Summary of Basic Session Papers

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AAPPS-DPP Conference,
Chengdu, PRC
Sep.18-22,2017

Basic Papers' Statistics

Plenary: 5
Invited: 21
Oral: 10
Poster: 20

Total: 56

- Complex(dusty) plasmas
- Quantum Plasmas
- Diagnostics/A&M
- Space Propulsion
- Wave propagation expts
- Ion sources
- Linear /Mirror machine expts (diag)
- Magnetic reconnection heating

Apologies: Non-exhaustive, "selective" summary

Written summary will be more complete

Strongly Coupled Plasmas

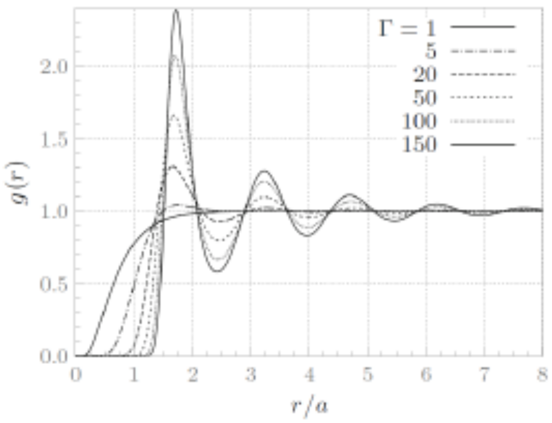
- Strong correlations omnipresent in nature – from electrolytes to dense plasma – quark-gluon plasmas, ultra-cold ions and dusty plasmas - lead to long range order – liquid like or crystals – collective modes.

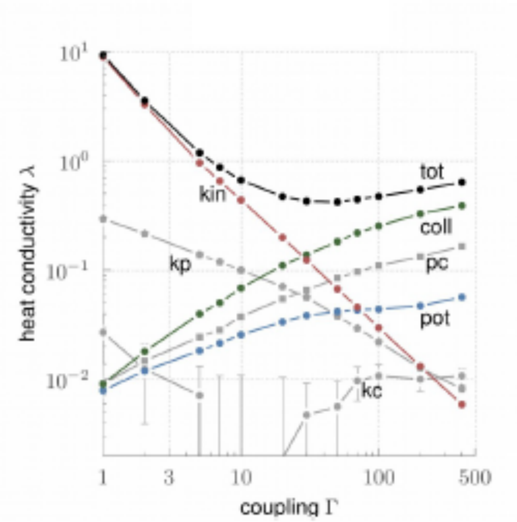
- Exptal observations often difficult due to need for extreme conditions

- Dusty plasma is an exception – strong coupling can be obtained at room temp and observations are easy to make

- This feature has been exploited a great deal in recent years – provide insight for other systems.

M. Bonitz





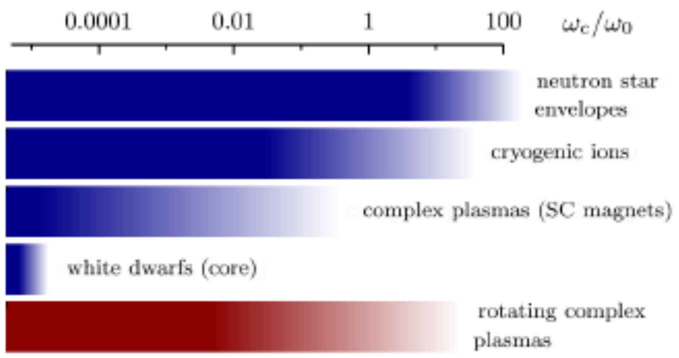
Structure
phase transitions

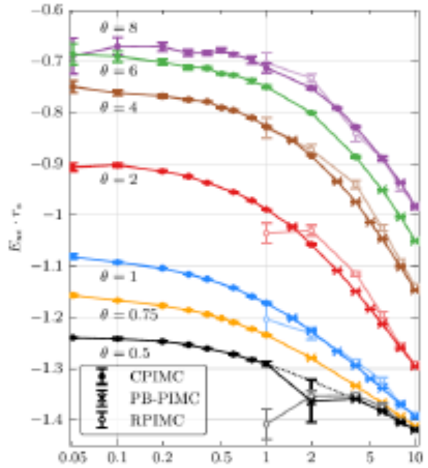
Transport
***ab initio* results**

Strongly coupled plasmas

Magnetization effects

Quantum and spin effects





"Quasi-magnetization" of the dust particles [1]

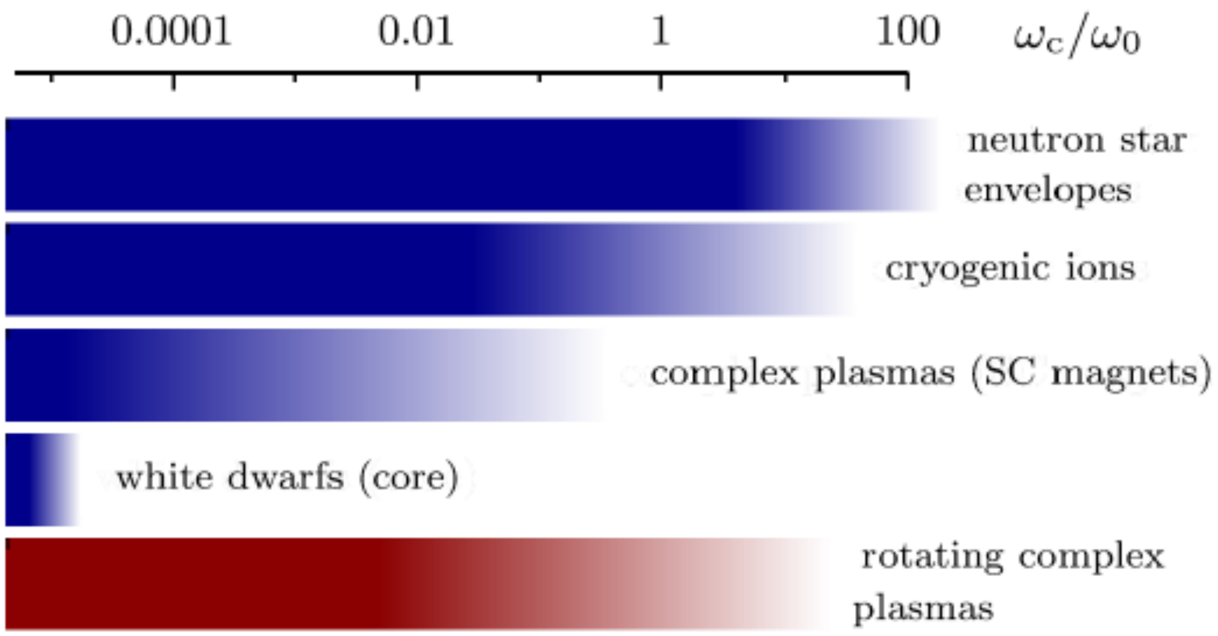
Use rotating gas flow to rotate the dust

replace Lorentz force with Coriolis force

basically no effect on electrons and ions

$\Omega \sim 10$ Hz, $Q \sim 10^4$ e, $m \sim 10^{-12}$ kg

$\longrightarrow$ $B_{eff} \sim 10^4$ T



Dusty / Complex Plasmas - Experiments

Lin I

- Sheared by a laser beam, a 2D cold dusty plasma liquid exhibits avalanche-like cracking/healing of ordered domains through stick-slip type collective small domain rotation

Wan Wang

- Dynamics of surface-assisted crystalline domain growth in cooled 3D dusty plasma liquids

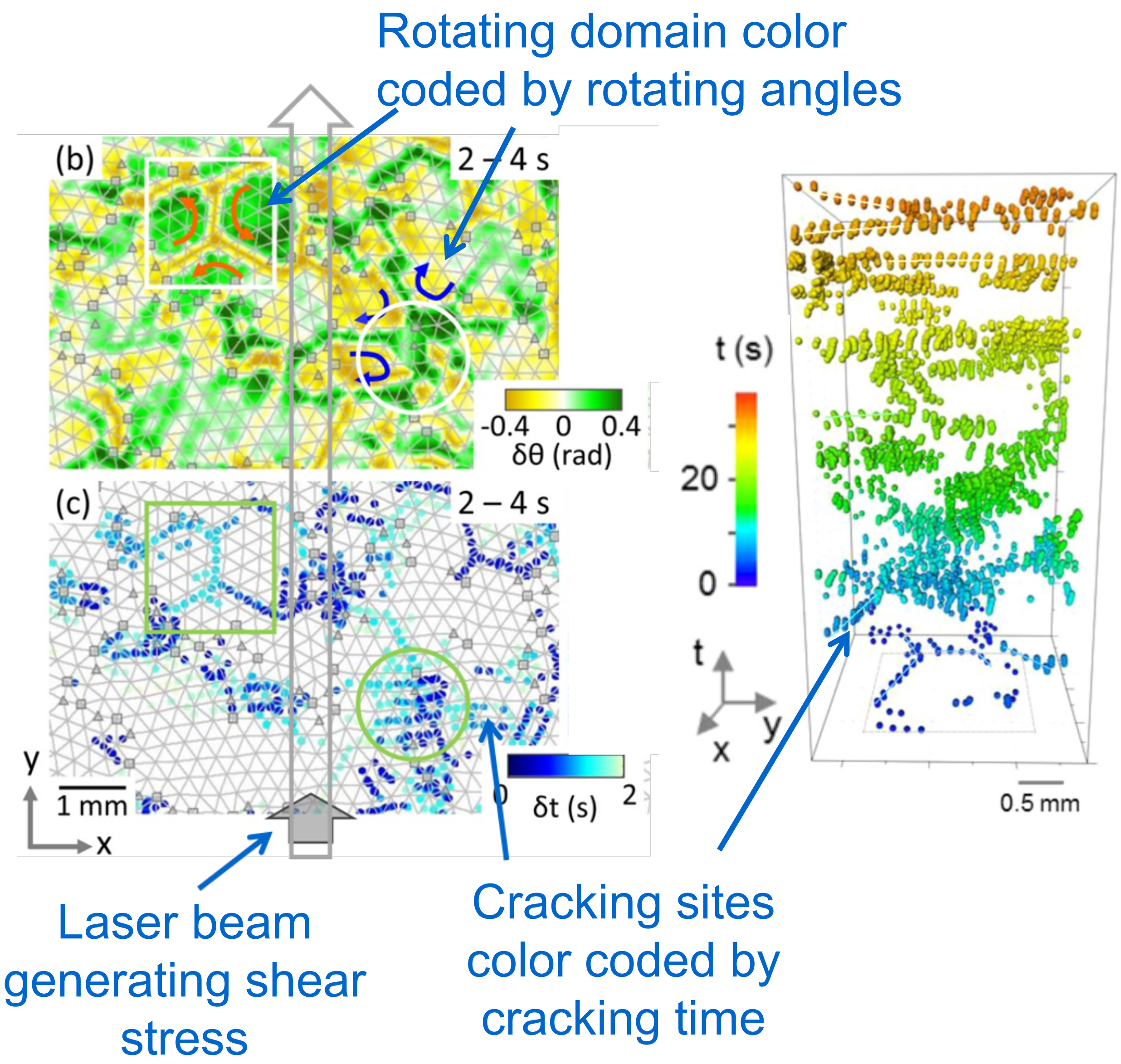
H. Wei Hu

- Transient dynamics of 2D Yukawa crystal melting

Po-C Lin

- Characterization of dust acoustic wave turbulence using Spatiotemporal Empirical Mode decomposition
- Shows existence of multi-scaled acoustic vortices with helical waveforms winding around short-lived defect filaments.

