UNIVERSITY OF MALAYA

Inaugural Lecture

QUANTUM AND PHOTON REVOLUTION

OR DR. C. H. RAYMOND OOI
F PHYSICS, FACULTY OF SCIENCE
R SCIENCE (HIGH IMPACT RESEARCH)
UNIVERSITY OF MALAYA

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Quantum and Photon Revolution

Inaugural Lecture

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SYNOPSIS

What the future holds for Quantum and Laser Science? We are at the brink of a scientific revolution based on quantum and photon science. I will share my research topics that were carried out over the last 15 years, ranging from photonic crystals to laser cooling and quantum nonlinear plasmonics to intense laser physics. These topics are at the forefront of physics research and emerging technologies, and have led to several Nobel prizes for a century. The roles of atoms and photons are becoming increasingly important and significant in the nanotechnology era. Thus, quantum effects are valuable assets for the emerging and baffling technologies.

One example is the GPS that uses laser cooling. The quantum revolution couples with the laser revolution is making a quantum leap at the heart of information and medical technologies; bringing unimaginable future possibilities to reality. But all these wonders come hand in hand with the strokes of the pen as the base, the know-how of theoretical calculations and simulations using the laws of electromagnetism and quantum theory with unlimited imagination and inspiration from above.

Quantum and Laser Science

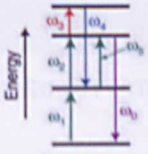
Laser technologies are everywhere, benefiting the world since its invention. From the CD-ROM in all computers to the GPS using cold atoms and laser eye treatment and laser surgery. Quantum optics has enabled the production of light sources with quantum properties and manipulation of quantum systems with light. My research is in Atomic and Molecular Physics, Quantum Optics, Laser Physics, Nonlinear Optics, with the following topics

- *Quantum Optics and Information*
- *Nanophotonics and Plasmonics*
- *Photonic Crystals and Metamaterials*
- *Nonclassical Light and Novel Lasers*
- *Intense Laser Interactions*
- *Nonlinear Optics and Spectroscopy*
- *Ultracold Atoms and Molecules*

The pioneers who laid the foundations in the fields


JC Maxwell

$$\nabla\cdot\mathbf{E}(\mathbf{r},t) = \rho(\mathbf{r},t)/\varepsilon_o$$
$$\nabla\times\mathbf{E}(\mathbf{r},t) = -\frac{\partial}{\partial t}\mathbf{B}(\mathbf{r},t)$$
$$\nabla\cdot\mathbf{B}(\mathbf{r},t) = 0$$
$$\nabla\times\mathbf{B}(\mathbf{r},t) = \varepsilon_o\mu_o\frac{\partial}{\partial t}\mathbf{E}(\mathbf{r},t)+\mu_o\mathbf{J}(\mathbf{r},t)$$




N Bloembergen

$$P(t) \propto \chi^{(1)}E(t) + \chi^{(2)}E^2(t) + \chi^{(3)}E^3(t) + \cdots$$


E. Schrodinger

$$(-\frac{\hbar^2}{2m}\nabla^2 + \hat{V})\Psi(r,t) = i\hbar\frac{\partial}{\partial t}\Psi(r,t)$$

$$[\hat{q},\hat{p}] = i\hbar$$

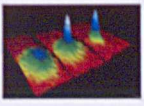
$$\Psi = \frac{1}{\sqrt{2}}|\quad\rangle + \frac{1}{\sqrt{2}}|\quad\rangle$$


W Heisenberg

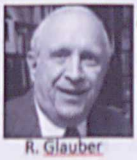
$$\frac{\partial}{\partial t}\hat{\rho}(t) = \frac{1}{i\hbar}[\hat{V}_{sr},\hat{\rho}(t)]$$


PAM Dirac

$$\hat{\mathbf{E}}(\hat{\mathbf{R}}) = i\sum_{\mathbf{k},\lambda}\sqrt{\frac{\hbar\omega_{\mathbf{k}\lambda}}{2\varepsilon_o V}}(\hat{\varepsilon}_{\mathbf{k}\lambda}\hat{a}_{\mathbf{k}\lambda}e^{i\mathbf{k}\cdot\hat{\mathbf{R}}} - \hat{\varepsilon}^*_{\mathbf{k}\lambda}\hat{a}^\dagger_{\mathbf{k}\lambda}e^{-i\mathbf{k}\cdot\hat{\mathbf{R}}})$$

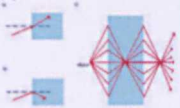



A Einstein


R. Glauber

$$G^{(2)} = \mathrm{tr}\{\rho E^{(-)}(\mathbf{r}_1 t_1)E^{(-)}(\mathbf{r}_2 t_2)E^{(+)}(\mathbf{r}_3 t_3)E^{(+)}(\mathbf{r}_4 t_4)\}$$

$$\hat{a}|\alpha\rangle = \alpha|\alpha\rangle$$




J Pendry

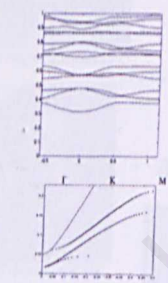
Some wonders and exciting possibilities in quantum and laser technologies

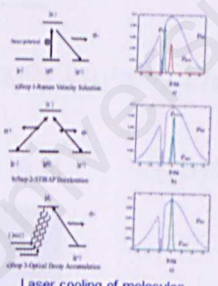
- Improving eyesight with light.
- Slowing light pulse to a walking speed.
- Producing light from heat.
- Making an object invisible.
- Cooling a gas to one millionth of a degree.
- Levitation of particles using lasers.

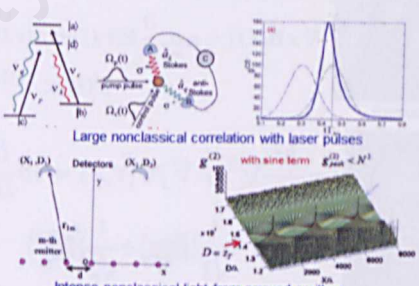
Recent active research development in using lasers to manipulate quantum systems hold exciting prospects for disruptive quantum nonlinear optical technologies in years ahead such as

1. ultrasensitive nanoplasmonic sensors of single molecules
2. quantum microscopy, imaging and lithography beyond the diffraction limit
3. much faster, smaller, compact optical processors containing optical circuits and nanolasers
4. unbreakable and secure encryption using quantum cryptography
5. quantum computers that can process information at much faster speed
6. production of new quantum degenerate matter (BEC) using laser cooling technology

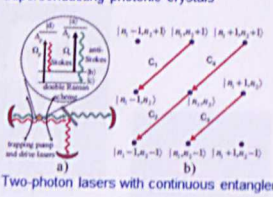
Montage of my research works

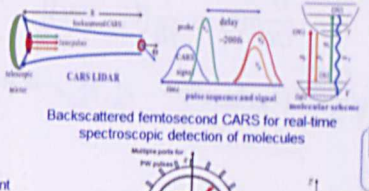

superconducting photonic crystals


Laser cooling of molecules

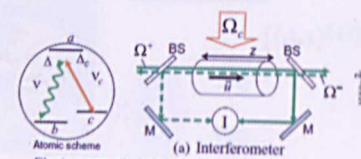

Large nonclassical correlation with laser pulses

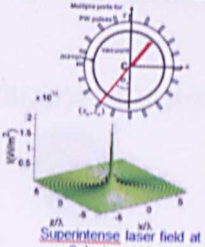
Intense nonclassical light from arrayed emitters

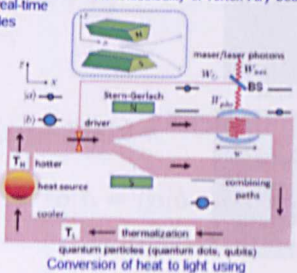

Two-photon lasers with continuous entanglement


Backscattered femtosecond CARS for real-time spectroscopic detection of molecules

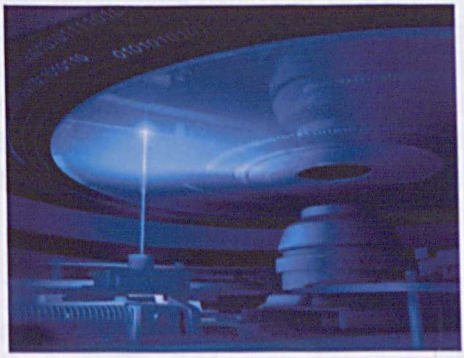

Nonclassicality of vortex Airy beams


Electromagnetic induced transparency for optical transistor and quantum velocimeter

