

National Institute of Physics
College of Science, University of the Philippines
Diliman, Quezon City 1101

Structure and Dynamics Research Program Annual Report

Period Covered: January – December 2012

Program Coordinator: Dr. Cristine Villagonzalo

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A. Milestones and Summary of Activities

A.1 Summary

A.1.1 Current members

Faculty Members:	Dr. Ronald Banzon	
	Dr. Francis Paraan - (as of November 2012)	
	Dr. Cristine Villagonzalo	
Ph.D. Students	Micielle Capili – University Research Associate 1	
	Carlos Baldo III	
	Neris Ilano	
M.S. Students	Gina Rose Tongco	(working student)
	Hilton Lazo	(working student)
Undergraduate Apprentices	Joachim Suico	(as of August 2012)
	Xavier Puspup	(as of August 2012)
	King Karl Seroje	(as of August 2012)
	Joshua Dizon	(as of August 2012)

A.1.2 Activities / Highlights

Dr. Rayda Gammag, who defended her Ph.D. Dissertation in October 2011, was able to complete the requirements for her NIP – CHED Ph.D. scholarship with two ISI publications. Soon after, she proceeded to POSTECH, Pohang, Republic of Korea for her post-doctoral fellowship.

In the summer of 2012, the Structure and Dynamics Group accepted three students from the Philippine Science High School provincial campuses for the Summer Science Internship Program. The student interns were taught and exposed to the fundamentals of computational physics, error analysis and numerical intergration.

Due to the less number of members and conflicting schedules of working students and faculty members having administrative positions, the weekly seminars became a bi-monthly event for most of 2012. In August of 2012, third- and fourth- year undergraduate students were accepted as apprentices to the laboratory.

Dr. Francis Paraan, an NIP alumnus, who completed his Ph.D. at Stony Brook University, NY, USA, returned in November to join NIP as a faculty member and a member of SanD.

A.2 List of students who graduated in 2012

A.2.1 Micielle N. Capili – M.S. in Physics

Thesis: Determination of the Critical Exponent in Site Percolation Using Average Percolation Probability on a Square Lattice

Thesis Co-Advisers: Dr. Ronald Banzon and Dr. Cristine Villagonzalo

A.2.2 Hilton Lazo – B.S. Physics

Thesis: Zero – Temperature Glauber Dynamics of the 1D Ising Model with Long Range Interactions

Thesis Co-Advisers: Dr. Ronald Banzon and Dr. Cristine Villagonzalo

B. Research Projects

B.1 NIP Faculty Grant

B.1.1. Project Leader: Dr. Ronald Banzon
Title: Percolation critical exponent of a constrained lattice
Duration: January – December 2012
Amount: Php 42,000.00
Student involved: Micielle Capili
Other SanD member: Dr. Cristine Villagonzalo

Abstract:

“We implement the Average Occupation Probability to treat site percolation on a square lattice with banned sites. It was found that the introduction of banned sites increases the value of the percolation probability while reducing the value of the critical exponent β . The deviation of β in site percolation of a constrained lattice from that of a regular system suggests that these lattice topologies belong to two different universality classes.” [C.3.3]

B.1.2. Project Leader: Dr. Cristine Villagonzalo
Title: Low Lying Spin Excitations in Ferromagnetic Systems
Duration: January – December 2012
Amount: Php 42,000.00
Student involved: Carlos Baldo III

Abstract:

“To see the spin excitation effects of both Rashba and Dresselhaus spin-orbit interactions on a spin-polarized electron along a curved path, we obtain the system’s exact energy spectrum taking into account the Zeeman effect. This approximates the motion of an electron in a one-dimensional wire. Our results show that the lifted degeneracy between spins of opposite polarization does not only depend on both Rashba and Dresselhaus coupling constants, but also on the radius of curvature.” [C.3.2]

B.2 Unfunded Research Project

Title: Ising Spin Quantum Computer Model
Project Leaders: Dr. Ronald Banzon and Dr. Cristine Villagonzalo
Duration: January – December 2012
Student involved: Neris Ilano

Abstract:

“We consider the dynamics of an Ising spin quantum computer with a radio frequency (RF) pulse distribution. The effect of the frequency spread decreases the resonant transition probability and increases the near-resonant transition probability. Also, we apply the $2\pi k$ method to suppress the near-resonant transition. However, it has an unwanted effect on the probability of the resonant transition. It turns out that the desirable result can be obtained if we use the lowest possible value of k .” [C.3.1]

C. Publications

C.1 ISI Publications

- C.1.1.** R. Gammag and C. Villagonzalo. Quenching of the DOS beats in two-dimensional electron gas in tilted magnetic fields. *Solid State Commun.* **152** (2012) 757 – 761
- C.1.2.** R. Gammag and C. Villagonzalo. Persistent spin-splitting of a two-dimensional electron gas in tilted magnetic fields. *Eur. Phys. J. B* **85** (2012) 22

C.2 ISI Conference Proceedings

The following papers appear in the refereed proceedings of the 26th International Conference on Low Temperature Physics (LT26) by the IOP Publishing.