Avalanche domain cracking/healing of sheared dusty plasma liquids near freezing

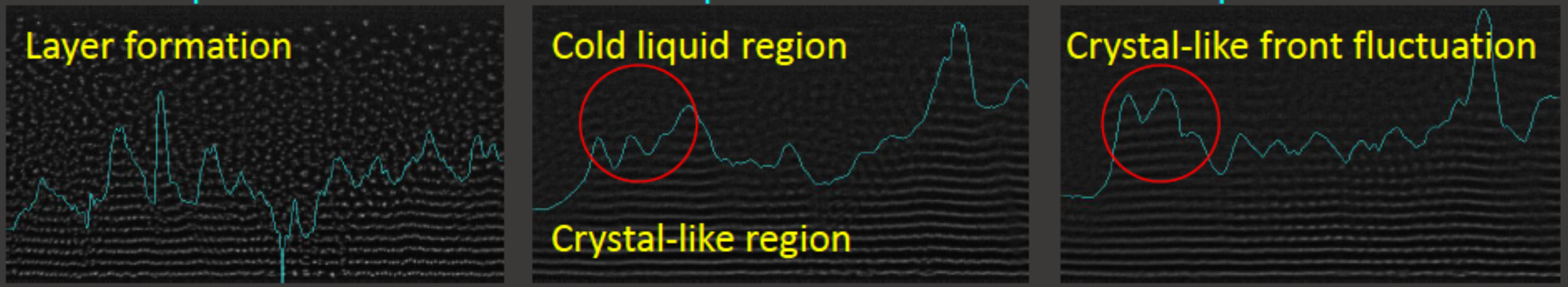


Sheared by a laser beam, a 2D cold dusty plasma liquid exhibits avalanche-like cracking/healing of ordered domains through stick-slip type collective small domain rotation

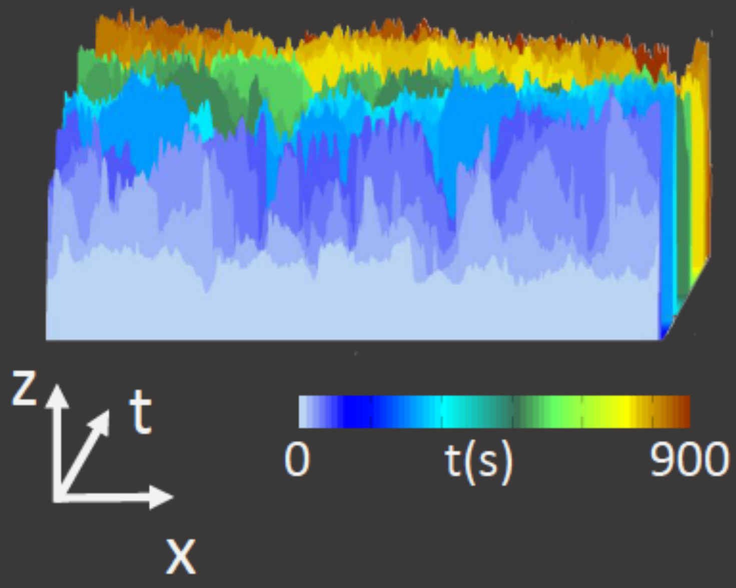
Dynamics of surface-assisted crystalline domain growth in cooled 3D dusty plasma liquids

Wen Wang, Hao Wei Hu
and Lin I
National Central University, Taiwan

Exposure 1 s | Exposure 50 s | Exposure 100 s

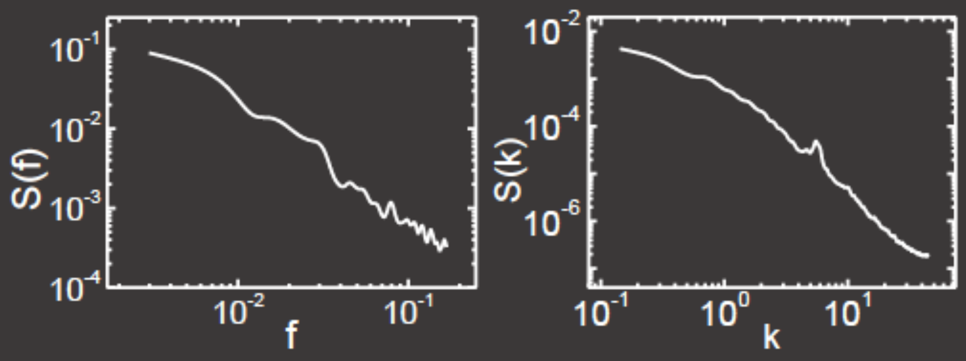


Front profile in xzt space



Spectrum of front

In time | In x space



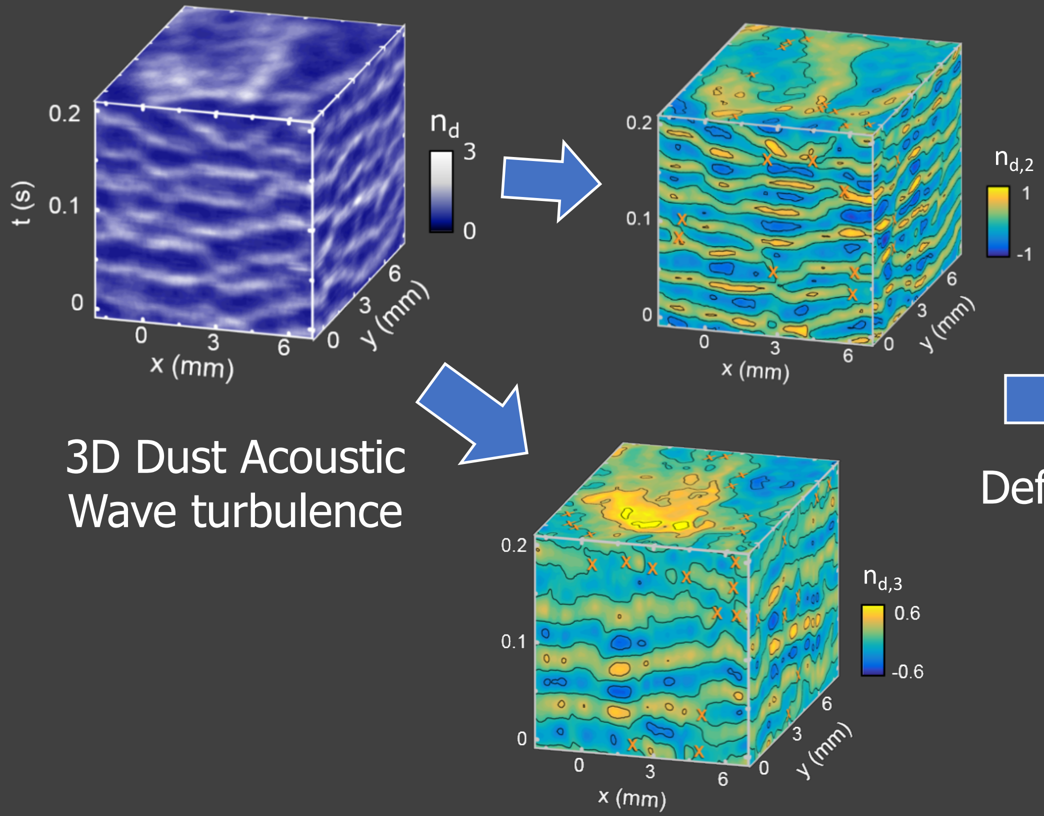
Power law scaling

Coherent motions in dust acoustic wave turbulence

Po-Cheng Lin and Lin I

National Central University, Taiwan

Hilbert-Huang transform on 3D wave turbulence

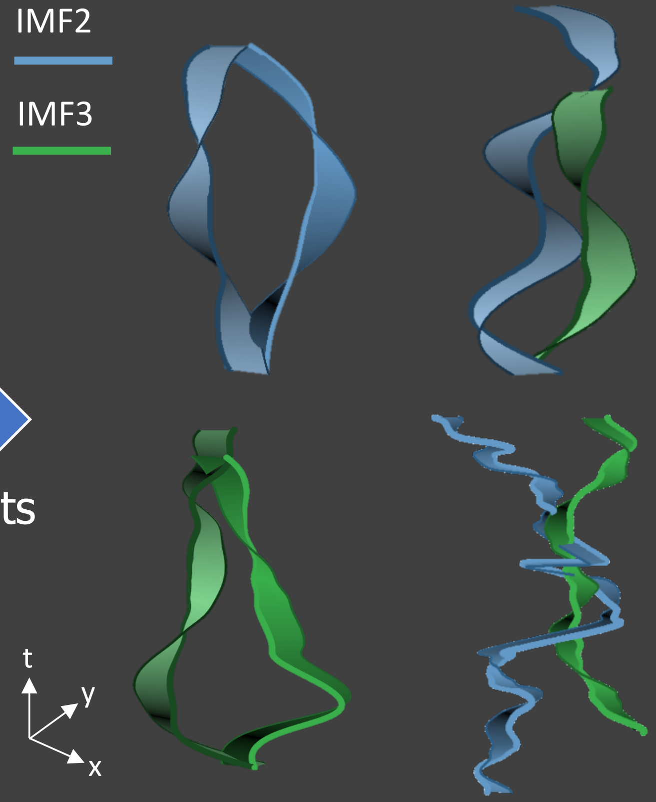


3D Dust Acoustic Wave turbulence

Multi-scale spatiotemporal undulation

Defects

Acoustic vortices as multi-scale coherent excitations



Pair generation and annihilation

Entanglement and synchronization

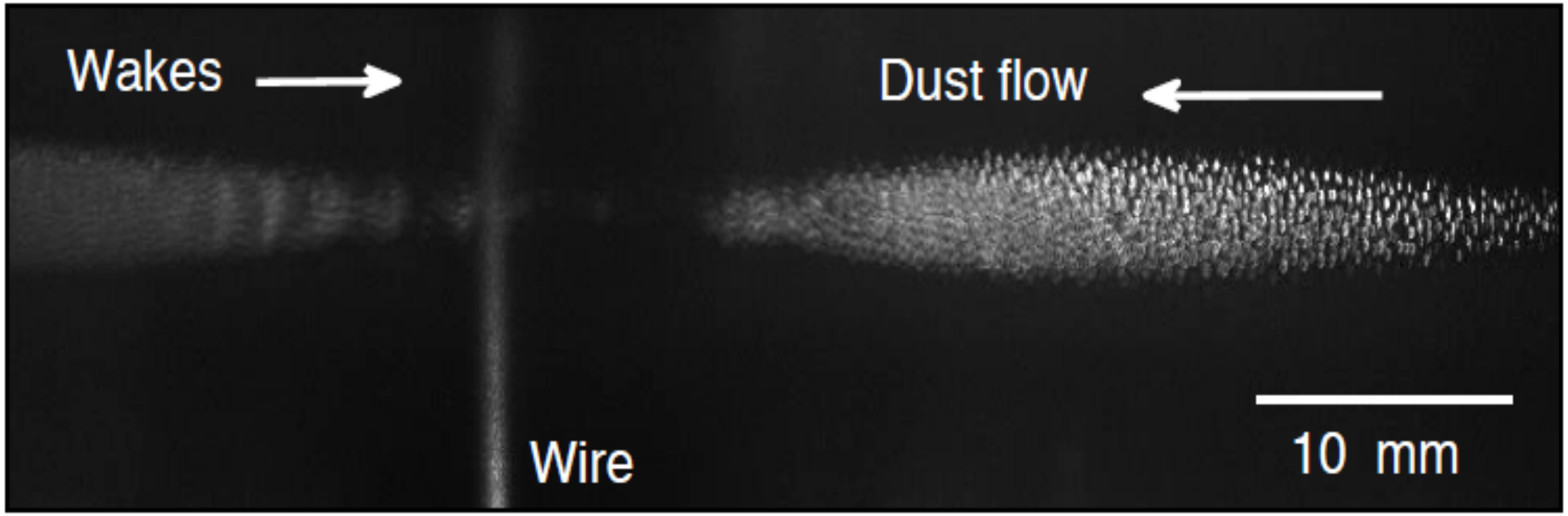
Dusty / Complex Plasmas – Experiments

S. Jaiswal

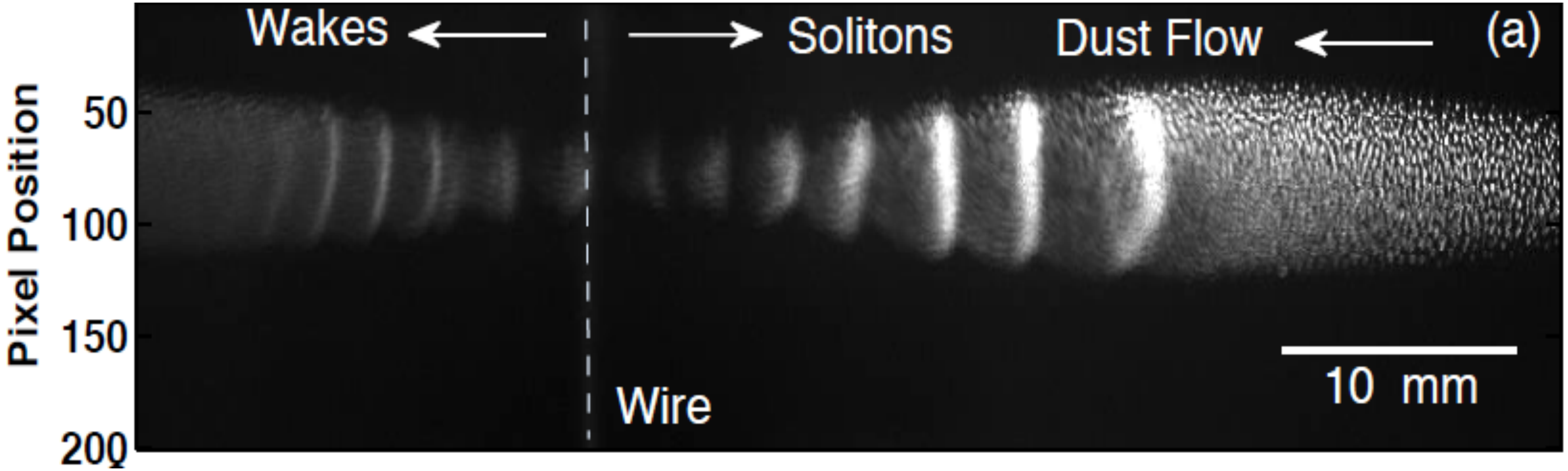
- Exptal study of supersonic flow of dust liquid over an electrostatic potential
- Novel nonlinear fore-wake excitations – precursor solitons