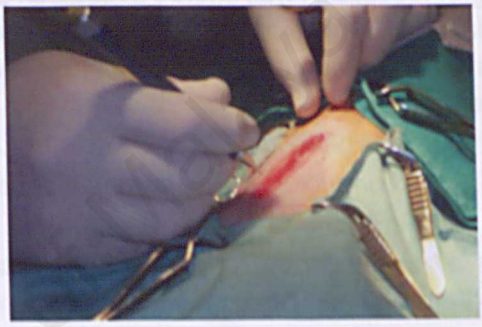

Superintense laser field at Schwinger's limit


Conversion of heat to light using Townes' maser-laser engine

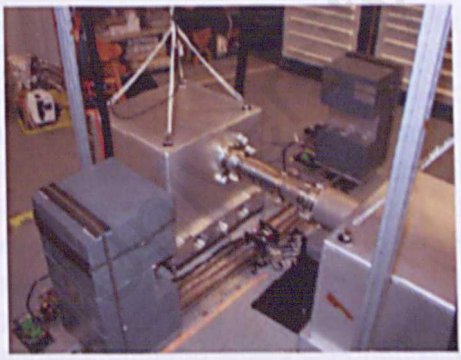
Existing Technologies and Applications



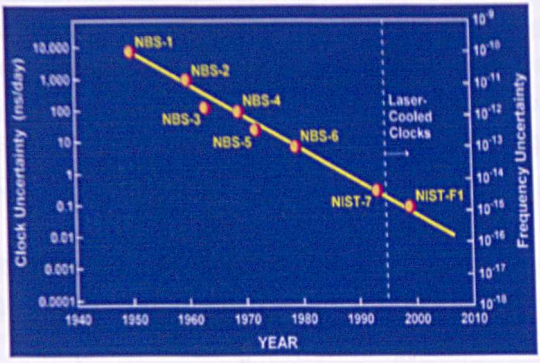
Blue laser in DVD makes features ~0.5micron



laser surgery



Gravity sensor using cold atoms



improvement of atomic clock used in GPS

The journey starts

My interest in physics was collectively shaped by television documentaries & science fiction movies, articles in newspapers and books in the British Council library, an ingenious classmate, a dedicated astronomer Dr Chong Hon Yew. Since primary school, my late grandmother always reminded me of the importance of education. It enabled me to make it to university along with a state government loan. The subjects that I excel in BSc and my final year project with Prof David R Tilley determined the direction of my research interest.

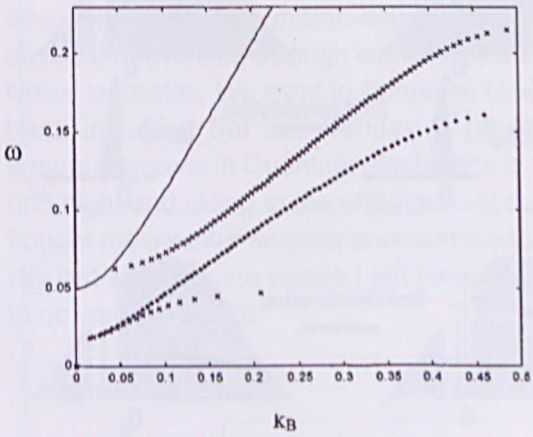
The postgraduate years (at Singapore & Konstanz)

After a couple of years as engineer at Hewlett-Packard Malaysia, I went all the way for research. I was offered a research stipend to pursue M.Eng in photonics at Nanyang Technological University. I worked on theoretical aspect of photonic crystals and proposed the first superconducting photonic crystal. Three papers were published in about a year.

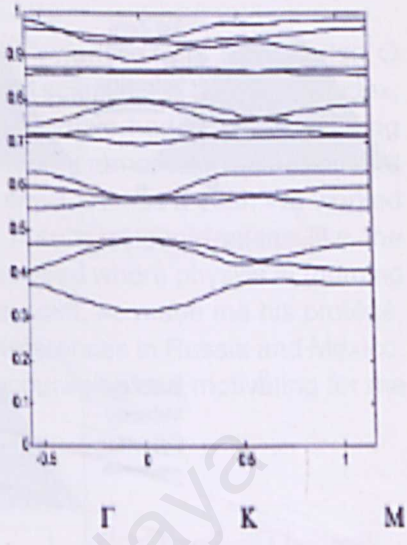
1. *C. H. Raymond Ooi and Au Yeung T. C., (1999) "Polariton gap in a superconductor–dielectric superlattice", Physics Letters A 259, 413.*
2. *C. H. Raymond Ooi, Au Yeung T. C., Kam C. H. and Lim T. K., (2000) "Photonic band gap in a superconductor-dielectric superlattice", Physical Review B 61, 5920*
3. *C. H. Raymond Ooi, T. C. Au-Yeung, T. K. Lim and C. H. Kam, (2000) "General electromagnetic density of modes for a one-dimensional photonic crystal", Physical Review E 62, 7405.*

Photonic bandgap structures are usually made of dielectric and had found wide applications in optics and photonics using current fabrication technology. Introducing superconductors into the structures allows the use of magnetic field and temperature to control of the dispersion of light especially in the microwave, terahertz and far infrared regimes. This work stimulated many subsequent works on using superconductors in photonic crystals. Recent development in plasmonics and metamaterials has stimulated new topics of superconducting metamaterials [1] and superconducting plasmonics as a way to reduce signal loss, Superconducting photonic bandgap structures can also be incorporated into optoelectronics and microwave devices providing potential integration of superconducting electronics with photonics devices.

1. *Jianqiang Gu et al, "Terahertz superconductor metamaterial", Applied Physics Letters 97, 071102(2010).*
2. *C. Kurter, A. P. Zhuravel, J. Abrahams, C. L. Bennett, A. V. Ustinov, and Steven M. Anlage, "Superconducting RF Metamaterials Made With Magnetically Active Planar Spirals", IEEE Transcaction on Applied Superconductivity 21, 709 (2011)*



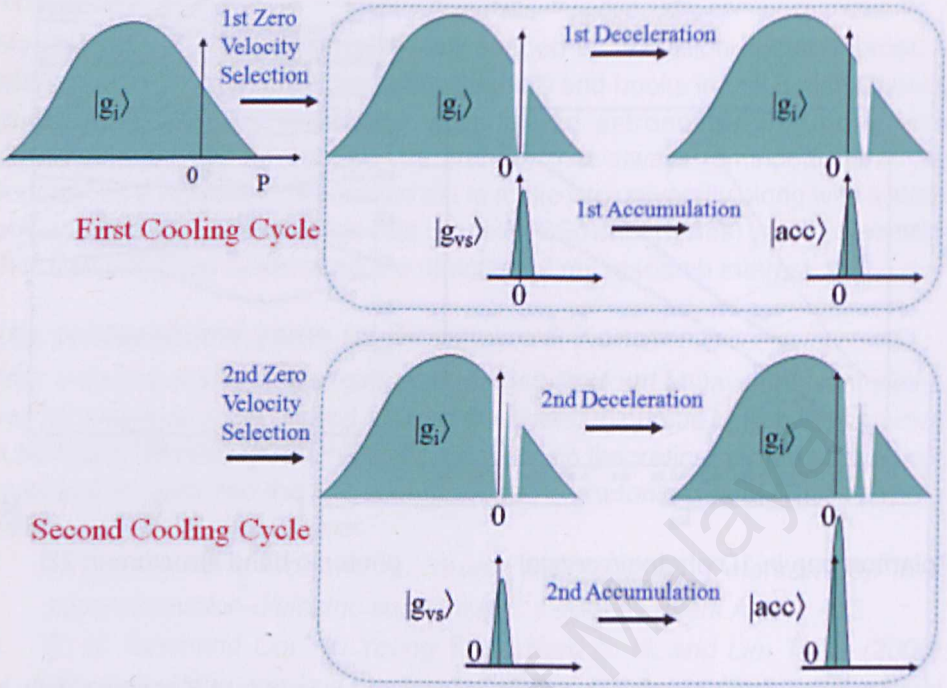
Polariton gap in 1D photonic crystal



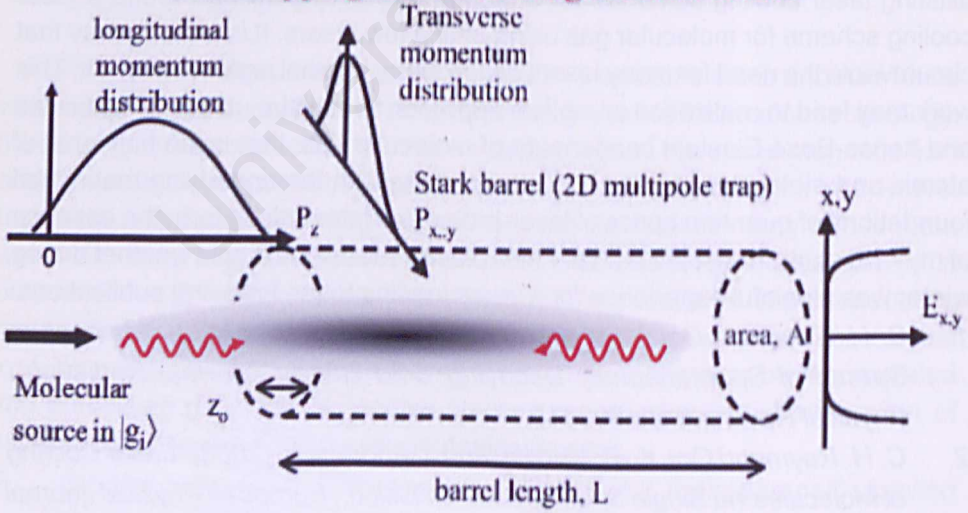
photonic band structure in 2D

My research in quantum optics started at Universitaet Konstanz with a "mission impossible" – to find a scheme to laser-cool molecules. Laser cooling techniques for atoms, which led to the 1997 Nobel Prize in physics cannot be applied to molecules due to the many quantum levels. After exploring all existing laser cooling schemes for atoms and a lot of thinking I found a laser cooling scheme for molecular gas using only a few lasers. It is a clever way that circumvents the need for many lasers on the many internal molecular levels. This work may lead to realization all-optical approach to achieve ultracold molecules and hence Bose-Einstein condensate of molecular gas, that is the holy grail of atomic and molecular physics. This work, along with the underlying theoretical foundations of quantum optics of laser-molecules interactions form the essence of my PhD study. Konstanz is a very nice place. However, the cold weather during winter was a painful experience for 3 years leading to the following publications.

