TIFR Annual Report 2010 - 11

Department of Theoretical Physics

High Energy Physics

Highlights

An explanation was proposed of the CDF measurement of anomalous forward-backward asymmetry in the top and anti-top quark production at the Tevatron in terms of new gauge bosons.

The application of top quark/antiquark tagging techniques through substructure of boosted jets was used to study new physics models such as universal extra dimensions and supersymmetry.

A next-to-leading order study of production at the LHC was carried out in a bulk Randall-Sundrum model.

An analysis was carried out of the impact of recent measurements of the branching ratio on a class of models including the constrained MSSM, showing that a large portion of the previously allowed parameter space is ruled out. For the constrained MSSM, the allowed parameter space is likely to be soon accessible to LHC experiments.

LHC signals for R-parity violating supersymmetry were studied that would correspond to large effects at low energies.

Observable signatures of supernova neutrino oscillations at future large underground neutrino detectors were studied.

An analysis was performed indicating that a source-to-detector distance of 2540 km offers multiple advantages for a low energy neutrino factory with a detector that can identify muon charge.

The effect of different Lorentz structures of new physics on decay modes involving transitions was analysed.

A global fit was made to flavour-physics data, obtaining constraints on the quark-mixing parameter space with four generations.

The effects of new physics on Wilson coefficients were analysed.

It was demonstrated that the mixed chiral action formulation is a promising approach to do lattice QCD simulation both with heavy and light quarks, but with substantially less computational cost than the full overlap action simulation.

An investigation was carried out using quenched and dynamical lattice simulation indicating that the lightest scalar mesons sigma and kappa have large tetraquark components.

It was demonstrated that chiral symmetry restoration in the screening correlation lengths of pions and scalar mesons occurs at 1.33 times the chiral transition temperature. Using external fermion sources, a chemical potential was introduced in the overlap action such that the lattice action has exact invariance under chiral transformations.

Lattice predictions for the shape of fluctuations in heavy-ion collisions were matched to experimental data for the first ever experimental determination of the crossover temperature of quantum chromodynamics.

Charmonium production at the Large Hadron Collider was studied.

A study of event-shape variables at colliders was carried out in the soft gluon limit.

The fate of heavy quarkonium states in an anisotropic hot QCD medium was analysed.

A quasiparticle description was provided for the (2+1)-flavour lattice QCD equation of state.

Studies were performed of the thermodynamics geometry of hot QCD, quarkonium states and complex systems.

Text

Research in High Energy Physics was carried out in the broad areas of Physics beyond the Standard Model, Non-perturbative strong interaction physics and Quantum Chromodynamics.

Top quark forward-backward asymmetry

The CDF measurement of forward-backward asymmetry in the top and anti-top quark production at the Tevatron shows significant deviation from the Standard Model prediction in the large invariant mass region. An explanation of this was devised using models with new gauge bosons. Further, the role of a recently proposed observable – the one-sided forward-backward asymmetry – as a probe of the existence of such new particles was investigated. [B. Bhattacherjee, S.S. Biswal and D. Ghosh]

Top quark tagging at the LHC as a probe of new physics

One of the novel features at the Large Hadron Collider is the fact that because of the high energy of the machine, heavy particles undergoing hadronic decays will be highly boosted and the decay products will appear as fat jets with substructure, instead of a multiplicity of isolated jets. This can be used to tag, among others, top quarks. Such top-jet tagging techniques were used to study the LHC production of heavy Kaluza-Klein resonances of vector bosons in a model with a Universal Extra Dimension. It was demonstrated that tagged top quarks can be as effective in the search for these particles as the traditional leptonic triggers. [B. Bhattacherjee, S. Raychaudhuri and K. Sridhar with M. Guchait (DHEP/TIFR)]

At the LHC, supersymmetric cascade decays originating in gluinos and third generation squarks could be copious sources of highly-boosted top quarks. It was shown that top-tagging techniques using the jet substructure algorithm can be very useful in identifying such boosted top quarks from final states which would otherwise be indistinguishable from backgrounds. [B. Bhattacherjee with P. Bandyopadhyay (KIAS, Seoul)]

Top quark pair production in the bulk Randall Sundrum model

The bulk Randall-Sundrum Model is a model of warped extra dimensions with the gauge fields and fermions along with the graviton in the extra-dimensional bulk and with only the Higgs field localised on the brane. The Kaluza-Klein excitation of the gluon, which primarily decays into top quarks, is the best signal to test this model. At leading order, however, this excitation is produced only through initial states, which is not a large contribution. Therefore, the gluon-initiated contribution at next-to-leading order in QCD has been studied. [K. Sridhar with B. Allanach and J. Skittrall (Cambridge) and F. Mahmoudi (Clermont-Ferrand)]