Mangilal

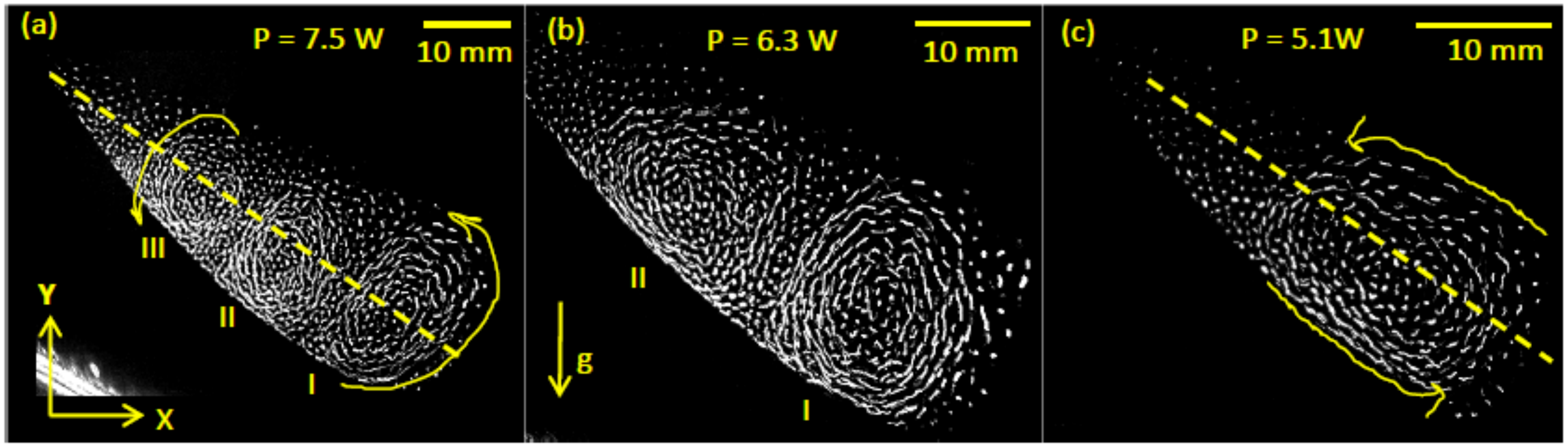
- Experimental observation of co-rotating vortices in an extended dust grain medium with inhomogeneous plasma background
- Quantitative analysis based on the charge gradient to understand the vortex motion and its multiplicity.



Wake formation for subsonic case



Precursor soliton formation in upstream and wake formation in downstream region respectively



➢ PIV images

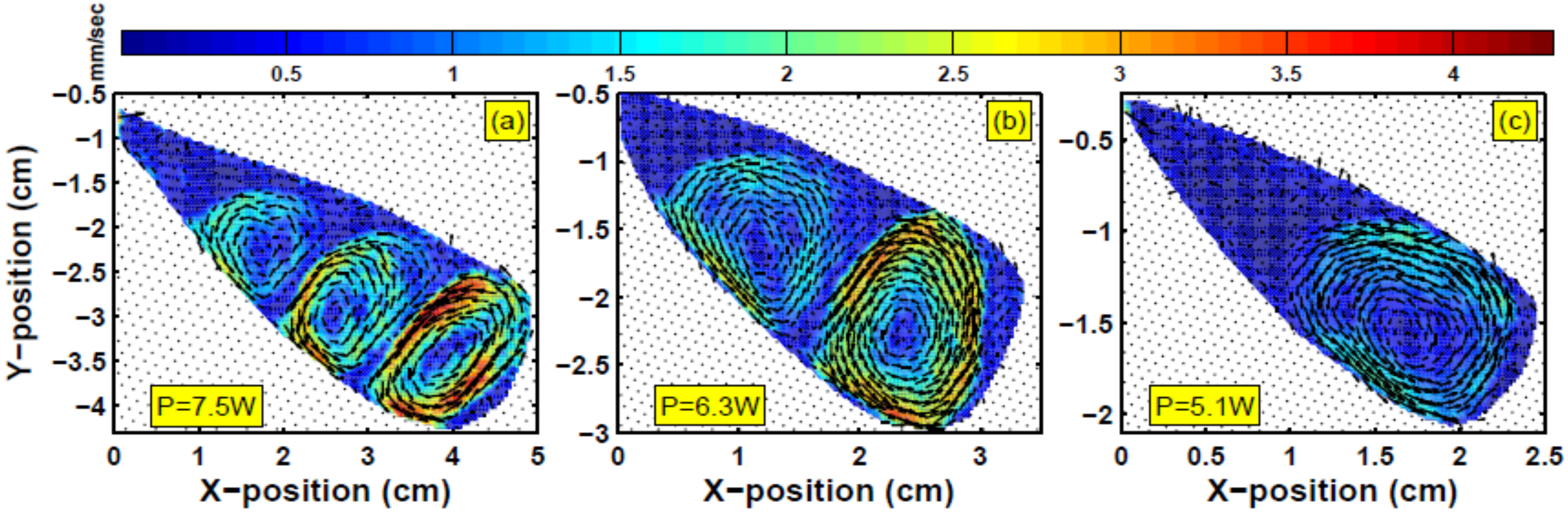


Fig.1 Video images show the multiple co-rotating vortices and its PIV images at constant Ar gas pressure (p = 0.04 mbar). Transition from multiple to single vortex is observed with lowering the input rf power.

Dusty / Complex Plasmas - Theory

Yan Feng

- Derivation of Equation of State for a 2D dusty plasma
- Based on calculation of pressure in Yukawa liquids using MD simulations
- Useful for deriving exact expressions for material characteristics like Bulk modulus

N. Saini, K. Singh, N. Kaur

- Collision of DIA solitons, DA shock waves, DIA cnoidal waves,
- DA soliton collisions, dust rogue waves .....
- DA solitons, Gardner solitons …

↓

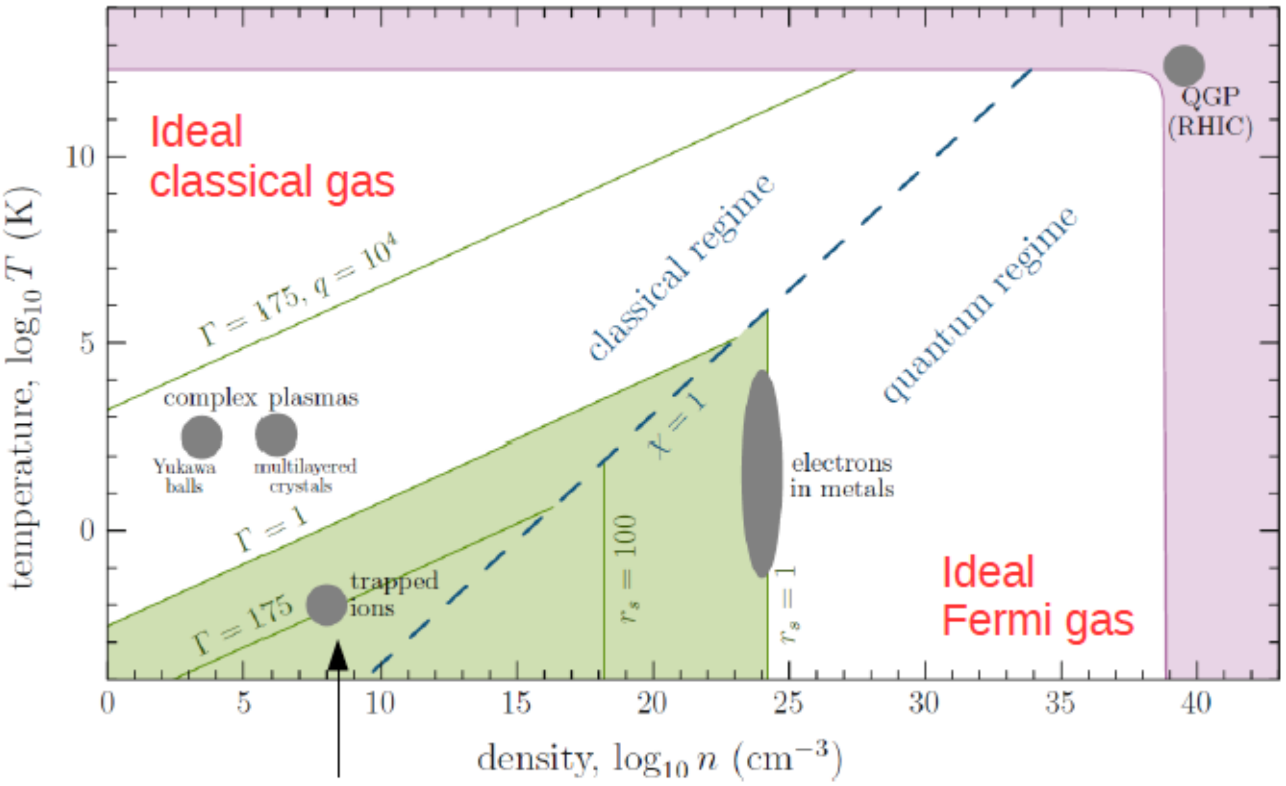
Done with Kappa distributions for electrons or ions as observed in Space plasmas

Quantum Plasmas

A. P. Mishra
D. Chatterjee
D. Zhou

- High density, low temperature plasmas where for example De Broglie wavelength >> inter-particle distance
- Metals, semi-conductors, interior of white dwarfs
- Influence of quantum effects on linear and nonlinear wave propagation
    - Landau Damping -
    - multi-plasmon resonances
    - Modified Nonlinear Schrodinger equation
    - Magnetized quantum plasmas – Alfven waves

One-component plasma: quantum effects



Strong correlations

Quantum effects:

- finite electron extension
- exchange effects
- Fermi statistics
- quantum correlations

quantum coupling parameter:

$$\Gamma_{qa} \equiv \left(\frac{\hbar\omega_{pa}}{E_{Fa}}\right)^2 \sim$$

$$r_s \equiv \frac{d_a}{a_B} \sim n_a^{-1/3}$$

quantum degeneracy parameter

$$\chi_a = n_a \Lambda_a^3 \sim \left(\frac{\Lambda_a}{d}\right)^3 \sim \left(\frac{E_{Fa}}{k_B T}\right)^{3/2} \equiv \Theta_a^{-3/2}; \qquad \Lambda_a^2 = \frac{h^2}{2\pi m_a k_B T}$$

DeBroglie wavelength, Fermi energy

M. Bonitz, *Quantum Kinetic Theory*, 2nd ed. (Springer 2016)

LINEAR LANDAU RESONANCE (Phase velocity and one-plasmon resonances):

- Classical (Vlasov):

$$1+\frac{\omega_p^2}{kn_0}\int_C \frac{\partial_v f^{(0)}(v)}{\omega-kv}dv=0.$$

- Semiclassical limit of Wigner-Moyal: [Barman & Misra, POP (2017); Chatterjee & Misra POP (2016)] $(\hbar k/mv_F \ll 1)$

$$1+\frac{\omega_p^2}{kn_0}\int_C \left[\frac{\partial_v+\left(\hbar^2/24m^2\right)\partial_v^3}{\omega-kv}\right] f^{(0)}(v)dv=0.$$

- Quantum (Wigner-Moyal):[Eliasson & Shukla, JPP (2010)] $(\hbar k/mv_F \gtrsim 1)$

$$1-\frac{\omega_p^2}{n_0}\int_C \frac{f^{(0)}(v)}{(\omega-kv)^2-\hbar^2k^4/4m^2}dv=0.$$