1. *C. H. Raymond Ooi, K.-P. Marzlin and J. Audretsch, (2002) "Momentum Spread of Spontaneously Decaying Cold Gas in Thermal Radiation", Physical Review A 66, 063413.*
2. *C. H. Raymond Ooi, K.-P. Marzlin, and J. Audretsch, (2003) "Laser Cooling of Molecules via Single Spontaneous Emission", European Physical Journal D 22, 259.*
3. *C. H. Raymond Ooi, (2003) "Rotational cooling of polar molecules by Stark-tuned cavity resonance", Physical Review A 68, 013410.*

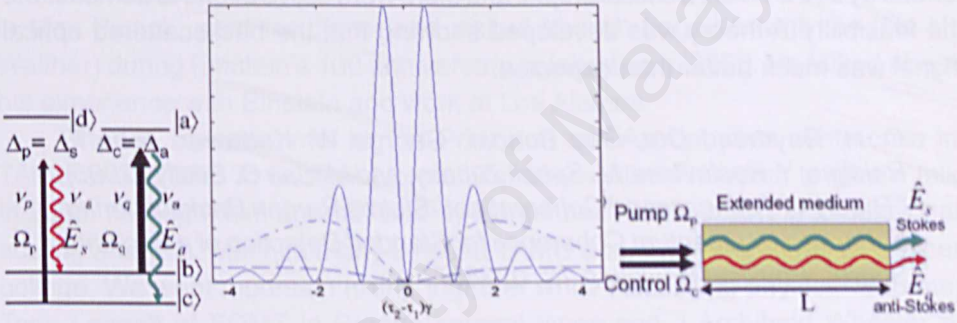


2 D trapping and 1D cooling in Stark barrel



As a postdoc in USA

I spent 3 wonderful years as a postdoc in USA working with Prof Marlan O Scully, one of the most influential and resourceful scientists in US, high h-index, now age 75. He had million-dollar grants then and we had good times doing physics, networking through workshops attended by remarkable scientists and Nobel laureates. We went to Princeton University 3-5 times a year. We worked hard, including Sat and Sunday to present results at conferences like the annual Progress in Quantum electronics at Snowbird where physics at morning and night and skiing in the afternoon. At some point, he made me his protégé, bought me a winter sweater and sent me to conferences in Russia and Mexico. His last words to me before I left him were encouraging and motivating for me to do well in science.



$$G^{(2)}(\vec{r}_1,t_1;\vec{r}_2,t_2)=\langle \hat{E}_S^-(\vec{r}_1,t_1)\hat{E}_{AS}^-(\vec{r}_2,t_2)\hat{E}_{AS}^+(\vec{r}_2,t_2)\hat{E}_S^+(\vec{r}_1,t_1)\rangle$$

We worked on several topics ranging from coherent Raman scattering from quantum particles to collective entanglement and Bose-Einstein condensate. But my main focus was on nonclassical photon correlations. We proposed the first controllable entangled photon pairs with large quantum correlation[1]. Such nonclassical property of light is useful for quantum information technology. We pioneered the study of correlated photon sources in quantum systems using the full quantum theory, the Heisenberg-Langevin formalism with noise operators and spatial propagation to compute the Glauber's correlation function $G^{(2)}$[2]. Our works shed light on the importance of noise operators and how spatial propagation and laser field affect the nonclassical photon correlation [3]. It is a challenging problem as the variables to be solved are quantum operators. We have laid the foundation for the development of intense nonclassical light and enhance the understanding of the quantum nature of light in mesoscopic quantum systems.

1. *M. O. Scully and C. H. Raymond Ooi, (2004) "Improving quantum microscopy and lithography via Raman photon pairs: II. Analysis", Journal of Optics B: Quantum Semiclassical Optics 6, S816. (becomes JOURNAL OF PHYSICS B-ATOMIC MOLECULAR AND OPTICAL PHYSICS)*
2. *C. H. Raymond Ooi, Qingqing Sun, M. Suhail Zubairy and Marlan O. Scully, (2007) "Correlation of Photon Pairs from Double Raman Amplifier: Generalized Analytical Quantum Langevin Theory", Physical Review A 75, 013820.*
3. *C. H. Raymond Ooi and M. Suhail Zubairy, (2007) "Role of noise operators on two-photon correlations in an extended coherent Raman medium", Physical Review A 75, 053822.*

The real time detection of IEDs (bombs made by terrorists) and chemicals funded by DARPA was a critical project and there were active efforts to demonstrate the feasibility. A theory was developed showing that the backscattered optical signal was much better than expected.

C. H. Raymond Ooi, Guy Beadie, George W. Kattawar, John F. Reintjes, Y. Rostovtsev, M. Suhail Zubairy, and Marlan O. Scully, (2005) "Theory of Femtosecond Coherent anti-Stokes Raman Backscattering Enhanced by Quantum Coherence for Standoff Detection of a Bacterial Spore", Physical Review A 72, 023807.

The theory has been refined to compute the coherent Raman spectra for actual molecules by incorporating the many body transform theory and information from absorption spectra.

C. H. Raymond Ooi, (2009) "Theory of coherent anti-Stokes Raman scattering (CARS) for mesoscopic particle with complex molecules: angular-dependent spectrum", Journal of Raman Spectroscopy 40, 714.

As the result of our summer visit to Max-Planck Institute for Quantenoptik hosted by Prof Herbert Walther and interesting discussions we had a paper published in the prestigious Physical Review Letters within 3 months upon submission.

Marlan O. Scully, Edward S. Fry, C. H. Raymond Ooi and Krzysztof Wodkiewicz, (2006) "Directed Spontaneous Emission from an Extended Ensemble of N Atoms: Timing is Everything", Physical Review Letters 96, 010501 (selected for the January 2006 issue of Virtual Journal of Quantum Information).

A combined expertise from previous works in laser theory applied to BEC and the inclusion of interactions in BEC with the quantum statistical approaches we had a book chapter with Nobel laureate W Ketterle.

Vitaly V. Kocharovsky, Vladimir V. Kocharovsky, Martin Holthaus, C. H. Raymond Ooi, Anatoly Svidzinsky, Wolfgang Ketterle, and Marlan O. Scully, (2006) "Fluctuations in Ideal and Interacting Bose-Einstein Condensates: From the laser phase transition analogy to squeezed state mathematics applied to Bogoliubov quasiparticles", Advances in Atomic, Molecular and Optical Physics 53, 291.

Close Encounters with Nobel Laureates

While we have to pay and applied to Lindau every year to interact with Nobel laureates, I had multiple opportunities to meet many of them while in USA.

Roy Glauber- first met him in Casper summer workshop in 2003 and then in Max Planck, went for dinner and visited Munich (together with the late H. Walther) during Einstein's 100 anniversary celebration in 2005. He talked about his experience with Einstein and work at Los Alamos.

Charles Townes - met him at Princeton and Astrophysics conference in TAMU and ICORS in Boston. Normal Ramsey visited Princeton to give a talk in 2003. I brought him around. Dudley Herschbach is an expert in dimensional scaling analysis. Met him many times at TAMU & summer workshop at Casper college. We went mountain hiking together while discussing physics. Also met Tony Leggett at FQMT in Prague several times and J Archibald Wheeler at Wheeler fest near Princeton.

In Korea

At the end of my J1 visa tenure, I was offered a research position at KAIST, Daejeon. During this time I explored the effects of dipole-dipole interactions in two-particle systems on photon correlations and wrote a number of single authored papers collaborating with a quantum optics group.

C. H. Raymond Ooi, (2007) "Quenching the Effects of Dipole-dipole Interaction on Two-Photon Correlation from Two Double-Raman Atoms", Physical Review A 75, 043817.

C. H. Raymond Ooi, Byung-Gyu Kim and Hai-Woong Lee, (2007) "Coherent Effects on Two-Photon Correlation and Directional Emission of Two Two-level Atoms", Physical Review A 75, 063801

I joined Korea University as Assistant Professor with teaching duties. At this time, I found an exact method to compute the photon correlation driven by arbitrary laser pulses.

C. H. Raymond Ooi, (2008) "Effects of Chirped Laser Pulses on Nonclassical Correlation and Entanglement of Photon Pairs from Single Atom", Physical Review A 77, 063805. (selected for June 2008 issue of Virtual Journal of Quantum Information)

I also proposed an idea to control the directional flow of light and showed that the device and function like an optical transistor.

C. H. Raymond Ooi, (2008) "Controlling Irreversibility and Directional Flow of Light with Atomic Motion: Optical Transistor and Quantum Velocimeter", New Journal of Physics 10, 123024.

During my stay in Korea, I expanded my research to intense laser science through participating of Asien Intense Laser Science (ASILS) workshops. This has led me to propose a scheme to produce superintense laser fields.

