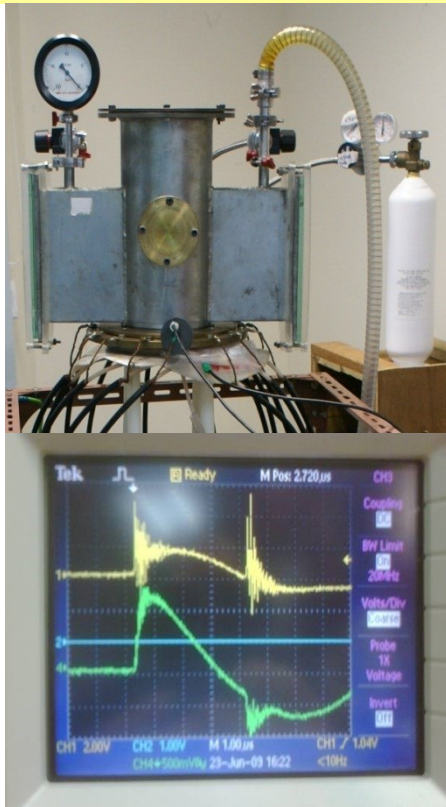




INTI
International University
LAUREATE INTERNATIONAL UNIVERSITIES*

Plasma Focus & Pulse Power Laboratory Centre for Plasma Research



Significant Discoveries/Results

- * Pinch Current limitation — optimum inductance
- * Scaling laws for neutron and x-ray yields
- * The cause and cure of neutron saturation
- * Scaling for ion beams and plasma streams
- * Radiative Collapse in plasma focus- for HED High Energy Density Studies
- * SFM- A superior mode of operation for advanced materials research
- * Throughput Scaling and the Breakeven Plasma Focus

May 2018

PLASMA RESEARCH GROUP
CENTRE FOR PLASMA RESEARCH
INTI INTERNATIONAL UNIVERSITY

| | |
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| Member | Arwinder Singh Jigiri Singh, Associate Professor Dr Lee Sing, Professor Dr Chong Tet Vui, Associate Professor Dr Saw Sor Heoh, Professor Dr (Nilai University) Roslan Abd. Shukor, Professor Dato' Dr (UKM) |
| Research Students | Teh Thiam Oun Foo Kim Eng Loh Shin King |
| Administration Support | Siti Mastura Mohd Yunus |
| Collaborators | Institute for Plasma Focus Studies, Australia , http://www.plasmafocus.net/ Nilai University, Nilai, Malaysia Radiation Sources Laboratory, NIE-NTU, Singapore http://ckplee.myplace.nie.edu.sg/plasmaphysics/ The Asian African Association for Plasma Training , www.aaapt.org/ Plasma Research Laboratory, University of Malaya http://fizik.um.edu.my/plasma/ International Centre for Theoretical Physics, Plasma Focus Laboratory, Trieste, Italy http://mlab.ictp.it/plasma/pfd.html Department of Physics, Syria Atomic Energy Commission, Damascus, Syria International Atomic Energy Agency, Vienna, Austria, http://www.iaea.org/ Kansas State University, Department of Mechanical and Nuclear Engineering Plasma Physics Research Center, Science and Research Branch (I.A.U), Tehran, Iran http://pprc.srbiau.ac.ir/ Comision Chilena de Energia Nuclear (CCHEN), Chile Nanotechnology Research Alliance, Universiti Teknologi Malaysia, Johor, Malaysia Sofia University, Faculty of Physics, Sofia, Bulgaria, Kathmandu University, Dhulikhel, Nepal Tribhuvan University, Kathmandu, Nepal Jazan University, Saudi Arabia International Centre for Dense Magnetised Plasmas, Warsaw, Poland Turkish Science and Research Foundation, Ankara, Turkey Institute of Physics, Belgrade, Serbia Institute of Experimental Physics V, Ruhr-University Bochum, Germany Czech Technical University, Prague, Czech Republic School of Applied Physics, Universiti Kebangsaan Malaysia, Malaysia |

INTRODUCTION

The Centre for Plasma Research at INTI International University was conceived in July 2007 and set up in November 2007, with the appointment of Adjunct Professor Dr Lee Sing and the launching of the Universal Plasma Focus Laboratory Facility (UPFLF), hosted at INTI IU with initiative of Prof Dr Saw Sor Heoh and foresight of (the late) President Prof Dr Lee Fah On.

Many series of numerical experiments using UPFLF have since been successfully carried out on plasma focus PF machines in Argentina, Germany, Egypt, USA, Chile, Malaysia, Singapore, Russia, China, Pakistan, India, Estonia, Italy, Iran, Syria and the International Centre for Dense Magnetised Plasmas (ICDMP), Poland. This has resulted in more than 200 papers, including 107 published papers most in top level ISI physics journals such as Applied Phys Lett, Phys of Plasmas, IEEE Trans Plasma Sci, J Fusion Energy, J Applied Phys, and 63 plenary/keynote/ review lectures at international conferences. INTI IU is among the top-rated plasma focus groups in the world.

INTI College hosted the International Workshop on Plasma Computations and Applications 2008 (IWPCA 2008) under the leadership of Dr Saw Sor Heoh. This has become a series of Asian African Association for Plasma Training AAAPT workshops/Conferences held annually in Singapore, China, Iran, Thailand and Nepal. Prof Lee and Prof Saw presented plenary/keynote/invited papers at all these Workshops. In 2012 Prof Dr Saw was elected Vice President of AAAPT for the period 2012-2016, re-elected in 2016 for period 2017-2021. Prof Dr Lee remains the Advisor to AAAPT.

On 24 Dec 2008, the Plasma Focus and Pulse Technology Laboratory was started with the gift of the 3 kJ UNU/ICTP PFF machine, from the Plasma Radiation Sources Laboratory, National Institute of Education, NTU, Singapore headed by Assoc Prof Dr Paul Lee.

Prof Lee and Prof Saw were invited by the Turkish Science and Research Foundation (TUBAV) to present keynote papers at the Nuclear and Renewable Energy Resources Conference, Ankara (NURER) 2009 and 2010; followed by a lecture tour of Turkish atomic and scientific establishments and conferment on both of Honorary Life Membership of TUBAV. The Turkish collaboration led to Fusion Energy Workshop at Gazi University, and co-organization of International School on Magnetohydrodynamics and Fusion Applications ISMFA 2011, September, Turunc, Turkey in collaboration with Prof Dr Erol Kurt of Gazi University, and research and curriculum discussions at Centre for Plasma Physics and Lasers, Crete and Bilgi University, Istanbul.

Prof Dr Saw organized a Collaborative Workshop on Diagnostic Development for Plasma Focus at INTI-IU August 2010 and Seminar on PF Experiments SPFE, followed by an ICTP (Trieste, Italy)- funded Regional Workshop on PF Diagnostic Development RCWS 2011, June and SPFE 2011, co-sponsored with Universiti Teknologi Malaysia.

Prof Lee and Prof Saw lectured and run a Workshop on PF Numerical Experiments at the IAEA-ICTP Workshop on Dense Magnetized Plasmas and Plasma Diagnostics, Trieste Italy 15-26 November 2010; and in 2012 at ICTP gave the Opening Lecture, invited lectures and a PF workshop at the School and Training Course on Dense Magnetized Plasma as a Source of Ionizing Radiations, their Diagnostics and Applications.

Prof Lee and Prof Saw carried out research and conducted a 26-hour hands-on Numerical Experiments Workshop at the Department of Mechanical and Nuclear Engineering at Kansas State University in May-June 2010. Other major participations include iCREATE 2009 where Prof Dr Saw presented the first keynote paper and Group members presented 4 papers; and invited papers at the International Conference on Frontiers of Plasma Physics and Technology, April 2011, Singapore; as Members of the International Organising Committee.

INTI IU was awarded a prestigious contract grant from the International Atomic Energy Agency, Vienna as part of a Coordinated Research Programme on “Investigations of Materials under High Repetition and Intense Fusion Relevant Pulses”. Professor Dr Saw, as Chief Scientific Investigator presented a paper at the First Research Coordination Meeting (RCM) December 2011 at IAEA, Vienna and chaired a session. June 12-14 INTI IU co-hosted the RCM and the International Symposium on PF 2013 at which our CPR presented 2 Invited papers to 15 international experts on pulsed plasmas from Austria, Russia, Poland, Ukraine, Iran, Czech Republic, Germany, Netherlands, Singapore, Malaysia, Chile, India, Estonia and Bulgaria. Prof Saw presented papers at IAEA Technical Committee Meeting in Costa Rica January 2014 and Prague, Czech Republic October 2015.

In 2015 CPR achieved two landmarks. 1. Raised the academic standing of INTI IU by producing its first two PhD's and 2. Developed a new concept of SFM slow focus mode operation of the plasma focus to obtain a larger and more uniform plasma stream for materials fabrication. A dual PF DuPF is in process of patenting. The DuPF has been designed, the parts have been constructed and 90% installed. At 160 kJ, it is the largest PF in the world being installed specifically for materials research.

Research activities continue to progress with steady collaboration with our national and international partners.

HIGHLIGHTS

- November 2007 Set-up of Centre for Plasma Research. Appointment of Adjunct Professor Dr Lee Sing. Launching of the Universal Plasma Focus Laboratory Facility
www.intimal.edu.my/school/fas/uflf/
- April 2008 Internet Course on Plasma Focus Numerical Experiments – Institute For PF Studies (IPFS) and INTI-UC.
- July 2008 International Workshop on Plasma Computations & Applications (IWPCA 2008) - INTI-UC staff gave Keynote Addresses. Foundation for continuing series.
- November 2008 Visit to Plasma Radiation Sources Laboratory, NIE/NTU to check and arrange shipment of the 3kJ UNU/ICTP PFF Plasma Focus Machine donated by NIE/NTU to INTI-UC.
- January 2009 Assembly of Plasma Focus Machine, the INTI PF.
- June 2009 First Plasma Focus shot of INTI PF achieved on 23 June.
- July 2009 International Workshop on Plasma Diagnostics & Applications (IWPDA 2009) - INTI-UC staff gave the Keynote Address.
- August 2009 2nd Internet Course on PF Numerical Experiments (IBC2). 3rd Teachers' Workshop for Science and Mathematics Teachers.
- September 2009 International Conference on Nuclear and Renewable Energy Sources, Ankara, Turkey- INTI staff gave the first Keynote Address and an Invited Paper; INTI staff was interviewed on National TV TRT Turk - 30 minutes live broadcast.
- October 2009 Special Scientific Lecture Programme under Turkish Science and Research Foundation (TUBAV) in Ankara. Conferment of Honorary Life Membership of TUBAV on Professor Dr Lee and Professor Dr Saw
- November 2009 International Conference on Recent and Emerging Advanced Technologies in Engineering (iCREATE 2009). INTI-UC Team gave first Keynote Address and four papers.