NONLINEAR LANDAU RESONANCE (Group velocity/Phase velocity & multi-plasmon resonances): [The resonance velocity is shifted due to plasmon energy and momentum: $v_{res\pm}=\frac{\omega}{k}\pm n\frac{\hbar k}{2m},\ n=1,2,3,....$]

- **Modulation of electrostatic waves (Modified NLS equation):**

$$i\frac{\partial\phi}{\partial\tau}+P\frac{\partial^2\phi}{\partial\xi^2}+Q|\phi|^2\phi+\frac{R}{\pi}\mathcal{P}\int\frac{|\phi(\xi',\tau)|^2}{\xi-\xi'}d\xi'\phi=0, \tag{1}$$

PLASMA PROPULSION SYSTEMS

Plasma Propulsion Systems

K. Komurasaki

- Space Propulsion Powered by Millimeter-Wave Discharge

S. Shinohara

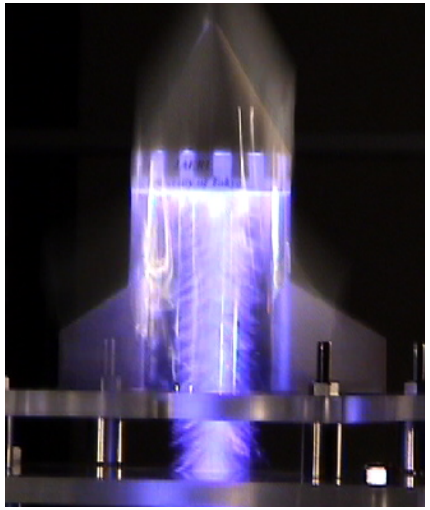
Advanced Electrodeless Propulsion using High-Density Helicon Plasma Source

S. Isayama

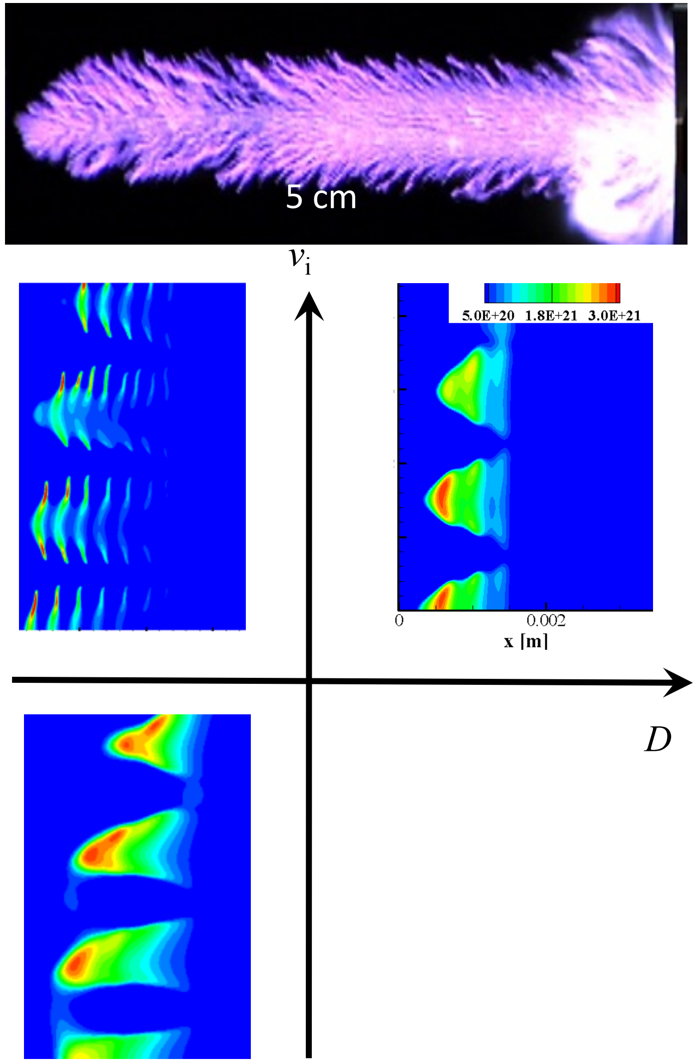
- Self-consistent model of the helicon discharge

Space Propulsion Powered by Millimeter-Wave Discharge

Space Propulsion Powered by Millimeter-Wave Discharge.



Atmospheric Millimeter-wave Discharge in a Rocket.



Observed (top) and computed (bottom) millimeter-wave discharge.

✓Electrically powered launcher is a challenge for future low-cost space transportation and a MW-class gyrotron is a beam source for it.

✓Millimeter-wave discharge was found to have unique comb-shape filamentary structure with a pitch of 0.85λ.

✓This 3D structure enhanced discharge extension speed by 50%.

Komurasaki

Advanced Electrodeless Propulsion using High-Density Helicon Plasma Source

SHINOHARA Shunjiro (Tokyo Univ. of Agri. & Technol., Japan)

Extensive Helicon Plasma Science

★Sources w/ Very Wide Range Scales: (After Our Development)

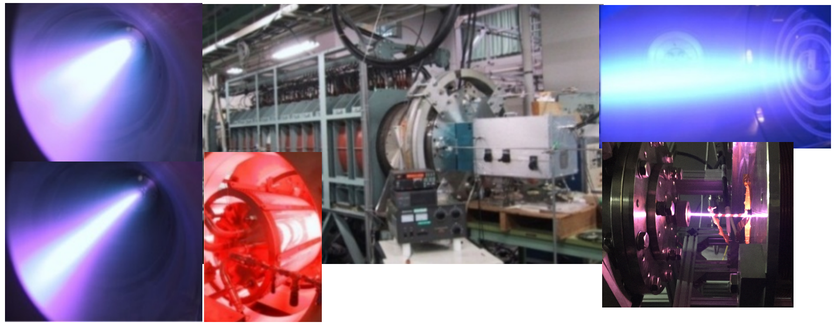
D = 0.1 ~ 74 cm (< 10^3 times), L = 4.7 ~ 486 cm (~ 10^2 times)

V < 1 cm^3 ~ 2 m^3 (> 10^6 times)

★Electrodeless Conditions w/ Flexible External Parameters:

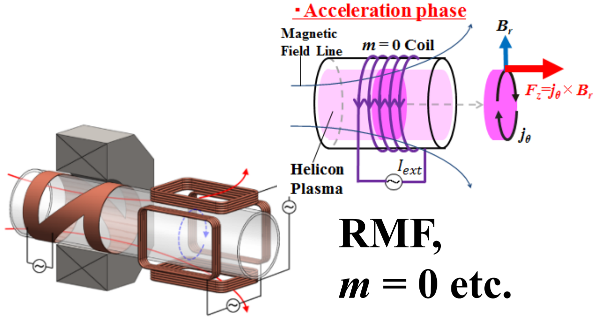
High-Density (~ 10^{13} cm^{-3}) Production

Electromagnetic Acceleration



Various Helicon Sources Developed

Project
2009-2014
& Beyond

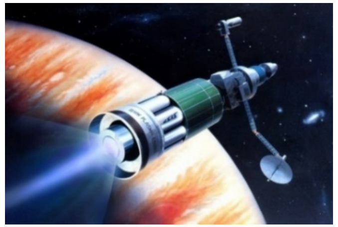


RMF,
m = 0 etc.

Many Proposed Schemes

★Promising, Future Advanced Thruster

Long Life with High Efficiency



Spin-Off
Hybrid Areas

Self-consistent model of the Helicon Discharge

- A self-consistent fluid model, which includes wave excitation, collisional electron heating, and diffusion of plasma and neutrals to investigate the temporal behavior of the helicon discharge.

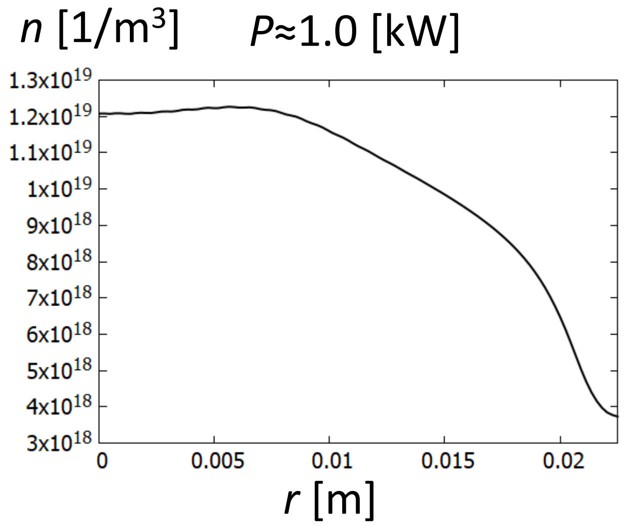
- Results agree well with experimental data

