TFM proposals 2020

Cosmology, Relativity, Fields and Particles

Director: **Igor Bandos** (igor.bandos@ehu.eus)

Title: **Modern problems of String/M-theory**

The strategic goal of the research will be to gain new insights in the theory of fundamental interaction and in the structure of the Universe in the framework of String/M-theory. The characteristic predictions of this are supersymmetry, the symmetry between bosons and fermions, and extra spacetime dimensions. The project will deal with supergravity, a supersymmetric generalization of the Einstein General Relativity, which describes the low energy limit of String/M-theory, and with supersymmetric extended objects, supermembrane and higher p-branes in multidimensional spacetime, which appear as non-perturbative states in String/M-theory. As the field is progressing very rapidly and new interesting directions might appear, a more detailed specification of the research project is postponed till fall of this year.

Directors: **Jose J. Blanco-Pillado** (joseblancopillado@gmail.com), **Jose Queiruga**

Title: **Classical and Quantum decay of excited solitons**

Solitons are long lived configurations that appear in many non-linear field theories in many branches of physics; from String Theory to Condensed Matter. Many of these solutions also admit localized excitations that may decay by classical or quantum processes. In this work we will study some of these models with the aim of understanding these processes and numerically compute their decay life time. In this work, we will make extensive use of lattice field theory simulations so some experience with C++ would be desirable.

Director: **David Brizuela** (david.brizuela@ehu.eus)

Title: **Relativistic effects in the Schrödinger-Newton equation**

The complete quantization of general relativity has shown to be a very difficult task. Therefore, one could think about different approximations that might provide certain insight on the expected physical effects. In particular considering the Newtonian potential, that describes the non-relativistic gravitational interaction, and performing the usual quantization, one ends up with a quantum theory described by the so-called Schrödinger-Newton equation. In scenarios where the velocities of the particles are relatively small, this quantization should provide trustable results. The goal of this master thesis would be to generalized this approach by considering, instead of the non-relativistic Newtonian potential, post-Newtonian potentials which encode relativistic effects as a power series in the ratio between the particle velocity and the speed of light. The quantization of this system should be performed, which would lead to a Schrödinger-Newton equation with relativistic corrections. Finally this equation should be solved in order to obtain quantum-gravity effects in different situations of interest.

Director: **Marco de Cesare, David Brizuela** (david.brizuela@ehu.eus) - *one choice among these two:*

Title: **Gravitational waves in bimetric gravity**

Bimetric gravity is a recently developed extension of general relativity with two independent dynamical metric fields coupled by non-linear interactions. In this project, we will study different aspects of bimetric gravity, including its Lagrangian and Hamiltonian formulation, both in the metric and in the tetrad (*vierbein*) formulation. The main goal will be to study the dynamics of gravitational waves in bimetric gravity in cosmological backgrounds, and compare the predictions with general relativity.

Title: **Conformal invariance in gravitational theories**

Conformal transformations act on the spacetime metric by rescaling it, i.e. they preserve the light-cone structure; thus, in conformal geometry different spacetime geometries are regarded as equivalent if they are conformally related. In a hypothetical universe where the laws of Nature are conformally invariant, there can be no dimensional fundamental constants and phenomena taking place at different scales are related by symmetry. In this project, we will review existing approaches to conformal gravity, the corresponding geometric framework, and study their Lagrangian and Hamiltonian formulations. The Hamiltonian formulation in particular reveals the existence of an extra first class constraints (in addition to the scalar and diffeomorphisms constraints of general relativity), which generates Weyl transformations. We will then study the problem of the spontaneous breakdown of conformal symmetry, that is necessary to ensure compatibility with general relativity at low energy scales. Finally, we will focus on simple cosmological models with a finite number of degrees of freedom (i.e., minisuperspace) to study the dynamics of the quantum theory.

Director: **Iñaki Garay** (inaki.garay@ehu.eus)

Title: **Spinor formalism for loop quantum gravity: dynamics and semiclassical limit**

Loop quantum gravity (LQG) is a well established proposal for the quantization of spacetime. Among its main results we find the description of the microscopic origin of the black hole entropy and, within the cosmological version of the theory (known as loop quantum cosmology), the avoidance of the initial singularity. Nevertheless, the implementation of the dynamics and the semiclassical limit are still open problems of the theory. In this project, we will explore the framework given by the so-called spinor formalism for LQG in order to study these issues in carefully constructed models with sensible physical interpretation, such as cosmological models, simple models to implement dynamics on them, or models suitable for coarse-graining procedures in order to look for the semiclassical limit.