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| May-June 2010 | INTI-UC presented a 26-hour hands-on Numerical Experiments Research Programme at the Department of Mechanical & Nuclear Engineering, KSU, Kansas, USA. |
| July 2010 | Second International Conference on Nuclear and Renewable Energy Resources, Ankara, Turkey 4-7 July - INTI-UC Team presented Keynote Address and Invited Paper and a 18-hour NURER 2010 Fusion Workshop (part internet-based) |
| August 2010 | Collaborative Workshop on Diagnostics Development for Plasma Focus (DiDPF 2010) with Plasma Radiation Sources Laboratory, NIE/NTU at INTI-UC; and SPFE 2010. |
| October 2010 | International Workshop on Plasma Science and Applications (IWPSA 2010) in Xiamen, China- third in the series initiated by Professor Dr Saw- INTI IU staff are Advisors and Invited Speakers. |
| November 2010 | IAEA-ICTP Workshop on Dense Magnetized Plasmas and Plasma Diagnostics, Trieste Italy 15-26 November 2010. INTI IU staff presented Invited Lectures and the Workshop on Plasma Focus Numerical Experiments. |
| April 2011 | International Conference on Frontiers of Plasma Physics and Technology, Singapore (associated with IAEA). INTI IU staff are in IOC and presented Invited Papers. |
| June/July 2011 | CPR received grant from ICTP Trieste for Regional Collaborative Workshop on PF Diagnostic Development and Applications RCWS 2011 20-30 June and SPFE 2011 1 July; co-sponsored with UTM, Malaysia. |
| September 2011 | Prof Lee and Prof Saw co-organized the International School on Magnetohydrodynamics and Fusion Applications ISMFA 2011 9-16 September, Turunc Turkey with Prof Dr E Kurt of Gazi University; delivering 4 Invited Lectures and a 10-hr Workshop on PF Numerical Experiments. |
| October 2011 | Prof Lee and Prof Saw were International Advisors and Keynote Speakers at IWPSA 2011, Tehran, Iran, 27-28 October; and held discussions with Iranian groups on joint PhD programmes and research collaboration. |
| 13 th November 2011 | VC Walter Wong in a STAR interview described the CPR as 'one of the biggest development at INTI' |

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| December 2011 | INTI IU was awarded a contract grant NO. 16934 from the International Atomic Energy Agency, as part of a Coordinated Research Programme on “Investigations of Materials under High Repetition and Intense Fusion Relevant Pulses”. Prof Saw, as Chief Scientific Investigator attended First Research Coordination Meeting 6-9 Dec 2011 at IAEA, Vienna; presented an Invited Paper and chaired a session. Members of the CRP include advanced research groups from Russia, Germany, Italy, Estonia, Bulgaria, Czech Republic, Poland, Chile, Kazakhstan, Ukraine, India, and Singapore. |
| 4 th - 5 th October 2012 | INTI IU Professors gave invited opening lecture at IWPSA 2012 Bangkok. Prof Dr Saw elected Vice-President of AAAPT 2012-2016. |
| 8 th - 12 th October 2012 | INTI IU team gave invited opening lectures, and a workshop on Plasma Focus numerical experiments at ICTP Trieste Italy. |
| 21 st - 23 th March 2013 | Prof Lee and Prof Saw were Lead Invited Speakers at Siam Physics Congress SPC2013, Chiangmai, Thailand |
| 12 th - 14 th June 2013 | Prof Dr Saw organised Part 2 of Second RCM of the IAEA and International Symposium on Plasma Focus at INTI IU (15 nations). INTI staff gave Invited papers and poster papers. |
| 8 th – 12 th July 2013 | INTI IU staff conducted a plasma focus workshop for a Jazan University Team resulting in a research paper and collaboration |
| 26 th Sept – 8 th Oct 2013 | INTI IU staff conducted a Numerical Experiment on Plasma Focus (NEW PF) for 30 researchers at Kathmandu University, Dhulikhel, Nepal; which resulted in a joint research paper and possible collaboration for research and PhD programmes |
| 3 rd Sept – 6 th Sept 2013 | Prof Dr Lee was First Plenary Speaker ICPSA 2013 Singapore and Prof Dr Saw was Invited Speaker. Several other papers were presented by INTI IU staff |
| 27 th – 29 th January 2014 | 21st IAEA TM on Research Using Small Fusion Device, Puerto Rico- Prof Saw represented Malaysia and presented a paper |
| 20 th June 2014 | COPE 2014 in series SPFE at INTI IU |
| 21 st – 25 th September 2014 | Prof Dr Saw and Prof Dr Lee organized a NEWPF workshop and were Keynote Speakers at ICPSA2014 Kathmandu, and attended AAAPT Council Meeting. Assoc Prof |

Arwinder Singh was Invited Speaker

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| 28 th October 2014 | Joint-experiments with MNA to set-up radiation monitoring of INTI PF. |
| 20 th November 2014 | 1 st Research Presentations on Plasma Focus Research Experiments & New Applications attended by researchers from UTM, MNA and INTI IU. 9 Speakers made presentations |
| 5th January 2015 | PhD course accreditation |
| 17 May 2015 | CPR Director Prof Dr Saw awarded National Outstanding Educator Award 2015, (Researcher, Physics Education – University Category) |
| 12 th – 14 th October 2015 | 22 nd IAEA TM on Research Using Small Fusion Device, Prague. Prof Saw represented Malaysia and presented a paper |
| October 2015 | Installation of 160 kJ DuPF started at CPR. |
| 5 th November 2015 | Conference on Plasma Focus in series SPFE 2015 |
| 16 th – 17 th November 2015 | Prof Dr Saw Sor Heoh and Prof Dr Lee Sing invited to run First Plasma Focus Workshop - Designing for Fusion Neutrons by Malaysian Nuclear Agency, Bangi, Malaysia |
| 4 th – 6 th December 2015 | Pecipta'15, held at Kuala Lumpur Convention Centre. Plasma Focus Apparatus and System by Prof. Dr Saw Sor Heoh, Vahid Damideh and Prof. Dr. Lee Sing. They won a bronze medal. |
| 9 th December 2015 | Senate approval of PhD theses of Arwinder Singh and Federico Roy- these are first PhD theses awarded in INTI IU |
| End December 2015 | Successful completion of FRGS/2/2013/SG02/INTI/01/1 and IAEA contract grant No. 16934. A patent has been filed for the DuPF, Patent No. PI 2015702605- Filing Date: 11th August 2015 |
| 12-15 January 2016 | Presentation of results of IAEA contract grant 16934 by Prof Dr Saw at Third RCM of CRP at IAEA Vienna, Austria |
| 11th March 2016 | Senate approval of PhD thesis of Vahid Damideh |

- 22 June 2016 Prof Lee reviewed the academic production record of the CPR (renamed CoE PR). The group has produced 90 INTI-affiliated ISI papers and 3 PhD students over the CPR years. Compared with one of the most productive units of High Impact Research of the highest ranked university in Malaysia our CPR, having $\frac{1}{4}$ of the funding, but more ISI publications and the same number of PhD theses, is several times more productive. This is in comparison with one of the most highly rated physics groups in Malaysia.
- 5 August 2016 INTI IU Graduation Ceremony- graduation of first three PhD's of INTI IU, Dr Arwinder Singh, Dr Federico Roy and Dr Vahid Damideh, all from the CPR
- 28-30 November 2016 9th ICPSA, Langkawi, Malaysia. Prof Dr Lee Sing and Prof Dr Saw Sor Heoh were invited keynote speakers and Assoc Prof Dr Arwinder Singh was an invited speaker. As an activity of ICPSA2016, Profs Lee & Saw ran a 6 –week internet-based certificated numerical plasma workshop NEWPF2016 with 13 successful participants from 8 countries. Prof Dr Saw elected Vice-President AAAPT 2017-2021.
- October 2017 Prof Lee was Invited Plenary Speaker at 10th ICPSA, Thailand, Prof Dr Saw gave an Invited Keynote Paper. Assoc Prof Dr Arwinder Singh and Mr Teh T O presented papers.
- November 2017 Prof Lee and Prof Saw were Invited Speakers at York Plasma Institute, University of York, UK.

Research Projects (completed and ongoing in 2018)

COMPLETED PROJECTS (32)

- 1 **Effect of reduction of circuit inductance on plasma focus performance**
3 papers published

Pinch Current Limitation Effect in Plasma Focus

S Lee and S H Saw, Appl. Phys. Lett. **92**, 021503 (2008),

Numerical Experiments on Plasma Focus Pinch Current Limitation

S Lee, P Lee, S H Saw and R S Rawat, Plasma Phys. Control. Fusion **50** 065012 (2008)

Response to “Comment on ‘Pinch Current Limitation Effect in Plasma Focus”

S Lee and S H Saw, Appl. Phys. Lett. **94**, 076101 (2009)

- 2 **Numerical experiments on a range of plasma focus machines to determine neutron scaling laws**
1 paper published

Neutron Scaling Laws from Numerical Experiments

S Lee and S H Saw, J Fusion Energy, **27** 292-295 (2008) [.doi:10.1007/s10894-008-9132-7](https://doi.org/10.1007/s10894-008-9132-7)

- 3 **Developing numerical techniques to determine plasma focus pinch current from measured discharge current**
1 paper published

Computing Plasma Focus Pinch Current from Total Current Measurement

S Lee, S H Saw, P C K Lee, R S Rawat and H Schmidt, Appl. Phys. Lett. **92**, 111501 (2008), DOI:10.1063/1.2899632

- 4 **Numerical experiments on megajoule plasma focus machines in relation to current, neutron scaling and saturation**
2 papers published

Current and Neutron Scaling for Megajoule Plasma Focus Machines

S Lee, Plasma Phys. Control. Fusion, **50** 105005 (2008)

Neutron Yield Saturation in Plasma Focus-A Fundamental Cause

S Lee, Appl. Phys. Lett. **95**, 151503 (2009)

- 5 **Implementing Oxygen in the Lee Model**
1 paper published

Numerical Experiments on Oxygen Soft X-Ray Emissions from Low Energy Plasma Focus Using Lee Model

M Akel, Sh Al-Hawat, S H Saw and S Lee, J Fusion Energy (2010) **29**: 223-231.

- 6 **Implementing Nitrogen in the Lee Model**

2 papers published

Numerical Experiments on Soft X-ray Emission Optimization of Nitrogen Plasma in 3 kJ Plasma Focus SY-1 Using Modified Lee Model

M Akel, Sh Al-Hawat and S Lee, J Fusion Energy (2009) **28**: 355-363

Pinch Current and Soft x-ray Yield Limitation by Numerical Experiments on Nitrogen Plasma Focus

M Akel, S Hawat, S Lee, J Fusion Energy, (2010) **29**: 94-99 DOI 10.1007/s10894-009-9238-6

**7 Modelling of plasma focus with admixture operation
1 paper published**

Order of Magnitude Enhancement in Neutron Emission with Deuterium-Krypton Admixture Operation in Miniature Plasma Focus Device

Rishi Verma, P Lee, S Lee, S V Springham, T L Tan, R S Rawat and M Krishnan, Appl. Phys. Lett. **93**, 101501 (2008)

**8 Understanding and optimizing operation of miniature plasma focus device using Lee model
2 papers published**

Compact Sub-kilojoule Range Fast Miniature Plasma Focus as Portable Neutron Source

Rishi Verma, M V Roshan, F Malik, P Lee, S Lee, S V Springham, T L Tan, M Krishnan and R S Rawat, Plasma Sources Sci. Technol. **17** 045020 (11pp) (2008)

Effect of Cathode Structure on Neutron Yield Performance of a Miniature Plasma Focus Device

Rishi Verma, R S Rawat, P Lee, S Lee, S V Springham, T L Tan and M Krishnan, Physics Letters A Volume **373**, Issue 30, 2568-2571 (2009)

**9 Optimizing the UNU/ICTP PFF for Neon soft x-rays
1 paper published, 2 conference papers**

Optimizing UNU/ICTP PFF Plasma Focus for Neon SXR Operation

S H Saw, P C K Lee, R S Rawat and S Lee, IEEE Trans Plasma Sci, **37**, July 2009