- Delineates the roles of the helicon wave and the TG wave

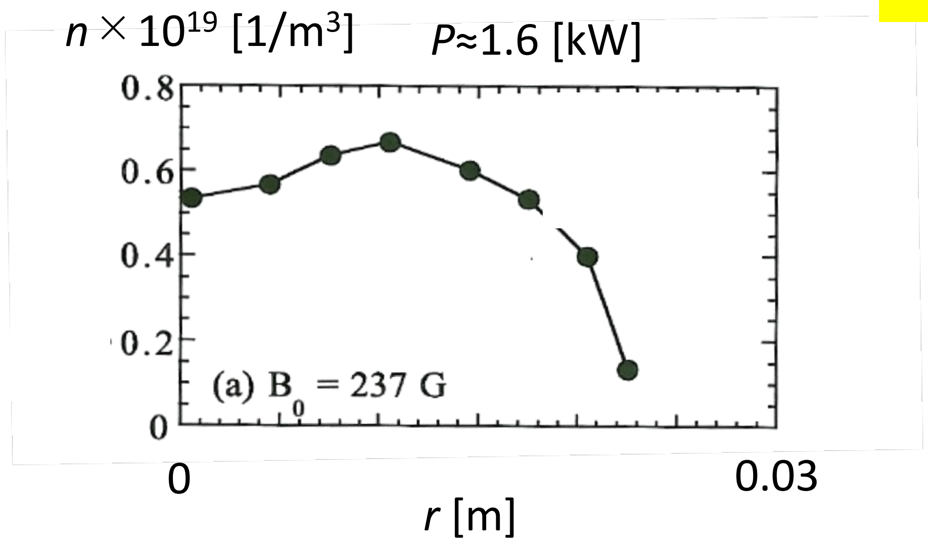
Isayama

○Radial density profile

Simulation

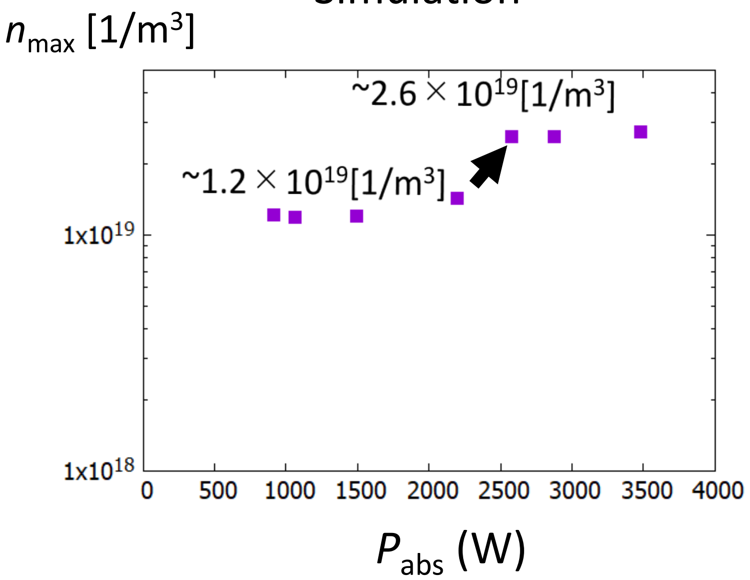


Experiment

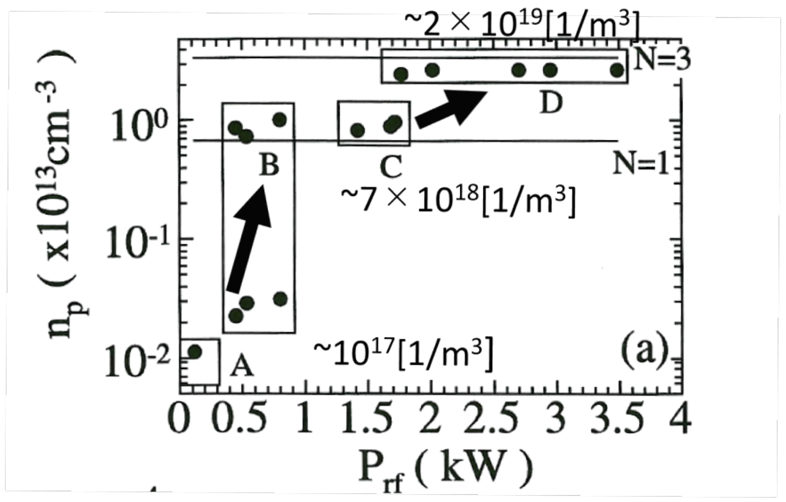


○Dependence of the plasma density on the rf input power

Simulation



Experiment



Diagnostics

You have just heard the following plenary talk so will not discuss it further

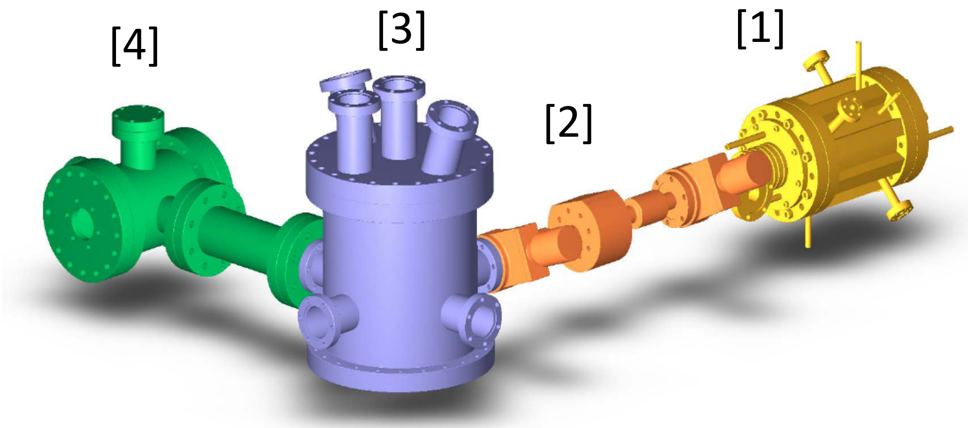
* H. Akatsuka

Diagnostics of N2 based Gas Discharge Plasma by Optical Emission Spectroscopy on Atomic and Molecular Processes

Lamb shift and electric field measurement in plasmas

F. Doveil, *PIIM, Marseille, France*

- Direct, non-intrusive measurement of static and fluctuating electric field in plasma, a long challenge in plasma physics
- Based on two properties of hydrogenoïds: i) Mixing of 2s and 2p levels induced by Stark effect, ii) Lamb shift due to radiative corrections
- **Intensity of Lyman-α emission of a probe test hydrogen beam proportional to E^2, and resonant at 1,058 Ghz**
- Localization by measuring Lyman-α light with spectrometer perpendicular to beam
- Results with H^+ ion and H(2s) atomic beam:
  - -static field between two plates in vacuum, and in plasma sheath
  - -RF field in vacuum and in plasma
  - -**E^2 law verified and saturation explained** by geometrical effects
  - -resonance at Lamb frequency
- Install in a magnetized plasma, and in ISHTAR (Garching)

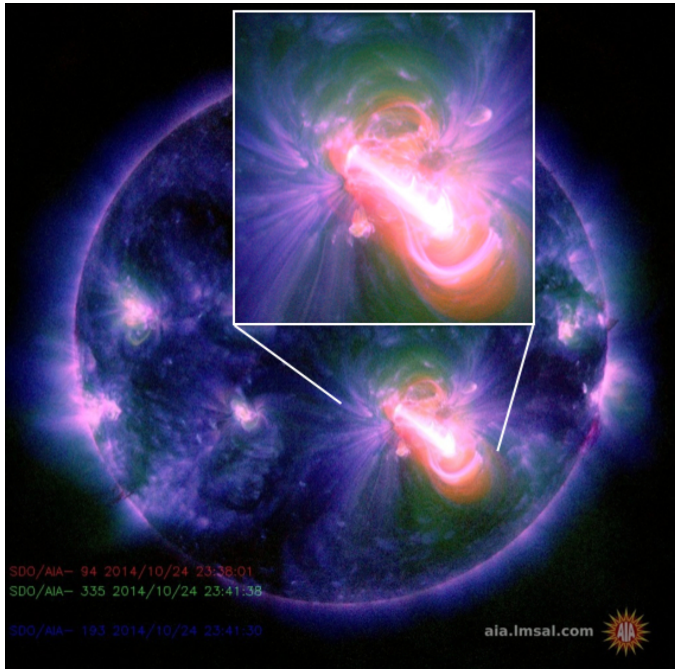


<u>Scheme of the experiment</u>: [1] plasma source and Einzel extraction lenses, [2] neutralization by Cs vapor oven, [3] test chamber and Argon discharge, [4] UV spectrometer for Lyman-α light collection

L. Chérigier-Kovacic et al., Rev. Sci. Instrum., 86, 063504 (2015)

Y. Yang

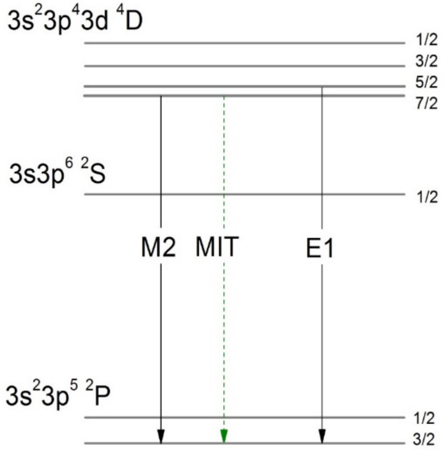
Magnetic Induced Transitions and the possibility of using such to measure/monitor the active Solar Corona magnetic field.



An underlying cause of a solar flare is the conversion of magnetic energy to thermal energy in the corona

It is therefor interesting to know that there is, currently, no space based method to measure this magnetic field strength, expected to be of the order 0 – 0.2 T.

Through careful studies of atomic structure we have proposed a possible method to measure this field strength using a line ratio in the soft x ray spectrum of Fe^{9+}.



Due to a close energy degeneracy between the $^4D_{7/2}$ (metastable) level and the $^4D_{5/2}$ in Fe^{9+}, a MIT is opened up in the presence of an external magnetic field. As this degeneracy is very close (3.5 cm-1 or 0.043 milli eV) this transition is sensitive to fields of the order of those found in the active Corona. Fe^{9+} is abundant in the solar corona.

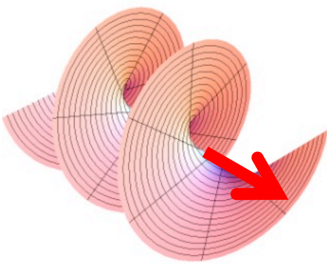
New Doppler Spectroscopy Using Optical Vortex (OV) Beam

M. Aramaki

Laguerre – Gaussian mode

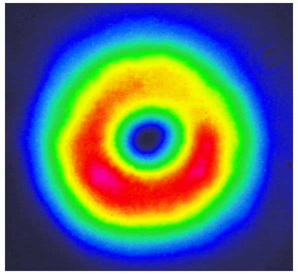
Property of OV beam

3-D structure
Phase front

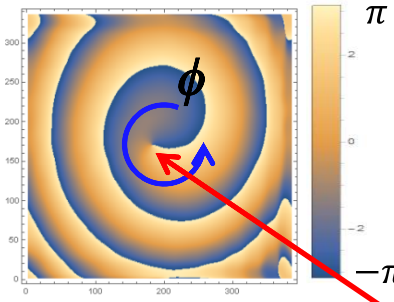


2-D structure in beam cross-section

Intensity



Phase

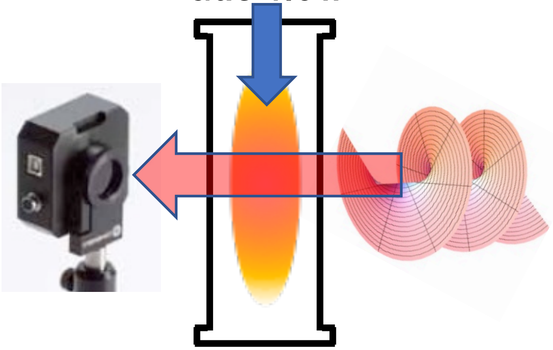


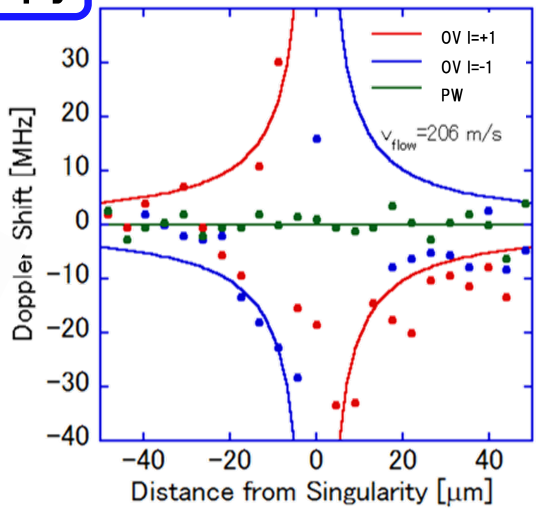
Doppler shift

$$\delta_{OV} = -kV_z - \left(\frac{l}{r}\right)V_\phi$$

Azimuthal Doppler shift

OV Doppler Spectroscopy



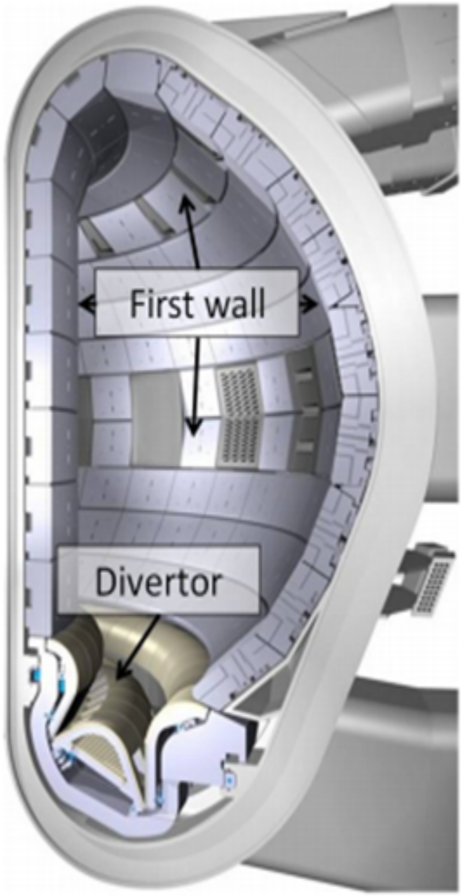


Conventional Doppler spectroscopy has no sensitivity to motion across the beam, but OV spectroscopy can detect it.

