIS MODELS AND ELLIPTICAL GALAXIES

C. Maraston (1,2) L. Greggio (2,3), A. Renzini (4), S. Ortolani (3), R. P. Saglia (2), T. H. Puzia (2), and M. Kissler–Patig (4)

(1) Max–Planck–Institut für extraterrestrische Physik, Giessenbachstraße, D-85748 Garching b. München, Germany
(2) Universitäts–Sternwarte München, Scheinerstraße 1, D–81679 München, Germany
(3) Osservatorio Astronomico di Padova, vicolo dell'Osservatorio, Padova, Italy
(4) European Southern Observatory, Karl–Schwarzschild–Straße 2, D–85748 Garching, Germany

Abstract: An empirical calibration is presented for the synthetic Lick indices (e.g. Mg_2, $\langle\mathrm{Fe}\rangle$, $\mathrm{H}\beta$, etc.) of Simple Stellar Population (SSP) models that for the first time extends up to solar metallicity. This is accomplished by means of a sample of Milky Way globular clusters (GCs) whose metallicities range from $\sim Z_\odot/30$ to $Z \sim Z_\odot$, thanks to the inclusion of several metal rich clusters belonging to the Galactic bulge (e.g., NGC 6553 and NGC 6528). This metallicity range approaches the regime that is relevant for the interpretation of the integrated spectra of elliptical galaxies. It is shown that the spectra of both the globular clusters and the Galactic bulge follow the same correlation between magnesium and iron indices that extends to elliptical galaxies, showing weaker iron indices at given magnesium indices with respect to the predictions of models that assume solar-scaled abundances. This similarity provides robust empirical evidence for enhanced $[\alpha/\mathrm{Fe}]$ ratios in the stellar populations of elliptical galaxies, since the globular clusters are independently known to have enhanced $[\alpha/\mathrm{Fe}]$ ratios from spectroscopy of individual stars. We check the uniqueness of this α–overabundance solution by exploring the whole range of model ingredients and parameters, i.e. fitting functions, stellar tracks, and the initial mass function (IMF). We argue that the *standard* models (meant for solar abundance ratios) succeed in reproducing the Mg–Fe correlation at low metallicities ($[\mathrm{Z/H}] \lesssim -0.7$) because the stellar templates used in the synthesis are Galactic halo stars that actually are α–enhanced. The same models, however, fail to predict the observed Mg–Fe pattern at higher metallicities ($[\mathrm{Z/H}] \gtrsim -0.7$) (i.e., for bulge clusters and ellipticals alike) because the high-metallicity templates are disk stars that are

not α-enhanced. We show that the new set of SSP models which incorporates the dependence on the $[\alpha/\mathrm{Fe}]$ ratio (Thomas, Maraston & Bender 2002) is able to reproduce the Mg and Fe indices of GCs at all metallicities, with an α-enhancement $[\alpha/\mathrm{Fe}] = +0.3$, in agreement with the available spectroscopic determinations. The Hβ index and the higher–order Balmer indices are well calibrated, provided the appropriate morphology of the Horizontal Branch is taken into account. In particular, the Balmer line indices of the two metal rich clusters NGC 6388 and NGC 6441, which are known to exhibit a tail of warm Horizontal Branch stars, are well reproduced. Finally, we note that the Mg indices of very metal-poor ($[\mathrm{Z/H}] \lesssim -1.8$) populations are dominated by the contribution of the lower Main Sequence, hence are strongly affected by the present-day mass function of individual globular clusters, which is known to vary from cluster to cluster due to dynamical effects.

Astronomy and Astrophysics 400 (2003), 823.

DEVELOPMENT OF A CRYOGENIC DETECTION CONCEPT FOR GNO

J.-C. Lanfranchi (1), T. Lachenmaier (1), W. Potzel (1), and F. von Feilitzsch (1)

(1) Technische Universität München, Physik–Department E15, James–Franck–Straße, D–85748 Garching, Germany

Abstract: The Gallium–Neutrino–Experiment GNO measures solar neutrinos radiochemically via the reaction ^{71}Ga(ν,e)^{71}Ge. In order to reduce statistical and systematic uncertainties in detecting the decay of ^{71}Ge to ^{71}Ga, a favourable way could be the use of high–resolution cryogenic detectors instead of the presently integrated miniaturized proportional counters. After the successful development of a highly efficient 4π–detector, optimization of thermal Ge–deposition and decoupling of deposition and detection, present activity concentrates on low background considerations, enhancement of external and internal shielding of the cryostat and a longterm run with artificially activated ^{71}Ge to prove the feasibility of "cryoGNO" in our Underground Laboratory in Garching.