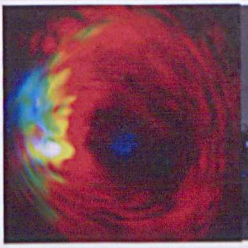
C. H. Raymond Ooi, (2010) "Superintense Laser Fields from Multiple Laser Pulses Retro-reflected in Circular Geometry", Journal of Applied Physics, 107, 043110

C. H. Raymond Ooi and T. Y. Tou, (2010) "Superintense Laser Fields Circular Array: Effects of Phase and Pulse Jitters", Applied Physics B 101, 825.

Back in Malaysia

I decided to return to Malaysia to develop the exciting laser science and quantum photonics research as I realized that these fields are lacking and would like to do something to develop my own country.

I was at Monash University (Sunway) shortly before joining University of Malaya. Through the High Impact Research (HIR) Grant from the Ministry of Education that was spearheaded by Tan Sri Dr Ghauth Jasmon and managed by Prof Dato' Dr Lam Sai Kit, I develop the Quantum and Laser Science (QLS) group with a lab equipped with the most advanced laser, the Ti:Sa femtosecond laser with amplifier for quantum nonlinear optics experiments. The QLS group conducts cutting-edge research, the first of its kind in Malaysia, strive for world-class research and publications in high impact journals.



Filamentation of focused ultrashort laser pulses

Modulation of femtosecond laser pulses

Our research topics have significant impact on the advancement of quantum and photon science, and will contribute to the development of new technologies that are futuristic and surprisingly magical in years ahead. These areas of research have been actively pursued in all developed countries, but have only been significantly initiated in Malaysia until recently. Our collaborators are scientists from USA, Korea, China, Japan and India. Facilities for experimental works such as the latest femtosecond laser system and high resolution spectroscopy are being set up. It will enhance the quality of research by having both experimental with theory results that complement each other. We worked very hard to meet the targeted number of papers and to drive UM to top 100 in QS ranking.

In 2013, I won the Malaysian Toray Science Foundation (MTSF) Science and Technology Award. The award was given for my seminal works on quantum optics, laser and molecular physics, and photonic materials, in particular, for the development of theoretical framework to study nonclassical photons, for pioneering a laser cooling technique for molecular gas, and for introducing a new class of artificially engineered photonic materials using superconductors. This was a significant moment. It provides motivation for me to excel further.

Acknowledgements

I am very thankful to my beloved late mother (passed away in Oct 2014) for nurturing me well, my father for struggling to support a big family through a small business, and my late grandmother who set me on the path of education. May God bless them and they get the share of all the good merits I earn.

I thank all my supervisors and mentors for their guidance, support and time. I thank my students and postdocs who have contributed to my research. I also thank helpful colleagues in HIR, department of physics and several staff and friends in University Malaya.

Unlimited Future

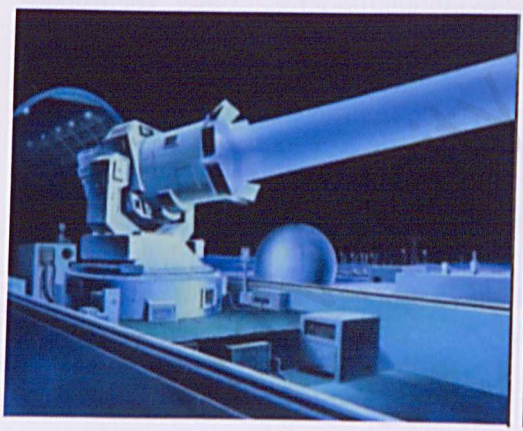
Superadvanced science, technology and civilization start from freeing the mind. Who cares what we believe as long as we keep our sanity through reasoning, universal virtues and respect for Nature. It will become increasingly clear that we are not the most advanced civilization and therefore we must open our mind to the unlimited, exciting and marvellous possibilities to progress scientifically as well as spiritually.

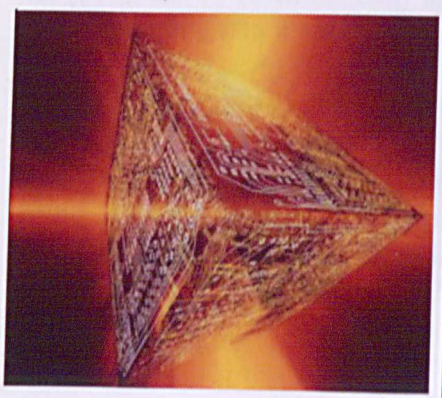
Most importantly is not to play God, not to act as if we can make ultimate judgement of what is right and what is wrong and what is not possible, and not to imprison ourselves and other living beings with fixed norms.

He who thinks he knows is not learned –https://sites.google.com/site/qtmphoton/philosophy

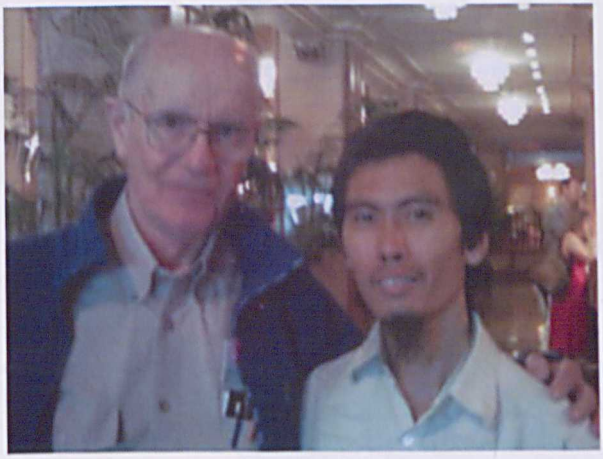
My website: https://sites.google.com/site/qtmphoton/

Inspiring Photos





Memorable Photos

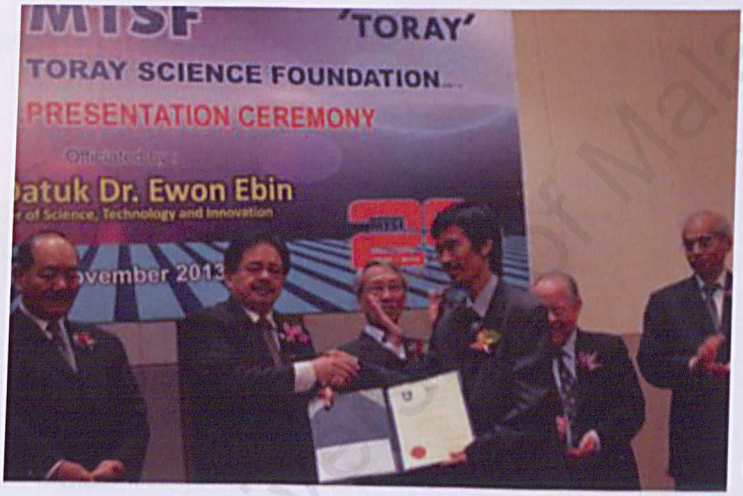


Me and MO Scully

Me and R Glauber (Nobel physics 2015)

Pankaj, D Herschbach (Nobel chemistry), Me, Anatoly, students

Me, Rasat and Ogawa group visit



MTSF award with Minister

Me and PhD Students

EDUCATION

- Dr. rer. nat. (Doctor of Natural Science): March 2000-June 2003
  Universitaet Konstanz, Konstanz, Germany

- Master of Engineering (Photonics): October 1998 - November 1999
  Nanyang Technological University, Singapore

- Bachelor of Science, 2nd Upper Hons (Physics): July 1993-April 1997
  Universiti Sains Malaysia

GRANTS (>150k per year as PI)

1. Exploratory Research Grant Scheme (ERGS) by MoHE: RM110,000 (24 Aug 2011-25 Aug 2013) – Quantum correlations of photons at high intensity for subwavelength resolution (as PI)

2. High Impact Research (HIR) by MoHE : RM2.7 million (4 Jul 2011-3 July2015)- Quantum and Laser Science (as PI)

3. High Impact Research (HIR) by MoHE : RM234,000 (15 Mar 2011) - Generation of Novel Light Sources by Nonlinear Frequency Conversions (as PI)

4. Fundamental Research Grant Scheme (FRGS) by MoHE: RM36,000 (1 Oct 2010-30 Sep 2012) - Generation of Nonclassical Light from Low Dimensional Structures (as PI)

5. University of Malaya Research Grant (UMRG): RM56k, RM26k (1 May 2010-30 Apr 2011-30 Apr 2012) - Novel Properties of Light in Photonic Structures (as PI)

6. Monash University internal (seeding) grant: RM23, 000 (June 2008- June 2009) - Novel Properties of Light in Artificially Engineered Structures (as PI)

7. Korean Research Foundation 2008 Junior Research Grant (KRW22 million) -Nonclassical Correlation of Photon Pairs at High Intensity (as PI)

AWARDS AND RECOGNITIONS

a) Malaysia Toray Science Foundation (MTSF) Science & Technology Award 2013
b) Marquis Who's Who in the World 2012 edition
c) Marquis Who's Who in the World 2009 edition
d) Distinguished Research Prize (March 2007): Department of Physics, KAIST.