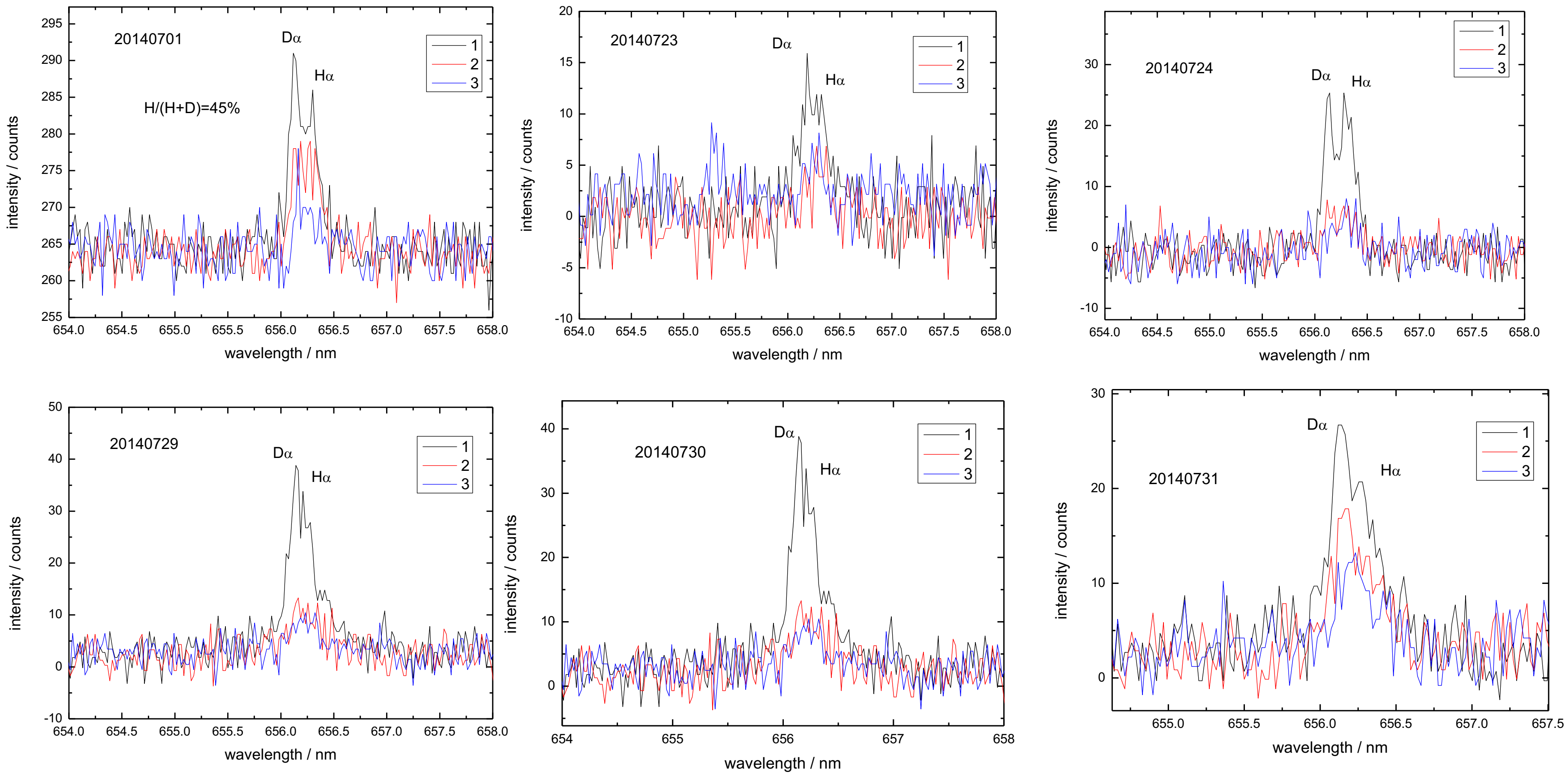
Application of Laser Induced Breakdown Spectroscopic (LIBS) for characterization of impurities deposits and deuterium retention on the first wall in EAST tokamak

Hongbin Ding
Department of Physics, Dalian University of Technology, China

- Analysis and understanding of wall erosion, material transport, D retention are among the most important tasks for EAST and future fusion device, ITER .
- Laser-based technique (like LIBS) is most promising candidates for the Wall behavior analysis.
- **An in-situ LIBS wall-diagnosis system in EAST has been developed since 2014 ;**
- **The H/D retention in the co-deposited layer on the first wall of EAST was in-situ measured by LIBS approach;**
- **LIBS can provide chemical composition and depth profile analysis in the interface between the co-deposited layer and the substrate of the first wall.**



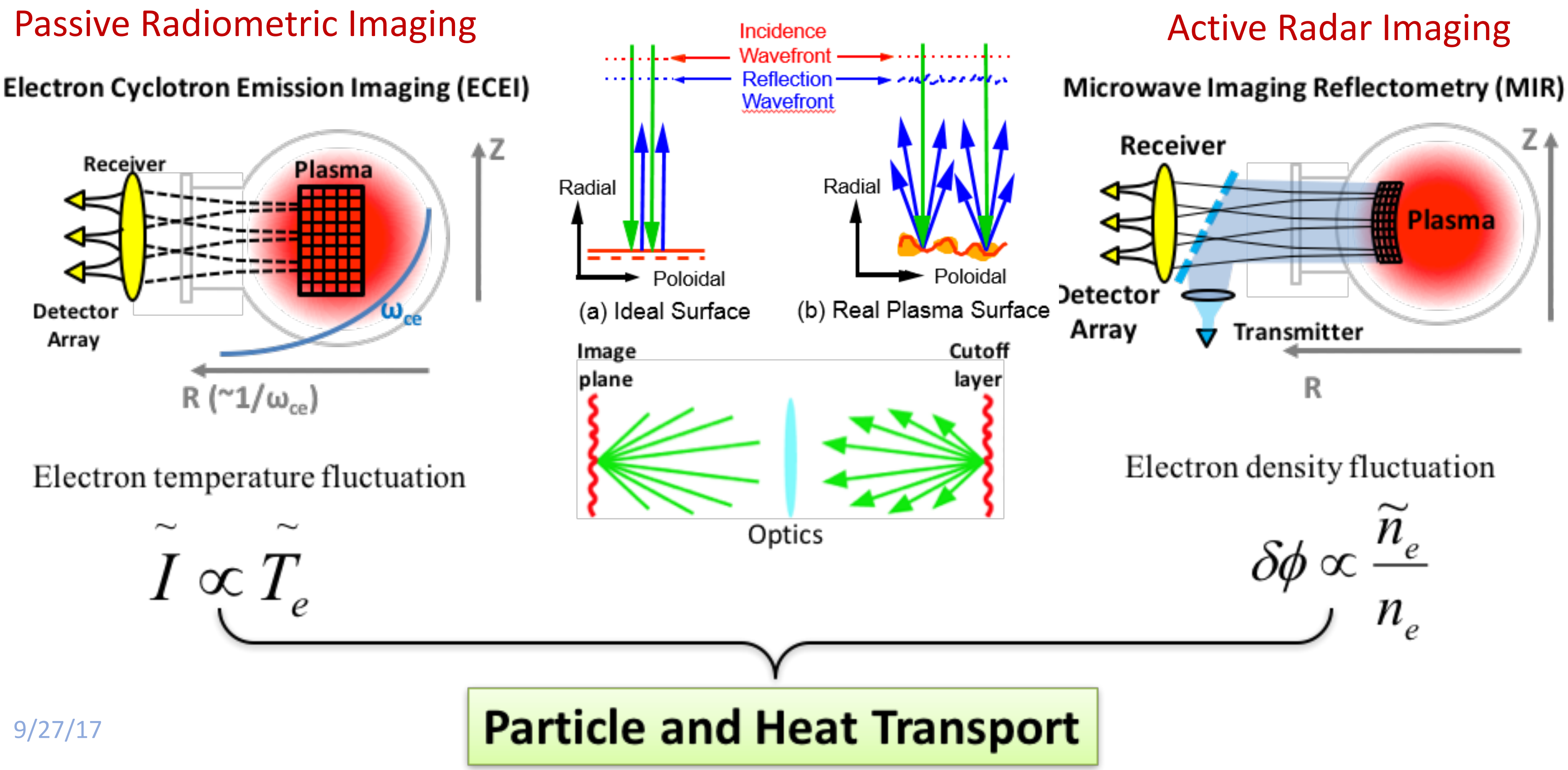
Measuring H/D retention on the first wall of EAST using LIBS approach



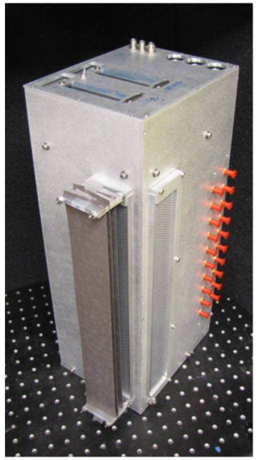
H/D ratio on the different operation days during EAST 2014 campaign

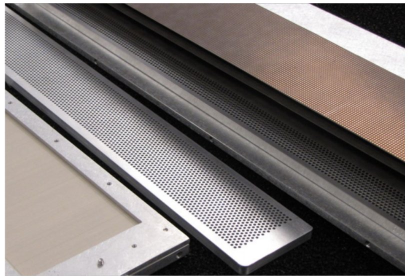
Millimeter Wave Fusion Plasma Imaging Diagnostics