Generation of Soft X-Ray (SXR) from Plasma Focus

Federico A Roy Jr, Chong Perk Lin, Sor Heoh Saw, Lee Sing. Paper presented by Federico A Roy Jr at iCREATE 2009 at Pan Pacific Hotel, KLIA, Malaysia, 23-24 November 2009

Optimization of Soft X Ray (SXR) Yield of the UNU/ICTP PFF

Federico A Roy Jr, Chong Perk Lin, Sor Heoh Saw, Lee Sing

Presented at Seminar on Plasma Focus Experiments- Diagnostic Development of Plasma Focus; at (SPFE 2010) INTI International University 27 August 2010

**10 Neon soft x-rays scaling laws through numerical experiments
2 papers published**

Soft X-ray Yield from NX2 Plasma Focus

S. Lee, R. S. Rawat, P. Lee and S. H. Saw, J. Appl. Phys. **106**, 023309 (6 pp) (2009)

Numerical Experiments on Plasma Focus Neon Soft X-ray Scaling

- 11 Neutron yield versus operating pressure through numerical experiments and comparison with measured results**
1 paper published

Numerical Experiments on Plasma Focus Neutron Yield versus Pressure

S Lee, S H Saw, L Soto, S V Springham and S P Moo, Plasma Phys & Control. Fusion **51** 075006 (11pp) (2009)

- 12 Study of advanced plasma focus systems: high voltage and current-steps**
1 Paper published

Current-Step Technique to Enhance Plasma Focus Compression and Neutron Yield

S. Lee and S. H. Saw
J Fusion Energ (2012) 31:603–610 DOI 10.1007/s10894-012-9506-8

- 13 Model parameters and variation with pressure and machines**
1 paper published

Model parameters vs gas pressure in two different plasma focus devices operated in Argon and Neon

Sh Al-Hawat, M. Akel, S. Lee, S. H. Saw, J Fusion Energ (2012) 31:13–20
DOI 10.1007/s10894-011-9414-3

- 14 Magnetic field characteristics of the plasma focus**
2 papers published, 1 paper presented at conference

Magnetic Probe Measurements in INTI Plasma Focus to Determine Dependence of Axial Speed with Pressure in Neon

S H Saw, M Akel, P C K Lee, S T Ong, S N Mohamad, F D Ismail, N D Nawi, K K Devi, R M Sabri, A H Baijan, J Ali and S Lee, J Fusion Energ DOI 10.1007/s10894-011-9487-z

Magnetic Reynolds Number and Neon Current Sheet Structure in the Axial Phase of a Plasma Focus

S Lee, S H Saw, P C K Lee, R S Rawat, K Devi
J Fusion Energ (2013) 32:50–55 DOI 10.1007/s10894-012-9521-9

Design of Calibration Unit and Magnetic Field Diagnostic Probe for Plasma Focus

K K A Devi, S Lee and S H Saw
Presented by K K A Devi at Seminar on Plasma Focus Experiments- Diagnostic Development of Plasma Focus; at INTI International University (SPFE 2010) 27 August 2010

- 15 Characterising plasma focus according to high or low static inductance**
1 paper published

Characterising Plasma Focus Devices– Role of Static Inductance– Instability Phase Fitted by Anomalous Resistance

S Lee, S H Saw, A E Abdou and H Torreblanca
J Fusion Energy Volume **30**, Issue 4 (2011), Page 277-282

16 Circuit and High Pulsed Current Technology

3 papers published

In-situ determination of the static inductance and resistance of a plasma focus capacitor bank

S H Saw, S Lee, F Roy, PL Chong, V Vengadeswaran, ASM Sidik, YW Leong & A Singh
Review Sci Instruments (2010) **81**, 053505

Pulsed Current Measurements in Plasma Focus Machines

S Lee, S H Saw, R S Rawat, P Lee, A Talebitaher, H Murtqaza, A E Abdou, Mohamed Ismail, Amgad Mohamed, H Torreblanca, Sh Al-hawat, M Akel, P L Chong, F Roy, A Singh, D Wong, K Devi, INTI Journal (2011) pg 89-102

Measurement and Processing of Fast Pulsed Discharge Current in Plasma Focus Machines

S Lee, S H Saw, R S Rawat, P Lee, R Verma, A. Talebitaher, S M Hassan, A E Abdou, Mohamed Ismail, Amgad Mohamed, H Torreblanca, Sh Al Hawat, M Akel, P L Chong, F Roy, A Singh, D Wong And K Devi
J Fusion Energ (2012) 31:198–204 <http://www.springerlink.com/content/g554264034424m55/>

17 Correlation of Neon SXR pulses and the dynamics computed from the Lee Model code

2 papers published

Correlation of measured soft x-ray pulses with modeled dynamics of the plasma focus

S Lee, S H Saw, R S Rawat, P Lee, A. Talebitaher, A E Abdou, P L Chong, F Roy, A Singh, D Wong, and K Devi, IEEE TRANSACTIONS ON PLASMA SCIENCE, VOL. 39, NO. 11, NOVEMBER 2011, 3196-3202

SXR measurements in INTI PF operated in neon to identify typical (Normal N)

Profile for shots with good yield

S H Saw, R S Rawat, P Lee, Alireza Talebitaher, Ali E. Abdou, P L Chong, F. Roy Jr, Jalil Ali,

18 Radiative Plasma Focus

1 invited paper presented at Conference, 2 papers published

Multi-Radiation Modelling of the Plasma Focus

S Lee and S H Saw, Invited review paper presented at the 5th International Conference on the Frontiers of Plasma Physics and Technology, 18-22 April 2011, Singapore

Numerical Experiments on Radiative Cooling and Collapse in Plasma Focus Operated in Krypton

S. Lee, S. H. Saw, Jalil Ali, J Fusion Energ DOI 10.1007/s10894-012-9522-8, published online 26 February 2012.

Radiative Collapse in Plasma Focus Operated with Heavy Noble Gases

M. Akel and S. Lee, J Fusion Energ DOI 10.1007/s10894-012-9535-3, published online 31 March 2012

19 Review of Numerical Experiments in Plasma Focus in Various Gases

1 invited paper presented and 1 paper published

Collaborative Research Work-Experiments Using the AECS Plasma Focus Devices (AECS PF-1 and AECS PF-2)

M. AKEL, Sh AL-HAWAT, S H SAW and S LEE, Invited Review Paper- IPFS

Conference, 30 March to 1 April 2012, Bangkok, Thailand, Proceedings “Study of Plasma Focus- Enhancing Knowledge and Applications Potential” pg 71-85

Numerical Experiments in Plasma Focus Operated in Various Gases

Mohamad Akel, Sing Lee, and S. H. Saw, *IEEE Trans Plasma Science, Volume: 40, Issue: 12, Part: 2* (8 pages), published online 21 November 2012; Digital Object Identifier: <http://dx.doi.org/10.1109/tps.2012.2220863>

20 Industrial possibilities of the Plasma Focus

4 Invited Review papers presented at International Conference

From Electric Birth to Streaming Death of the Plasma Focus-Knowledge and Applications

S Lee - Invited Opening Paper-IPFS Conference, 30 March to 1 April 2012, Bangkok, Thailand, Proceedings “Study of Plasma Focus- Enhancing Knowledge and Applications Potential” pg 1-12

Basis and Results of Research at the IPFS

S Lee - Invited Review Paper- IPFS Conference, 30 March to 1 April 2012, Bangkok, Thailand, and

Proceedings “Study of Plasma Focus-Enhancing Knowledge and Applications Potential” pg 14- 25

Plasma Focus Research at INTI-IU

S H Saw, Invited Review Paper- IPFS Conference, 30 March to 1 April 2012, Bangkok, Thailand, Proceedings “Study of Plasma Focus- Enhancing Knowledge and Applications Potential” pg 26-37

Collaborative Research Work-Experiments Using the AECS Plasma Focus Devices (AECS PF-1 and AECS PF-2)

M. Akel, Sh AL-Hawat, S H Saw and S Lee, Invited Review Paper- IPFS Conference, 30 March to 1 April 2012, Bangkok, Thailand, Proceedings “Study of Plasma Focus-Enhancing Knowledge and Applications Potential” pg 71-85

21 Axial phase model parameters from tube voltage (back emf) measurements

1 paper published

Some generalised characteristics of the electro-dynamics of the plasma focus in its axial phase- illustrated by an application to independantly determine the drive current fraction and the mass swept-up fraction

S. Lee, S. H. Saw, H. Hegazy, Jalil Ali, V. Damideh, N. Fatis, H. Kariri, A. Khubrani, A. Mahasi; *J Fusion Energy*, **33** (3) 235-241 (2014) DOI 10.1007/s10894-013-9658-1

22 Properties of Ion Beams in various Gases

3 papers published

Plasma Focus Ion Beam Fluence and Flux –for various gases

S Lee & S H Saw *Phys. Plasmas* **20**, 062702 (2013); DOI: 10.1063/1.4811650.

Properties of Ion Beams Generated by Nitrogen Plasma Focus

M. Akel, S. Alsheikh Salo, S. H. Saw, S. Lee, *J Fusion Energ* (2014) **33**:189-197, DOI 10.1007/s10894-013-9660

Characterization of oxygen ion beams emitted from plasma focus

Mohamad Akel, Sami Alsheikh Salo, Sor Heoh Saw, Sing Lee, *Vacuum* **110** (2014) 54-57

23 Short-lived Radioisotopes from plasma focus

2 papers published

Interaction of the high Energy Deuterons with the Graphite Target in

the Plasma Focus Devices Based on Lee Model

M. Akel, S. Alsheikh Salo, Sh. Ismael, S. H. Saw and S. Lee, PHYSICS OF PLASMAS 21, 072507 (2014) (2014)

Potential medical applications of the plasma focus in the radioisotope production for PET imaging

M.V.Roshan, S.Razaghi, F.Asghari, R.S.Rawat, S.V.Springham, P.Lee, S.Lee, T.L.Tan, , Physics Letters A 378 (2014) 2168–2170 <http://dx.doi.org/10.1016/j.Phys>

24 Comparative study of plasma focus machines 3 papers presented at Conference/Seminar

1 PhD thesis: Comparative Studies of Plasma Focus Machines

Arwinder Singh

Comparison of Device Parameters and Plasma Characteristics of Plasma Focus Device

Vengadeshwaran V, S H Saw and S Lee

Paper presented by Vengadeshwaran at iCREATE 2009 at Pan Pacific Hotel KLIA, Malaysia 23-24 November 2009

Basic comparative study of Plasma Focus machines

A Singh, S Lee and S H Saw

Presented by A Singh at Seminar on Plasma Focus Experiments- Diagnostic Development of Plasma Focus; at INTI International University (SPFE 2010) 27 August 2010

6 phase Fitting of Lee Model on INTI Plasma Focus machine (3kJ, 12kV) using Neon gas for 1.8 Torr to 2.1 Torr

A Singh, S Lee and S H Saw

Presented by A Singh at Seminar on Plasma Focus Experiments 2011 (SPFE2011) 1st July 2011

Numerical experimentation on focusing time and neutron yield in GN1 Plasma Focus machine, A Singh, S Lee , S.H.Saw, Plasma Science and Applications (ICPSA 2013)

International Journal of Modern Physics: Conference Series Vol. 32 (2014) 1460325 (6 pages) DOI: 10.1142/S2010194514603251

25 Collaborative Research with the Kansas State University Plasma Focus 2 papers published, several conference papers

Preliminary Results of Kansas State University Dense Plasma Focus

A E. Abdou, M I. Ismail, Amgad E. Mohamed, S. Lee, S H Saw, R Verma

IEEE Trans on Plasma Sci, Volume: 40 , Issue: 10 Page(s): 2741- 2744

DOI: [10.1109/TPS.2012.2209682](https://doi.org/10.1109/TPS.2012.2209682) (2012)