Decay and supersymmetry at the LHC

The recent measurements of the branching ratio of B^+ to $\tau^+ + \nu_\tau$ were shown to have a serious impact on models with minimal flavour violation involving a charged Higgs boson, ruling out a large portion of the currently-allowed parameter space. In the constrained minimal supersymmetric standard model, a tension between the measurements of B^+ to $\tau^+ + \nu_\tau$ and the anomalous magnetic moment of the muon was pointed out, unless tan β is small, $\mu>0$, and A_0 takes a large negative value. In fact, a very small region of the parameter space of this model, with small values of m_0 and $m_{1/2}$, was shown to survive all the constraints at 95% C.L. It is remarkable that this specific region is still consistent with the lightest supersymmetric particle as the dark matter. Moreover, it predicts observable SUSY signals in the early runs of the LHC, even perhaps at 7 TeV. [B. Bhattacherjee, A. Dighe, D. Ghosh and S. Raychaudhuri]

Flavor physics and R-parity violation at the LHC

The R-parity-violating version of supersymmetry was studied simultaneously in two regimes, viz. the low-energy regime probing meson production and decay modes, and the high energy regime accessible to the LHC. Choosing R-parity-violating couplings of the type that may give large effects in ill-measured low-energy processes, it was shown that the same couplings, together with reasonably light superparticles, could be expected to give rise to clear signals at the LHC, including multileptons of the same sign. An early discovery of such signals in the 7 TeV would lead to the prediction of large deviations from the Standard Model predictions in the corresponding low-energy processes. [B. Bhattacherjee and S. Raychaudhuri with G. Bhattacharyya (SINP, Kolkata)]

Search for the minimal universal extra dimension model at the early LHC run.

An analysis was performed of the potential of the LHC to discover signals for a Universal Extra Dimension in runs at the centre-of-mass energy 7 TeV with an accumulated luminosity of an inverse femtobarn. It was found that the LHC will be able to discover strongly interacting KK particles with masses up to 800 – 900 GeV. [B. Bhattacherjee with K. Ghosh (HRI, Allahabad)]

Signatures of supernova neutrino oscillations at large detectors

The expected neutrino signal from a future galactic supernova burst at large next-generation underground detectors was calculated for various neutrino mixing scenarios, taking into account the neutrino-neutrino interactions. The most striking signatures of these interactions would be the presence of peculiar energy dependent modulations associated with Earth matter crossing, present only in portions of the SN neutrino energy spectra. The observability of these signatures at proposed large water Cherenkov, scintillation, and liquid Argon detectors was explored. [A. Dighe, with S. Choubey (HRI, Allahabad), B. Dasgupta (Ohio State U.) and A. Mirizzi (U. of Hamburg)]

Bimagic baseline for neutrino oscillation parameters

It was pointed out that a source-to-detector distance of 2540 km offers multiple advantages for a low energy neutrino factory with a detector that can identify muon charge. At this baseline, for any neutrino hierarchy, the wrong-sign muon signal is almost independent of CP violation and the mixing angle in certain energy ranges. This reduces the uncertainties due to these parameters and allows the identification of the hierarchy in a clean way. In addition, part of the muon spectrum is also sensitive to the CP violating phase and θ_{13}, so that the same setup can be used to probe these parameters as well. [A. Dighe, with S. Goswami (PRL, Ahmedabad) and S. Ray (Cornell U.)]

New physics Lorentz structures and transitions

A comprehensive study of the impact of new-physics operators with different Lorentz structures on observables involving transition was carried out. The effects of new vector-axial vector, scalar-pseudoscalar and tensor interactions on the CP-conserving as well as CP-violating observables were calculated. A combined analysis of future measurements of these observables would enable the detection of physics beyond the Standard Model, and may reveal its Lorentz structure. [A. Dighe and D. Ghosh, with A. Alok, D. London (Montreal), A. Datta and M. Duraisamy (Mississippi)]

Four-generation quark mixing matrix from a fit to flavour-physics data

In the scenario with four quark generations, constraints on the mixing parameters were obtained by performing a fit to all the clean flavor-physics observables. While strong constraints were obtained on the mixing of the fourth generation quarks with the first three generations, this still was shown to allow for the possibility of new physics signals in B_d, B_s and rare K decays. [A. Dighe, with A. Alok and D. London (U. of Montreal)]