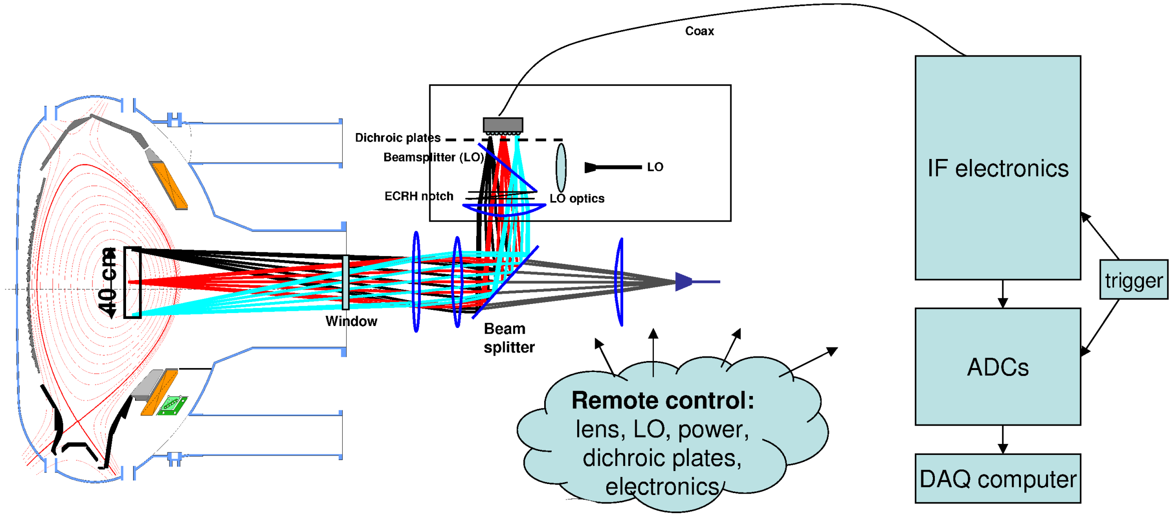
N. Luhmann

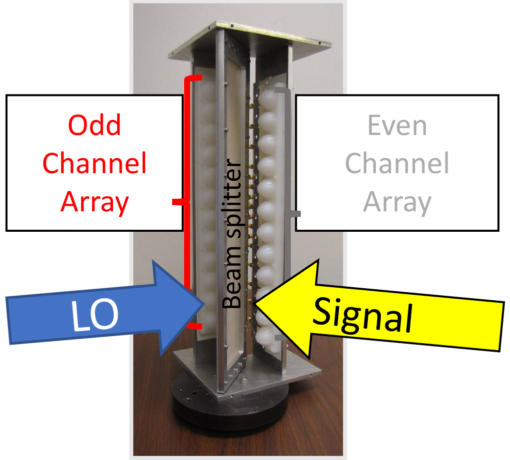


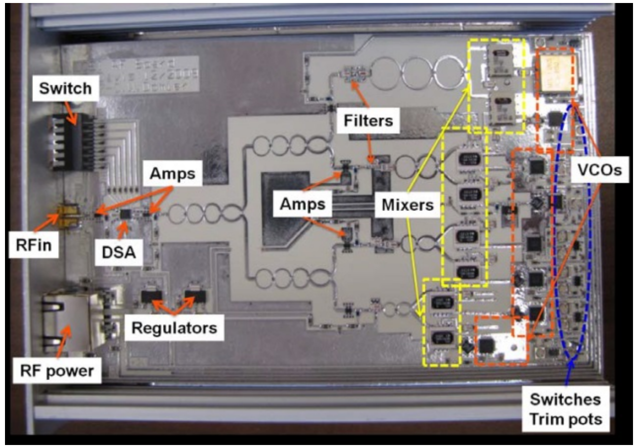
ECEI Systems: Optics & Electronics

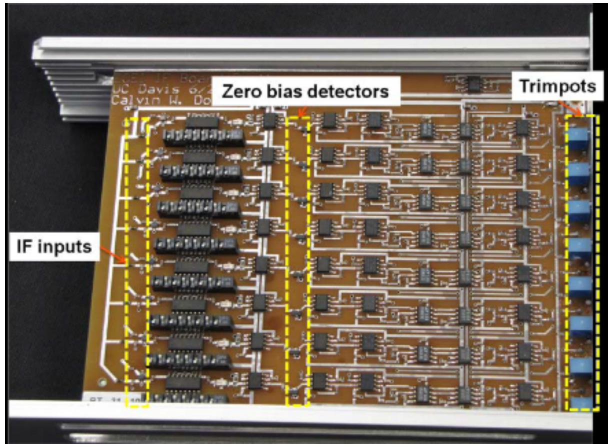


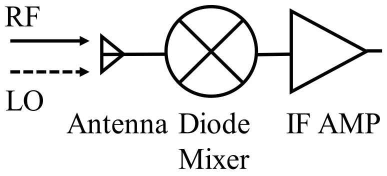




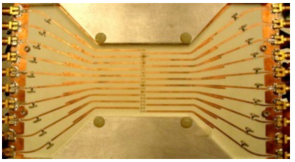








Diode Mixer

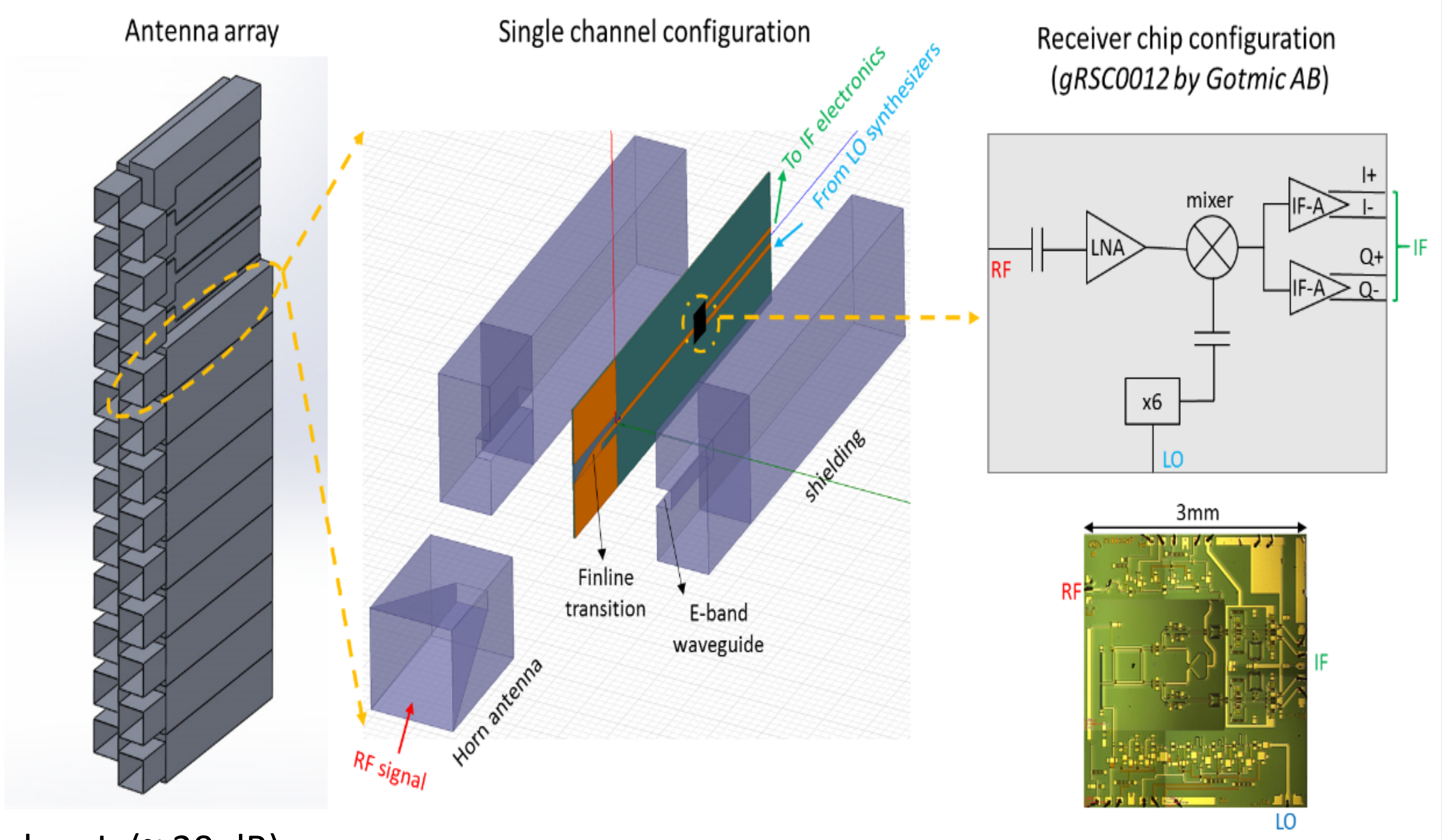


Mixer: conversion loss L_C(~ 20 dB),
noise temp. T_m(~ 5,000 K)
IF Amp: noise temp. T_{IF}(~ 500 K)

High noise temperature due to L_C

System noise temperature:
$T_s = T_m + L_C T_{IF}$ (~ 55,000 K)

System-on-Chip Based Horn Array for DIII-D



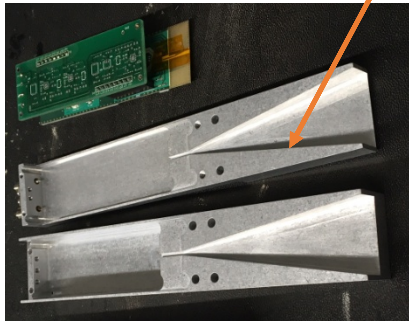
Mixer: conversion loss L_C(~ 20 dB),
noise temp. T_m(~ 5,000 K)
IF Amp: noise temp. T_{IF}(~ 500 K)
Pre Amp: gain G_0 (~15 dB)
noise temp. T_0 (~ 500 K)

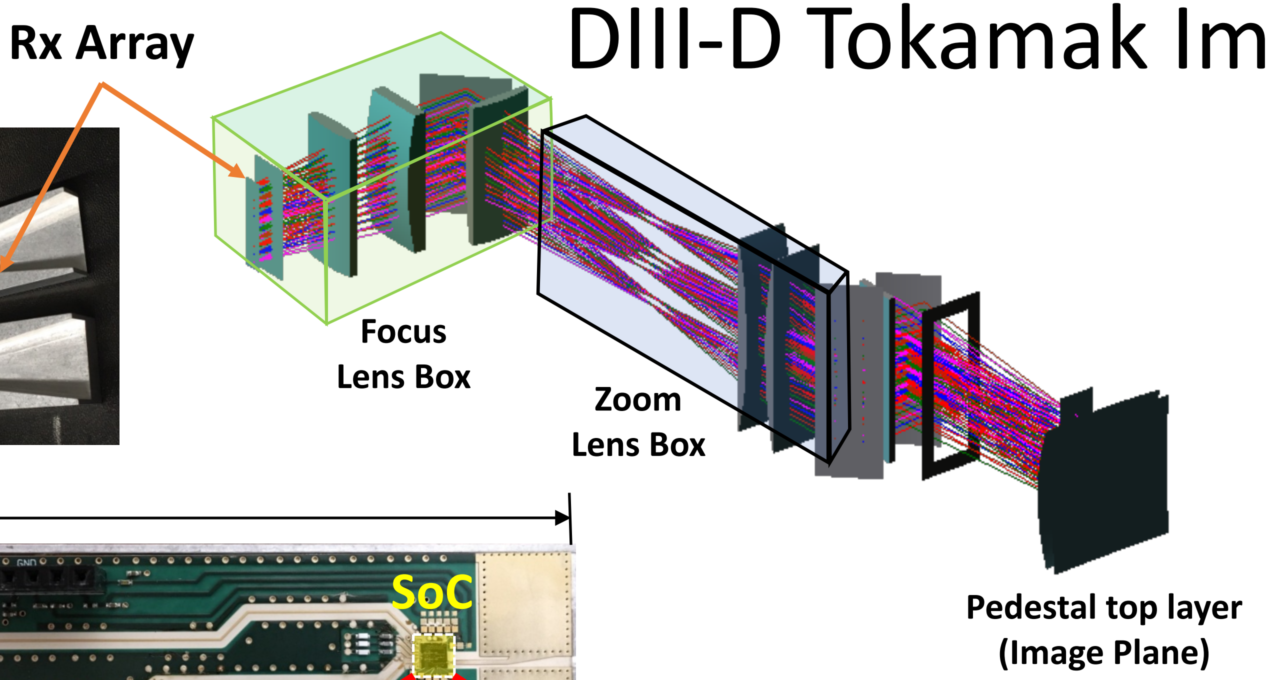
Friis' equation for cascaded stages

$$F_{cas} = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \ldots$$

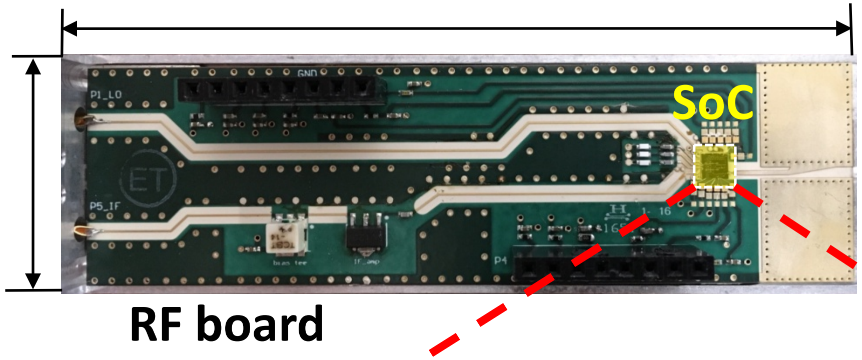
System noise temperature:
$T_s = T_0 + T_m/G_0 + L_C T_{IF}/G_0$ (~ 2,239 K)

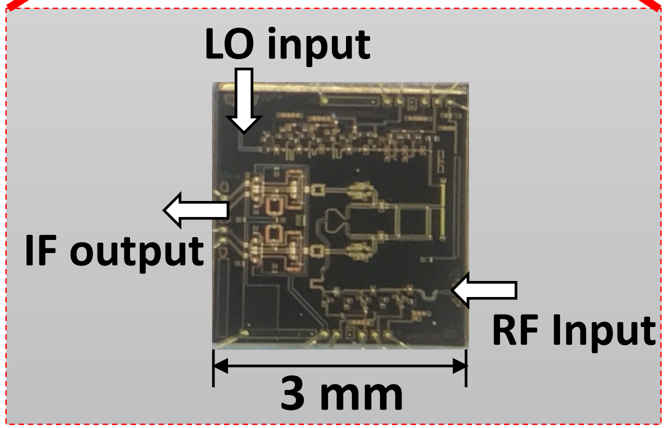
DIII-D Tokamak Implementation

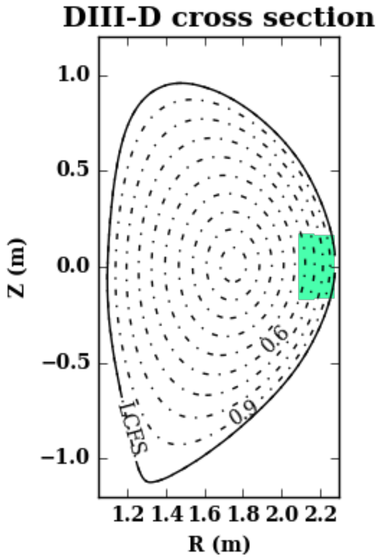




- High Efficiency
- Shielding
- Higher resolution
- Chips - production







Shanghai EBIT Facility

- An electron beam ion trap (EBIT) , Shanghai-EBIT, has been built in Fudan.
- An EBIT uses a monochromatic and tunable electron beam to produce ,trap and interact with highly charged ions. It is possible to selectively study the electron-ion collision processes.
- The highest electron energy of Shanghai-EBIT reaches about 150 keV, which is the second highest in the world.
- To study the edge plasma physics, two compact low-energy EBITs were also developed in the Shanghai-EBIT Lab. These two EBITs can reach electron energy as low as a few tens eV.
- Combining these EBITs, electron energy from 30eV to 150 keV can be reached, therefore covers the main electron energy region of fusion plasmas.