Directors: **Ruth Lazkoz** (ruth.lazkoz@ehu.es), **Enzo Salzano**

Title: **Cosmographic reconstruction of the luminosity distance and the Hubble function**

Depicting the expansion history of the universe through cosmography is a relevant task. It involves a precise determination of the beginning and the end of the evolution as well as of intermediate stages, such as the matter domination epoch or the beginning of the current accelerated phase. The ultimate problem in this context is estimating the current value of the Hubble factor, which seems to be quite discrepant depending on the astrophysical data sets considered. This lack of certainty makes it very appealing to resort to approaches with as few assumptions as possible so as to avoid biases and at the same time answer to these questions: does a cosmological constant provide the best framework to explain the current accelerated expansion? would evolving dark energy models perform better? is there any compatibility window for modified gravity perhaps? Approaches based on minimal assumptions can be somewhat relaxed about the physical constraints at the onset and can be used to generate synthetic data to test future experiments and are less prone to " double check" inconsistencies. One such method is the cosmographic analysis which typically expands the Hubble function and relevant cosmological distances (luminosity distance, angular diameter distance) as a series of powers of the redshift z around the origin, but convergence problems among others with it are well known. Interestingly we can also mention the lack of a rigorous way to describe cosmological perturbations as reading a crucial parameter such as the fractional density of dark matter is not a well-posed problem. Our alternative idea rests on proposing a very general ansatz on the mathematical form of the luminosity distance which can serve many of the purposes above. This provides a very amenable framework to the statistical power of supernovae data which allows to work out several relevant physical features at all redshifts analytically: the effective equation of state parameter, criteria for the departure from the cosmological constant case, the usual cosmographic functions (deceleration parameters and jerk), etc. And perhaps more interestingly, our models will, by construction, stay all the way up to high redshifts very close to the concordance scenario (dark matter+cosmological constant), thus offering a nice potentiality for the generation of mock datasets.

Directors: **Joanes Lizarraga** (joanes.lizarraga@ehu.eus), **Jon Urrestilla** (jon.urrestilla@ehu.eus)

Title: **Lattice simulations of Superconducting Cosmic Strings**

Superconducting strings, as predicted by Witten, can be formed in systems with U(1)xU(1) symmetry when only one of the U(1) symmetries is spontaneously broken. This symmetry breaking leads to the formation of stable vortices or strings. The field associated to the unbroken symmetry condensates at the core of those vortices and formes superconducting flux tubes. The formation of superconducting strings is predicted in many supersymmetrical and inflationary cosmological scenarios, thus they could be relevant in some early universe models. Even though they have been studied from different perspectives, e.g. using field theory or approximating to Namgu-Goto strings, the full dynamics of networks of superconducting strings has not been simulated yet. Lattice simulations bring the possibility to explore a wide range of interesting and fundamental properties such as intercommutation, formation of stable superconducting loops, etc. In addition the student will be able to study the evolution of superconducting string in cosmological backgrounds, where some cosmological observables can also be computed. The project will be developed exclusively from a numerical point of view and the student will acquire valuable skills in advanced numerical methods and lattice simulations.

Quantum matter, simulations, and technologies

Directors: **Dario Bercioux** (dario.bercioux@dipc.org)

Title: **Quasiparticle cooling using a Topological insulator-Superconductor hybrid quantum wire junction**

In this project we will investigate the thermoelectric properties of a hybrid junction realised in a topological insulator quantum wire hybridized with a conventional s-wave superconductor. We focus on the ballistic devices and study the quasiparticle flow, carrying both electric and thermal currents, adopting a scattering matrix approach based on conventional Blonder-Tinkham-Klapwijk formalism. The project will consists of analytical and numerical studies.