COMPLETED SUPERVISIONS
(chronologically, 1 PhD & 1 Master)

Completed PhD studies :

1.	Lee Su-Yong	(2009, KAIST)	co-supervised (partial)
2.	Eyob A Sete	(2012, Texas A&M University)	co-supervised
3.	Pankaj K. Jha	(2012, Texas A&M University)	co-supervised
4.	Nor Hazmin	(2013, UM)	Individual
5.	Lee Choo Yong	(2013, UM)	Individual
6.	Ho Wai Loon	(2014, UM)	Individual

Completed Master studies :

1.	Kim Byung-Gyu	(2008 KAIST)	co-supervised
2.	Higa Ryota	(2012, Osaka)	co-supervised
3.	Nurul Diyana	(2012, UM, course+research)	Individual
4.	Tan Kai Shuen	(2013, UM)	Individual
5.	Low Ka Chun	(2013, UM)	Individual
6.	Seow Pohchoo	(2013, UM	Individual
7.	Aini Syahida bt Sumairi	(2013, UM)	Individual
8.	Khoo Yee Yang	(2013, UM)	Individual

Completed Final Year Projects :

a) 3 final year (2009, Monash University) - Tan Joo Khong, Ng Kin Fei, Yong Hao Zhi
b) 2 final year (2011, UM) - Moosa Shafiu, Ho Wai Loon
c) 2 final year (2013, UM) – Tiong Teck Sen, Lee Say Hoe
d) 2 trainee teachers (B.Eds.)

Ongoing (6 PhD)

1. Ng Kam Seng - Space-time metric warped by intense laser field

2. Davoud Ghodsi – Path integral approach to nanophotonics
3. Faisal Mathkoor- Quantum Correlation in Two-Photon Laser
4. Mohd Ridzuan – Imaging and holography of particles
5. Mohsen Amirmojahedi – Optical techniques for detection of scouring
6. Loh Wai Ming - Nonlinear Laser Spectroscopy of Quantum Plasmonics/ High Index Microparticles
7. Toh Lee Roy - Atoms and molecules in laser fields combining HF, TDDFT, Transform Theory.
8. Pang Harn Fung - Quantum Coherence in Entanglement and Microscopy
9. Wong Wen Wei - Ultrashort Laser Pulses Propagation & Quantum Interactions with Matter
10. Ahmed Nadi - Intense nonclassical light source (subw qtm mic & qtm litho)

*Kaizen (applying) - The interaction of photons with superconducting materials and Bose-Einstein Condensate of Polaritons
*Postpone: Yap Chee Kian-Ultra-high intensity laser nonlinear interaction with vacuum

UNDERGRADUATE COURSES

At University of Malaya (CTES > 3.5/5)

Session 2012/2013
Physics Of Atoms And Molecules (SMES3202) Semesters 1 & 2- Lectures

Session 2012/2013
Advanced Mathematical Methods (SMES3303) Semester 3- Lectures
Physics Of Atoms And Molecules (SMES3202) Semesters 1 & 2- Lectures
Basic Of Forces (SMES1502) Semester 1 - Tutorials

Session 2011/2012
Quantum Mechanics(SMES2201) Semester 2 - Tutorials
Basic Mathematical Methods (SMES1102) Semester 2 - Lectures and Tutorial
Basic Mathematical Methods (SMES1102) Semester 1 - Tutorials

Session 2010/2011
Thermal Physics(SMES1202) 2010/2011 Semester 2 - Lectures and Tutorials
Thermal Physics(SMES1202) 2010/2011 Semester 1 - Lectures and Tutorials

Session 2009/2010
Instrumentation (SMES2209) 2009/2010 Semester 2 - Lectures and Tutorials

At Monash University (Sunway)

Session Feb - July 2009
Advanced Engineering Mathematics A (ENG2091) - Lectures and Tutorials
Optimization, Estimation and Numerical Methods (ENG3093) - Lectures and Tutorials

Session July - Nov 2009
Advanced Engineering Mathematics B (ENG2092), - Lectures and Tutorials
Optimization, Estimation and Numerical Methods (ENG3093) - Lectures and Tutorials

At Korea University

September 2008- December 2008
General Physics (undergraduate level)
Atomic Spectroscopy (graduate level).

March 2008- June 2008
General Physics (undergraduate level)
Special topics of atomic physics (graduate level).

September 2007- December 2007
General Physics (undergraduate level)
Atomic Spectroscopy (graduate level).

At KAIST

March 2006- June 2007
Lasers and Quantum Optics (graduate level).

September 2006- December 2007
Nonlinear optics (graduate level),

PROFESSIONAL PROFILE

- **Associate Professor:** 8 Feb 2010-now
  University of Malaya, Malaysia
  Thermal Physics, Instrumentation, Quantum Mechanics, Basic Maths, Physics of atoms and molecules, Advanced Mathematical Methods

- Visiting Prof/Fellow at NTU 2014, 2015.

- **Visiting Research Scientist:** 7 June-6 July 2011
  School of Physics, Peking University
  State Key Laboratory for Artificial Microstructure & Mesoscopic Physics

- **Visiting Research Scientist:** Nov-Dec 2009
  Nanyang Technological University, Singapore
  Research collaboration at School of Electrical and Electronic Engineering

- **Senior Lecturer (C1, top level):** 2 January 2009-7 February 2010
  Monash University, Malaysia (Sunway Campus)
  Advanced Engineering Mathematics A and B
  Optimization, Estimation and Numerical Methods

- **Assistant Professor:** 1 September 2007-1 January 2009
  Korea University
  General Physics (undergraduate level), Atomic Spectroscopy (graduate level).
  Service: member of organizing committee for a conference (http://newton.kias.re.kr/aqis08/)

- **Research Professor:** 15 September 2006-31 August 2007
  Korea Advanced Institute of Science and Technology (KAIST)
  Nonlinear optics (graduate level), Lasers and Quantum Optics (graduate level).

- **Postdoctoral Research Associate:** 26 June 2003-25 June 2006
  Institute for Quantum Studies, Department of Physics, Texas A&M University, USA
  Service: presented in conferences, helped organize workshops, contributed to grant proposals.

- **Visiting Scientist:** summer 2004, 2005 and 12 July 2006-1 September 2006
  Max-Planck Institute for Quantum Optics, Garching, Germany
  Research collaboration with host, local scientists and visiting scientists.

- **Visiting Research Associate:** 18 September 2003-1 January 2004
  Frick Laboratory, Chemistry Department, Princeton University, USA
  Research on quantum correlation, tutor for graduate students, helped organize seminars by distinguished guests and Nobel laureates.

- **Research Assistant (Mitarbeiter):** March 2000-June 2003
  Universitaet Konstanz, Germany (Theoretical Quantum Optics Group)
  Project: Laser cooling schemes for molecules
  Teaching duties: Gave tutorials to undergraduate students.

PROFESSIONAL MEMBERSHIPS

a) Member: Optical Society of America (OSA)
b) Member: Institute of Physics, Malaysia (MIFM)
c) Council Committee Member: Institute of Physics, Malaysia (IFM)
d) Member: YSN-ASM member,
e) National Science Challenge committee, PISA exhibition

UNIVERSITY SERVICES

a) Think Tank committee, Global Planning and Strategic Centre (PPSG) : 2011-2013
b) Academic Staff Selection Committee (JPCSA): 2011-2015
c) Faculty of Science Research Committee member : 2011-12
d) Quality Manager, Department of Physics : 2011-12
e) Committee member for Research/Publication/Consultation, Department of Physics: 2012-13
f) Committee member for E-Learning, Department of Physics: 2012-13
g) Mentor/Advisor for Chinese Cultural Arts Society: 2013-14

PROFESSIONAL SERVICES

a) Editor: Central European Journal of Physics (http://www.versita.com/science/physics/cejp/)
b) Chief Editor of Jurnal Fizik Malaysia, Institute of Physics Malaysia: 2011-2013
c) Referee for Q1 journals-Applied Physics Letters, Physical Review Letter, Physical Review A, Physical Review B, Physical Review E, Journal of Optics
d) Referee for Q2 and Q3 journals- IEEE, European Physical Journal D, Optics Communications

CONTRIBUTIONS TO SOCIETY

a) Secretary: International Meeting on Frontier of Physics (IMFP 2013)
b) Organizing committee: Asia Pacific Conference and Workshop on Quantum Information Science (APCWQIS 2012)
c) Organizing committee: National Physics Conference (PERFIK 2010)
d) Organizing committee: Asian Conference on Quantum Information Science(AQIS 2008)

RESEARCH PUBLICATIONS (KPI: >3 ISI per year)

(from Web of Science)
h-index=11
503 citations
73 ISI journal papers
14 Conference papers
20 Invited talks

A. Journal papers

1) C. H. Raymond Ooi and Au Yeung T. C., (1999) "Polariton gap in a superconductor–dielectric superlattice", Physics Letters A 259, 413.
Q2, IF=2.17 18 citations

2) C. H. Raymond Ooi, Au Yeung T. C., Kam C. H. and Lim T. K., (2000) "Photonic band gap in a superconductor-dielectric superlattice", Physical Review B 61, 5920
Q1, IF= 3.77 42 citations

3) C. H. Raymond Ooi, T. C. Au-Yeung, T. K. Lim and C. H. Kam, (2000) "General electromagnetic density of modes for a one-dimensional photonic crystal", Physical Review E 62, 7405.
Q1, IF= 2.50

