Summary on the

US-Japan IEC Workshop

16th US-Japan Workshop on
Inertial Electrostatic Confinement Fusion

Madison, Wisconsin

30 September – 2 October, 2014

Joe Khachan
School of Physics, University of Sydney

THE UNIVERSITY OF SYDNEY

THE UNIVERSITY OF SYDNEY

Keynote talk

Jaeyoung Park gave the keynote talk about recent successful experiments on the Polywell at the Energy Matter Conversion Corporation. It was shown that the confinement time of injected electrons increased by, approximately, three orders of magnitude when the device was operated in high beta mode.

This is a significant milestone in the development of the Polywell towards a power reactor. These experiments now enable future work on the device to produce electrostatic trapping and heating of ions by the virtual cathode, which will be produced from the energetic electrons trapped by the high beta cusp fields.

THE UNIVERSITY OF SYDNEY

Dinner talk

Bob Hirsch gave a very interesting talk showing some of the history of IEC. The advantage of IEC were highlighted. These were contrasted against the economic and technical challenges of Tokamaks, which cast some doubt over the future of the longevity of projects such as ITER. An example of an alternative fusion concept was present as an example of the type of thinking that one must adopt in finding better solutions to fusion energy devices.

Progress in Research Programs

Kai Masuda presented a non-destructive method of detecting based on a neutron in and neutron out analysis for the detection of special nuclear materials, such as U-235. The restriction of scanning 400 shipping containers per day is a very demanding restriction. However , success in meeting this target has been achieved under some circumstances.

Jerry Kulcinski gave an overview of experimental program at the University of Wisconsin. Discussed were the improvement in UW-IEC facilities, Material studies such as irradiation in MITE-E, linear neutron source, surface analysis/simulations (TRIM), 300 kV instabilities, neutral particle analysis, spatial distribution with time of flight studies, VICTER code, Polywell simulations, He-3 on the move and methods of recovering it.

Progress in Research Programs

George Miley gave an overview of the different types of IEC research going of all IEC devices past and present including gridded IEC and virtual cathode devices, as well as applications such as thrusters and neutron sources. The talk highlights from George's recent book on IEC (a very good read) .

Joe Khachan presented the recent history on Polywell research at Sydney University, reverse polarity IEC, embedded fusion and the charge exchange thruster.

Neutron sources and their application

Dan Barnes outlined the use of a penning trap as a candidate for an intense neutron source. In this system virtual cathode that have the potential of 2/3 of the applied voltage. It was suggested that further theoretical work could include a relativistic treatment.

Ross Radel gave an overview of the neutron sources developed at Phoenix National Labs. Technical details of the ions source, beam extraction, fusion targets, beam densities, focusing elements, lens stack, differential pumping etc. Neutron rates of 2X10^11 are routinely produced.

Neutron sources and their application

Greg Peifer talked about the SHINE medical technologies and highlighted the need for Mo-99. Details were given about the use of the neutron source from PNL to produce Mo-99 through the use of low enriched Uranium. An overview of the international need for Mo-99 and gave details of the medical procedure that use them such as in cancer detection as well has various hear conditions.

D-T burning IEC plasmas

Masami Ohnishi talked about the setting up of the lab in order to produce fusion between D and T in IECF. It is expected that the first D-T burning experiment will be carried out in January 2015, with neutron radiography to be carried out in October 2015. An indication of the hazards of tritium was discussed.

Yasushi Yamamoto: the details of the getter pump for tritium handling was given. The relocation and remote operation were given. The OKTAVIAN facility was discussed with the 3X10^12 n/s at 20 mA. Also details of the Cockroft-Walton accelerator were given.

THE UNIVERSITY OF SYDNEY

Polywell Physics

John Santarius presented the physics required for modelling the Polywell. These include a 3D approach, beta, space charge, electric field, steep gradients, flows, non-adiabicity, collisions, sheath physics, fuel and power input details, plasma surface interactions. Gave a simplified 2D approach (spindle cusp) approach for some 3D sheath physics but misses some drift physics.

Devlin Baker carried out particle-in-cell simulations but combined with a hybrid model to do a rapid parametric study on the Polywell. This hybrid model is needed for plasma devices that combine slow and fast particle simultaneously.

THE UNIVERSITY OF SYDNEY

Polywell Physics

John Hedditch discussed the difficulty in choosing the appropriate theoretical for Polywell. An approached based on Maxwell's equation combined with a relativistic treatment was outlined.

IEC Simulations

Gil Emmert has extended the VICTER code to include electrons - in particular their spatial and energy distribution. The code now includes secondary electron emission from the cathode, and ion and electron ionization of the background gas in the intergrid region.

Drew Chap
Use additional grids to focus ion beams. Dodecahedral grids 12 faces, six beams. Ion bunching. 4 Grid IEC to improved focusing and bunching of higher density ions. Magnetic grids and electron confinement.

IEC experiments

Hodaka Osawa talked about the running of parallel grids, which has some very interesting properties. One highlight was that the breakdown voltage is proportional to the anode radius. The double IEC breaks-down at lower pressures.

Gabriel Becerra gave an outline and results on his PhD work that was about the neutral particle analysis in IEC devices. Technical details were given of the stripping foils and its role in the neutral particle analyser. The measured energy distributions of neutral at different pressures were presented.

IEC experiments

Kazuki Nanjo cylindrical IEC. Applying bias between anode and wall. Axial cusp magnetic field at the wall reduced the breakdown voltage and increase NPR. Azimuthal magnetic field around chamber. Measured ion energy distribution with Doppler shift.

George Chen: Plasma flow from the helicon into the IEC. Modify the IEC grid to make a space thruster and inject plasma from a Helicon discharge. Coupling between Helicon discharge and the IEC. Sheath measurements using a spherical Langmuir probe. Flow rate of ions calculation and measurements.

IEC experiments

Matt Michalak: Pushing HOMER into lower pressure regimes. Past used 2 – 4 mTorr regime. New feedthrough for 300 kV operation. NPR scales linearly at 0.2 mTorr. No change in NPR for different anode sizes at the lower pressure regime.

Rehan Bandara: Reverse polarity IEC. Showed Buneman instability oscillations that local virtual cathodes. Ion acceleration was measured by these virtual cathodes using Doppler spectroscopy.

IEC experiments

Ryota Nakamatsu: Talked about issue of the delay time associated with the pulsed glow discharge associated with IEC device for the non-destructive detection of special nuclear materials. One major issues is the variability of the delay time to the discharge onset and it dependence on gas pressure and applied voltage

Andrew Seltzman: Location of ion collision location with the grid. Aim is to minimize grid collisions. Active cooling of the grid with a flowing liquid through it. Measure power dissipated in the grid. Ion collectors array placed on the grid to measure temperature distribution.

THE UNIVERSITY OF SYDNEY

IEC experiments

Aaron Fancher : Refinement and testing of the UW 300 kV feedthrough. Many aspects of the feedthrough were examined and tested. One of the results include the extension of the lifetime of the stalks.

High voltage supplies

Rich Bonomo outlined the challenges of introducing a switch for the 300 kV power supply and the challenges of removing the subsequent arcing.

Hiroshi Horibe outlined strategies for earthing and connecting high voltage supplies to IEC.