Directors: **Aitor Bergara** (a.bergara@ehu.eus), **Aritz Leonardo** (aritz.leonardo@ehu.eus)

Title: **Molecular dynamics study of Calmodulin**

The complete resolution of the sequence of the human genome in 2016 has been a huge milestone that continuously reveals causal relations among pathologies and gene signaling. Moreover, the latest advances of experimental techniques, such as nuclear magnetic resonance, provide a direct access to 3D maps with atomic resolution of the proteins that form cell membranes. This new accessible structural information has become a revolution in biological sciences for the design of new drugs that improve the well-being of humans. Remarkably, 60% of the commercial drugs act precisely on the proteins located at the cell membranes. With this scenario in mind, physical models that mimic atomic interactions within the proteins and their posterior time evolution through molecular dynamics provide a very powerful tool for the prediction and comprehension of membrane phenomena. Theoretical simulations of proteins serve as a guidance for the design of new drugs and help understanding the enormous amount of experimental information available. In this Master Thesis we shall consider the Kv7.2 channel of neuron membranes — a potassium voltage-gated channel located in human neurons — whose functioning relies in a potential difference induced by calmodulin (CaM). By means of All-atom simulations, molecular dynamics and coarse grain models, we would like to validate two claims regarding the behavior of the secondary structure of the IQ motiv of the channel: 1) Both wild type and mutant can form stable helices without the ribosome; 2) Wild type can form an alpha helix at the ribosome whereas the mutant cannot.

Director: **Jorge Casanova** (jcasanovamar@gmail.com)

Title: **High field and low power, the optimal regime for quantum detection at the Nanoscale**

Quantum detection (QD) of nuclear species represents the first reliable application of quantum technologies. QD is a field that incorporates techniques from quantum computing, quantum control, and nuclear magnetism, as well as from different aspects of applied mathematics such as machine learning and Bayesian inference for signal reading and interpretation. Concerning technological applications, detecting and controlling nuclear spin species with unprecedented spatial resolution will significantly impact different areas. Among them we have, e.g., i) Quantum information processing, since nuclear spins in materials such as diamond are robust solid-state quantum bits (qubits) with extremely long coherence times that can be readily controlled at the quantum level with Nitrogen-Vacancy centers. ii) Medical imaging, as nuclear hyperpolarization techniques could enhance by 5 orders of magnitude the intensity of the signal emitted by ^{1}H nuclei of the soft tissues in the human body. In this project, we will study the benefits of introducing **high static magnetic fields** in these relevant scenarios, as well as the possibilities offered by new methods to irradiate samples **with low power microwave fields**. This is a theoretical project that requires knowledge in quantum mechanics, as well as an open attitude for learning different programing methods.

Director: **Xi Chen** (chenxi1979cn@gmail.com)

Title: **Shortcuts to Adiabaticity for Digital Quantum Computing**

Shortcut to adiabaticity (STA) are well-known techniques for the fast driving of a quantum system to a designated final state. Local counter-diabatic driving is one such STA method that has been successfully implemented in few-body quantum systems. The main purpose of the master thesis is to show the applicability of counter-diabatic driving to enhance the digital adiabatic quantum computing paradigm in terms of fidelity, simulation time and circuit depth. We shall first study the speeded-up evolution of an Ising spin chain using the digitized version of the STA technique and variational approach. Finally, we will apply this proposal to the Grover search algorithm, 3-STA and Max-Cut problems, and implement these algorithms on a publicly available superconducting quantum processor, proving its advantage for the noisy intermediate-scale quantum (NISQ) devices.

Director: **Aurelia Chenu** (achenu@dipc.org)

Title: **Open chaotic systems: decoherence and thermodynamics**

In this project, you will learn tools from open quantum systems and random matrix theory. You will develop models to study the thermodynamics of complex many-body systems with chaotic systems, under unitary and open dynamics. Such system are known to saturate the bound of decoherence. You will characterize their thermo-dynamics properties.

Director**: Adolfo del Campo** (adolfo.delcampo@gmail.com)

Title: **Adiabatic Quantum Computing in Finite Time**

Adiabatic quantum computing (AQC) is a form of quantum computing at the forefront of quantum technologies. Cutting-edge prototypes of quantum annealing devices have by now been developed (e.g. by D-wave) and explored by Google, NASA and LANL, among other companies and institutions. In essence, AQC exploits the application of the quantum adiabatic theorem to find the ground state of many-body Hamiltonians that encode the solution of a complex optimization problem of interest. Realistic annealing schedules in finite-time often lead to nonadiabatic dynamics and formation of excitations. In this context, the understanding acquired from the nonequilibrium dynamics across quantum phase transitions provides useful heuristics to design strategies for efficient quantum annealing. The Kibble-Zurek mechanism constitutes a useful framework in this context and predicts that the density of excitations scales as a universal power law with the annealing time. This paradigm can however be extended to account as well for the full counting statistics of defects, i.e., the distribution of the number of quasiparticles generated as a result of the breakdown of adiabatic dynamics in finite-time quantum annealing. The project aims at characterizing this distribution and design schemes to control and suppress the formation of excitations, achieving Efficient Quantum Annealing in finite time.

