Theoretical Projects

15. Topics in turbulence (MPhil or PhD)
(Prof. Ching, E.S.C., Room 344, ☎2609 6305,
E-mail: ching@phy.cuhk.edu.hk)

One student may be admitted to work on a project in turbulence. Turbulence is a state of fluid motion when the speed of flow is sufficiently high. The physical quantities of interest, e.g. velocity and temperature, exhibit irregular fluctuations. Moreover the drag increases compared to laminar flows. The problems that we are presently studying are: (i) the anomalous scaling of the temperature field in turbulent convection, (ii) turbulent drag reduction by polymers, and (iii) the effect of polymers on heat transport in turbulent convection.

References **:**

1. *Emily S.C. Ching and W.C. Cheng, "Anomalous scaling and refined similarity of an active scalar in a shell model of homogeneous turbulent convection", Physical Review E 77, pp 015303(R)(1-4) (2008).*
2. *Emily S.C. Ching, H. Guo, and T.S. Lo, "Refined similarity hypotheses in shell models of homogeneous turbulence and turbulent convection", Physical Review E 78, pp. 026303(1-10) (2008).*
3. *Roberto Benzi, Emily S.C. Ching, T.S. Lo, Victor S. L'vov, and Itamar Procaccia, "Additive equivalence in turbulent drag reduction by flexible and rodlike polymers", Physical Review E 72, pp. 016305(1-8) (2005).*
4. *Emily S.C. Ching, T.S. Lo, and Itamar Procaccia, "Turbulent drag reduction by flexible and rodlike polymers: Crossover effects at small concentrations", Physical Review E 74, pp. 026301(1-6) (2006).*
5. *Roberto Benzi, Emily S.C. Ching, Elisabetta De Angelis, and Itamar Procaccia, "Comparison of theory and direct numerical simulations of drag reduction by rodlike polymers in turbulent channel flows", Physical Review E 77, pp. 046309(1-5) (2008).*
6. *Itamar Procaccia, Victor S. L'vov, and Roberto Benzi, "Colloquium: Theory of drag reduction by polymers in wall-bounded turbulence", Review of Modern Physics 80, pp. 225-247 (2008).*

16. Topics in astrophysics and cosmology (MPhil or PhD)
(Prof. Chu, M.C., Room 106, ☎2609 6364,
E-mail: mcchu@phy.cuhk.edu.hk)

One student may be admitted to work on projects of mutual interest in theoretical astrophysics and cosmology. My current projects include probing physics of the early universe through cosmic microwave background anisotropies [1], dark matter astrophysics and cosmology [2], and neutrino astrophysics [3].

References **:**

1. *S.-C. Su and M.-C. Chu, "Is the universe rotating?", Astrophysical Journal 703, pp. 354-361 (2009); K.C. Chan and M.-C. Chu, "Cosmological constraints on radion evolution in the universal extra dimension model", Physical Review D 77, pp. 063525(1-9) (2008).*
2. *M.H. Chan and M.-C. Chu, "The existence of sterile neutrino halos in galactic centers as an explanation of the black hole mass - Velocity dispersion relation", Astrophysical Journal 692, pp. 212-216 (2009).*
3. *M.H. Chan and M.-C. Chu, "Decaying sterile neutrinos as a heating source in the Milky Way centre", Monthly Notices of the Royal Astronomical Society 389, pp. 297-300 (2008); "Heating of the intergalactic medium by the radiative decay of neutrinos", Astrophysical Journal 658, pp. 859-864 (2007).*

17. Neutrino oscillation and cosmic ray background (MPhil or PhD)
(Prof. Chu, M.C., Room 106, ☎2609 6364)

A new generation of neutrino oscillation experiments has been proposed around the world to measure various neutrino parameters such as the mixing angles. In particular, the value of the theta_13 parameter, which is important for constraining grand unification theories as well as testing leptogenesis models, is yet undetermined from previous experiments. An experiment has been proposed using the Daya Bay Nuclear Reactor[#], but careful study of the background and event rates is needed for optimizing the detector design. The most important backgrounds for this and other underground experiments are those induced by cosmic rays, and therefore an underground laboratory at Aberdeen Tunnel has been set up to study these. Students are expected to participate in all aspects of activities related to either the Daya Bay or the Aberdeen Tunnel experiments, including both experimental and theoretical works. [One student may be admitted.]