Exploring new physics in the C_7-C_7' plane

The Wilson coefficient C_7 governing radiative electromagnetic decays of the B meson has been calculated to a very high accuracy in the Standard Model, but to date there is no convincing model-independent experimental bound on either its magnitude or sign. A systematic approach was made to constrain both the magnitude and sign of already-measured observables like the branching ratios of $B \to X_s \mu^+ \mu^-$ and $B \to X_s \gamma$, the isospin and CP asymmetries in $B \to K^* \gamma$, as well as A_{FB} and FL in $B \to K^* l^+ l^-$. The transverse observable AT2, once measured, may help to disentangle some of the scenarios considered. It was found that the existing constraints need to be relaxed up to 1.6 sigma to allow for the ‘flipped-sign’ solution of C_7. Semi-numerical expressions for all these observables were presented as functions of the relevant Wilson coefficients at the low scale. [D. Ghosh with S. Descotes-Genon (Orsay), J. Matias and M. Ramon (U. of Barcelona)]

Overlap valence on 2+1 flavor domain wall fermion configurations

It was demonstrated that overlap valence on 2+1 flavor domain wall fermion configurations is a promising approach to do lattice QCD simulation with light, strange, and charm quark together in the same fermion lattice formulation but with substantially less computational cost than the full overlap simulation. The eigenvalue deflation along with HYP smearing was demonstrated to be a very efficient procedure for inversion and it was shown that the Z3 grid source with low-mode substitution can reduce error in two-point correlators up to a factor 4. Preliminary results obtained for the meson spectrum are very encouraging. With appropriate mixed action partially quenched chiral perturbation theory, chiral extrapolation and then continuum extrapolation are being pursued. Furthermore, it was found that the behaviour in the hyperfine splitting (HFS) between vector and pseudoscalar mesons extends to the charm quark range and the result for the HFS is quite encouraging. This motivates an extensive study of charm-light, charm-strange and charm-charm spectra and other related phenomenologies in the future. [N. Mathur with A. Li (Duke U.), A. Alexandru (George Washington U.), T. Draper (U. of Kentucky), F. Lee (George Washington U.), Keh-Fei Liu (U. of Kentucky) of ChiQCD collaboration]

Spectroscopy of light tetraquark states

Using dynamical lattice QCD simulation an investigation was made whether there is any light tetraquark state as predicted by various phenomenological studies. A search for possible light tetraquark states with $J^{PC}=0^{++}$ and I=0,1/2,3/2,2 on the lattice was performed by using the two-flavor dynamical simulation with chirally improved quarks and the quenched simulation with overlap quarks. The spectrum was determined using improved generalized eigenvalue method with various tetraquark operators at the source and the sink. In all the channels, the lowest scattering states were found to be $\pi(k)\ \pi(-k)$ or $K(k)\ \pi(-k)$ with back-to-back momentum k=0, 2p/L,... However, an additional light state in the I=0 and I=1/2 channels was observed, which may be interpreted as the observed resonances σ and κ with a sizable tetraquark component. In the exotic repulsive channels I=2 and I=3/2, no additional light state was found which is also in accordance with experiments. The main goal was to find out whether the lightest scalar mesons σ and κ have large tetraquark components and results indicated such a strong overlap. [N. Mathur with S. Prelovsek (Ljubljana), T. Draper (Kentucky), C. Lang (Graz), Keh-Fei Liu (Kentucky), M. Limmer and D. Mohler (TRIUMF).]

Renormalized Polyakov loop in the fixed scale approach

The Polyakov loop, defined as the product of the time-like gauge links at a given site, is the order parameter for the deconfinement transition. The Polyakov loop needs to be renormalized for it to be physical while the bare Polyakov loop vanishes in the limit of vanishing lattice spacing. Previous attempts to renormalize it depended on perturbation theory or other technical assumptions. Earlier work on the so-called fixed scale approach of simulations was continued. Temperature is varied by in this approach by changing the temporal lattice size. Using four different cut-offs, a unique renormalized Polyakov loop was obtained from even coarse lattices with four temporal sites. The details of the shape of the physical order parameter are scale-dependent in the plasma phase. None the less, it is universal once a choice is made. In order to mimic the perturbative renormalization scheme its point-divergent contribution was estimated. Eliminating it, the high temperature approach to the asymptotic value was demonstrated to be from above. [R.V. Gavai]