Director: **José A. Fernández** (josea.fernandez@ehu.eus)

Title: **Structural determination of molecular aggregates using mass-resolved laser spectroscopy and DFT methods.**

Intermolecular interactions are weak forces of pure quantum nature. Despite their small module, they are of paramount importance for life on Earth, due to their influence in the environment. In addition, life makes extensive use of such forces. They are used to control fundamental processes such as docking of a ligand into a protein, or molecular recognition. Thus, having a deep knowledge of such forces is required to understand such processes, and therefore, there is a strong demand for high-quality experimental data from systems attached by intermolecular forces. In the "Grupo de Espectroscopía", we form molecular aggregates using supersonic expansions, which cool the molecules to a few Kelvin, preparing them to be probed by means of a combination of UV and IR lasers. Using several mass-resolved spectroscopic techniques, important structural information is extracted from the aggregates, which is afterwards interpreted on the light of quantum-mechanical calculations.

Directors: **Aran Garcia-Lekue** (wmbgalea@ehu.eus), **Daniel Sánchez-Portal**

Title: **Tuning the topological properties of graphene nanostructures**

As recently demonstrated, 1D graphene nanostructures may exhibit topological electronic states, which could be of relevance for many technological applications, such as quantum computing. This project aims at exploring different strategies to tune the topological properties and associated magnetism of these nanostructures, e.g. by chemical doping or strain. For this purpose, we plan to combine *ab-initio* simulations and tight-binding models, in order to provide a more intuitive picture. Besides, a strong collaboration with experimental groups experts in the field is envisioned.

Directors: **Julen Ibañez-Azpiroz** (julen.azpiroz@gmail.com), **Michele Modugno** (michele.modugno@ehu.eus)

Title: **A new perspective on the modern theory of polarization and magnetization in solids**

Around 20 years ago, the theory of polarization -- and later on magnetization -- of solids was rewritten and firmly established using the modern language of the Berry phase, a quantum geometrical phase acquired by the electronic wave function that had escaped the attention of physicists over the years. Dubbed as the modern theory, it is nowadays extensively used to describe these important properties in a wide range of materials. This theoretical scheme, however, gives only access to the macroscopic value of these quantities, whereas the non-local microscopic contributions are averaged out, and these become important when dealing with time-dependent responses. This project proposes developing a theoretical and computational framework for the calculation of non-local microscopic contributions to the polarization and magnetization of solids, based on a recent proposal by researchers at the University of Toronto. The project will combine theoretical work and developing a computational code for obtaining numerical results. The developed algorithm will be applied to the well-known Haldane model, with the aim of exploring the role of non-local contributions when the system goes through a topological phase transition.

Directors: **Maia G. Vergniory** (maiagv@gmail.com), **Luis Elcoro**

Title: **Model Hamiltonians and topological analysis for iron-based superconductors**

Majorana modes can be used to realize topological quantum computing because of their topological protection and non-Abelian braiding statistics [1]. One platform to achieve the realization of Majorana modes is the high-temperature topological superconductor that hosts non-trivial topological band structures. These materials will have conventional superconductivity in the bulk but topological superconductivity on the surface [2]. Developing model Hamiltonians for their bands structures becomes necessary and it is not a trivial task. In this master project we propose to use Topological Quantum Chemistry [3,4] to develop a code with an interface with the Irrep code [5] to automatically generarte the model Hamiltonians of the crystal system of the Fe-based topological superconductors. We will use these models to study topology in superconducting real materials.

[1] C. Nayak, S. H. Simon and A. Stern, Rev. Mod. Phys 80, 1083-159 (2008)
[2] Gang Xu, Biao Lian, Peizhe Tang, Xiao-Liang Qi, and Shou-Cheng Zhang, Phys. Rev. Lett. **117**, 047001 (2016)
[3] Barry Bradlyn, L Elcoro, Jennifer Cano, MG Vergniory, Zhijun Wang, C Felser, MI Aroyo, B Andrei Bernevig, Nature **547** (7663), 298 (2018)
[4] MG Vergniory, L Elcoro, Claudia Felser, Nicolas Regnault, B Andrei Bernevig, Zhijun Wang, Nature **566** (7745), 480-485 (2019)
[5] M. Iraola, J. L. Mañes, T. Neupert, M. G. Vergniory and S. S. Tsirkin, in preparation (https://github.com/stepan-tsirkin/irrep)