Reference **:**

[#] *http://theta13.phy.cuhk.edu.hk/*

18. Topics in the condensed matter physics and quantum information theory (MPhil)
(Prof. Gu, S.J., Room 217, ☎2609 6301,
E-mail: sjgu@phy.cuhk.edu.hk)

One or two students may be admitted to work on any of the following projects in the field of condensed matter physics and quantum information theory. (1) Transport properties in low-dimensional systems; (2) Issues on the role of quantum entanglement in quantum critical phenomena; (3) Issues in the optical lattice. Students are expected to be honest and hard-working with solid background in undergraduate physics and mathematics.

References **:**

1. *S.-J. Gu, V.M. Pereira, and N.M.R. Peres, "Scaling study of the metal-insulator transition in one-dimensional Fermion systems", Physical Review B 66, pp. 235108(1-7) (2002).*
2. *Y.-Q. Li, S.-J. Gu, Z.-J. Ying, and U. Eckern, "Exact results of the ground state and excitation properties of a two-component interacting Bose system", Europhysics Letters 61, pp. 368-374 (2003).*
3. *S. Sachdev, "Quantum phase transitions", Cambridge University Press (2000).*
4. *A. Osterloh, L. Amico, G. Falci, and R. Fazio, "Scaling of entanglement close to a quantum phase transition", Nature 416, pp. 608-610 (2002); T.J. Osborne and M.A. Nielsen, "Entanglement in a simple quantum phase transition", Physical Review A 66, pp. 032110(1-14) (2002).*

5. *S.-J. Gu, H.-Q. Lin, and Y.-Q. Li, "Entanglement, quantum phase transition, and scaling in the XXZ chain", Physical Review A 68, pp. 042330(1-4) (2003); S.-J. Gu, G.-S. Tian and H.-Q. Lin, "Ground-state entanglement in the XXZ model", Physical Review A 71, pp. 052322(1-5) (2005).*
6. *J. Vidal, G. Palacios, and R. Mosseri, "Entanglement in a second-order quantum phase transition", Physical Review A 69, pp. 022107(1-4) (2004); J. Vidal, R. Mosseri and J. Dukelsky, "Entanglement in a first-order quantum phase transition", Physical Review A 69, pp. 054101(1-4) (2004).*
7. *S.-J. Gu, S.-S. Deng, Y.-Q. Li, and H.-Q. Lin, "Entanglement and quantum phase transition in the extended Hubbard model", Physical Review Letters 93, pp. 086402(1-4) (2004).*
8. *S.-J. Gu, C.-P. Sun, and H.-Q. Lin, "Universal role of correlation entropy in critical phenomena", Journal of Physics A: Mathematical and Theoretical 41, pp. 025002(1-18) (2008).*
9. *S.-J. Gu, R. Fan, and H.-Q. Lin, "Ground state of a mixture of two species of fermionic atoms in a one-dimensional optical lattice", Physical Review B 76, pp. 125107(1-9) (2007).*

19. Topics in statistical physics and complex systems (MPhil or PhD)

(Prof. Hui, P.M., Room 209, ☎2609 6351, E-mail: pmhui@phy.cuhk.edu.hk)

Up to two highly motivated students are sought to join my group. My current interests include (i) competing and evolutionary games in complex networks and their applications (1); (ii) the physics and applications of co-evolving dynamical processes (2); and (iii) the interplay between functionality and connectivity in complex networks (3). Students with strong undergraduate physics background and some experience in carrying out numerical computations are encouraged to apply. The students are expected to work hard and be self-motivated. It is important to realize that it is NOT that I need some students to carry out specific projects FOR me, instead my intention is to provide a platform for highly motivated students to learn and to develop himself/herself. Other topics that I am currently interested in include: Transmission of electromagnetic waves in metallic patterned films (4) and the physics of traffic flow problems. I also welcome applicants with his/her own intended research direction, proposal, or plan. Only students who take postgraduate studies really seriously need to apply.