Towards faster computation of quark number susceptibilities in QCD

The critical point in the phase diagram of QCD at finite temperature and density has recently attracted a lot of theoretical and experimental attention. The TIFR group had earlier advocated estimating its location by computing the radius of convergence of the series in the baryonic chemical potential of the quark number susceptibility. The current state-of-the-art estimates are up to the eighth order susceptibility. While higher orders are important for the accurate estimation of the critical point, the number of fermion matrix inversion, i.e, computational cost, increases as does the estimated error. We employ our own proposal for the lattice Dirac operator at finite density which could be a viable alternative for reducing both. As a first step, a procedure was suggested to remove the unphysical cut-off artifacts it has and all the coefficients of the expansion were computed with less computational effort for temperatures higher than the chiral-symmetry restoration temperature. [R.V. Gavai, S. Gupta and S. Sharma].

On the exact chiral invariance of overlap fermions at finite density:

The critical point in the QCD phase diagram is associated with chiral symmetry restoration transition. It is therefore important to use fermions with exact chiral symmetry on the lattice. The commonly used fermion actions for lattice simulations either break chiral symmetry explicitly or have only a remnant of it. Lattice Overlap fermions have exact chiral symmetry but at zero chemical potential. In our previous work, we have shown that the existing Overlap fermion action at finite fermion density does not have chiral symmetry on the lattice. Using external fermion sources, chemical potential was introduced in the Overlap action starting from the first principles. It was shown that the action remains invariant under chiral transformation of the fermionic source terms. Thermodynamic quantities for free fermions were studied using the new operator. [R.V.Gavai, R. Narayanan and S. Sharma].

Determining initial-state fluctuations from flow measurements in heavy-ion collisions

Good understanding of the initial conditions for hydrodynamic evolution of the matter produced in relativistic heavy-ion collisions is essential for a reliable extraction of the properties of the medium, such as its shear viscosity. In event-by-event hydrodynamics, the initial distribution of participants in the azimuthal plane fluctuates from event to event. A number of independent flow observables that can be measured using multiparticle azimuthal correlations in relativistic heavy-ion collisions were presented. By taking ratios of these observables, quantities which were insensitive to the hydrodynamic response of the medium were constructed. They directly probe the initial conditions for the hydrodynamic evolution. Predictions were presented for these ratios using two Monte-Carlo models, one based on the Glauber model and the other motivated by the colour-glass condensate, and they were compared to available data. Taken together, these measurements will allow for a more precise determination of the medium properties than is currently possible. [R.S. Bhalerao with M. Luzum and J.-Y. Ollitrault (Saclay)]

Probing the QCD plasma with screening correlators

Lattice QCD predicts that the strongly interacting matter goes over to a new phase, called quark-gluon-plasma (QGP), at sufficiently high temperatures. The Relativistic Heavy Ion Collider (RHIC) at BNL and the LHC at CERN are thought to be capable of producing such extreme conditions, and a lot of excitement has been created by the discovery at RHIC of QGP being a perfect liquid. Screening correlators of hadronic operators can potentially help to understand the QGP phase better by distinguishing its nature from that of the low temperature hadronic phase. Such mesonic spatial correlators in QCD with two flavours of dynamical staggered quarks were studied on lattices with cutoff a=1/6T, where T is temperature, and the corresponding screening masses were extracted. The temperature ranged in the study from 0.89 T_c to 1.92 T_c, where T_c is the cross-over temperature separating the hadronic and the quark-gluon plasma phases. While chiral symmetry restoration appears to take place close to T_c for the spin 1 mesons, it occurs for $1.33T_c$ in the spin-0 channel. Varying spatial lattice sizes, very little volume dependence was found in the results. Defining a measure of the interaction strength using correlator normalizations and susceptibilities, again different behaviour was found at temperatures at and above T_c in the spin-0 channel. Similarly employing chiral projections of the correlation functions, full chiral symmetry restoration was demonstrated to occur at temperatures above T_c. Using these independent pieces of analysis it was argued that across the cross-over temperature , there is no qualitative change in the nature of the plasma. Only at higher temperatures of around , does one see the characteristic high temperature plasma behaviour. This work was done on the CRAY-X1 of the ILGTI, TIFR. [D. Banerjee, R.Gavai and S. Gupta]