Director: **Michele Modugno** (michele.modugno@ehu.eus)

Title: **Ultracold atomic gases: a toolbox for quantum physics**

Ultracold quantum gases represent one of the most fascinating research areas of modern physics. They are being employed in many laboratories around the world for investigating fundamental problems from disparate areas (including e.g. solid state physics, superfluids, non-linear and disordered systems), representing one of the current platforms for quantum simulations. The student can choose a project in any of the above areas, to be carried out with analytical and numerical methods. Collaborations with international experimental groups are also possible.

Director: **Gonzalo Muga** (jg.muga@ehu.eus)

Title: **Control of quantum system dynamics and structure for quantum technologies**

Quantum dynamics offers a vast potential of applications but they are hindered by decoherence. A general way to mitigate decoherence is to implement “Shortcuts to adiabaticity” (STA), a set of techniques developed by the group to speed up the processes without residual excitations. STA work by inverse engineering the time-dependent external control. They have been applied to a broad range of systems such as qubits in different physical platforms (trapped ions, superconducting circuits, neutral atoms in optical lattices,...) to implement interferometry, or quantum information processing. STA extend as well beyond quantum mechanics to make optical or mechanical devices more compact and robust. Fundamental questions remain such as determining the “cost of the shortcuts ’’in quantum engines; different techniques, such as variational approaches have to be developed for practical applications; connections with supersymmetry are also to be explored. As for the structure, different Hamiltonian types allow for different phenomena. We are in particular interested in asymmetrical devices such as “diodes’’, “valves’’, “Maxwell demons”, or “rectifiers ’’at a microscopic scale. They will be key to develop new quantum technologies. Symmetry plays an important role in determining selection rules that tell us what (nonHermitian) Hamiltonians should be implemented to achieve these effects. Open research here would be both fundamental (to develop group theory for nonHermitian Hamiltonians) and applied (to work out specific devices with optical and/or quantum-optical realizations).

Directors: **Mikel Palmero** (mikel_palmero@hotmail.com), **Sofía Martínez-Garaot** (sofia.martinez@ehu.eus)

Title: **From quantum control to dynamical control of classical systems**

We have developed a set of analytical and numerical tools called shortcuts to adiabaticity (STA), that help dynamically manipulate quantum systems for a myriad of applications in quantum optics and quantum information. Most notably, these methods can help in the implementation of quantum technologies such as quantum computers by dramatically improving fidelities limited by the state-of-the-art technology. Interestingly enough, many classical systems that need to be dynamically manipulated can be explained by similar Hamiltonians as the quantum systems we have been studying so far, so the same techniques can be applied there. Mechanical systems are particularly suitable for this, including examples such as cranes, drones carrying a load, or water wells. For this master’s thesis, we propose extensively exploring other disciplines with complex dynamical problems that could potentially benefit from applying these imported quantum STA techniques, and proposing a set of concrete applications that could be improved by applying specific STA methods. These disciplines may include aerospace industry, chemical industry, life sciences and med- ical devices, material science, quantitative finances, hydrodynamics, et cetera. Depending on the available time, the student will also choose one of the potential applications and dig deeper into it.

Title: **Machine learning to optimize quantum control**

We have developed a set of analytical and numerical tools called shortcuts to adiabaticity (STA), that help dynamically manipulate quantum systems for a myriad of applications in quantum optics and quantum information. Most notably, these methods can help in the implementation of quantum technologies such as quantum computers by dramatically improving fidelities limited by the state-of-the-art technology. For this project, the student will develop a machine learning algorithm as an alternative, or even as a complement, to these STA techniques. We will first apply the machine learning algorithm to dynamical problems that have already been treated with other STA techniques, and compare the performance of the different methods. Specially interesting is the comparison with optimal control theory, another purely numerical optimization method that has been extensively used for control of dynamics in quantum systems. After this, the student can move forward to apply the method to more difficult (and meaningful) problems, where analytical solutions are not applicable, and numerical methods like this acquire more strength.

