Abolhassan Vaezi

Title:

Local Temperature Ansatz: A novel quantum-entanglement-based algorithm for solving quantum problems

Abstract:

The exact solution to interacting quantum problems is, in general, an exponentially hard task due to the exponential growth of the Hilbert space with the system size. As a result, despite extensive research during the past several decades we still do not have a good understanding of strongly correlated systems even for the simplest ones such as the Hubbard model. We can only obtain exact results for special and very limited classes of models. For example, quantum Monte Carlo (QMC) method which evaluates path integrals stochastically is an exact and unbiased numerical method provided the notorious sign-problem is absent. In this talk, I will introduce our recently developed algorithm that can find the reduced density matrix associated with a finite subsystem of an infinite system. This paradigm was inspired by ideas from Hawking-Unruh radiation in black hole physics. As an example, I will demonstrate that this method can obtain the exact ground-state energy and scaling dimensions of the 1D Heisenberg model in the thermodynamic limit by solving a few sites problem. I will then show that within this new approach, the sign problem is practically circumvented and QMC can be applied to generic local models even at extremely low temperatures. I will finally show that this paradigm can also enhance the accuracy of matrix/tensor product states significantly by allowing gigantic bond dimensions.

Jahanfar Abouie

Title:

Supersolids in Mixed-Spin Systems

Abstract:

Supersolids are characterized by the coexistence of diagonal solid and off-diagonal superfluid long-range orders. Combination of these two apparently antithetical properties has attracted the attentions of both experimentalists and theorists, and searching for this exotic phenomenon has become one of the main subjects of condensed matter and cold atoms physics [1-7].
In this talk, by giving a review on the different properties of supersolid phases in spin systems, I will theoretically demonstrate that frustrated mixed-spin systems are an appropriate ground for searching various supersolid phases [8, 9].

For theoretical predictions and experimental observations see:

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2. Thouless, D. J. **The flow of a dense superfluid**. *Annals of Physics* **52**, 403–427 (1969).

3. Liu, K.-S. & Fisher, M. E. **Quantum lattice gas and the existence of a supersolid**. *Journal of Low Temperature Physics* **10**, 655–683 (1973).

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5. Li, J.-R. *et al*. **Stripe phase with supersolid properties in spin–orbit-coupled Bose–Einstein condensates**. *Nature* **543**, 91–94 (2017).

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7. Tsurkan, V. *et al*. **Ultra-robust high-field magnetization plateau and supersolidity in bond-frustrated MnCr2S4**. *Science Advances* **3**, e1601982 (2017).

Supersolid phases in mixed-spin systems:

8. Heydarinasab, F. & Abouie, J. **Inhomogeneous hard-core bosonic mixture with checkerboard supersolid phase: Quantum and thermal phase diagram**. *Physical Review B* **96**, 104406 (2017).

9. Heydarinasab, F. & Abouie, J. **Spin supersolid phase in coupled alternating spin chains**. *Scientific Reports* **8**, 7955 (2018).

Hossein Esteky

Title:

The Organization of Consciousness

عنوان : ساختار خوداگاهی

Abstract:

Brain is the most complex matter known to human. It has emerged over 500,000,000 years ago and has now evolved into its most complex form: the human brain. Higher levels of cognitive abilities such as perception, memory, problem solving, language, social cognition and consciousness have gradually emerged as more complex brains with more neurons have evolved. In large brains, physical limitations in the long distance connectivity have resulted in the creation of relatively independent and spatially distributed modules. Empirical evidence suggest that multiple and parallel "conscious experiences" emerge from these modules. In normal brains, the conscious modules work covertly (are not subjectively accessible to the "self"). The covert conscious modules are integrated to create an overt and unified sense of self. In brain impairments, the slave conscious modules could get separated from the master self and generate a unique conscious perception of the world that controls the behavior independent from the master self.

Jalal Sarabadani

Title:

To examples of physics of polymers: Polymer melt, and DNA chain translocation through a nanopore

Abstract:

In this talk, firstly the physics of a polymer melt confined between two solid surfaces is presented. Using extensive molecular dynamics simulations the changes in the static and dynamic properties of the system due to the presence of the solid boundaries and also due to the roughness on one of the boundaries are investigated [1]. Then, the DNA (polymer) translocation through a nanopore is investigated. It should be mentioned that one of the suggested methods (which would be rapid and cheap) for DNA sequencing, is the translocation of DNA chain through a nanopore. Using this method it would be possible to extract information about the DNA sequencing by studying the interaction between different nucleotides on the DNA chain and the nanopore. In this part, the physics of the pore-driven DNA chain (coarse grained polymer) translocation through a nanopore by using analytical model and also by molecular dynamics simulations is studied [2,3,4,5].