SU(N) gauge theory at large N

A detailed study of the thermodynamics of gauge theories was completed, by studying the theory numerically for on lattices with various lattice spacings and spatial volumes to take the continuum and thermodynamic limits. The equation of state was calculated, and the large limit investigated. No window of temperature in which a non-trivial conformal theory describes bulk thermodynamics was shown to exist. The latent heat of the first-order deconfinement phase transitions was extracted and good scaling with was found. For all quantities measured, strong scaling was shown to hold, except, possibly, very close to the transition temperature, however no evidence for scaling with the 'tHooft coupling in thermal quantities was found at the values of studied. [S. Datta and S. Gupta]

Screening in a quark-gluon plasma

Screening of meson-like sources in strongly interacting matter at high temperatures was studied using Monte Carlo study of the theory discretized on a lattice. The lattice computations were performed with 2 light quarks (corresponding to a pion mass of 220 MeV) and a strange quark, using improved staggered discretization. Cutoff and finite volume effects were estimated using three different lattice spacings and two volumes. It was found that at least upto a temperature of 140 MeV the pseudo-scalar screening mass remains almost equal to the corresponding zero temperature pseudo-scalar (pion) mass. In the deconfined state the pseudoscalar screening mass was found to be approaching the free theory value from below, and was quite close to the free value at temperatures $3T_c$, where T_c is the QCD crossover temperature. A comparison of the screening masses in the different channels also indicate that the chiral symmetry is restored approximately at the crossover to the deconfined state, while the effective restoration of the anomalous axial symmetry takes place at a larger temperature. [S. Datta with RBC-Bielefeld Collaboration.]

Scale for the phase diagram of Quantum Chromodynamics

Matter described by Quantum Chromodynamics (QCD), the theory of strong interactions, may undergo phase transitions when its temperature and the chemical potentials are varied. In the QCD phase diagram a boundary separates normal nuclear matter from a deconfined phase called the quark gluon plasma (the state of matter which may have existed in the early universe and which may exist in the cores of neutron stars). QCD at finite temperature was studied in the laboratory by colliding heavy-ions at varying beam energies. A test of QCD in the non-perturbative domain was presented through a comparison of thermodynamic fluctuations predicted in lattice computations with the experimental data of baryon number distributions in high-energy heavy-ion collisions. This study provided evidence for thermalization in these collisions. The success of this test made it possible to set a scale for the QCD phase diagram. [S. Gupta, X. F. Luo (USTC, Hefei), B. Mohanty (VECC, Kolkata), H.G. Ritter (LBNL, Berkeley), N. Xu (LBNL, Berkeley)]

Lattice QCD predictions for shapes of event distributions along the freeze-out curve in heavy-ion collisions

Lattice QCD results along the freeze-out curve of heavy-ion collisions were presented for the first time. Shape variables, such as the variance, skew and kurtosis of the event distribution of baryon number were studied through Padé resummations. Smooth behaviour of three ratios of these quantities at current RHIC and future LHC energies was predicted. It was pointed out that deviations from this at lower energies signal the presence of a nearby critical point. [R. V. Gavai and S. Gupta]

Quasi-static probes of the QCD plasma

Screening correlators and masses were studied at finite temperature in QCD with two flavours of dynamical staggered quarks on a lattice. The spectrum of screening masses was shown to follow a hierarchical approach to chiral symmetry restoration. Control of explicit chiral symmetry breaking through the quark mass was shown to be an important step to understanding this phenomenon. No sign of decays was found in the finite temperature scalar meson-like correlators in the confined phase. [D. Banerjee, R. V. Gavai and S. Gupta]

η_c production at Large Hadron Collider

Non-relativistic QCD (NRQCD) has enjoyed success in predicting cross-sections of the various quarkonium states at the Tevatron. However, the effective theory has only been tested in predictions of the differential distributions but not the absolute values of the cross-sections. Moreover, the polarisation of J/ψ at large p_T measured by the Tevatron experiments are clearly at variance with NRQCD predictions. These latter predictions come from the heavy-quark symmetry of NRQCD. This symmetry can also be used to predict the cross-section for at the Large Hadron Collider. The study of this state at the LHC will be important in understanding quarkonium dynamics. [S.S. Biswal and K. Sridhar]