References **:**

1. *D.F. Zheng, H.P. Yin, C.H. Chan, and P.M Hui, "Cooperative behavior in a model of evolutionary snowdrift games with N-person interactions", Europhysics Letters 80, pp. 18002(1-4) (2007).*
2. *O. Gräser, C. Xu, and P.M. Hui, "Disconnected-connected network transitions and phase separation driven by co-evolving dynamics", Europhysics Letters 87, pp. 38003(1-6) (2009).*
3. *L.-X. Zhong, D.-F. Zheng, B. Zheng, C. Xu, and P.M. Hui, "Networking effects on cooperation in evolutionary snowdrift game", Europhysics Letters 76, pp. 724-730 (2006).*
4. *Haiping Yin and P.M. Hui, "Controlling enhanced transmission through semiconductor gratings with subwavelength slits by a magnetic field: Numerical and analytical results", Applied Physics Letters 95, pp. 011115(1-3) (2009).*

20. Topics in cavity QED and quantum optomechanics (MPhil)

(Prof. Law, C.K., Room 307, ☎3163 4334, E-mail: cklaw@phy.cuhk.edu.hk)

One or two MPhil students may be admitted to work on theoretical investigations of photon-atom interactions and photon-mirror interaction inside microcavities and circuit QED environments. These projects explore novel effects of radiation pressure, and quantum dynamics in strong coupling regimes. Students are required to have a strong background in electrodynamics and quantum mechanics.

References **:**

1. *T.S. Tsoi and C.K. Law, "Single-photon scattering on Lambda-type three-level atoms in a one-dimensional waveguide", Physical Review A 80, pp. 033823(1-7) (2009).*
2. *T.S. Tsoi and C.K. Law, "Quantum interference effects of a single photon interacting with an atomic chain inside a one-dimensional waveguide", Physical Review A 78, pp. 063832(1-5) (2008).*
3. *C.K. Law and S.K.Y. Lee, "Dynamic photon-mode selection in Dicke superradiance", Physical Review A 75, pp. 033813(1-6) (2007).*

21. Gravitational waves from compact stellar objects (MPhil or PhD)

(Prof. Leung, P.T., Room 204, ☎2609 6396, E-mail: ptleung@phy.cuhk.edu.hk)

It is generally believed that gravitational waves emitted from violent astrophysical processes in compact stellar objects (e.g. black holes and neutron stars) can be observed in a few years. In addition to providing cogent support for general relativity, gravitational wave detection indeed opens up a new channel for us to infer the internal structure of compact stellar objects far away from our galaxy. In this project, one student will be accepted to study gravitational wave spectra of different compact stellar objects and develop appropriate schemes to infer their physical properties (e.g. mass, size and equation of state). The student is expected to be conversant with standard analytic and numerical techniques.

References **:**

1. *E.S.C. Ching, P.T. Leung, W.M. Suen, and K. Young, "Quasinormal mode expansion for linearized waves in gravitational systems", Physical Review Letters 74, pp. 4588-4591 (1995).*
2. *P.T. Leung, Y.T. Liu, W.M. Suen, C.Y. Tam, and K. Young, "Quasinormal modes of dirty black holes", Physical Review Letters 78, pp. 2894-2897 (1997).*
3. *L.K. Tsui and P.T. Leung, "Perturbative analysis of universality and individuality in gravitational waves from neutron stars", Astrophysical Journal 631, pp. 495-505 (2005).*
4. *L.K. Tsui and P.T. Leung, "Probing the interior of neutron stars with gravitational Waves", Physical Review Letters 95, pp. 151101(1-4) (2005).*

22. Topics in the physics of novel materials (MPhil or PhD)
(Prof. Lin, H.Q., Room 110, ☎2609 6365,
E-mail: hqlin@phy.cuhk.edu.hk)

Students are expected to be honest and hard-working with solid background in undergraduate physics and mathematics.