[1] J. Sarabadani, A. Milchev and T. A. Vilgis, J. Chem. Phys. **141**, 044907 (2014).
[2] J. Sarabadani, T. Ikonen and T. Ala-Nissila, J. Chem. Phys. **141**, 214907 (2014).
[3] J. Sarabadani, T. Ikonen and T. Ala-Nissila, J. Chem. Phys. 143, 074905 (2015).
[4] J. Sarabadani, B. Ghosh, S. Chaudhury and T. Alal-Nissila, EuroPhys. Letts. **120**, 38004 (2017).
[5] J. Sarabadani, T. Ikonen, H. Mokkonen, T. Ala-Nissila, S. Carson and M. Wanunu, Sci. Rep. **7**, 7423 (2017).

جلال سرابادانی

عنوان:

دو مثال از فیزیکِ پلیمرها: مذابِ پلیمری، و عبورِ زنجیره دی ان آ از حفره نانومتری

چکیده:

در این سخنرانی ابتدا فیزیکِ یک مذابِ پلیمری که در ناحیه بین دو صفحه محدود شده است ارائه می شود. با کمک شبیه سازیِ دینامیک مولکولی تغییر خواص استاتیک و دینامیک سیستم در اثر حضور صفحات مرزی و نیز در اثر وجود ناهمواری بر روی یکی از سطوح مورد مطالعه قرار میگیرد [۱]. سپس عبور دی ان آ (پلیمرِ درشت دانه) از حفره نانومتری مورد بررسی قرار می گیرد. لازم به ذکر است که یکی از روش های پیشنهاد شده برای توالی یابی بر روی زنجیره دی ان آ (که سریع و ارزان خواهد بود) عبورِ آن از داخل حفره نانو متری می باشد. با استفاده از این روش استخراج اطلاعات درباره توالی بر روی زنجیره دی ان آ توسط مطالعه برهم کنش بین نوکلءوتیدها و حفره نانومتری امکان پذیر خواهد بود. در این بخش به طور مختصر دینامیکِ سیستم هنگامی که نیروی خارجی در حفره بر روی مونومرهای زنجیره پلیمری اعمال می شود، به وسیله مدلِ تحلیلی و شبیه سازی دینامیک مولکولی مطالعه می شود [۲و۳و۴و۵] .

Leili Javidpour

Title:

Confinement effects on Protein Folding and Nanoparticle Encapsidation in Proteinaceous (Viruslike) Shells

Abstract:

Protein folding is one of the important contemporary problems in biology, whose understanding has attracted a lot of attention from biophysicists as well. In specific, protein folding in confined media has been of mounting interest, as both *in vivo* and *in virto* proteins are often found to be surrounded by other macromolecular surfaces. In the first part of this talk, I will discuss a coarse-grained model of intermediate resolution that we have developed for proteins with varying lengths and an alpha-helix folded state and which we have used to simulate protein folding in nanoslits using Discrete Molecular Dynamics methods. We show that, despite the accepted notion that protein folding is always assisted by a confinement cage having purely repulsive walls, proteins can indeed misfold in such cases due to the higher entropy of misfolded states in contrast to the folded states. In the case of our model proteins, beta structures represent the misfolded states. In the second part of the talk, I will discuss another series of works we have done on modeling and studying electrostatic stability of proteinaceous shells (capsids) of viruses, with applications to nanoparticle (such as the commonly used gold nanoparticle) encapsidation. Viral capsids can have dimensions of around 10 nm up to a couple of micrometers, with small viruses tending to take nearly spherical shapes. We have thus modeled viral capsids as thin ion- and solvent-permeable charged spherical shells, being in our case immersed in an electrolyte solution, having a finite concentration of added multivalent ions as typically used in experiments. Using Monte-Carlo simulation methods, we have studied the distribution of ions and the electrostatic (osmotic) pressure acting on the shell. I will discuss the effects due to salient factors in the problem, such as strong electrostatic coupling of multivalent ions with the charged shell, Debye screening effects, electrostatic image charges, and the elongated shape of multivalent ions, both in the presence and in the absence of a core that can either be taken as a genome-like charge droplet or an encapsidated metallic nanoparticle. I will discuss various regimes of positive (outward) and negative (inward) osmotic pressure and its consequences on the stability and formation of viruslike particles from the electrostatic point of view.