Power corrections in event shape variables using soft gluon limit

Event shape variables at colliders were studied in the soft gluon limit. Event shapes such as thrust, c-parameter, angularity etc. are useful for precise determination of strong coupling constant and provide analytical insights into non-perturbative physics of hadronisation. These variables become sensitive to low scales through vacuum polarization insertions, renormalons, which give factorial growth to the perturbation series. The series is not Borel summable and the ambiguity in the Borel sum gives an estimate of the power corrections i.e., of the terms of the form which cannot arise from perturbation theory. Results for the power corrections arising from renormalons are available in the literature. Although the complete computations require involved calculations, the important parts of the result arise from contributions coming from soft gluons. Calculations become difficult because of the nonlinear expressions of the event shape variables such as c-parameter and angularity. The computation was carried out using soft gluon limit and the expressions of the event shape variables were systematically approximated. Using our simplified definitions the soft and some collinear parts of the thrust, c-parameter and angularity distributions could be exactly reproduced, giving a simple way of identifying the leading power corrections for event shape variables which can be used for obtaining the power corrections for newly proposed shape variables at the hadron colliders. [A. Tripathi with E. Gardi (U. of Edinburgh) and L. Magnea (Turin U.)]

Fate of heavy quarkonia in anisotropic hot QCD medium

The fate of heavy quarkonia states was investigated in QCD at high temperature when the plasma has a small momentum space anisotropy within a quasi-particle model. We obtained a real time static potential by employing the quasi-parton equilibrium distribution functions extracted from hot QCD equations of state of $O(g^5)$ and $O(g^6 \ln(1/g))$. It was found that interactions significantly modify the inter-quark potential and screening properties of the hot QCD plasma. Further, this work explored that Debye mechanism may not always be a dominant mechanism to decide the fate of heavy quarkonia states in a hot QCD medium. [Vinod Chandra Joshi with V. Ravishankar (IIT, Kanpur)]

A quasi-particle description of (2+1)-flavor lattice QCD equation of state

A quasi-particle model was proposed to describe the (2+1)-flavor lattice QC D equation of state with physical quark masses. The interaction part of the equation of state was mapped to the effective fugacities of otherwise non-interacting quasi-gluons and quasi-quarks. The mapping is found to be exact for the equation of state. The model led to non-trivial dispersion relations for quasi-partons. A virial expansion was obtained to interpret the effective fugacities and role of interactions in the hot QCD medium. This is perhaps the first time such a virial expansion has been obtained for hot QCD. The interactions are found to appear only via two ways, namely via the effective fugacities and the modified dispersion relations. It was shown that the effective fugacities renormalize the quasi-parton charges in the hot QCD medium. [Vinod Chandra Joshi with V.

Ravishankar (IIT, Kanpur)]

Thermodynamics geometry of hot QCD

The nature of the covariant thermodynamic geometry arising from the free energy of hot QCD was studied. The underlying equilibrium thermodynamic configurations of the free energy of 2- and 3-flavor hot QCD with or without including thermal fluctuations in the neighborhood of the QCD transition temperature was systematically analyzed. It was shown that there exists a well-defined thermodynamic geometric notion for QCD thermodynamics. The geometry thus obtained has no singularity as an intrinsic Riemannian manifold. Further there is a close connection of this geometric approach with the existing studies of correlations and quark number susceptibilities in hot QCD. [Vinod Chandra Joshi with S. Bellucci and B.N. Tiwari (INFN Frascati)]

Thermodynamic geometric stability of quarkonia states

Exact thermodynamic geometric properties of the non-abelian quarkonium bound states from the consideration of one-loop strong coupling were determined. From the general statistical principle, the intrinsic geometric nature of strongly coupled QCD was analyzed for the Coulombic, rising and Regge rotating regimes. For a range of physical parameters, in each case it was shown that there exists a well-defined, non-degenerate, curved, intrinsic Riemannian manifold. [V. Joshi with S. Bellucci and B.N. Tiwari (INFN Frascati)]

Thermodynamic geometry of Tsallis and Renyi entropies

A general investigation was made of to the intrinsic Riemannian geometry for complex systems, from the perspective of statistical mechanics. The form of the entropy used commonly is the Shannon entropy. However, for modeling complex systems, it is often useful to make use of entropies such as the Renyi and Tsallis entropies. In this analysis, the thermodynamic geometry arising from the Shannon, Renyi, Tsallis, Abe and structural entropies was studied. The covariant metric tensors of the thermodynamic geometry for these entropies have well defined, definite expressions, and led to non-degenerate intrinsic Riemannian manifold. In particular, any finite particle system described in terms of Renyi, Tsallis, Abe and structural entropies, always corresponds to an interacting statistical system. In contrast, a statistical description by the Gibbs-Shannon entropy corresponds to a non-interacting system. [Vinod Chandra Joshi with S. Banerjee (IIT, Rajasthan), B.N. Tiwari (INFN, Frascati)]