4) C. H. Raymond Ooi, K.-P. Marzlin and J. Audretsch, (2002) "Momentum Spread of Spontaneously Decaying Cold Gas in Thermal Radiation", Physical Review A 66, 063413.
Q1, IF=2.91

5) C. H. Raymond Ooi, K.-P. Marzlin, and J. Audretsch, (2003) "Laser Cooling of Molecules via Single Spontaneous Emission", European Physical Journal D 22, 259.
Q2, IF= 1.476

6) C. H. Raymond Ooi, (2003) "Rotational cooling of polar molecules by Stark-tuned cavity resonance", Physical Review A 68, 013410.
Q1, IF=2.91

7) M. O. Scully and C. H. Raymond Ooi, (2004) "Improving quantum microscopy and lithography via Raman photon pairs: II. Analysis", Journal of Optics B: Quantum Semiclassical Optics 6, S816. (becomes JOURNAL OF PHYSICS B-ATOMIC MOLECULAR AND OPTICAL PHYSICS)
Q2, IF=2.09 27 citations

2005

8) C. H. Raymond Ooi, Guy Beadie, George W. Kattawar, John F. Reintjes, Y. Rostovtsev, M. Suhail Zubairy, and Marlan O. Scully, (2005) "Theory of Femtosecond Coherent anti-Stokes Raman Backscattering Enhanced by Quantum Coherence for Standoff Detection of a Bacterial Spore", Physical Review A 72, 023807.
Q1, IF=2.91 11 citations

9) Anil K. Patnaik, C.H. Raymond Ooi, Yuri Rostovtsev and Marlan O. Scully, (2005) "Injection time effects on lasing without inversion with microwave driven non-degenerate ground states", Physica E 29, 111.
Q3, IF=1.53

10) Anil K. Patnaik, Girish S. Agarwal, C. H. Raymond Ooi and Marlan O. Scully, (2005) "Quantum correlations between a pair of Raman photons from single atom under arbitrary excitation condition", Physical Review A 72, 043811.
Q1, IF=2.91

2006

11) Marlan O. Scully, Edward S. Fry, C. H. Raymond Ooi and Krzysztof Wodkiewicz, (2006) "Directed Spontaneous Emission from an Extended Ensemble of N Atoms: Timing is Everything", Physical Review Letters 96, 010501 (selected for the January 2006 issue of Virtual Journal of Quantum Information).
Q1, IF=7.62 90 citations

12) Z. Deng, D.-K. Qing, P. R. Hemmer, C. H. Raymond Ooi, M. S. Zubairy, and Marlan O. Scully, (2006) "Time-Bandwidth Problem in Room Temperature Slow Light", Physical Review Letters 96, 023602.
Q1, IF=7.62 25 citations

13) Vitaly V. Kocharovsky, Vladimir V. Kocharovsky, Martin Holthaus, C. H. Raymond Ooi, Anatoly Svidzinsky, Wolfgang Ketterle, and Marlan O. Scully, (2006) "Fluctuations in Ideal and Interacting Bose-Einstein Condensates: From the laser phase transition analogy to squeezed state mathematics applied to Bogoliubov quasiparticles", Advances in Atomic, Molecular and Optical Physics 53, 291.
Q1, IF=4.95 36 citations

14) A. N. Jordan, C. H. Raymond Ooi, and A. Svidzinsky, (2006) "Fluctuation statistics of Bose-Einstein condensation: reconciling the master equation with the partition function to revisit the Uhlenbeck-Einstein dilemma", Physical Review A 74, 032506.
Q1, IF=2.91

2007

15) C. H. Raymond Ooi, Qingqing Sun, M. Suhail Zubairy and Marlan O. Scully, (2007) "Correlation of Photon Pairs from Double Raman Amplifier: Generalized Analytical Quantum Langevin Theory", Physical Review A 75, 013820.
Q1, IF=2.91 19 citations

16) C. H. Raymond Ooi, (2007) "Effects of Spontaneously Generated Coherence on Two-Photon Correlation in a Double-Cascade Scheme", Physical Review A 75, 043818.
Q1, IF=2.91

17) C. H. Raymond Ooi, (2007) "Quenching the Effects of Dipole-dipole Interaction on Two-Photon Correlation from Two Double-Raman Atoms", Physical Review A 75, 043817.
Q1, IF=2.91

18) C. H. Raymond Ooi, Byung-Gyu Kim and Hai-Woong Lee, (2007) "Coherent Effects on Two-Photon Correlation and Directional Emission of Two Two-level Atoms", Physical Review A 75, 063801
Q1, IF=2.91

19) C. H. Raymond Ooi, Y. Rostovtsev, and M. O. Scully, (2007) "Two-Photon Correlation of Radiation Emitted by Two Excited Atoms: Detailed Analysis of a Dicke Problem", Laser Physics 17, 956 (in the Memory of Professor Herbert Walther).
Q1, IF=3.60

20) C. H. Raymond Ooi, (2007) "Continuous source of phase-controlled entangled two-photon laser", Physical Review A 76, 013809. (selected for the July 2007 issue of Virtual Journal of Quantum Information)
Q1, IF=2.91 13 citations

21) C. H. Raymond Ooi and M. Suhail Zubairy, (2007) "Role of noise operators on two-photon correlations in an extended coherent Raman medium", Physical Review A 75, 053822. (selected for the June 2007 issue of Virtual Journal of Quantum Information)
Q1, IF=2.91

22) C. H. Raymond Ooi and Marlan O. Scully, (2007) "Two-photon Correlation of Cascade Amplifier: Propagation Effects via Constant Gain or Loss and Limitation of Semiclassical Noiseless Theory", Physical Review A 76, 043822.
Q1, IF=2.91

2008

23) C. H. Raymond Ooi, (2008) "Extended Photon Correlation in Negative Temperature Medium", Physical Review A 77, 053820. (selected for June 2008 issue of Virtual Journal of Quantum Information)
Q1, IF=2.91

24) C. H. Raymond Ooi, (2008) "Effects of Chirped Laser Pulses on Nonclassical Correlation and Entanglement of Photon Pairs from Single Atom", Physical Review A 77, 063805. (selected for June 2008 issue of Virtual Journal of Quantum Information)
Q1, IF=2.91

25) C. H. Raymond Ooi, (2008) "Controlling Irreversibility and Directional Flow of Light with Atomic Motion: Optical Transistor and Quantum Velocimeter", New Journal of Physics 10, 123024.
Q1, IF=4.18

2009

26) C. H. Raymond Ooi, (2009) "Theory of coherent anti-Stokes Raman scattering (CARS) for mesoscopic particle with complex molecules: angular-dependent spectrum", Journal of Raman Spectroscopy 40, 714.
Q1, IF=3.53

27) Byung-Gyu Kim, C. H. Raymond Ooi, Manzoor Ikram and Hai-Woong Lee, (2009) "Directional Property of Radiation Emitted from Entangled Atoms", Physics Letters A 373, 1658.
Q2, IF=2.17

28) Su-Yong Lee, Jiyong Park, Se-Wan Ji, C.H. Raymond Ooi and Hai-Woong Lee, (2009) "Nonclassicality generated by photon annihilation-then-creation and creation-then-annihilation operations", Journal of the Optical Society of America B 26, 1532.
Q1, IF=2.18

2010(7)

29) C. H. Raymond Ooi and P. R. Berman, (2010) "Preservation of Bosonic commutation relation: Explicit evaluation of quantum Langevin operator products", Physica E 42, 407.
Q3, IF=1.53

30) C. H. Raymond Ooi and Chan Hin Kam, (2010) "Echo and Ringing of Optical Pulse in Finite Photonic Crystal with Superconductor and Dispersive Dielectric", Journal of Optical Society of America B 27, 458.
Q1, IF=2.18

31) C. H. Raymond Ooi, (2010) "Superintense Laser Fields from Multiple Laser Pulses Retro-reflected in Circular Geometry", Journal of Applied Physics, 107, 043110.
Q1, IF=2.20

32) C. H. Raymond Ooi and Chan Hin Kam, (2010) "Controlling quantum resonances in photonic crystals and thin films with electromagnetically induced transparency", Physical Review B 81, 195119.
Q1, IF=3.77

33) C. H. Raymond Ooi and B. L. Lan, (2010) "Nonclassical Two-Photon Talbot Effect from Arrayed Double-Raman Emitters", Physical Review A 81, 063832.
Q1, IF=2.91

34) C. H. Raymond Ooi and T. Y. Tou, (2010) "Superintense Laser Fields Circular Array: Effects of Phase and Pulse Jitters", Applied Physics B 101, 825.
Q1, IF=2.28

35) C. H. Raymond Ooi, (2010) "Laser Cooling of Molecules by Zero Velocity Selection and Single Spontaneous Emission", Physical Review A 82, 053408.
Q1, IF=2.91

2011(8)

36) C H Raymond Ooi, S W Harun, Harith Ahmad, (2011) "Quantum Coherence Effects in Raman Amplifier", Journal of Modern Optics 58, 11.
Q3, IF=1.17

37) C H Raymond Ooi, (2011) "Conversion of heat to light using Townes' maser-laser engine: Quantum optics and thermodynamic analysis", Physical Review A 83, 043838.
Q1, IF=2.91