Abdollah Langari

Title:

Emergent many-body localization: disorder free mechanisms

Abstract:

Most of recent investigations evince the existence of many-body localization (MBL) in a closed quantum system through the presence of two key ingredients:
quenched disorder in the Hamiltonian and localization of all single-particle states. Here, I will discuss the emergence of MBL within two new mechanisms, which do not need the basic requirements of the conventional MBL.
In the first approach [1], we consider the Kitaev toric code on the ladder geometry, where different types of anyonic defects carry different masses.
Our study verifies that the presence of anyons generates a complex energy
landscape solely through braiding statistics, which suffices to suppress the diffusion of defects in such clean, multicomponent anyonic liquid. This nonergodic dynamics suggests a promising scenario for investigation of
quasi MBL, which shows a glassy dynamics with an exponentially diverging time scale of the full relaxation.
In the second mechanism [2], we introduce a clean cluster spin chain coupled to fully interacting spinless fermions, forming an unconstrained Z2 lattice gauge theory (LGT), which possesses dynamical proximity effect controlled by the entanglement structure of the initial state. We expand the machinery of interaction-driven localization to the realm of LGTs such that for any starting product state, the matter field exhibits emergent statistical bubble localization, which is driven solely by the cluster interaction, having no topologically trivial noninteracting counterpart, and thus is of a pure dynamical many-body effect. Our proposed setting provides possibly the minimal model dropping all the conventional assumptions regarding the existence of MBL.

[1] H. Yarloo, A. Langari and A. Vaezi, Phys. Rev. B 97, 054304 (2018),
"Anyonic self-induced disorder in a stabilizer code: quasi-many body localization in a translational invariant model".
[2] H. Yarloo, M. Mohseni-Rajaee, A. Langari, Phys. Rev. B 99, 054403 (2019),
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Alireza Qaiumzadeh

Title:

Antiferromagnetic Spintronics

Abstract:

Antiferromagnets "are extremely interesting from the theoretical viewpoint, but do not seem to have any application"! Less than 50 years after this *false* statement in the 1970 Nobel lecture of Louis Néel, spintronics based on antiferromagnets becomes an active area of research in condensed-matter physics and materials science.

In this talk, I will first review some theoretical and experimental progresses which have opened up the pathway towards antiferromagnetic spintronics in the past 15 years. Next, I present our recent theoretical proposals for ultrafast manipulation of the antiferromagnetic order parameter and spin transport in antiferromagnetic insulators. Finally, I show the recent experimental discovery of long-distance spin transport in a crystalline antiferromagnetic iron oxide (hematite).

علیرضا قیوم زاده

عنوان:

اسپینترونیک بر پایه‌ی مواد پادفرومغناطیسی

چکیده :

لوئیس نیل در جزوه‌ی نوبل خود در سال ۱۹۷۰ بیان کرد در حالی‌که پادفرومغناطیس‌ها از نظر تئوری بسیار جالب توجه اند ولی کاربردی برای آن‌ها قابل تصور نیست. کمتر از نیم قرن پس از این گفته‌ی اشتباه، اسپینترونیک برپایه‌ی مواد پادفرومغناطیسی به یکی از شاخه‌های بسیار فعال در فیزیک ماده چگال و علم مواد تبدیل شده است.

در این سخنرانی، ابتدا برخی پیشرفت‌های تئوری و تجربی که در ۱۵ سال گذشته به پیدایش اسپنیترونیک بر پایه‌ی مواد پادفرومغناطیسی انجامیده است را مرور می‌کنم. سپس تعدادی از راه‌کارهای تئوری‌مان برای کنترل بسیار سریع پارامتر نظم پادفرومغناطیسی و ترابرد اسپین در پادفرومغناطیس‌های نارسانا را بیان می‌کنم. در پایان، کشف تجربی اخیر در مورد ترابرد اسپینی دوربرد در یک بلور اکسید آهن (هماتیت) را نشان خواهم داد.