Current Sheet Axial Dynamics of 2.5 KJ KSU-DPF under High Pressure Regime

Amgad E. Mohamed, Ali E. Abdou, Mohamed I. Ismail, S. Lee, S.H. Saw

IEEE Trans on Plasma Sci 40, issue10, 2736-2740 DOI: [10.1109/TPS.2012.2210738](https://doi.org/10.1109/TPS.2012.2210738) (2012)

Characterization of the Kansas State University Dense Plasma Focus as a Multi- Radiation Source,

A E abdou, R Verma, S Lee, R S Rawat, P Lee, S V Springham

Presented at IEEE Conference on Plasma Science ICOPS 2010, Virginia, USA June 2010

Initial Results of Kansas State University Dense Plasma Focus,

A Abdou, S Lee, S H Saw, R Verma, P Lee, R Rawat, QA Mohamed, M Ismail

Presented at Joint ICTP-IAEA Workshop on Dense Magnetised Plasmas and Plasma Diagnostics 15-26 November 2010, Trieste, Italy

2.5 KJ KSU-Dense Plasma Focus under High Pressure Regime

A. E. Mohamed, A. E. Abdou, M. I. Ismail, S. Lee, S. H. Saw

Presented at IEEE 38th ICOPS, Chicago June 26th to 30th of 2011 IP3F-34
Kansas State University Dense Plasma Focus (KSU-DPF) Initial Neutron Results
M. I. Ismail, A. E. Abdou, A. E. Mohamed, S. Lee, S. H. Saw
Presented at IEEE 38th ICOPS, Chicago June 26th to 30th of 2011 IP3F-35

Short Circuit Test - Complete Analysis for the Dense Plasma Focus

A. E. Mohamed, A. E. Abdou, M. I. Ismail, S. Lee, S. H. Saw
Presented at IEEE 38th ICOPS, Chicago June 26th to 30th of 2011 IP3F-36

26 Development of Gas Mixture Algorithm for plasma focus computation in Lee Model code

1 paper published, 1 paper presented at conference

The Effect of Specific Heat Ratio on Neutron Yield

Sor Heoh Saw, Perk Lin Chong, Rajdeep Singh Rawat, Claudia Tan Li Ching, Paul Lee, Alireza Talebitaher, and Sing Lee, IEEE Trans Plasma Sci 42 (1) 99 – 104, (2014); DOI:10.1109/TPS.2013.2288945

Computation of Effective Specific Heat Ratio

P L Chong, S Lee, S H Saw; Paper presented at SPFE, 12 July 2012, Nilai Malaysia

27 Neutron yield versus pressure

1 papers published

Lee Comparison of Measured Neutron Yield Versus Pressure Curves for FMPF-3, NX2 and NX3 Plasma Focus Machines Against Computed Results Using the Lee Model Code.

S. H. Saw, P. Lee, R. S. Rawat, R. Verma, D. Subedi, R. Khanal, P. Gautam, R. Shrestha, A. Singh, S. Lee
J Fusion Energ (Online 13 Dec 2014) J Fusion Energ (2015) 34:474-479 DOI 10.1007/s10894-014-9824-0

28 The question of matching of capacitor impedance to plasma focus for energy transfer optimisation

S Lee and S H Saw

There are inconsistencies and misconceptions that keep arising over the past decades. This is apparent from plasma focus research publications. There appears to be a tendency to try to match certain impedances e.g. bank impedance with plasma impedance or axial tube impedance with pinch impedance etc on the assumption that such matching will favour optimum energy or power transfer. Our experience is that there is no such magic matching. Our preliminary work with non-dimensionalised equations governing the axial phase and the radial phase indicate that time matching dominates (capacitor bank time, axial transit time and radial transit time); and that the consequential impedances for the axial phase requires the lowest possible static inductance L_0 for the highest energy transfer. For the radial phase, L_0 needs to be bigger (e.g. 10x) than L_a (the axial phase full tube inductance) whilst L_{pinch} needs to be $\gg L_a$ (say 100x) for energy transfers of greater than 50% going into the plasma focus pinch. This important fundamental question needs to have formalized authoritative answers. This project will strive to provide the plasma focus community.

Developing a Plasma Focus Research Training System for the Fusion Energy Age

S Lee- Plenary Paper, International Conference on Plasma Science & Applications ICPSA2013, Singapore 3-6 December 2013

29 Optimisation of radiations yields from Plasma Focus using Lee Model Code and INTI PF device

S Lee and S H Saw

5 keynote/review papers presented at international conferences; 2 papers published, 1 PhD

Numerical Experiments of Ion Beams from Plasma Focus

S H Saw and A Lee, 21-23 March 2013, Siam Physics Congress SPC2013, Chiangmai, Thailand

Scaling Trends for Deuteron Beam Properties at Plasma Focus Pinch

Exit

S H Saw and S Lee – Invited Paper International Symposium on Plasma Focus in series SPFE2013 INTI International University Nilai Malaysia, 14 June 2013

Scaling of Ion Beams from Plasma Focus in Various Gases

S Lee & S H Saw- Invited Paper International Symposium on Plasma Focus in series SPFE2013 INTI International University Nilai Malaysia, 14 June 2013

Radiative Cooling and Collapse-Comparative study of a range of gases

Jalil Ali, S H Saw, M Akel and S Lee- Invited Paper, International Symp on Plasma Focus in series SPFE2013 INTI International University Nilai Malaysia, 14 June 2013

Plasma Focus Ion Beam Scaling Laws- S H Saw Invited Paper, International Conference on Plasma Science & Applications ICPSA2013, Singapore 3-6 Dec 2013

Plasma focus ion beam fluence and flux-Scaling with stored energy

S. Lee and S. H. Saw; Phys. Plasmas 19, 112703 (2012); doi: 10.1063/1.4766744
View online: <http://dx.doi.org/10.1063/1.4766744>

Plasma Focus Ion Beam Fluence and Flux –for various gases

S Lee and S H Saw Phys. Plasmas 20, 062702 (2013); doi: 10.1063/1.4811650.

Investigation and Optimisation of Neon Soft X-Ray of the INTI Plasma Focus at 12kV

PhD thesis by F Roy

30 Optimising conditions for production of graphene

Status: Completed. FRGS project completed. Report submitted

31. Collection of data on ‘pinch’ resistance for elicitation of 6-phase modeling

S Lee^{1,2,3}, S H Saw^{1,2}, Sh. Al- Hawat⁴ and M Akel⁴

¹Institute for Plasma Focus Studies, 32 Oakpark Drive, Chadstone, VIC 3148, Australia

²INTI International University, 71800 Nilai, Malaysia

³Natural Sciences and Science Education, National Institute of Education, Nanyang Technological University, Singapore-637616

⁴Department of Physics, Atomic Energy Commission, Damascus, P.O. Box 6091, Syria.

Pinch resistance has been referred to often as very important for the energetic of the PF. However little quantitative data has been collected or published. The 6-phase model has shown a way to produce quantitative data on the amplitude and time characteristics of ‘pinch resistance’ which are measurable from current waveform by the now-familiar method of current waveform fitting using the 6-phase model. Such data will be useful for the further understanding of PF pinch mechanisms. A standardised Rogowski coil (measuring I_{dot} which is numerically integrated for the current I) will be used by the collaborating parties for the data collection.

Status: Completed- one joint paper published

Characterising Plasma Focus Devices – Role of Static Inductance – Instability Phase

Fitted by Anomalous Resistance. S Lee, S H Saw, A E Abdou & H Torreblanca, J Fusion Energ Volume 30, (4), 272-282, (2011), DOI 10.1007/s10894-010-9372-1

32 Radiative Collapse in Plasma Focus- an international collaborative project

S Lee, S H Saw, M Akel (SAEC, Syria) H-J Kunze (Bochum Germany), J Ali (UTM, Malaysia), P Kubes (Czech Tech Univ, Czech Republic), M Pavel (ICDMP, Poland)

Status: Completed: 4 conference papers presented, 5 papers published IEEE Trans Plasma Sci, Nukleonika, Phys of Plasmas and J Fusion Energy

Conditions for Radiative Cooling and Collapse in Plasma Focus illustrated with Numerical Experiments on the PF1000. S Lee, S H Saw, M Akel, H-J Kunze, P Kubes, M Paduch. IEEE Trans Plasma Sci. 44 (2) :165 – 173 (2016). DOI: 10.1109/TPS.2015.2497269

The study of pinch regimes based on radiation-enhanced compression and anomalous resistivity phenomena and their effects on hard x-ray emission in a Mather type dense plasma focus device (SABALAN2). D.Piriaci, T.D.Mahabadi, S.Javadi, M.Ghoranneviss, S H Saw and S Lee, Physics of Plasmas 22, 123507 (2015); doi: 10.1063/1.4936801

Experiments and Simulations on the Possibility of Radiative Contraction/Collapse in the Plasma Focus PF-1000- Mohamad Akel, Jakub Cikhardt, Pavel Kubes, Hans-Joachim Kunze, S Lee, M. Paduch, Sor Heoh Saw, NUKLEONIKA 2016;61(2):145-148, doi: 10.1515/nuka-2016-0025

Measurement of Radiative Collapse in 2.2 kJ PF: Achieving High Energy Density (HED) Conditions in a Small Plasma Focus, S. H. Saw, S. Lee, J Fusion Energ (2016) 35:702–708, DOI 10.1007/s10894-016-0095-9

Effects of Power Terms and Thermodynamics on the Contraction of Pinch Radius in Plasma Focus Devices using the Lee Model, M. Akel, Sh. Ismael, S. Lee, S. H. Saw and H.J. Kunze, J Fusion Energy Volume 35 (6) pp 807–815 (2016). doi:10.1007/s10894-016-0108-8

33 Materials under intensive fusion-relevant pulses-scaling and properties

S H Saw, S Lee and INTI IU CPR members

Numerical experiments to verify scaling properties and laws related to plasma focus operation, specifically related to particle beams, neutrons and plasma stream; in conjunction with irradiation and damage on target samples - Part of IAEA CRP

Status: Completed – 9 Invited Keynote and Review Papers, 1 published paper

Scaling Laws for Plasma Focus Machines from Numerical experiments

S H Saw and S Lee, Invited Paper presented by S H Saw at International Workshop on Plasma Diagnostics & Applications IWPDA 2009, Singapore 2-3 July 2009, Procs IWPDS 2009

Scaling the Plasma Focus for Fusion Energy Considerations

S Lee and S H Saw, Invited Paper presented by S H Saw at TUBAV Conferences: Nuclear & Renewable Energy Sources Ankara, Turkey, 28 & 29 September 2009. Procs Nuclear & Renewable Energy Sources, pgs 61-70 (2009)

Insights from Plasma Focus Numerical Experiments- Scaling Properties t Scaling Laws ,

S Lee and S H Saw , Invited Review paper at Joint ICTP-IAEA Workshop on Dense

Magnetized Plasmas & Plasma Diagnostics, Trieste, Italy 15-26 Nov 2010; ICTP series 2168-3

Introduction to the Plasma Focus- Machines, Applications and Properties

S Lee and S H Saw, Invited review paper ISMFA- International School on Magnetohydrodynamics and Fusion Applications 9-16 September, Institute for Theoretical and Applied Physics, Turunc Turkey

Plasma Focus- The Machine and Scaling Properties

S H Saw and S Lee, Invited review paper at ISMFA- International School on Magnetohydrodynamics and Fusion Applications 9-16 September, Institute for Theoretical and Applied Physics, Turunc Turkey

Review of Plasma Focus Numerical Experiments- Scaling and Compression Enhancement,

S H Saw and S Lee, Invited paper at International

Workshop on Plasma Science and Applications 27-28 October 2011, Tehran, Iran

Investigation of Fusion Relevant Pulses from Plasma Focus Devices-

Scaling and Properties, S H Saw and S Lee, First Research Coord Meet of Coordinated Research Programme on “Investigations of Materials under High Repetition and Intense Fusion Relevant Pulses” – Investigation of Fusion Relevant Pulses from PF Devices-Scaling and Properties- 6-9 Dec 2011 IAEA Vienna

Ion Beams and Plasma Streams- some results from numerical experiments

S Lee & S H Saw, Invited Paper Presented at SPFE 2012, Nilai Malaysia

Scaling Laws for Ion Beam Number (and energy) Fluence and Flux,

S Lee & S H Saw, Invited Paper Presented at School and Training Course on Dense magnetized Plasma as a Source of ionizing Radiations, their Diagnostics and Applications 8-12 October 2012, ICTP Trieste.