- C.2.1.** C. Baldo III and C. Villagonzalo. Low-lying spin excitations due to next-nearest neighbour interactions in a ferromagnetic lattice with a body-centred cubic (bcc) crystal structure. *Journal of Physics: Conference Series* **400** (2012) 032007
[doi:10.1088/1742-6596/400/3/032007]
- C.2.2.** R. Gammag and C. Villagonzalo. The interplay of Rashba spin-orbit interaction and Landau level broadening on a two-dimensional electron gas under a tilted magnetic field. *Journal of Physics: Conference Series* **400** (2012) 042009
[doi:10.1088/1742-6596/400/4/042009]

C.3 National Conference Proceedings

The following papers appear in the refereed Proceedings of the 30th Samahang Pisika ng Pilipinas (SPP) National Physics Congress held at the De La Salle Health Sciences Institute, Dasmariñas City, Cavite last 22 – 24 of October, 2012:

- C.3.1.** Neris Ilano, Cristine Villagonzalo and Ronald Banzon, “The effect of RF distribution on the implementation of quantum CN gate in an Ising spin chain” (Manuscript # SPP–2012–56)
- C.3.2.** Carlos Baldo III and Cristine Villagonzalo, “Rashba and Dresselhaus Spin-Orbit Interactions in a Curvilinear Motion of a Spin Polarized Electron” (Manuscript # SPP–2012–54)
- C.3.3.** Micielle Capili, Cristine Villagonzalo and Ronald Banzon, “Percolation critical exponent of a constrained lattice” (Manuscript # SPP–2012–04)

D. Future Plans

D.1 Two-dimensional Electron Gas

Tilting of a two-dimensional electron gas (2DEG) relative to an applied magnetic field has recently allowed the observation of novel behaviors such as crossings or degeneracies of spin-split Landau levels and beating patterns in magneto-oscillations at large tilt angles. Dr. Villagonzalo will continue to collaborate with work with Dr. Gammag in the hope of being able to demonstrate that the above mentioned phenomena are inherent to a 2DEG in large tilted fields with Rashba spin orbit interaction and Zeeman splitting and we are able to explain recent experimental results in literature. From the exact derivation of the eigenvalues incorporating such interaction potentials, numerical calculations will be performed to tune the tilt angle and check for multi-level crossings at a single large tilt angle. The goal is to establish the behavior of the spin gap with increasing Rashba spin-orbit strength and the tilting of the magnetic field, and, more importantly, to distinguish which features of the 2DEG can be expected from the spin-orbit interaction and which are from the nonparabolicity of the bands due to the magnetic field's orientation.

D.2 Quantum Entanglement

Dr. Paraan intends to propose a research grant on the "Quantum entanglement in low-dimensional systems: quantum spin chains and continuum systems." Understanding of quantum correlations in these systems is a fundamental tool in studies on quantum computing and condensed matter systems. Through his grant, he intends to upgrade the computational facilities of SanD. Dr. Paraan intends to recruit graduate students to mentor in his proposed research field.

D.3 Spin-Orbit Effects in One-Dimensional Transport

Mr. Baldo and Dr. Villagonzalo have previously re-derived the energy spectrum of a spin-polarized electron along a curved path in the presence of an externally applied magnetic field. This approximates the motion of electrons in a one-dimensional curved wire. In obtaining the eigenstates, we have considered the Zeeman effect and the Rashba and Dresselhaus spin-orbit interactions. The next step is to derive the eigenfunctions and the current density given the specified constraints. The aim of this project then is to obtain the scattering states of such an electron and their dependence on the Rashba and Dresselhaus coupling constants and the radius of curvature of the wire. Knowing the spin-orbit effects on the transport of electrons in a wire is a step toward controlling spin and charge flow in low dimensional spintronic devices.

D.4 Percolation

The study on the percolation in constrained lattices will be continued. The focus is to establish whether the critical exponent of the lattice is affected by a reduced dimensionality and its correlation with fractal dimension.