Sadegh Raeisi

Title:

Novel Technique for Robust Optimal Algorithmic Cooling

Abstract:

Heat-bath algorithmic cooling (HBAC) provides algorithmic ways to improve the purity of quantum states. These techniques are complex iterative processes that change from each iteration to the next and this poses a signicant challenge to implementing these algorithms. Here we introduce a new technique that on a fundamental level, shows that it is possible to do algorithmic cooling and even reach the cooling limit without any knowledge of the state and using only a single xed operation, and on a practical level, presents a more feasible and robust alternative for implementing HBAC. We also show that our new technique converges to the asymptotic state of HBAC and that the cooling algorithm can be e-ciently implemented, however, the saturation could require exponentially many iterations and remains impractical. This brings HBAC to the realm of feasibility and makes it a viable option for realistic application in quantum technologies.

صادق رئیسی

عنوان:

تکنیکی جدید برای سرمایش الگوریتمیک بهینه و مقاوم

چکیده:

سرمایش الگوریتمی، راهکارهایی برای بهبود خلوص حالت های کوانتمی ارائه می کند. این راهکارها، عموما روش های مرحله به مرحله و پیچیده ایی هستند که از هر مرحله به مرحله بعد تغییر می کنند و این مشکل بزرگی را بر سر پیاده سازی این روشها ایجاد می کند. ما در اینجا روش جدیدی را ارائه می کنیم که در یک سطح بنیادی، به این سوال پاسخ می دهد که آیا سرمایش الگوریتمی و حتی رسیدن به حد سرمایش این روشها بدون دانشی از حالت و با یک عمل ثابت امکان دارد. همچنین در سطحی عملی، یک گزینه قابل اجرا تر و مقاوم تر برای پیاده سازی سرمایش الگوریتمی ارائه می دهیم. ما نشان می دهیم که روش جدید ما، به صورت مجانبی به حد سرمایش روشهای الگوریتمی میل می کند و همچنین سرمایش در این روش مقرون به صرفه است، اگرچه رسیدن به حد سرمایش، می تواند به تعداد زیادی گام که به صورت نمایی زیاد می شود، نیاز داشته باشد و در نتیجه، رسیدن به حد سرمایش الگوریتمی، همچنان غیر عملی باقی می ماند. با این وجود، روش جدید، پیاده سازی و استفاده عملی از سرمایش الگوریتمی را یک گام به واقعیت نزدیکتر می کند و آن را به گزینه ایی واقع بینانه برای کاربرد های عملی در فناوری های کوانتمی بدل می کند.

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Alireza Valizadeh

Title:

Neural oscillations: How order emerges from irregular components

Abstract:

Brain recording which capture the activity of thousands to millions of neurons, show temporal oscillations known as the brain rhythms. However, the activity of the individual neurons participating in the generation of population oscillations, is irregular. The question is far beyond the theory of coupled oscillators: How order emerges from the interaction of disordered components?

I will address this question through an introductory talk on the theories and experimental findings about the function and the generation of the brain oscillations.

Abbas Ali Saberi

Title:
Appearance of a new universality class in a competition

Abstract:
During the last decade, it has been shown that the universality in various growth models belonging to the Kardar-Parisi-Zhang (KPZ) class holds beyond the second moment in which the height fluctuations of the (1+1)-D model are connected to the Tracy-Widom (TW) distribution of the Gaussian unitary (and orthogonal) random matrix ensembles (GUE or GOE). In this talk, I will first review the progress in the field and then report on the universality of height fluctuations at the crossing point of two interacting (1+1)-D KPZ interfaces with curved and flat initial conditions. I will show that a new class will show up in the competition. I will also discuss possible applications in nonequilibrium transport and traffic flow.

عباس علی صابری

عنوان:
تولد یک کلاس جهانشمولی در یک رقابت

چکیده:

در دهه اخیر ارتباط جالبی بین کلاس جهانشمولی افت و خیزهای ارتفاع در معادله یکبعدی کاردر-پاریزی-ژنگ با طبقه بندی نظریه ماتریس های تصادفی مختلف توسعه داده شده است. در این سخنرانی ابتدا مروری بر این ارتباط خواهیم داشت و سپس نشان می دهیم که چگونه رفتار جهانشمول افت و خیزها تحت تاثیر رقابت بین کلاس ها به شیوه ای خاص میتواند منجر به تولد یک رفتار جد ید در مدل برهمکنشی آن ها گردد. نتایج این یافته میتواند بالقوه در توصیف و درک سیستم های دور از تعادل نظیر مدل های ترافیک و ... مورد استفاده قرار گیرد.

Mehdi Vaez Allaei

Title:
Disorder and Crystallization in dense granular flows: wet vs dry systems