Two to three students may be accepted to work on any of the following research projects:

1. Cold atom systems (e.g., Dynamics of fermionic atoms in optical lattices)
   S J. Gu, R. Fan, and H. Q. Lin, "Ground state of a mixture of two species of fermionic atoms in a one-dimensional optical lattice", Physical Review B 76, pp. 125107(1-9) (2007).
2. Superconductivity and magnetism in layer compounds
   Xiao-Jia Chen, Jiang-Long Wang, Viktor V. Struzhkin, Ho-Kwang Mao, Russell J. Hemley, and Hai-Qing Lin, "Superconducting behavior in compressed solid SiH_4 with a layered structure", Physical Review Letters 101, pp. 077002(1-4) (2008).
   J. An, H.Q. Lin, and C.D. Gong, "Coexistence of f-wave superconductivity, charge order, and spin antiferromagnetism around nonmagnetic impurities in $Na_{0.33}CoO_2 \cdot 1.3H_2O$", Physical Review Letters 96, pp. 227001(1-4) (2006).
3. Novel phenomena induced by orbital degree of freedom in many-body systems
   W.L. You, G.S. Tian, and H.Q. Lin, "Existence of long-range orbital order in a two-dimensional orbital-only model", Physical Review B 75, pp. 195118(1-10) (2007).
   C.D. Batista, J.E. Gubernatis, J.Bonca, and H.Q. Lin, "Intermediate coupling theory of electronic ferroelectricity", Physical Review Letters 92, pp. 187601(1-4) (2004).
4. Issues in quantum Monte Carlo simulations
   Y.Q. Wang, H.Q. Lin, and J.E. Gubernatis, "Zero temperature numerical studies of multiband lattice models of strongly correlated electrons", Review Article in Communications in Computational Physics 1, pp. 575-615 (2006).
5. Quantum entanglement and quantum phase transition
   S.J. Gu, S.S. Deng, Y.Q. Li, and H.Q. Lin, "Entanglement and quantum phase transition in the extended Hubbard model", Physical Review Letters 93, pp. 086402(1-4) (2004).
   S.J. Gu, G.S. Tian, and H.Q. Lin, "Local etanglement and quantum phase transition in spin models", New Journal of Physics 8, pp. 61(1-13) (2006).
   S.J. Gu, G.S. Tian, and H.Q. Lin, "Pairwise entanglement and quantum phase transition in spin systems", Chinese Physics Letters 24, pp. 2737-2740 (2007).
   Shuo Yang, Shi-Jian Gu, Chang-Pu Sun, and Hai-Qing Lin, "Fidelity susceptibility and long-range correlation in the Kitaev honeycomb model", Physical Review A 78, pp. 012304(1-6) (2008).
6. Magnetic properties of transition metals
   S.Q. Su, Z.B. Huang, R. Fan, and H.Q. Lin, "Numerical study of ferromagnetic fluctuation and pairing correlation in the single-band Hubbard model on triangular lattice", Physical Review B 77, pp. 125114(1-7) (2008).

23. Foundations of quantum computing and quantum physics (PhD or MPhil)
(Prof. Liu, R.B., Room 205, ☎2609 6312,
E-mail: rbliu@phy.cuhk.edu.hk)

One or two students are to be admitted to study in theory the physics of quantum computing in solid-state systems and fundamental issues in quantum physics, such as (1) electron spin decoherence in mesoscopic spin baths, (2) quantum optics of semiconductor quantum dots, (3) optimal control and quantum measurement of quantum systems in mesoscopic environments, (4) thermodynamics and statistical physics of small quantum systems, and (5) direct measurement of spin currents in semiconductors. Honesty, strong motivation, and hard-working are a must. Solid background in quantum mechanics and solid-state physics and interest in numerical simulations are preferred. Priority is given to applications for the PhD program. Applicants are encouraged to contact the supervisor for better mutual understanding.