Plasma Focus Ion Beam Fluence and Flux –Scaling with Stored Energy

S Lee & S H Saw, Phys. Plasmas **19**, 112703 (2012) <http://dx.doi.org/10.1063/1.4766744>

Deuterium Plasma Focus as a Tool for Testing Materials of Plasma Facing Walls in Thermonuclear Fusion Reactors,

M Akel, S. Alsheikh Salo, Sh. Ismael, S. H. Saw, S. Lee, J Fusion Energy , 35(4) 694-701 DOI 10.1007/s10894-016-0092-z, 2016

ONGOING RESEARCH PROJECTS

Status: On-going

- 34 Development and construction of a dual mode 160kJ plasma focus for advanced materials deposition- Arwinder Singh, S H Saw, S Lee, V Damideh, P Lee, R S Rawat, Jalil Ali**

In existing plasma focus facilities it is the established practice to maximize the yield in the production of any desired radiation. This in almost all cases means adjusting the plasma focus for intense compression is a selected gas; for example for fusion neutrons, deuterium is selected; for srx lithography, neon is selected, for micro-machining, argon or a deuterium-argon or argon-krypton mixture. On the other hand for good deposition conditions it may be necessary to reduce focus intensity; using the focusing not so much for its explosive emission of intense radiation but for its storage of plasma energy and a subsequent release of the stored energy into streaming plasma.

Status : On-going- 1 PhD completed:

COMPARATIVE STUDY OF FAST FOCUS MODE AND SLOW FOCUS MODE IN PLASMA FOCUS DEVICES –Vahid Damideh, PhD, INTI IU 2016

And 3 papers:

Damage Study of Irradiated Tungsten using Fast Focus Mode of a 2.2 kJ Plasma Focus,

S H Saw, V Damideh, Jalil Ali, R S Rawat, P Lee, S Lee, Vacuum, 144, Pages 14-20, Oct (2017)

A160 KJ Dual Plasma Focus (DUPF) For Fusion-Relevant Materials Testing and Nano-Materials Fabrication, Plasma Science and Applications (ICPSA 2013),

S H Saw, V Damideh, P Lee, R S Rawat, S Lee, International Journal of Modern Physics: Conf Series 32,(2014) 1460322 (10 pages) DOI: 10.1142/S2010194514603226

The Slow Focus Mode in Plasma Focus for Fast Plasma Stream Nano-materials Fabrication: Selection of Energy of Bombarding Particles by Pressure Control,

S Lee and S H Saw J Science Engineering and Technology 10 (11) 17-23, 2014

35 Nitriding of samples for applications including tools and moulds

Status: On-going- 1 PhD progressing well

2 papers presented at conferences, submitted for publication

36 Throughput Scaling of the DPF

Status: On-going, 1 plenary paper presented at international conference, 1 paper in preparation

Publications

- 1 Pinch Current Limitation Effect in Plasma Focus**
S. Lee & S H Saw Applied Physics Letters **92**, 021503 (2008), DOI:10.1063/1.2827579
- 2 Neutron Scaling Laws from Numerical Experiments**
S Lee & S H Saw J of Fusion Energy, **27**, 292-295 (2008), DOI: 10.1007/s10894-008-9132-7
- 3 Numerical Experiments on Plasma Focus Pinch Current Limitation**
S Lee, P Lee, S H Saw & R S Rawat, Plasma Physics Controlled Fusion **50** 065012 (2008)
- 4 Computing Plasma Focus Pinch Current from Total Current Measurement**
S Lee, S H Saw, P C K Lee, R S Rawat & H Schmidt, Applied Physics Letters **92**, 111501 (2008), DOI:10.1063/1.2899632
- 5 Current and Neutron Scaling for Megajoule Plasma Focus Machines**
S Lee, Plasma Physics Controlled Fusion, **50** 10500 (2008)
- 6 Order of Magnitude Enhancement in Neutron Emission with Deuterium-Krypton Admixture Operation in Miniature Plasma Focus Device,**
Rishi Verma, P Lee, S Lee, S V Springham, T L Tan, R S Rawat & M Krishnan Appl. Phys. Lett. **93**, 101501 (2008)
- 7 Nano-phase Titanium Dioxide Thin Film Deposited by Repetitive Plasma Focus Ion Irradiation and Annealing Based Phase Transformation and Agglomeration,** R S Rawat, V Aggarwal, M Hassan, P Lee, S V Springham, T L Tan & S Lee Appl Surface Sci **255**, 2932-2941 (2008)
- 8 Compact Sub-kilojoule Range Fast Miniature Plasma Focus as Portable Neutron Source**
Rishi Verma, M V Roshan, F Malik, P Lee, S Lee, S V Springham, T L Tan, M Krishnan & R S Rawat , Plasma Sources Sci. Technol. **17** 045020 (11pp) (2008)
- 9 Response to “Comment on ‘Pinch Current Limitation Effect in Plasma’”**
S Lee & S H Saw, Applied Physics Letters **94** (2009)
- 10 Numerical Experiments on Plasma Focus Neutron Yield versus Pressure**

- S Lee, S H Saw, L Soto, S V Springham & S P Moo Plasma Phys and Control. Fusion, **51** 075006 (11pp) (2009)
- 11 Optimizing UNU/ICTP PFF Plasma Focus for Neon Soft X-ray Operation**
S H Saw, P C K Lee, R S Rawat & S Lee, IEEE Trans Plasma Sci, 37(7) 1276-1382 (2009)
 - 12 Soft x-ray yield from NX2 Plasma Focus**
S Lee, R S Rawat, P Lee & S H Saw, J. Appl. Phys. 106, 023309 (6 pages) (2009)
 - 13 Numerical Experiments on Plasma Focus Neon Soft X-ray Scaling**
S Lee, S H Saw, P Lee & R S Rawat, Plasma Phys & Controlled Fusion, 51, 105013 (2009)
 - 14 Numerical Experiments on Soft X-ray Emission Optimization of Nitrogen Plasma in 3 kJ Plasma Focus SY-1 Using Modified Lee Model**
M Akel, Sh Al-Hawat & S Lee, J Fusion Energ 28: 355-363 (2009), DOI 10.1007/s10894-009-9203-4
 - 15 Neutron Yield Saturation in Plasma Focus-A Fundamental Cause**
S Lee, Appl. Phys. Lett. **95** 151503 (2009)
 - 16 Effect of Cathode Structure on Neutron Yield Performance of a Miniature Plasma Focus Device**
Rishi Verma, R S Rawat, P Lee, S Lee, S V Springham, T L Tan & M Krishnan, Physics Letters A, Volume **373**, Issue 30, pages 2568-2571 (2009)
 - 17 The Effect of Anode Shape on Neon Soft X-ray Emissions and Current Sheath Configuration in Plasma Focus Device**
M A Mohammadi, S Sobhanian, C S Wong,
S Lee, P Lee & R S Rawat, J. Phys. D: Appl. Phys. **42** 045203 (10pp) (2009)
 - 18 Backward High Energy Ion Beams from Plasma Focus**
M V Roshan, P Lee, S Lee, A Talebitaher, R S Rawat & S V Springham
Phys. Plasmas **16** 074506 (2009); DOI:10.1063/1.3183715 (2009)
 - 19 Pinch Current & Soft X-ray Yield Limitation by Numerical Experiments on Nitrogen Plasma Focus**
M Akel, Sh Al-Hawat & S Lee, J Fusion Energ 29: 94-99(2010)
 - 20 Numerical Experiments on Oxygen Soft X-Ray Emissions from Low Energy Plasma Focus Using Lee Model**
M Akel, Sh Al-Hawat, S H Saw & S Lee, J Fusion Energ Volume 29, Number 3: 223-1(2010), DOI 10.1007/s10894-009-9262-6
 - 21 Radiation Emission Correlated with the Evolution of Current Sheath from a Deuterium Plasma Focus**
M Shahid Rafique, P Lee, A Patran, R S Rawat & S Lee, J Fusion Energ Volume 29, Number 3, 295-304, (2010) DOI 10.1007/s10894-010-9276-
 - 22 Scaling Laws for Plasma Focus Machines from Numerical Experiments**
S H Saw & S Lee, *Energy and Power Engineering*, 65-72, (2010), DOI:10.4236/epe.2010.21010
 - 23 Numerical Experiments providing new Insights into Plasma Focus Fusion Devices**
S Lee & S H Saw, Invited Review Paper for *Energies: special edition on "Fusion Energy" Energies 3*, 711-737; (2010), DOI:10.3390/en3040711
 - 24 In-situ Determination of the Static Inductance and Resistance of a Plasma Focus Capacitor Bank**
S H Saw, S Lee, F Roy, PL Chong, V Vengadeswaran, ASM Sidik, YW Leong & A Singh, Review Sci Instruments **81**, 053505 (2010)
 - 25 Neon Soft X-ray Yield Optimization from PFSy-1 Plasma Focus Device**
M Akel, Sh Al-Hawat & S Lee, J Fusion Energ (2010), DOI:10.1007/s10894-010-9338-3,
 - 26 Scaling the Plasma Focus for Fusion Energy Considerations**
S H Saw & S Lee, International J of Energy Research (35:81-88) (2011), DOI:10.1002/er.1758.
 - 27 Characterising Plasma Focus Devices – Role of Static Inductance – Instability Phase Fitted by Anomalous Resistance**
S Lee, S H Saw, A E Abdou & H Torreblanca, J Fusion Energ Volume 30, (4), 272-282, (2011), DOI 10.1007/s10894-010-9372-1