38) C. H. Raymond Ooi, (2011) "Near-Field and Particle Size Effects in Nonlinear Optical Scattering", Progress in Electromagnetics Research (PIER) 117, 479.
Q1, IF=5.30

39) C. H. Raymond Ooi and Qihuang Gong, (2011) "Temperature dependent resonances in superconductor photonic crystal", Journal of Applied Physics 110, 063513.
Q1, IF=2.20

40) R. P. Chen and C. H. Raymond Ooi, (2011) "Evolution and Collapse of a Lorentz Beam in Kerr medium", Progress in Electromagnetics Research (PIER) 121, 39-52.
Q1, IF=5.30

41) R. P. Chen and C. H. Raymond, (2011) "Nonclassicality of vortex Airy beams in Wigner representation", Physical Review A 84, 043846
Q1, IF=2.91

42) C. H. Raymond Ooi, (2011) "Exact Transient Photon Correlation with Arbitrary Laser Pulses", Physical Review A 84, 053842.
Q1, IF=2.91

43) P. R. Berman and C. H. Raymond Ooi, (2011) "Single-photon pulse propagation in and into a medium of two-level atoms: Microscopic Fresnel equations", Physical Review A 84, 063851.
Q1, IF=2.91

2012(9)

44) C. H. Raymond Ooi and Qihuang Gong, (2012) "Nonclassical photon correlations nanoparticle in microcavity", Physical Review A 85, 023803.
Q1, IF=2.91

45) Eyob A. Sete and C. H. Raymond Ooi, (2012) "Continuous-variable entanglement and two-mode squeezing in a single-atom Raman laser", Physical Review A 85, 063819.
Q1, IF=2.91

46) Sudha Singh, C. H. Raymond Ooi and Amrita, (2012) "Dynamics for two atoms interacting with intensity-dependent two-mode quantized cavity fields in the ladder configuration", Physical Review A 86, 023810.
Q1, IF=2.91

47) C. H. Raymond Ooi, WaiLoon Ho and A. D. Bandrauk, (2012) "Photoionization spectra by intense linear, circular and elliptic polarization laser pulses", Physical Review A 86, 023410.
Q1, IF=2.91

48) C. H. Raymond Ooi, K. C. Low, Ryota Higa and Tetsuo Ogawa, (2012) "Surface Polaritons with Arbitrary Magnetic and Dielectric Materials: New Regimes, Effects of Negative Index and Superconductors," Journal of Optical Society of America B 29, 2691.
Q1, IF=2.18

49) S. Abdel Khalek, K. Berrada, and C. H. Raymond Ooi, (2012) "Beam Splitter Entangler for Nonlinear Bosonic Fields", Laser Physics 22, 1449.
Q1, IF=3.60

50) K. Berrada, Abdel Khalek and C. H. Raymond Ooi, (2012) "Quantum metrology with binomial coherent states of a single mode field", Physical Review A 86, 033823.
Q1, IF=2.91

51) P. R. Berman and C. H. Raymond Ooi, (2012) "Pulse propagation in a medium of Λ-type atoms", Physical Review A 86, 053812.
Q1, IF=2.91

52) C. H. Raymond Ooi and Y. Y. Khoo, (2012) "Controlling the repulsive Casimir force with the optical Kerr effect", Physical Review A 86, 062509.
Q1, IF=2.91

2013 (9+3)

53) C. H. Raymond Ooi, S. N. Hazmin and Sudha Singh, (2013) "Nonclassical dynamics with time- and intensity-dependent coupling", Quantum Information Processing 12, 2103–2120
Q1, IF=2.08

54) K S Ng and C H Raymond Ooi, (2013) "Gravitational Force of Bessel Light Beam", Laser Physics 23, 035003.
Q1, IF=3.60

55) Biswajit Sen, Sandip Kumar Giri, Swapan Mandal, C. H. Raymond Ooi, and Anirban Pathak, (2013) "Intermodal entanglement in Raman processes", Physical Review A 87, 022325.
Q1, IF=2.91

56) C. H. Raymond Ooi and Tan Kai Shuen, (2013) "Controlling Double Quantum Coherence and Electromagnetic Induced Transparency with Plasmonic Metallic Nanoparticle", Plasmonics 8, 891–898
Q1, IF=3.72

57) Pankaj K. Jha, C. Y. Lee and C. H. Raymond Ooi, (2013) "Controlling laser spectra in a phaseonium photonic crystal using maser", Appl. Phys. B 112, 115–121
Q1, IF=2.28

58) C. H. Raymond Ooi and Choo Yong Lee, (2013) "Ultrashort pulse propagation and nonlinear frequency conversion in superconducting and magnetic photonic crystal", Appl. Phys. B 112, 193–201
Q1, IF=2.28

59) C H Raymond Ooi and Choo Yong Lee, (2013) "Nonlinear photonic crystal: effects of negative refractive indices and dispersion in the resonant region", Journal of Optics. 15, 055102.
Q2, IF=1.573

60) K. Berrada, S. Abdel Khalek and C. H. Raymond Ooi, (2013) "Geometric phase and entanglement for a single qubit interacting with deformed-states superposition", Quantum Information Processing 12, 2177.
Q1, IF=2.08

61) C. H. Raymond Ooi, Wai-Loon Ho and P. Seow, (2013) "Orientation Dependent Coherent Anti-Stokes Raman Scattering (CARS) of Cylindrical Microparticle with Paraxial Focused Lasers", Journal of Optical Society of America B 30, 2427-2435.
Q1, IF=2.18

62) AiniSyahida Sumairi, S.N. Hazmin & C.H. Raymond Ooi (2013), "Quantum Entanglement Criteria", Journal of Modern Optics 60, 589–597.
Q3, IF=1.16

63) Zheng, H-P; Chen, R-P; Ooi, C. H. R. (2013), "Self-focusing Dynamics of Lorentz-Gaussian Beams in Kerr Media", Lasers in Engineering 24, 345-354.
Q4, IF=0.47

64) Jalal Rouhi, Shahrom Mahmud, Nima Naderi, CH Raymond Ooi and Mohamad Rusop Mahmood (2013), "Physical properties of fish gelatin-based bio-nanocomposite films incorporated with ZnO nanorods", Nanoscale Research Letters 8, 364
Q1, IF=2.52

YY Khoo & CHR Ooi, Casimir Force Control with Optical Kerr Effect, (Sains Malaysiana)

2014

65) Sandip Kumar Giri, Biswajit Sen, C H Raymond Ooi and Anirban Pathak, Single mode and intermodal higher order nonclassicalities in two-mode Bose-Einstein condensates, Physical Review A 89, 033628 (2014).

66) G. Davoud and C H R Ooi, Modeling of temperature-dependent shift of photoluminescence peak of In(Ga)As quantum dots considering acoustic and optical phonons as two oscillators - Journal of Optical Society of America B (2014)

68) P R Berman and CHR Ooi, Collapse and revivals in the Jaynes-Cummings model: An analysis based on the Mollow transformation, Physical Review A 89, 033845 (2014)

69) Jalal Rouhi, M. Alimanesh, R. Dalvand, C. H. Raymond Ooi, S. Mahmud, M. Rusop Mahmood, Optical properties of well-aligned ZnO nanostructure arrays synthesized by an electric field-assisted aqueous solution method, Ceramics International 40 11193–11198 (2014)

70) J. Rouhi, M. Alimanesh , S. Mahmud, R.A. Dalvand , C.H. Raymond Ooi, M. Rusop, A novel method for synthesis of well-aligned hexagonal cone-shaped ZnO nanostructures in field emission applications, Materials Letters 125, 147–150 (2014)

71) CHR Ooi, W L Ho & A D Bandrauk - Photoelectron angular distributions of excited atoms in intense laser fields, Phys Rev. A 90, 013417 (2014)

72) S. K. Singh and C. H. Raymond Ooi, Quantum Correlations of Quadratic Optomechanical Oscillator, J. Opt. Soc. Am. B 31, 2390 (2014).

73) E. Sete and CHR Ooi, Manuscript: 214305 Light-to-matter entanglement transfer in optomechanics, JOSA B 31, 2821(2014)

B. Conference Proceedings

1) "Two-dimensional superconductor dielectric photonic crystal", C. H. Raymond Ooi, Au Yeung T. C., Lim T. K. and Kam C. H., Photonics Technology into the 21st Century: Semiconductors, Microstructures, and Nanostructures, **Proceedings of the SPIE Volume: 3899**, 278 (1999).

2) "Crosstalk noise suppression in slow light for time-bandwidth product", De-Kui Qing, Z. Deng, C. H. Raymond Ooi, P. R. Hemmer, and Marlan O. Scully, **Proceedings of the SPIE Volume: 5842**, 282 (2005).

3) "Two-Photon Correlation of Photon Pairs: Near Field and Polarization Effects", C. H. Raymond Ooi, Anil K. Patnaik and Marlan O. Scully, Noise and Information in Nanoelectronics, Sensors, and Standards III, **Proceedings of the SPIE Volume: 5846**, 1 (2005) (*plenary paper*).

4) "Nonclassical Correlation of Macroscopic Raman Photon Pairs", C. H. Raymond Ooi, **Proceeding of Quantum Communications and Measurement Conference** (QCMC 2006, 28 Nov. – 3 Dec 2006, Tsukuba, Japan).