Directors: **Marisa Pons** (marisa.pons@ehu.eus), **Dmitri Sokolovski** (dgsokol15@gmail.com)

Title: **Quantum measurement theory and its applications**

The project will be an introduction to the field of measurement in Quantum Mechanics and the investigation of bosonic hybrid devices to monitor the evolution of a quantum system. Quantum Measurement Theory (QMT) is important to understand the quantum world, and it has, due to the technological progress, a large number of “quantum engineering” applications. The project involves both analytical and numerical work.

Directors: **Enrique Rico** (enrique.rico@ehu.eus), **Íñigo Egusquiza** (inigo.egusquiza@ehu.eus)

Title: **Symmetry protected qubit**

We will consider a particular limit of a very light particle on a circle, in the presence of half of the flux quantum. With this flux, the ground state of the system is doubly degenerate and the rest of the spectrum is separated by large energy gaps from the ground state. At low-temperatures, we can neglect contributions of all states except for the ground state. The ground state space coincides with the one for a spin-1/2. problems to be addressed:
(1) Discuss the symmetry and topological aspects of the problem and characterise the symmetry protected subspace that realises a qubit.
(2) Couple two protected qubit and study any interaction that respects the symmetries of the combined system.

(3) Study the quantum computational power of the proposed qubit.
(3) Analyse a particular implementation of a single and two protected qubits in terms of superconducting circuits.
(4) Propose a minimal quantum circuit realisation for a set of symmetry protected qubits.

Directors: **Mikel Sanz** (diracmatrix@gmail.com), **Lucas Céleri**

Title: **Microwave quantum illumination**

Quantum resources, in particular entanglement, can be employed to improve the sensibility of detection, metrology and sensing protocols, for instance quantum radars or medical imaging. The study of these protocols in the microwave regime which shows particular experimental constraints, but also unique advantages, is particularly interesting. In this thesis, we will continue developing this novel technology, which shows both mathematical and experimental challenges, in collaboration with several experimental groups in Europe.

Directors: **Mikel Sanz** (diracmatrix@gmail.com), **Vahid Salari**

Title: **Digital-analog quantum computation**

Quantum computing makes use of entanglement and superposition in order to speed up certain algorithms. The implementation of quantum algorithms in noisy near-term quantum processors is even more challenging than in a universal quantum computers equipped with quantum error correction. A combination of analog quantum computation, which is extremely robust, with digital quantum computing, which is quite flexible, has been recently proposed to overcome these problems. In this thesis, we will continue developing the mathematical theory behind digital-analog quantum computation and work with our experimental collaborations for the implementation.

Director: **Evgeny Sherman** (evgeny.sherman@ehu.eus)

Title: **Quantum mechanics with spin-orbit coupling**

The aim of this Master project is to study analytically and/or numerically quantum motion determined by spin-related properties of single particles and condensed matter. We will consider systems with spin-orbit interaction, where the particle spin is strongly coupled to its momentum. The systems we are going to investigate in detail are electrons in solids or very cold Bose-Einstein condensates and atomic Fermi gases.

Director: **Jens Siewert** (jens.siewert@ehu.eus)

Title: **Bloch Representation of Finite-Dimensional Composite Systems**

The Bloch representation (that is, the mathematical description of quantum-mechanical density operators in terms of a matrix basis) is a powerful — yet far from fully developed — tool to solve quantum mechanics problems. Its language is deeply rooted in geometry and therefore its concepts are amenable to geometric intuition. Only recently, methods have been presented to adequately visualize higher-dimensional state spaces, such as the Bloch-sphere analog of a three-level system (qutrit) and that of bipartite systems, and there is much potential for further research. The central theme of this master thesis project is the relation between quantum correlations (in particular entanglement), geometry, and technical aspects of the Bloch representation for bipartite as well as multipartite systems. Options for this master thesis project are the investigation of separability, entanglement and/or nonlocality in mixed bipartite states, monogamy of
entanglement for multipartite systems, or the existence of specific families of highly entangled multi-party states.

Director: **Lianao Wu** (lianaowu@gmail.com)

Title: **Self-protected quantum algorithms based on quantum state tomography**

Only a few classes of quantum algorithms are known which provide a speed-up over classical algorithms. However, these and any new quantum algorithms provide important motivation for the development of quantum computers. We once proposed a quantum algorithms based on quantum state tomography. These include an algorithm for the calculation of several quantum mechanical expectation values and an algorithm for the determination of polynomial factors. It is remarkable that these quantum algorithms are immune to a large class of errors. These algorithms can be implemented on IBM cloud quantum computer and verified.