- 28 Pulsed Current Measurements in Plasma Focus Machines**
S Lee, S H Saw, R S Rawat, P Lee, A Talebitaher, H Murtqaza, A E Abdou, Mohamed Ismail, Amgad Mohamed, H Torreblanca, Sh Al-hawat, M Akel, P L Chong, F Roy, A Singh, D Wong & K K Devi, INTI Journal pg 89-102, (2011)
- 29 Nuclear Fusion Energy- Mankind's Giant Step Forward**
S Lee & S H Saw, J Fusion Energ 30 (5) 398-403,(2011), DOI: 10.1007/s10894-011-9390-7
- 30 Numerical Experiments on Neon Soft X-Ray Optimization of AECS-PF2 Plasma Focus Device**
Sh Al-Hawat, M Akel, S Lee, J Fusion Energ **30**, 494-502 (2011) DOI:10.1007/s10894-011-9416-1
- 31 Correlation of Soft x-ray Pulses with Modeled Dynamics of the Plasma Focus**
S Lee, S H Saw, R S Rawat, P Lee, A.Talebitaher, A E Abdou, P L Chong, F Roy, A Singh, D Wong & K Devi, IEEE Trans on Plasma Sci **39**, No 11, 3196-3202 (2011)
- 32 Radiation self absorption effect in Ar gas NX2 mather type plasma focus**
Z. Ali, S. Lee, F.D. Ismail, Saktioto, J. Ali, P.P. Yupapin, Phys Procedia 8, 393 – 400 (2011).
- 33 Model Parameters vs Gas Pressure in two Different Plasma Focus Devices Operated in Argon and Neon**
Sh Al-Hawat, M Akel , S Lee, S H Saw, J Fusion Energ 31:13–20 (2012), DOI 10.1007/s10894-011-9414-3-3
- 34 Measurement and Processing of Fast Pulsed Discharge Current in Plasma Focus Machines**
S Lee, S H Saw, R S Rawat, P Lee, R Verma, A.Talebitaher, S M Hassan, A E Abdou, Mohamed Ismail, Amgad Mohamed, H Torreblanca, Sh Al Hawat, M Akel, P L Chong, F Roy, A Singh, D Wong & K Devi; J Fusion Energ 31:198–204, (2012)
- 35 Dependence of Plasma Focus Argon Soft X-Ray Yield on Storage Energy, Total and Pinch Currents**
M Akel & S Lee, J Fusion Energy 31:143-150, (2012)
- 36 Practical Optimization of AECS PF-2 Plasma Focus Device for Argon Soft X-ray Operation**
M Akel & S Lee, J Fusion Energy 31:122-129 , (2012)
- 37 Magnetic Probe Measurements in INTI Plasma Focus to Determine Dependence of Axial Speed with Pressure in Neon**
S H Saw, M Akel, P C K Lee, S T Ong, S N Mohamad, F D Ismail, N D Nawawi, K Devi, R M Sabri, A H Baijan, J Ali & S Lee, J Fusion Energ 31:411–417 (2012)
- 38 Current-Step Technique to Enhance Plasma Focus Compression and Neutron Yield**
S Lee & S H Saw, J Fusion Energy Volume 31, Issue 6, pp 603-610 (2012)
- 39 Investigation of Structural Properties of Chromium Thin Films Prepared by a Plasma Focus Device**
S Javadi, M Habibi, M Ghoranneviss, S Lee, S H Saw & R A Behbahani Physica Scripta **86** 025801 (6pp) , (2012)
- 40 Preliminary Results of Kansas State University Dense Plasma Focus**
A E Abdou, M I. Ismail, Amgad E. Mohamed, S. Lee, S H Saw, R Verma, IEEE Trans on Plasma Sci, Volume: 40 , Issue: 10 Page(s): 2741- 2744 DOI: 10.1109/TPS.2012.2209682 (2012)
- 41 Current Sheet Axial Dynamics of 2.5 KJ KSU-DPF under High Pressure Regime**
Amgad E Mohamed, Ali E Abdou, Mohamed I. Ismail, S Lee, S H Saw, IEEE Trans on Plasma Sci 40, issue10, 2736-2740 DOI: 10.1109/TPS.2012.2210738 (2012)
- 42 Coded Aperture Imaging of Fusion Source in a Plasma Focus Operated with Pure D₂ and a D₂-Kr gas Admixture**
S V Springham, A Talebitaher, P M E Shutler, S Lee, R S Rawat, & P Lee, Appl. Phys. Lett. **101**, 114104 (2012), <http://dx.doi.org/10.1063/1.4752256>
- 43 Effects of Laser Energy Fluence on the Onset and Growth of the Rayleigh-Taylor Instabilities and its Influence on the Topography of the Fe Thin Film Grown in Pulsed Laser Deposition Facility**
S Mahmood, R S Rawat , Y Wang, S Lee, M Zakaullah, T L Tan, S V Springham, & P Lee Phys. Plasmas **19**, 103504 (2012); doi: 10.1063/1.4763555
- 44 Plasma Focus Ion Beam Fluence and Flux –Scaling with Stored Energy**
S Lee & S H Saw, Phys. Plasmas **19**, 112703 (2012) <http://dx.doi.org/10.1063/1.4766744>
- 45 Numerical Experiments in Plasma Focus Operated in Various Gases**
M Akel, S Lee, S H Saw, Digital Object Identifier: <http://dx.doi.org/10.1109/tps.2012.2220863>

- IEEE Transactions on Plasma Science, Volume: 40, Issue: 12, Part: 2 (8 pages) 2012
- 46 **The Plasma Focus- Trending into the Future**
S Lee & S H Saw, Int J of Energy Research ; Volume 36, Issue 15, pages 1366–1374, December 2012
- 47 **Numerical experiments on radiative cooling and collapse in plasma focus operated in krypton**
S Lee, S H Saw & Jalil Ali, J Fusion Energ 32:42–49, (2013) DOI 10.1007/s10894-012-9522-
- 48 **Magnetic Reynolds Number and Neon Current Sheet Structure in the Axial Phase of a Plasma Focus**
S Lee, S H Saw, P C K Lee, R S Rawat, K Devi
J Fusion Energ 32:50–55, (2013), DOI 10.1007/s10894-012-9521-9
- 49 **Scaling Laws of Nitrogen Soft X-Ray yields from 1 – 200 kJ Plasma Focus**
M Akel & S Lee, J Fusion Energ 32:107–110; (2013) DOI 10.1007/s10894-012-9537-1
- 50 **Radiative Collapse in Plasma Focus Operated with Heavy Noble Gases**
M Akel and S Lee, J Fusion Energ 32:111-116;(2013) DOI 10.1007/s10894-012-9535-3
- 51 **Soft X-Ray Emission in the Water Window Region with Nitrogen Filling in a Low Energy Plasma Focus.**
M Akel and S Lee, J. Fusion Energ 32:121-127; (2013) DOI 10.1007/s10894-012-9536-2
- 52 **Estimating Ratio of Peak to Uniform Values of Various Profiles of Relevance to Plasma Focus Pinch Columns**
CP Lin, Lee Sing, S Heoh
Journal of Engineering Science and Technology 8 (1), 27-33 (2013)
- 53 **Plasma Focus Ion Beam Fluence and Flux –for various gases**
S Lee & S H Saw Phys. Plasmas 20, 062702 (2013); DOI: 10.1063/1.4811650.
- 54 **SXR measurements in INTI PF operated in neon to identify typical (Normal N) Profile for shots with good yield**
S H Saw, R S Rawat, P Lee, Alireza Talebitaher, Ali E. Abdou, P L Chong, F. RoyJr, Jalil Ali, S Lee IEEE Trans Plasma Sci online 26 September 2013 DOI: 10.1109/TPS.2013.2281333
- 55 **The Effect of Specific Heat Ratio on Neutron Y**
Sor Heoh Saw, Perk Lin Chong, Rajdeep Singh Rawat, Claudia Tan Li Ching, Paul Lee, Alireza Talebitaher, and Sing Lee, IEEE Trans Plasma Sci 42 (1) 99 – 104, (2014) ISSN : 0093-3813; DOI:10.1109/TPS.2013.2288945
- 56 **Some generalised characteristics of the electro-dynamics of the plasma focus in Its axial phase- illustrated by an application to independently determine the drive current fraction and the mass swept-up fraction.**
S. Lee, S. H. Saw, H. Hegazy, Jalil Ali, V. Damideh, N. Fatis, H. Kariri, A. Khubrani, A. Mahasi ; J Fusion Energy, 33 (3) 235-241 (2014) DOI 10.1007/s10894-013-9658-1
- 57 **Properties of Ion Beams Generated by Nitrogen Plasma Focus**
M. Akel, S. Alsheikh Salo, S. H. Saw, S. Lee, J Fusion Energy (2014) 33:189-197, DOI 10.1007/s10894-013-9660-7
- 58 **Potential medical applications of the plasma focus in the radioisotope production for PET imaging**
M.V.Roshan, S.Razaghi, F.Asghari, R.S.Rawat, S.V.Springham, P.Lee, S.Lee, T.L.Tan, Physics Letters A 378 (2014) 2168–2170 <http://dx.doi.org/10.1016/j.Phys>
- 59 **PlasmFocus Radiative Model: Review of the Lee Model Code J Fusion Energy 33**
S Lee, 319-335 (2014) (10.1007/s10894-014-9683-8)
- 60 **Numerical Experiments on Neutron Yield and Soft X-Ray Study of a ~100 kJ Plasma Focus using the Current Profile Fitting Technique**
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S H Saw and S Lee
First Research Coordination Meeting of the Coordinated Research Programme on “Investigations of Materials under High Repetition and Intense Fusion Relevant Pulses” – Investigation of Fusion Relevant Pulses from Plasma Focus Devices-Scaling and Properties- 6-9 Dec 2011 IAEA Vienna
- 30 From Electric Birth to Streaming Death of the Plasma Focus- Knowledge and Applications**
S LEE
Invited Opening Paper- IPFS Conference, 30 March to 1 April 2012, Bangkok, Thailand, Proceedings “Study of Plasma Focus- Enhancing Knowledge and Applications Potential” pg 1-12
- 31 Basis and Results of Research at the IPFS**
S LEE
Invited Review Paper- IPFS Conference, 30 March to 1 April 2012, Bangkok, Thailand, Proceedings “Study of Plasma Focus- Enhancing Knowledge and Applications Potential” pg 14-25
- 32 Plasma Focus Research at INTI-IU**
S H SAW
Invited Review Paper- IPFS Conference, 30 March to 1 April 2012, Bangkok, Thailand, Proceedings “Study of Plasma Focus- Enhancing Knowledge and Applications Potential” pg 26-37
- 33 Collaborative Research Work-Experiments Using the AECS Plasma Focus Devices (AECS PF-1 and AECS PF-2)**
M. AKEL, Sh AL-HAWAT, S H SAW and S LEE,
Invited Review Paper- IPFS Conference, 30 March to 1 April 2012,

Bangkok, Thailand, Proceedings “Study of Plasma Focus- Enhancing Knowledge and Applications Potential” pg 71-85

- 34 Global view of the Lee Model code**
S H Saw
Invited Paper presented at the Third Seminar on Plasma Focus Experiments, 12 July 2012 Nilai Malaysia
- 35 Development of Projects based on the Lee Model Code**
S Lee
Invited Paper presented at the Third Seminar on Plasma Focus Experiments, 12 July 2012 Nilai Malaysia
- 36 Ion Beams and Plasma Streams- Some Results from Numerical Experiments**
S Lee and S H Saw
Invited Paper presented at the Third Seminar on Plasma Focus Experiments, 12 July 2012 Nilai Malaysia
- 37 Review of (UPFLF) Plasmas Focus Numerical Experiments**
S Lee and S H Saw
Keynote paper presented at International Workshop on Plasma Science and Applications (IWPSA2012), 4-5 October 2012, Chulalongkorn University, Bangkok, Thailand.
- 38 Numerical Experiments on Plasma Focus**
S H Saw and S Lee
Invited Paper presented at International Workshop on Plasma Science and Applications (IWPSA2012), 4-5 October 2012, Chulalongkorn University, Bangkok, Thailand.
- 39 Introduction to Dense Plasma Focus**
S Lee and S H Saw
Invited Opening Paper presented at School and Training Course on Dense Magnetized Plasma as a Source of Ionizing Radiations, their Diagnostics and Applications, 8-12 October 2012, International Centre for Theoretical Physics, Trieste, Italy
- 40 Introduction to Plasma Focus Numerical Experiments: Scaling Properties to Scaling Laws**
S Lee and S H Saw
Invited Paper presented at School and Training Course on Dense Magnetized Plasma as a Source of Ionizing Radiations, their Diagnostics and Applications, 8-12 October 2012, International Centre for Theoretical Physics, Trieste, Italy
- 41 Numerical Experiments Universal Plasma Focus Laboratory - The Lee model code**
S H Saw and S Lee
Invited Workshop/Lecture presented at School and Training Course on Dense Magnetized Plasma as a Source of Ionizing Radiations, their