Proceedings of "The Tenth International Workshop on Low Temperature Detectors (LTD–10)", Genova, Italy, 2003; accepted for publication in Nuclear Instruments and Methods in Physics Research – Section A.

PROGRESS IN GNO

T. A. Kirsten (1)

(1) for the GNO collaboration: E. Bellotti (spokesperson), C. Cattadori, N. Ferrari, F. Petricca, L. Zanotti (Milano Universita Bicocca and INFN); G. Cerichelli, M. Chiarini, G. Del Re (Universita dell'Aquila); E. Burkert, W. Hampel, F. X. Hartmann, G. Heusser, J. Kiko, T. Kirsten, D. Motta, H. Richter (MPIK Heidelberg); K.H. Ebert, E. Henrich (FZK Karlsruhe); M. Balata, L. Ioannucci, M. Laubenstein, S. Nisi, L. Pandola (LNGS Gran Sasso); M. Altmann, F. v. Feilitzsch, T. Lachenmaier, J. Lanfranchi, W. Potzel (TUM München); P. Belli, R. Bernabei, R. Cerulli, S. d'Angelo (Roma INFN); M. Cribier (CE Saclay).

Abstract: Recording of sub–MeV solar neutrinos (ν_{pp}, ν_{Be7}) in the Gallium Neutrino Observatory (GNO) is essential in further defining the neutrino oscillation parameters (masses, mixings). Continued error reduction is crucial in this context. The data set GNO II is now completed. The result from 43 runs (May 1998 through January 2002) is 65 $\pm$ 7 SNU. The total record is now 108 runs (65 Gallex, 43 GNO [19 GNO I, 24 GNO II]), the combined result is 71 $\pm$ 6 SNU. The systematical error in GNO is reduced to $\pm$ 3.0 SNU. This substantial error reduction has been achieved mainly through internal counter calibrations, an improved Rn-correction, and the introduction of neural network data analysis. The physics potential of future sub-MeV neutrino studies demands further efforts. Work is underway towards even better ^{71}Ge counting efficiency by application of cryotechnics and towards a new and more precise ^{51}Cr neutrino source experiment (>2.5 MCi) for an improved determination of the cross section for ν-capture on ^{71}Ga.

Nuclear Physics B (Proceedings Supplement) 118 (2003), 33.

THE TOP–DOWN INTERPRETATION OF ULTRA–HIGH ENERGY COSMIC RAYS

M. Drees (1)

(1) Physik Department, Technische Universität München, James–Franck–Straße, D–85748 Garching, Germany

Abstract: The origin of Ultra–High Energy ($E \gtrsim 10^{20}$ eV) Cosmic Rays (UHECR) remains mysterious. I discuss "top–down" models, where UHECR originate from the decay of very massive, long–lived particles. I summarize the calculation of the spectrum of decay products, discuss possible problems with this scenario, and describe ways to test it by searching for very energetic neutrinos and neutralinos.

Report–no.: hep–ph/0310331.

Proceedings of "The 3rd International Workshop for Comprehensive Study of the High Energy Universe – Toward Very High Energy Particle Astronomy – (VHEPA-3)", Tokyo, Japan, March, 20–22, 2003.

LEPTOGENESIS FROM A SNEUTRINO CONDENSATE REVISITED

R. Allahverdi (1) and M. Drees (2)

(1) Theory Group, TRIUMF, 4004 Wesbrook Mall, Vancouver, B.C., V6T 2A3, Canada

(2) Physik Department, Technische Universität München, James–Franck– Straße, D–85748

Abstract: We re–examine leptogenesis from a right–handed sneutrino condensate, paying special attention to the B–term associated with the see–saw Majorana mass. This term generates a lepton asymmetry in the condensate whose time average vanishes. However, a net asymmetry will result if the sneutrino lifetime is not much longer than the period of oscillations. Supersymmetry breaking by thermal effects then yields a lepton asymmetry in the standard model sector after the condensate decays. We explore different possibilities by taking account of both the low–energy and Hubble $B-$terms. It will be shown that the desired baryon asymmetry of the Universe can be obtained for a wide range of Majorana mass.

Report–no.: hep–ph/0401054.

Physical Review D, submitted.

CORE–COLLAPSE SUPERNOVAE AT THE THRESHOLD

H.-Th. Janka, R. Buras, K. Kifonidis, A. Marek, and M. Rampp

(1) Max–Planck–Institut für Astrophysik, Postfach 1317, D–85741 Garching, Germany

Abstract: Recent progress in modeling core–collapse supernovae is summarized and set in perspective. Two–dimensional simulations with state–of–the–art treatment of neutrino transport still fail to produce powerful explosions, but evidence is presented that they are very close to a success.