References:

1. *J. Du, X. Rong, N. Zhao, Y. Wang, J. Yang, and R.B. Liu, "Preserving electron spin coherence in solids by optimal dynamical decoupling", Nature (2009, in press).*
2. *W. Yang and R.B. Liu, "Universality of Uhrig dynamical decoupling for suppressing qubit pure dephasing and relaxation", Physical Review Letters 101, pp. 180403(1-4) (2008).*
3. *W. Yang and R.B. Liu, "Quantum many-body theory of qubit decoherence in a finite-size spin bath", Physical Review B 78, pp. 085315(1-13) (2008).*
4. *J. Wang, B.F. Zhu, and R.B. Liu, "Proposal for direct measurement of a pure spin current by a polarized light beam", Physical Review Letters 100, pp. 086603(1-4) (2008).*
5. *R.B. Liu, W. Yao, and L.J. Sham, "Control of electron spin decoherence caused by electron-nuclear spin dynamics in a quantum dot", New Journal of Physics 9, pp. 226(1-46) (2007).*
6. *W. Yao, R.B. Liu, and L.J. Sham, "Restoring coherence lost to a slow interacting mesoscopic spin bath", Physical Review Letters 98, pp. 077602(1-4) (2007).*
7. *W. Yao, R.B. Liu, and L.J. Sham, "Theory of control of the spin-photon interface for quantum networks", Physical Review Letters 95, pp. 030504(1-4) (2005).*

24. Topics in quantitative finance (MPhil or PhD)
(Prof. Lo, C.F., Room 207, ☎2609 6362,
E-mail: cflo@phy.cuhk.edu.hk)

Quantitative finance is one of the fastest growing areas in the modern banking and corporate world. The main reason behind this phenomenon has been the success of sophisticated quantitative methodologies in helping professionals to manage financial risks. In this project the students will carry out research in various areas in quantitative finance. Possible topics include option pricing, defaultable bond pricing, credit risk analysis, etc. The students are expected to be highly-motivated and hardworking persons who have strong background in mathematical and computational physics. No prior knowledge of finance is required.

References **:**
http://www.phy.cuhk.edu.hk/~cflo/finance.html

25. Topics in theoretical and computational physics (MPhil or PhD)
(Prof. Lo, C.F., Room 207, ☎2609 6362)

Postgraduate students may be admitted to work on the following projects:

- Application of quantum mechanics to materials modeling
- First passage time problems in stochastic modeling
- Quantum entanglement and quantum games

The students are expected to be highly-motivated and hardworking persons who have strong background in undergraduate physics and mathematics.

References **:**

1. *K.Y. Wong, C.F. Lo, W.Y. Sham, H.H. Fong, S.K. So, and L.M. Leung, "Theoretical investigation of a blue hydroxyquinaldine-based aluminum(III) complex", Physics Letters A 321, pp. 194-198 (2004).*
2. *M.Y. Yeung, C.F. Lo, and S.K. So, "An ab initio study of carbazole model compounds", Journal of Theoretical and Computational Chemistry 4, pp. 103-115 (2005).*
3. *C.F. Lo, "Exact solutions of the Fokker-Planck equations with moving boundaries", Annals of Physics 319, pp.326-332 (2005).*
4. *L.K. Chen, H. Ang, D. Kiang, L.C. Kwek, and C.F. Lo, "Quantum prisoner dilemma under decoherence", Physics Letters A 316, pp. 317-323 (2003).*
5. *C.F. Lo and D. Kiang, "Quantum oligopoly", Europhysics Letters 64, pp. 592-598 (2003).*
6. *C.F. Lo and D. Kiang, "Quantum Stackelberg duopoly with incomplete information", Physics Letters A 346, pp. 65-70 (2005).*

26. Topics in laser physics and photonic crystals (MPhil)
(Prof. Wang, L.G., Room 105, ☎2609 6103,
E-mail: lgwang@phy.cuhk.edu.hk)

One student may be admitted to work on any of the following research interests:

(1) Dispersive properties of atomic systems/ multilayered structures/ metamaterials.
(2) Quantum optics.