Diagnostics and Applications, 8-12 October 2012, International Centre for Theoretical Physics, Trieste, Italy

- 42 Numerical Experiments on Bora**
S H Saw and S Lee
Invited Workshop/Lecture presented at School and Training Course on Dense Magnetized Plasma as a Source of Ionizing Radiations, their Diagnostics and Applications, 8-12 October 2012, International Centre for Theoretical Physics, Trieste, Italy
- 43 Numerical Experiments Discussion of results from BORA numerical experiments and comparison with BORA measured results**
S H Saw and S Lee
Invited Workshop/Lecture presented at School and Training Course on Dense Magnetized Plasma as a Source of Ionizing Radiations, their Diagnostics and Applications, 8-12 October 2012, International Centre for Theoretical Physics, Trieste, Italy
- 44 Scaling laws for Ion Beam number (and energy) fluence and flux**
S Lee and S H Saw
Invited Paper presented at School and Training Course on Dense Magnetized Plasma as a Source of Ionizing Radiations, their Diagnostics and Applications, 8-12 October 2012, International Centre for Theoretical Physics, Trieste, Italy
- 45 From Electric Birth through Micro-nova to Streaming Demise of the Plasma Focus - Knowledge and Applications**
S Lee and S H Saw
21-23 March 2013, Siam Physics Congress SPC2013, Chiangmai, Thailand
- 46 Numerical Experiments of Ion Beams from Plasma Focus**
S H Saw and S Lee
21-23 March 2013, Siam Physics Congress SPC2013, Chiangmai, Thailand
- 47 Scaling Trends for Deuteron Beam Properties at Plasma Focus Pinch Exit**
S H Saw and S Lee
Invited Paper International Symposium on Plasma Focus in series SPFE2013 INTI International University Nilai Malaysia, 14 June 2013
- 48 Scaling of Ion Beams from Plasma Focus in Various Gases**
S Lee & S H Saw
Invited Paper International Symposium on Plasma Focus in series SPFE2013 INTI International University Nilai Malaysia, 14 June 2013
- 49 Radiative Cooling and Collapse-Comparative study of a range of gases**
Jalil Ali, S H Saw, M Akel and S Lee
Invited Paper, International Symposium on Plasma Focus in series SPFE2013 INTI International University Nilai Malaysia, 14 June 2013
- 50 Plasma Focus Ion Beam Scaling Laws**
S H Saw
Invited Paper, International Conference on Plasma Science & Applications ICPSA2013, Singapore 3-6 December 2013
- 51 Developing a Plasma Focus Research Training System for the Fusion Energy Age**

- S Lee
Plenary Paper, International Conference on Plasma Science & Applications
ICPSA2013, Singapore 3-6 December 2013
- 52 A plasma focus regime to improve nano-materials deposition- The Slow Focus Mode**
S H Saw and S Lee
Conference on Plasma Focus- 20 June 2014, Nilai, Malaysia
- 53 The Slow Focus Mode in Plasma Focus for Fast Plasma Stream Nano-materials Fabrication: Selection of Energy of Bombarding Particles by Pressure Control.**
S Lee and S H Saw.
Invited Keynote Paper. ICPSA September 2014, Kathmandu
- 54 The Plasma Focus Scaled for Neutrons, Soft X-rays, Fast Ion Beams and Fast Plasma Streams,**
S H Saw & S Lee .
Invited Keynote Paper. ICPSA September 2014, Kathmandu
- 55 Experiments and Simulations on the Possibility of Radiative Collapse in the Plasma Focus PF-1000**
M. Akel, J. Cikhardt, P. Kubes, H.-J. Kunze, S. Lee, M. Paduch, and S. H. Saw,
Plasma 2015, September 7-11, 2015
- 56 Radiative Cooling and Collapse in the Plasma Focus**
S H Saw & S Lee
22nd IAEA Technical Meeting (TM) on Research Using Small Fusion
Devices, 12-14 October 2015, Prague, Czech Republic
- 57 CPR's Research Projects & Collaborations – Way Forward**
S H Saw & S Lee
COPF in series SPFE 2015, INTI IU , 5 Nov 2015.
- 58 Exploring the Plasma Focus-From Electrodynamics to Radiative Collapse**
S Lee & S H Saw
COPF in series SPFE 2015, INTI IU , 5 Nov 2015.
- 59 160 kJ Dual Plasma Focus – Concept, Design & Installation**
S H Saw, V Damedih and S Lee
COPF in series SPFE 2015, INTI IU , 5 Nov 2015.
- 60 Compression mechanisms in the Plasma Focus Pinch.**
S Lee, S H Saw and Jalil Ali
Invited First Plenary Lecture presented at International Conference for
Plasma Science and Applications, Langkawi 28-30 November 2016, AIP
Conference Proceedings 1824, 020001 (2017); doi:
<http://dx.doi.org/10.1063/1.4978814>
- 61 Knowing the Dense Plasma Focus – The Coming of Age (of the PF) with Broad ranging Scaling Laws.**
S H Saw and S Lee
Invited Keynote Paper presented at International Conference for Plasma
Science and Applications, Langkawi 28-30 November 2016. AIP
Conference Proceedings 1824, 020002 (2017); doi:
<http://dx.doi.org/10.1063/1.4978815>
- 62 The current-voltage characteristics of the plasma focus – a deeper look**

S H Saw & S Lee

Invited Paper. 10th ICPSA October 2017, Nakhon Si Thammarat, Thailand.

63 From Beam-target to Thermonuclear Fusion in the Dense Plasma Focus Pinch

S Lee

Invited Plenary paper presented at 10th ICPSA October 2017, Nakhon Si Thammarat, Thailand.

Invited Talks

1 Plasma Focus Fusion Devices

S Lee & S H Saw

Invited talk jointly presented at **Technical Education Faculty, Gazi University, Ankara, Turkey**, 2 October 2009. (Special Lecture Tour Programme of Turkish Science & Research Foundation TUBAV)

2 Latest Trends in Plasma Focus Studies

S Lee & S H Saw

Invited talk jointly presented at **Saraykoy Nuclear Research Training Centre, Ankara, Turkey**, 1 October 2009. (Special Lecture Tour Programme of Turkish Science & Research Foundation TUBAV)

3 Energy Gain from Thermonuclear Fusion

S Lee & S H Saw

Invited talk jointly presented at **Turkish Science & Research Foundation, Ankara, Turkey**, 1 October 2009. (Special Lecture Tour Programme of Turkish Science & Research Foundation TUBAV)

4 Plasma Physics and Nuclear Fusion

S H Saw & S Lee

Invited talk presented by S H Saw at the 3rd Teachers' Workshop, INTI University College, Nilai, 27-28 August 2009

5 Trends in Plasma Focus Studies

S Lee and S H Saw

Invited lecture presented at Syrian Atomic Energy Commission, Damascus, Syria on 22 July 2010

6 Plasma Focus Research at INTI UC

S H Saw and S Lee

Invited lecture presented at University of Nebraska, Lincoln, USA, 27 May 2010

7 Soft X-Ray Yield Optimization of AECS PF-2 Plasma Focus Device with Different Filling Gases

M. Akel, Sh. Al-Hawat, S. H. Saw and S. Lee

Invited paper presented at the Seminar on Plasma Focus Experiments, 1 July

2011 Nilai Malaysia-

- 8 Numerical experiments to obtain the scaling law for neutron yield on Mather- Type Plasma focus machines below 500 Joules**
A Singh, S Lee , S H Saw
Invited Paper, International Conference on Plasma Science & Applications
ICPSA2014, Kathmandu, September 22-25 2014
- 9 Numerical experiments to study the variation of pressure on India Bhabha Atomic Research Center (BARC) and Imperial College Plasma Focus machines**
Arwinder Singh, Saw Sor Heoh and Lee Sing
Invited paper presented at ICPSA 2016, Langkawi, 28-30 November 2016 and to be published in J Phys Conf Series
- 10 Review of Plasma Focus Numerical Experiments**
S H Saw, M Akel, Jalil Ali and S Lee
Invited lecture presented at York Plasma Institute, University of York, 17 Nov 2017.
- 11 From Beam-target to Thermonuclear Fusion in the Dense Plasma Focus Pinch: Energy throughput scaling**
S Lee and S H Saw
Invited lecture presented at York Plasma Institute, University of York, 17 Nov 2017.

Other Talks and Presentations

- 1 Basic introductory study of Plasma Focus machines using Lee's model**
A.Singh, S Lee and S H Saw
Presented at Seminar on Plasma Focus Experiments at (SPFE 2012) INTI International University 12 July 2012
- 2 Numerical experimentation on Neutron yield in PF50J Plasma Focus machine**
A Singh, S Lee and S H Saw
Presented at International Conference on Plasma Science and Applications (ICPSA 2013) Nanyang Technological University 4-6 December 2013
- 3 Nitrogen Laser and a Nanosecond Shadowgraphy System**
S H Saw, A S Md Sidik and S Lee.
Paper presented by A S Md Sidik at iCREATE 2009 at Pan Pacific Hotel, KLIA, Malaysia, 23-24 November 2009
- 4 Generation of Soft X-Ray (SXR) from Plasma Focus**

Federico A Roy Jr, Dr Chong Perk Lin, S H Saw and S Lee
Paper presented by Federico A Roy Jr at iCREATE 2009 at Pan Pacific Hotel,
KLIA, Malaysia, 23-24 November 2009

- 5 Applications of Plasma in Material Processing**
Dr Chong Perk Lin, Federico A Roy Jr, S H Saw and S Lee
Paper presented by Dr Chong Perk Lin at iCREATE 2009 at Pan Pacific Hotel,
KLIA, Malaysia, 23-24 November 2009
- 6 Comparison of Device Parameters and Plasma Characteristics of Plasma Focus Device**
Vengadeshwaran V, Saw S H and S Lee
Paper presented by Vengadeshwaran V at iCREATE 2009 at Pan Pacific Hotel,
KLIA, Malaysia, 23-24 November 2009
- 7 Basic comparative study of Plasma Focus machines**
A Singh, S Lee and S H Saw
Presented at Seminar on Plasma Focus Experiments- Diagnostic Development of
Plasma Focus; at (SPFE 2010) INTI International University 27 August 2010
- 8 Modeling of Density Profile at Radial Phase**
Chong Perk Lin, S H Saw and S Lee
Presented at Seminar on Plasma Focus Experiments- Diagnostic Development of
Plasma Focus; at (SPFE 2010) INTI International University 27 August 2010
- 9 Modeling of Density Profile at Radial Phase**
Chong Perk Lin, S H Saw and S Lee
Presented at Seminar on Plasma Focus Experiments- Diagnostic Development of
Plasma Focus; at (SPFE 2010) INTI International University 27 August 2010
- 10 Optimization of Soft X Ray (SXR) Yield of the UNU/ICTP PFF**
Federico A Roy Jr, Chong Perk Lin, S H Saw and S Lee
Presented at Seminar on Plasma Focus Experiments- Diagnostic Development of
Plasma Focus; at (SPFE 2010) INTI International University 27 August 2010
- 11 Design of Calibration Unit and Magnetic Field Diagnostic Probe for Plasma Focus**
K K A Devi, S Lee and S H Saw
Presented at Seminar on Plasma Focus Experiments- Diagnostic Development of
Plasma Focus; at INTI International University (SPFE 2010) 27 August 2010
- 12 Role of Radiation Self-Absorption in Dense Plasma Focus**
Zahra Ali, Rabia Qindeel, Jalil Ali, Saktioto, Lee Sing and N A D Khatak
Presented at Seminar on Plasma Focus Experiments- Diagnostic Development of
Plasma Focus; at (SPFE 2010) INTI International University 27 August 2010
- 13 Characterization of the Kansas State University Dense Plasma Focus as a Multi-Radiation Source**
A E Abdou, R Verma, S Lee, R S Rawat, P Lee and S V Springham
Presented at IEEE Conference on Plasma Science ICOPS 2010, Virginia, USA