Report–no.: astro–ph/0401461, P–MPA1610e.

Proceedings of "Supernovae (10 Years of SN1993J)", (IAU Colloquium 192), Valencia, Spain, April, 22–26, 2003; Eds. J.M. Marcaide ad K.W. Weiler, Springer Verlag, to appear (2004).

EVOLUTION OF THE GALAXY LUMINOSITY FUNCTION IN THE FORS DEEP FIELD (FDF)

A. Gabasch (1), R. Bender (1), U. Hopp (1), R. P. Saglia (1), S. Seitz (1), J. Snigula (1), I. Appenzeller (2), J. Heidt (2), D. Mehlert (2), S. Noll (2), A. Böhm (3), K. J. Fricke (3), K. Jäger (3), and B. Ziegler (3)

(1) Universitäts–Sternwarte München, Scheinerstraße 1, D–81679 München, Germany
(2) Landessternwarte Heidelberg, Königstuhl, D–69117 Heidelberg, Germany
(3) Universitäts–Sternwarte Göttingen, Geismarlandstraße 11, D–37083 Göttingen, Germany

Abstract: With the large homogeneous dataset and the accurate photometric redshifts ($\Delta z/(z+1) \approx 0.03$) of the FORS Deep Field (FDF) we are able to study the evolution of the luminosity function in various bands from low ($\langle z \rangle = 0.3$) to high redshift ($\langle z \rangle = 4.5$). We find a strong brightening of M^* and decrease of ϕ^* with redshift in the restframe UV. We also find an increase of the star formation rate (SFR) between $0.5 < z < 1.5$, whereas the SFR remains approximately constant between $1.5 < z < 4.0$.

Proceedings of "Multiwavelength Cosmology", Mykonos Island, Greece, June, 17–20, 2003.

WHITEPAPER ON USING NUCLEAR REACTORS TO SEARCH FOR θ_{13}

P. Huber (1), J. Kersten (1), M. Lindner (1), T. Schwetz (1), W. Winter (1), M. Rolinec et al.

(1) Technische Universität München, Physik Department T30d, James–Franck–Straße D–85748 Garching, Germany

Abstract: There has been superb progress in understanding the neutrino sector of elementary particle physics in the past few years. It ist now widely recognized that the possibility exists for a rich program of measuring CP violation and matter effects in future accelerator ν experiments, which has led to intense efforts to consider new programs at neutrino superbeams, off–axis detectors, neutrino factories and beta beams. However, the possibility of measuring CP violation can be fulfilled only if the value of the neutrino mixing parameter θ_{13} is such that $\sin^2(2\theta_{13})$ greater than or equal to on the order of 0.01. The authors of this white paper are an International Working Group of physicists who believe that a timely new experiment at a nuclear reactor sensitive to the neutrino mixing parameter θ_{13} in this range has a great opportunity for an exciting discovery, a non–zero value to θ_{13}. This would be a compelling next step of this program. We are studying possible new reactor experiments at a variety of sites around the world, and we have collaborated to prepare this document to advocate this idea and describe some of the issues that are involved.

Report–no.: TUM–HEP–541/04.

TESTING θ_{13}, MATTER EFFECTS AND LEPTONIC CP VIOLATION

M. Lindner (1)

(1) Physik Department, Technische Universität München James–Franck–Straße, D–85748 Garching, Germany

Abstract: The prospects for improved limits or measurements of the small neutrino mixing parameter θ_{13}, matter effects and leptonic CP-violation with future long baseline accelerator and future reactor neutrino oscillation experiments are discussed. It will be shown that there exists a healthy physics program with a remarkable potential for very precise measurements of mass splittings and mixing angles which should ultimately allow measurements of leptonic CP violation. This program is very interesting. It will allow interesting insights into flavour physics, neutrino mass models and it is rather likely connected to the baryon asymmetry of the universe.

Report–no.: TUM–HEP–539/04.

NEUTRON STAR FORMATION AND BIRTH PROPERTIES

H.–T. Janka

(1) Max–Planck–Institut für Astrophysik, Karl–Schwarzschild–Straße 1, D–85741 Garching, Germany

Abstract: Our current knowledge of neutron star formation, progenitors, and natal masses, spins, magnetic fields, and space velocities is briefly reviewed from a theorist's perspective. More observational information is badly needed to constrain theoretical possibilities.

Report–no.: P–MPA1612e

Procceedings of "Young Neutron Stars and Their Environments" (IAU Symposium 218, ASP Conference Proceedings), Eds. F. Camilo and B.M. Gaensler.