The student is expected to be honest and hard working with solid background in electromagnetism and quantum mechanics.

References **:**

1. *L.G. Wang, H. Chen, and S.Y. Zhu, "Omnidirectional gap and defect mode of one-dimensional photonic crystals with single-negative materials", Physical Review B 70, pp. 245102(1-6) (2004).*
2. *L.G. Wang and S.Y. Zhu, "Superluminal pulse reflection from a weakly absorbing dielectric slab", Optics Letters 31, pp. 2223-2225 (2006).*
3. *L.G. Wang and S.Y. Zhu, "Dynamic pattern of finite-pulsed beams inside one-dimensional photonic band gap materials", Physical Review B 73, pp. 195119(1-7) (2006).*
4. *L.G. Wang and S.Y. Zhu, "Giant lateral shift of a light beam at the defect mode in one-dimensional photonic crystals", Optics Letters 31, pp. 101-103 (2006).*
5. *L.G. Wang, M. Ikram, and M.S. Zubairy, "Control of the Goos-Hänchen shift of a light beam via a coherent driving field", Physical Review A 77, pp. 023811(1-5) (2008).*
6. *L.G. Wang, et al., "Realization of Dirac point with double cones in optics", Optics Letters 34, pp. 1510-1512 (2009).*
7. *M.O. Scully and M.S. Zubairy, "Quantum Optics", (Cambridge 1997), related chapters.*

27. Topics in soft matter and metamaterials (MPhil or PhD)
(Prof. Yu, K.W., Room 206, ☎2609 6100,
E-mail: kwyu@phy.cuhk.edu.hk)

Up to two students may be admitted to work on the following topics: soft nonlinear optical materials, nano-optics in graded plasmonic waveguides, ac response of composites, electrokinetics of colloidal and biological cell suspensions, electrorheological and magnetorheological fluids and ferrofluids as well as related topics of mutual interest.

A metamaterial is an object that gains its material properties from its structure rather than from the inherent properties that it is composed of. This terminology is particularly relevant to materials which possess properties that are not found in nature. In order for the metamaterial to behave as a homogeneous material accurately described by an effective refractive index, the characteristic sizes must be much smaller than the wavelength of EM fields[#]. The constituent materials can be soft matter, thus giving the advantages of easy fabrication. Metamaterials are promising for a diversity of optical/microwave applications, such as new types of band-pass filters, superlenses, and perfect cloaking.

Reference **:**

[#] *J.P. Huang and K.W. Yu, "Enhanced nonlinear optical responses of materials: Composite effects", Physics Reports 431, pp. 87-172 (2006).*

28. Intense ion beams for high energy density physics and fusion (MPhil)
(Prof. Yu, S.S.L., Room 304, ☎2609 6155,
E-mail: ssyu@lbl.gov)

The understanding of intense ion beams has important implications for new frontiers in high energy density physics and inertial confinement fusion. To achieve the very high intensities required for these applications, we are investigating the transport and acceleration of space-charge-dominated ion beams, the compression of beams in the presence of a neutralizing plasma, as well as the physics of beam-target interaction. These projects are conducted in close collaboration with scientists from the US Virtual National Laboratory for Heavy Ion Fusion Sciences, a joint effort of the Lawrence Berkeley National Laboratory, the Lawrence Livermore National Laboratory, and the Princeton Plasma Physics Laboratory. Students who are interested in research topics involving both theory and experiment and/or large-scale computer simulations are preferred.