June 2010

- 14 Initial Results of Kansas State University Dense Plasma Focus**
A Abdou, S Lee, S H Saw, R Verma, P Lee, R Rawat, QA Mohamed and M Ismail
Presented at Joint ICTP-IAEA Workshop on Dense Magnetised Plasmas and Plasma Diagnostics 15-26 November 2010, Trieste, Italy
- 15 2.5 KJ KSU-Dense Plasma Focus under High Pressure Regime.**
A. E. Mohamed, A. E. Abdou, M. I. Ismail, S. Lee, S. H. Saw
Presented at IEEE 38th ICOPS, Chicago June 26th to 30th of 2011 IP3F-34
- 16 Kansas State University Dense Plasma Focus (KSU-DPF) Initial Neutron Results**
M. I. Ismail, A. E. Abdou, A. E. Mohamed, S. Lee, S. H. Saw
Presented at IEEE 38th ICOPS, Chicago June 26th to 30th of 2011 IP3F-35.
- 17 Short Circuit Test - Complete Analysis for the Dense Plasma Focus**
A. E. Mohamed, A. E. Abdou, M. I. Ismail, S. Lee, S. H. Saw. Presented at IEEE 38th ICOPS, Chicago June 26th to 30th of 2011 IP3F-36.
- 18 The 6-Phase Lee Model Code-The Term of Anomalous Resistance**
P L Chong¹, Lee^{1,2} and S H Saw^{1,2}
Presented at Seminar on Plasma Focus Experiments 2011(SPFE2011) 1st July 2011
- 19 6 phase Fitting of Lee Model on INTI Plasma Focus machine (3kJ, 12Kv) using Neon gas for 1.8 Torr to 2.1 Torr**
A Singh¹, Lee^{1,2} and S H Saw^{1,2}
Presented at Seminar on Plasma Focus Experiments 2011(SPFE2011) 1st July 2011
- 20 A Template to correlate SXR Measurements with Computed Plasma Focus Dynamics**
F A Roy Jr ¹, P L Chong¹, S H Saw^{1,2}, Lee^{1,2}, A Singh¹ and K K A Devi¹
Presented at Seminar on Plasma Focus Experiments 2011(SPFE2011) 1st July 2011
- 21 Design and Construction of Magnetic Probe for the Magnetic field measurement of Current Sheath in a Plasma Focus Device**
K K A Devi¹, S H Saw^{1,2}, S Lee^{1,2,3}, P Lee³, F A Roy Jr ¹, P L Chong¹ and A Singh¹
Presented at Seminar on Plasma Focus Experiments 2011(SPFE2011) 1st July 2011
- 22 Ultrasonic Study on Ni Substituted GdBaSrCu₃O_{7-δ} Superconductor**
Kim Eng FOO, Tet Vui CHONG and Abd-Shukor ROSLAN
Presented at Conference on Plasma Focus in series SPFE2015, 5th November 2015
- 23 Amending the Reflected Shock Phase of the Lee Code.** Lim Ling Hong, Yap Seong Ling, Saw Sor Heoh, Poh Hun Seng, Lee Ming Chuan and Lee Sing-

Presented at International Conference for Plasma Science and Applications, Langkawi 28-30 November 2016 and submitted to J Phys Conf Series

- 24 **Experiments to study the variation of pressure on India Bhabha Atomic Research Center (BARC) and Imperial College Plasma Focus Machines.** Arwinder Singh, Saw Sor Heoh, Lee Sing- Presented at International Conference for Plasma Science and Applications, Langkawi 28-30 November 2016 and submitted to J Phys Conf Series
- 25 **PMT –Scintillator System Set up for D-D Neutron TOF Measurements in INTI Plasma Focus Device.** S H Saw, V Damideh, A Sadihgzadeh, Jalil Ali, R S Rawat, P Lee, S Lee- Presented at International Conference for Plasma Science and Applications, Langkawi 28-30 November 2016 and submitted to J Phys Conf Series
- 26 **A numerical study on the ion production in the INTI plasma focus machine using Nitrogen gas,** presented at 10th ICPSA October 2017, Nakhon Si Thammarat, Thailand.
Arwinder Singh, Teh Thiam Oun, Ng Xue Yinn, Ng Chee An, Wong Jun Wen, Saw Sor Heoh and Lee Sing
- 27 **A study on the surface hardness obtained by nitriding with a plasma focus machine ,**presented at 10th ICPSA October 2017, Nakhon Si Thammarat, Thailand.
Teh Thiam Oun, Arwinder Singh, Jalil Ali, Ng Chee An, Ng Xue Yinn, Wong Jun Wen, Saw Sor Heoh and Lee Sing

Poster Presentations

1. **Numerical Experimentation on Neutron Yield in PF50J Plasma Focus Machine**
Arwinder Singh and Federico Roy
Presented at International Symposium on Plasma Focus (SPFE 2013) INTI International University
14 June 2013
2. **Study of Magnetic Field Behaviour Using Magnetic Probe in INTI Plasma Focus**
K.K.A. Devi, S.H.Saw, S. Lee, P.C.K. Lee, C.P. Lin
International Symposium on Plasma Focus 2013 (SPFE 2013) 14 June 2013
3. **A 160 kJ Dual Plasma Focus (DuPF) for Fusion-Relevant Materials Testing and Nano-Materials Fabrication**
S H Saw, V Damideh, P Lee, R S Rawat and S Lee
International Conference on Plasma Science and Applications (ICPSA)
4th-6th December 2013 (Singapore)
4. **Correlation of Measured Neon Soft X-Ray Pulses of the INTI Plasma Focus using Dimensionally Optimised Anode at 12KV**
Federico A. Roy Jr. Supervisor: Prof Dr Saw Sor Heoh and Prof. Dr Lee Sing

PhD Theses

- 1** Arwinder Singh. Comparative Study of Plasma Focus Machines PhD Thesis. INTI International University (2015)
Supervisor: Saw Sor Heoh
- 2** Federico Roy Jr. Investigation and Optimisation of Neon Soft X-ray of the INTI Plasma Focus at 12 kV. PhD Thesis. INTI International University. (2015)
Supervisor: Saw Sor Heoh
- 3** Vahid Damideh. A Comparative Study of Fast Focus Mode and Slow Focus Mode in Plasma Focus Devices. PhD Thesis. INTI International University. (2016).
Supervisors: Saw Sor Heoh and Lee Sing

StarEducate, Sunday 13 November 2011

As part of the Laureate International Universities network, INTI and INTI international colleges have access to numerous programmes and courses.

But the sheer number can confuse prospective students and make it difficult for them to select an appropriate course.

"That is why we have open days and career days to help students decide which path to walk down. Choosing a field fresh out of high school is usually hard.

"INTI's international college offers students who want time to think and make an informed decision a number of pre-university programmes," Prof Wong explains.

Spending a year or two in a pre-university programme usually helps students mature and figure out what they want to do when they graduate, he adds.

After completing their pre-university course, INTI's affiliates overseas offer a plethora of degree programmes to choose from, says Prof Wong.

In addition, there are also the university's homegrown degree courses in Quantity Surveying, Physiotherapy, Traditional Chinese Medicine and others to choose from.

➤ [Focus on research] —————

Prof Wong shares that one of the biggest developments at INTI is the establishment of the Centre for Plasma Research within the university.

"The research centre features a universal plasma focus laboratory which is used to study fusion energy," he says.

As non-renewable energy sources are depleting, the importance of fusion energy cannot be understated, says Prof Wong.

"Fusion energy is the solution to mankind's energy woes. Through research it can be a renewable source of energy based on the energy that powers the universe itself.

"By emulating nature we can solve our energy problems. Fusion energy is the only viable long-term energy source powerful enough to meet our needs," says Prof Wong.

The fuel used for the fusion process is deuterium (heavy hydrogen) found in water which can provide plentiful clean energy via



We want our students to have a holistic education ... and also a conscience to differentiate right from wrong.

— PROF WALTER WONG

fusion for year, he explains.

The universal plasma focus laboratory uses the Lee model, one of the most powerful and widely used simulation models for plasma focus machines.

"The universal plasma focus is one of only three such classes of devices capable of studying the fusion process for energy," says Prof Wong.

INTI served as a platform to learn how to use the Lee model for more than 100 scientists in six separate workshops conducted by the university's staff.

"Last year, INTI sent its team of professors to the Nuclear Fusion Workshop NURER in Ankara, Turkey and many other workshops to improve their understanding of fusion energy.

"Over the past 30 months, our plasma researchers have published a total of 75 publications and 30 journal papers, with eight of them in top ranked journals," adds Prof Wong.

While the university achieved a respectable Tier Four in the Rating System for Malaysian Higher Education (Setara) recently, INTI is continuously pushing itself to greater heights.

According to Prof Wong, INTI is doing everything in its power to achieve a Tier Five (excellent) classification in the next Setara exercise.

"The fundamentals are in place and we are fine-tuning the areas that are weak. We hope to reach the benchmark in the not so distant future," says Prof Wong.

INTI International University is a contributor to the Star Education Fund.



International Workshop on Plasma Diagnostics and Applications (IWPDA 2008) 14-15 July 2008



International Workshop on Plasma Diagnostics and Applications (IWPDA 2009) 2nd – 3rd July 2009



**Seminar on Plasma Focus Experiments (SPFE 2010)
27th August 2010**



Seminar on Plasma Focus Experiments (SPFE 2011) 1st July 2011



**Seminar on Plasma Focus Experiments (SPFE 2012)
12th July 2012**



**Seminar on Plasma Focus Experiments (SPFE 2013)
14th June 2013**



**Jazan University Summer Program at
INTI International University
8th – 12th July 2013**



**Centre for Plasma Research Open Day
17th June 2014**



**Conference on Plasma Focus in Series 2014
20th June 2014**



1st Research Presentation on Plasma Focus Experiments & New Applications 20th November 2014



Advancing the boundary - 3 Pioneer PhD's: 5 August 2016

**Research Opportunities at the Centre
for Plasma materials Research-**

| | |
|-----------------------------|-----------------------|
| Present (FF) | Future (SF) |
| surface modification | nano-materials |

INTI PF- 3 kJ Plasma Focus



Biggest PF fac fabrication-concept proven, designed and almost completed installing here at INTI IU





INTI
INTERNATIONAL UNIVERSITY
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School and Training Course on Device Magnetized Plasma As A Source of Ionizing Radiation,
Their Diagnostics and Applications
8-12 October 2012, ICTP, Trieste, Italy



IPFS Institute For Plasma Focus Studies
• Knowledge Should Be Freely Accessible To All •