5) "Directional property of radiation emitted from entangled atoms", B G Kim, C H Raymond Ooi, H W Lee, **Proceeding of Conference on Lasers and Electro-Optics/Pacific Rim 2007**, 941-942 (26-31 Aug 2007, Seoul, South Korea).

6) "Femtosecond Coherent Anti-Stokes Raman Spectroscopy (CARS) As Next Generation Nonlinear LIDAR Spectroscopy and Microscopy", C. H. Raymond Ooi, **AIP Conference Proceeding 1150,** 50-58 (Frontiers of Physics: 3rd International Meeting, Kuala Lumpur, Malaysia, 12-16 January 2009, Editor: S P Chia).

7) "Near-Field CARS with Micro- and Nano-Particle", **AIP Conference Proceedings 1267** (XXII International Conference on Raman Spectroscopy, Boston (MA), 8–10 August 2010, ISBN: 978-0-7354-0818-0, Editor(s): P. M. Champion, Northeastern University, L. D. Ziegler, Boston University).

8) "Superconducting Photonic Crystal with Nanostrips for Mid-Infrared Applications", Ooi C. H. Raymond, Malaysia Annual Physics Conference 2010 (PERFIK-2010): AIP Conference Proceedings Volume: 1328 Pages: 24-27 (2011).

9) "Quantum Thermodynamics of Photo and Solar Cells", Konstantin E. Dorfman, Kimberly R. Chapin, C. H. Raymond Ooi, Anatoly A. Svidzinsky, and Marlan O. Scully, AIP Conference Proceedings 1411, 256 (2011).

10) "Switching the negative refractive index and surface wavevector of superconducting metamaterials", C. H. Raymond Ooi and Ng Kin Fei, IEEE 2nd International Conference on Photonics, ISBN 978-1-61284-264-6, DOI: 10.1109/ICP.2011.6106814 (2011)

11) "Generalized Momentum of Tunnelling Ionization of Hydrogenic Atom in Linearly Polarized Laser", WaiLoon-Ho; C. H. Raymond Ooi, Bandrauk, A. D, IEEE, 3rd International Conference on Photonics (ICP 2012), 179-183 (2012).

12) "Nonlinear Photonic Crystal with Negative Index Materials", Choo Yong Lee; C. H. Raymond Ooi, IEEE, 3rd International Conference on Photonics (ICP 2012), 336-340 (2012).

13) "Weak Gravitational Field of Bessel Beam", Ng, K. S., Ooi, C. H. Raymond, AIP Conference Proceedings Volume: 1528, 456-460 (2013)
(National Physics Conference (PERFIK) Location: Bukit Tinggi, NOV 19-21, 2012)

14) "Surface Polariton with Arbitrary Dielectric and Magnetic Materials: New Regimes and SP Resonance in Large Frequency Range" , Low, K. C.; Ooi, C. H. Raymond, AIP Conference Proceedings Volume: 1528, 456-460 (2013)
(National Physics Conference (PERFIK) Location: Bukit Tinggi, NOV 19-21, 2012)

INVITED/PLENARY CONFERENCE TALKS

1. Quantum Optical Properties in Plasmonic System, **PERFIK 2014**, Sunway Resort, Petaling Jaya (18-19 November 2014)

2. Photon Correlation of Controllable Quantum Vacuum, **Third Saudi International Meeting on Frontiers of Physics,** Jazan University, Saudi Arabia, 18-20 Feb 2014. http://colleges.jazanu.edu.sa/sites/en/sci/physics/Pages//TSIMFP2014.aspx

3. Controlling Photon Correlations with Quantum Vacuum, **Quantum Optics Workshop 2013**, Jeju Island, S. Korea (Oct. 30~Nov. 2, 2013). http://qow.or.kr

4. Quantum Coherence with Near Field and Surface Plasmon, **International Meeting on Frontier of Physics (IMFP) 2013** (27-30 August 2013)

5. Quantum Control of Casimir Force, **7th Cross-Strait and International Conference on Quantum Manipulation**, Institute of Physics, Chinese Academy of Sciences, Beijing, China (28-30 June, 2013). http://theory.iphy.ac.cn/cascqm07/English/index.html

6. Photoionization spectra by intense lasers, **7th Asian Symposium on Intense Laser Science** (ASILS7), Hongo Campus, the University of Tokyo (8-9 November 2012). http://www.jils.jp/ASILS7/about.html

7. Laser cooling of molecules toward microKelvin, **10th Asian International Seminar on Atomic and Molecular Physics, AISAMP10**, Taipei, Taiwan (23-30 October, 2012).

8. Left-Handed Optics with Superconducting Photonic Crystals, **2nd International Conference on Photonics (ICP 2011),** Kota Kinabalu, Sabah (17-19 October 2011). http://icp2011.org/

9. Raman photonics: from coherent backscattering to nonclassical light, **TAMU/ Princeton Institute for Quantum Science and Engineering Summer School**, Jackson Hole, Wyoming, USA (24-30 July 2011). http://iqse.tamu.edu/conferences/SS2011.html

10. Transient Quantum Optics with Laser Pulses via Exact Langevin Solutions, **International Conference on Quantum Optics and Quantum Communications, ICQOQC 2011**, 24-26 March 2011, Jaypee Institute of Information Technology, Noida, India (invited, sponsored). http://www.jiit.ac.in/jiit/ICQOQC%20'11/

11. Controllable nonclassical light with high intensity from an array of emitters, **The 6-th CAS Cross-Strait and International Conference on Quantum Manipulation,** 11-12 Dec. 2010, Insitute of Physics, Chinese Academy of Sciences, Beijing, China (plenary). http://theory.iphy.ac.cn/cascqm07/English/program.html

12. Superconductor dielectric photonic crystal with nanostrips, National Physics Conference (PERFIK) 2010, Lumut, Perak, Malaysia (27-30 November 2010).

13. Role of Photonic Science and Technology on ICT in Malaysia, EU-Malaysia Trade & Investment Forum, Crowne Plaza Mutiara, Kuala Lumpur (15 April 2010).

14. Coherent Antistokes Raman Scattering (CARS) for new generation laser spectroscopy and microscopy: 3rd International Meeting on Frontiers of Physics (IMFP 2009), Awana Genting Highlands, Malaysia (12-16 January 2009). http://fizik.um.edu.my/IMFP/

15. Quantum noise and commutation relation: Member of the program Mathematical Horizons in Quantum Physics, Institute of Mathematical Sciences, National University of Singapore (28 July-21 Sep 2008). http://www.ims.nus.edu.sg/Programs/mhqp08/

16. How do pulsed lasers affect photon correlation and entanglement?: **Frontiers of Quantum and Mesoscopic Thermodynamics**, Prague, Czech Republic, (28 July - 2 August 2008). http://www.fzu.cz/activities/conferences/fqmt08/

17. Quantum correlation from quantum noise of atoms and photons in extended medium with quantum coherence: **Summer School on Quantum Optics and Molecular Physics**, Casper, Wyoming (July 15-21, 2007).

18. Physics of Excimer Laser Ablation on Cornea: 3rd Asian Symposium on Intense Laser Science (ASILS), Cameron Highlands, Malaysia (2-6 July, 2007). http://foe.mmu.edu.my/asils2007/

19. Role of quantum noise of atoms and photons on quantum correlation: KIAS-KAIST 2007 Workshop on Quantum Information Science, KIAS, Korea (25-27 June 2007). http://newton.kias.re.kr/QI/QIS2007.htm

20. **Photon Correlation in a Coherent Raman Medium:** Quantum Theory: Reconsideration of Foundations-3, Växjö University, Sweden (6-11 June, 2005) http://www.vxu.se/msi/aktuellt/konferens/quantumtheory2005.html.

RESEARCH VISITS & MEETINGS ATTENDED

1. Frontiers of Intense Laser Physics workshop at KITP: (Kavli institute for Theoretical Physics),University of California, Santa Barbara (18 Aug-12 Sept 2014)

2. Visited Swinburne University (18-20 Sep 2013) and Australian National University (16-17 Sep 2013)

3. Visited Center for Quantum Technologies, Faculty of Science, NUS, Singapore, hosted by Prof Oh Choo Hiap (4-7 Nov 2013)

4. Korean Physical Meeting, Daejeon and Visited Prof CH Nam at GIST and KAIST (21-27 April 2013)

5. University of Malaya Researchers' conference (UMRC), RMC (19-20 November 2013)

6. PERFIK 2012, Colmar Tropicale, Bukit Tinggi, Pahang (19-21 November 2012)

7. Invited to give a talk to A level students t HELP Academy (6 Dec 2013).

My research group http://sites.google.com/site/nonlinearsys/um

I started my research group "**Quantum and Laser Science**" since 2010 which conducts research on quantum systems interacting with nonclassical photons and lasers, encompassing the fields of quantum optics, quantum information, nonlinear optics and laser spectroscopy, interactions and propagation of ultrashort laser pulses, optics of novel photonic structures, atomic and molecular physics and ultracold quantum gases. Ambitious future plan is on the way, being supported by Ministry of Higher Education, to set up the first quantum nonlinear optics lab with femtosecond laser, OPA and detection systems that has research capabilities on nonclassical photons, nonlinear spectroscopy and microscopy. These areas are actively being pursued worldwide and would be the niche area of research to be developed in UM and Malaysia.