References **:**

1. *R.C. Davidson, et al., "Frontiers in high energy density physics - The X-games of contemporary science", National Academies Press (2003).*
2. *R.C. Davidson, et al., "Frontiers for discovery in high energy density physics", prepared by the National Task Force on High Energy Density Physics, July 7, 2004.*
3. *B.G. Logan, et al., "Recent U.S. advances in ion-beam-driven high energy density physics and heavy ion fusion"; and many other papers in the Proceedings of the 16th International Symposium on Heavy Ion Inertial Fusion, published in Nuclear Instruments and Methods in Physics Research A (2005).*
4. *S.S. Yu, et al., "Heavy-ion-fusion-science: summary of US progress", Nuclear Fusion 47, pp. 721-727 (2007).*

29. Control of a strong light signal by a weak beam: exploiting optical instabilities in semiconductor microstructures (MPhil or PhD)
(Prof. Leung, P.T., Room 204, ☎2609 6396, E-mail: ptleung@phy.cuhk.edu.hk)

Under certain conditions, two beams propagating along an axis but in opposite directions in a nonlinear medium can undergo directional instabilities: coherent beams of considerable intensity appear spontaneously in off-axis directions, sometimes forming patterns on a transverse plane [1]. The properties of these instabilities have been studied in the last two decades. A recent experiment [2] demonstrated that, in a medium of atomic vapors, the direction of an instability-generated, off-axis beam can be changed by shining a very weak control beam at the setup. This is an interesting example of controlling a stronger light signal with a weaker beam. Besides embodying some interesting physics, this result may have practical implications, as a common goal of technical schemes for switching light with light is to lower the threshold control intensity as far as possible.

The present project is a theoretical study of analogous transverse instabilities and light-beam switching in a semiconductor system made up of a quantum well embedded in a microcavity. Despite the analogy, the microscopic physics underlying these instabilities in a semiconductor is very different from that in the atomic vapor system. A microscopic theory of optical nonlinearity in the quantum-well microcavity has been set up [3]. Based on this theory, the student joining the project is expected to carry out numerical simulations of the instability-generated processes and the direction-switching by the control beam. The objective is to fully understand all important aspects of these processes. Some first results have been published [4]. Transverse instabilities in the quantum-well microcavity, but not the controlled switching by the weak beam, have been demonstrated experimentally. The efforts in both the atomic and semiconductor systems have recently been reviewed in [5].

The study described above is a joint project between Prof. P.T. Leung and Prof. Nai-Hang Kwong in the College of Optical Sciences at The University of Arizona, who will be visiting us in 2010-2011. The student joining the project is expected to have a solid background in undergraduate physics and experience in numerical computations.

References **:**

1. *E.g., J.B. Geddes, R.A. Indik, J.V. Moloney, and W.J. Firth, "Hexagons and squares in a passive nonlinear optical system", Physical Review A 50, pp. 3471–3485 (1994).*
2. *A.M.C. Dawes, L. Illing, S.M. Clark, and D.J. Gauthier, "All-optical switching in rubidium vapor", Science 308, pp. 672-674 (2005).*
3. *S. Schumacher, N.H. Kwong and R. Binder, "Influence of exciton-exciton correlations on the polarization characteristics of polariton amplification in semiconductor microcavities", Physical Review B 76, pp. 245324(1-11) (2007).*
4. *S. Schumacher, N.H. Kwong, R. Binder, and A.L. Smirl, "Low intensity directional switching of light in semiconductor microcavities", Physica Status Solidi - Rapid Research Letters 3, pp. 10-12 (2009).*
5. *A.M.C. Dawes, D.J. Gauthier, S. Schumacher, N.H. Kwong, R. Binder, and A.L. Smirl, "Transverse optical patterns for ultra-low-light-level all-optical switching", Laser and Photonics Reviews, DOI 10.1002/lpor.200810067 (2009).*