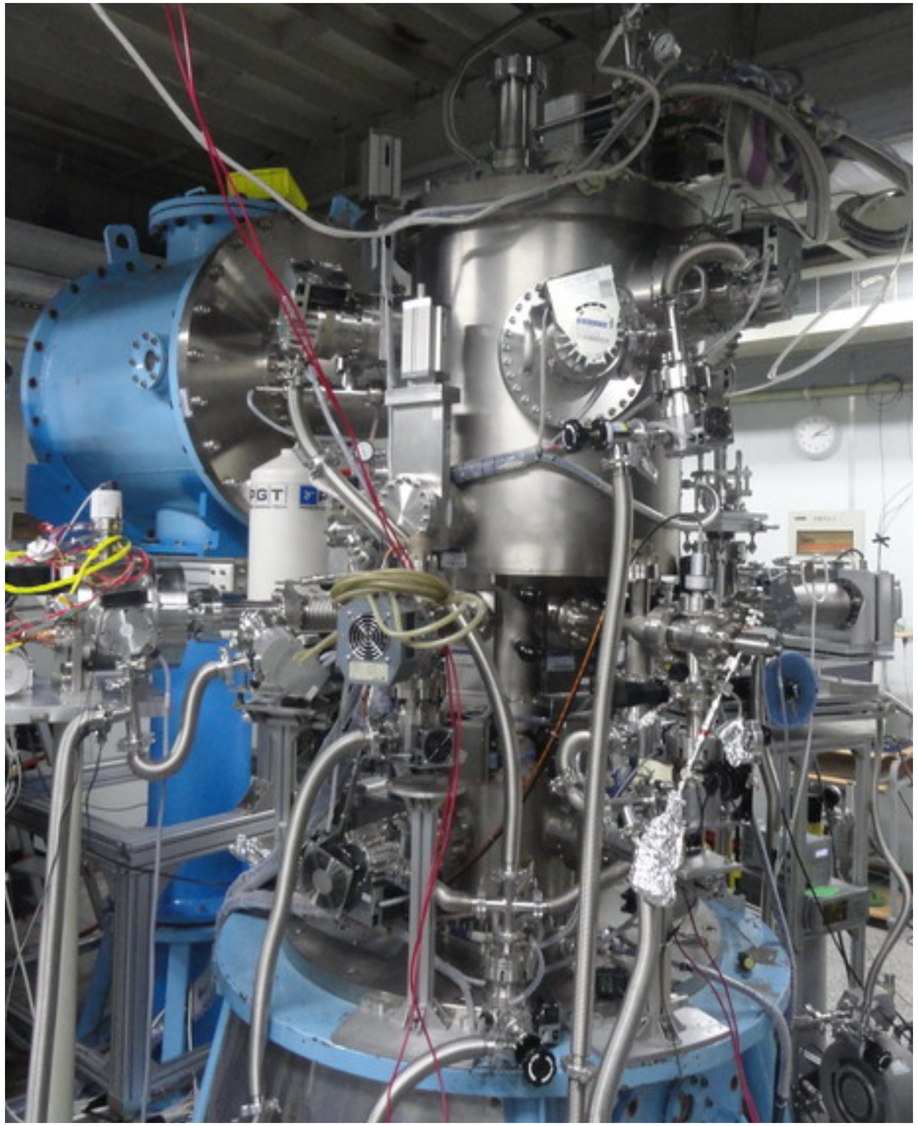
Shanghai-Electron Beam Ion Trap(EBIT)

Ke Yao
T. Xu

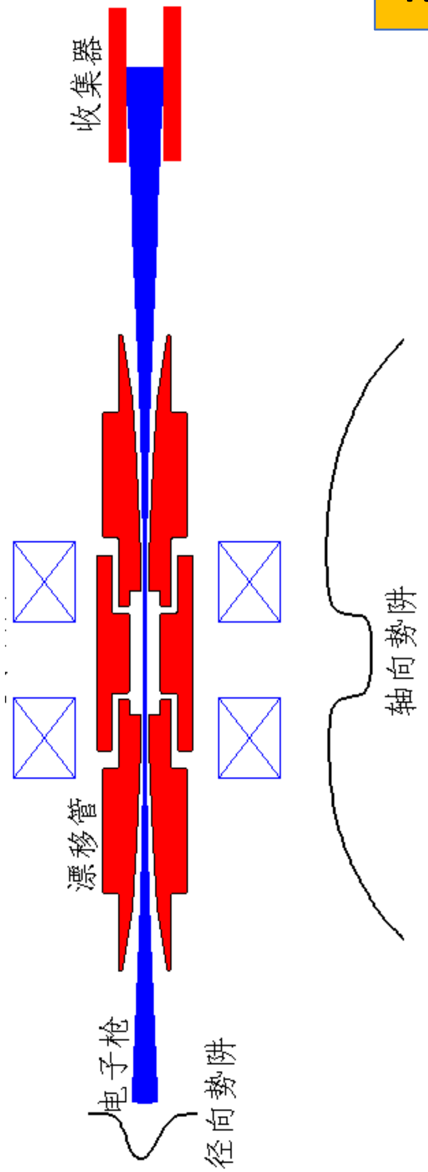
Pure-Ti

Non-Magnetic

Para. Achieved	
Beam energy	**151 keV**
Beam current	**215 mA**
B (Max.)	4.8 T
Beam radius	32.8 μm
Vacuum	~7.5×10^{-11} Torr
coolant	L-He (4.2 K)



D. Lu, *et. al*, Rev. Sci. Instrum. 85, 093301(2014)



Low Energy EBITs

Perm. Mag.: 0.5 T

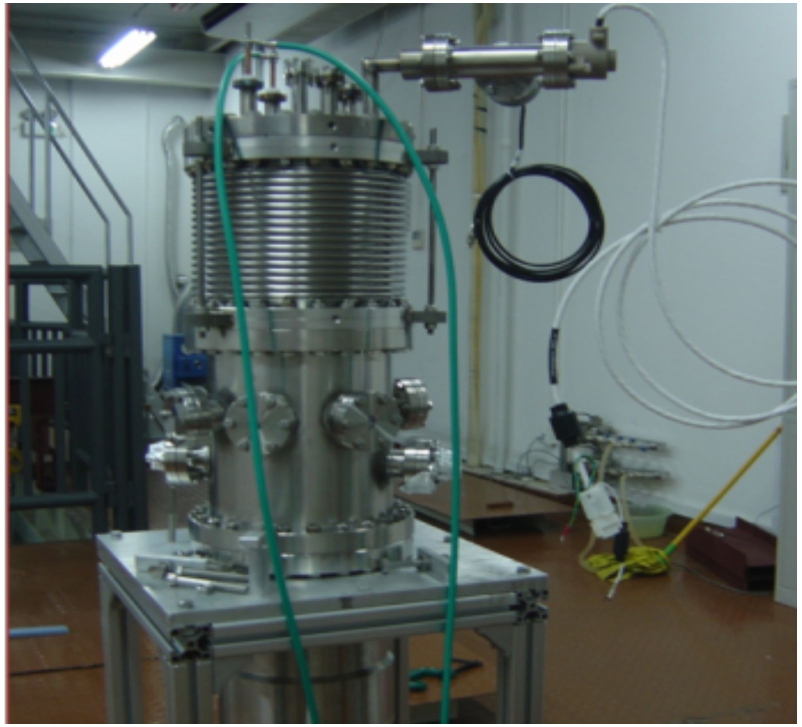
Ee：60-5000 eV

Ie：10 mA

HTSC Mag.: 0-0.25T

Ee: 30eV-5000eV

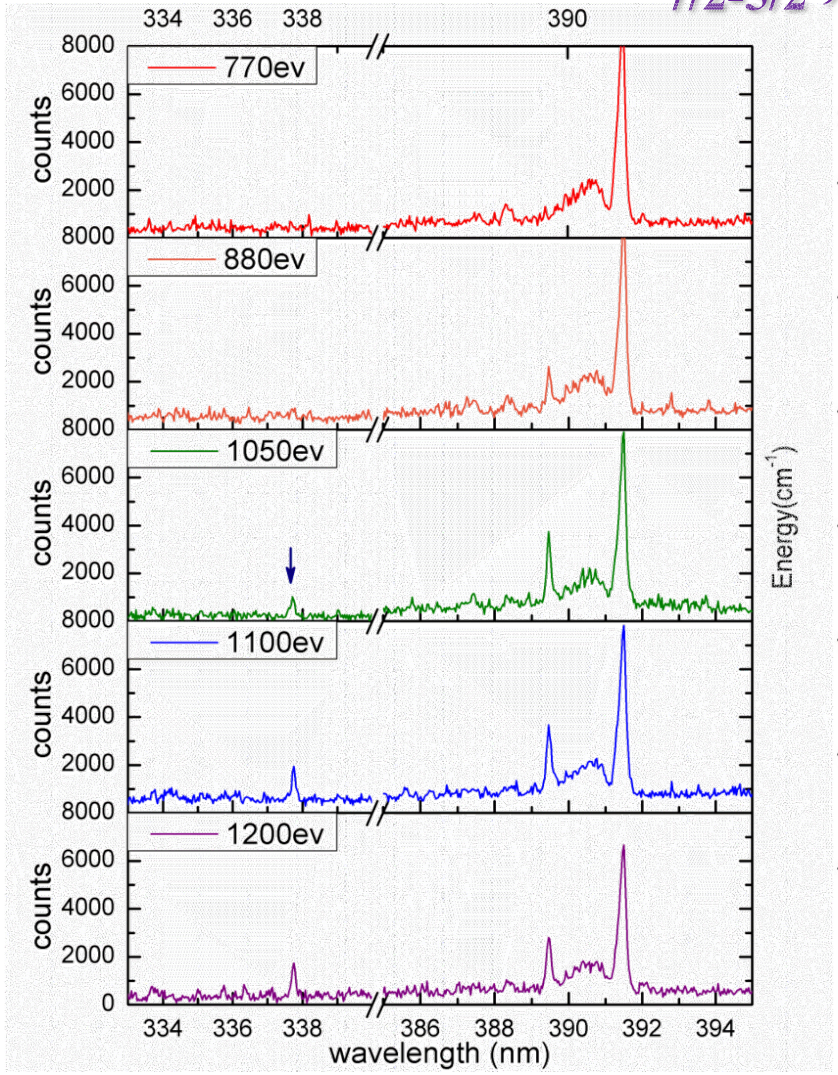
Ie：10 mA



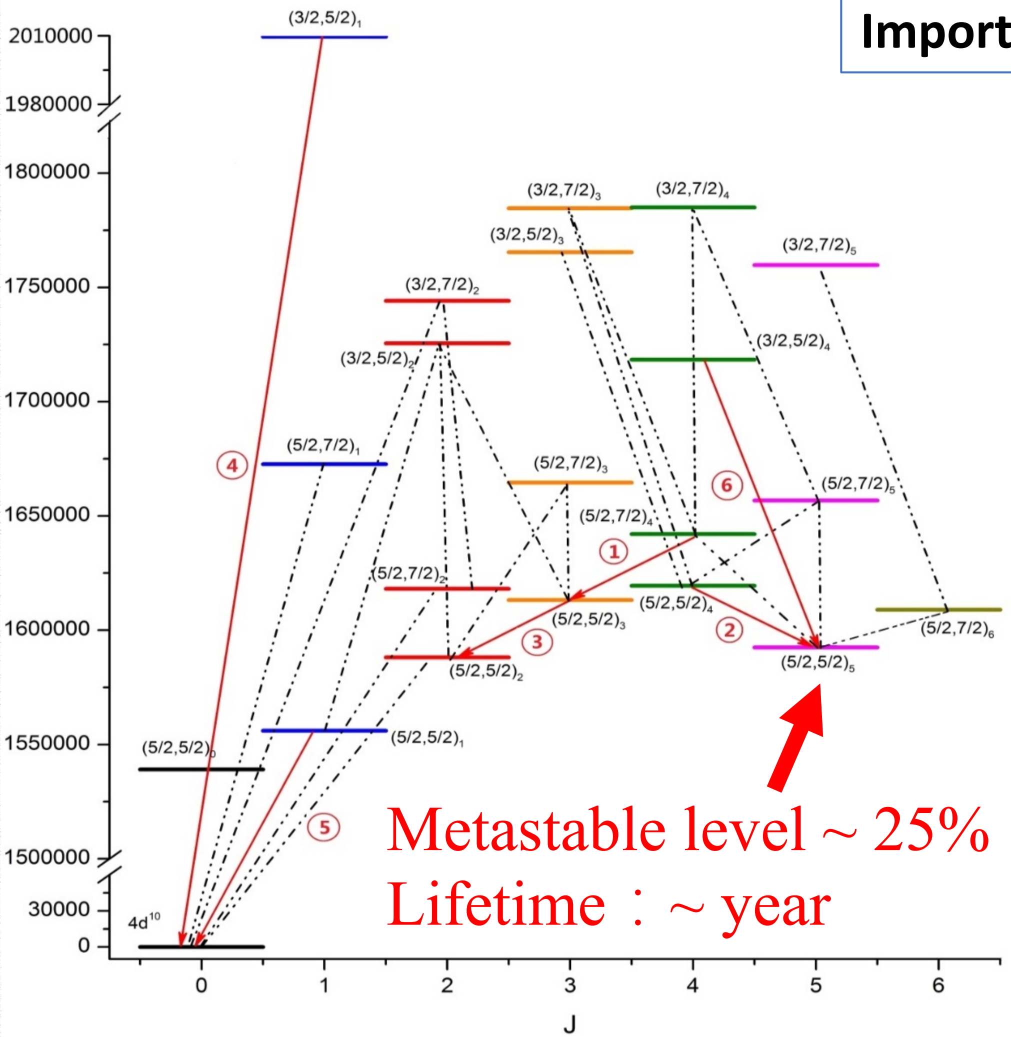
Visible lines from W^{27+} $4f_{7/2-5/2}$, and W^{28+}: $4d^94f$

Spectroscopy of W

Important for ITER



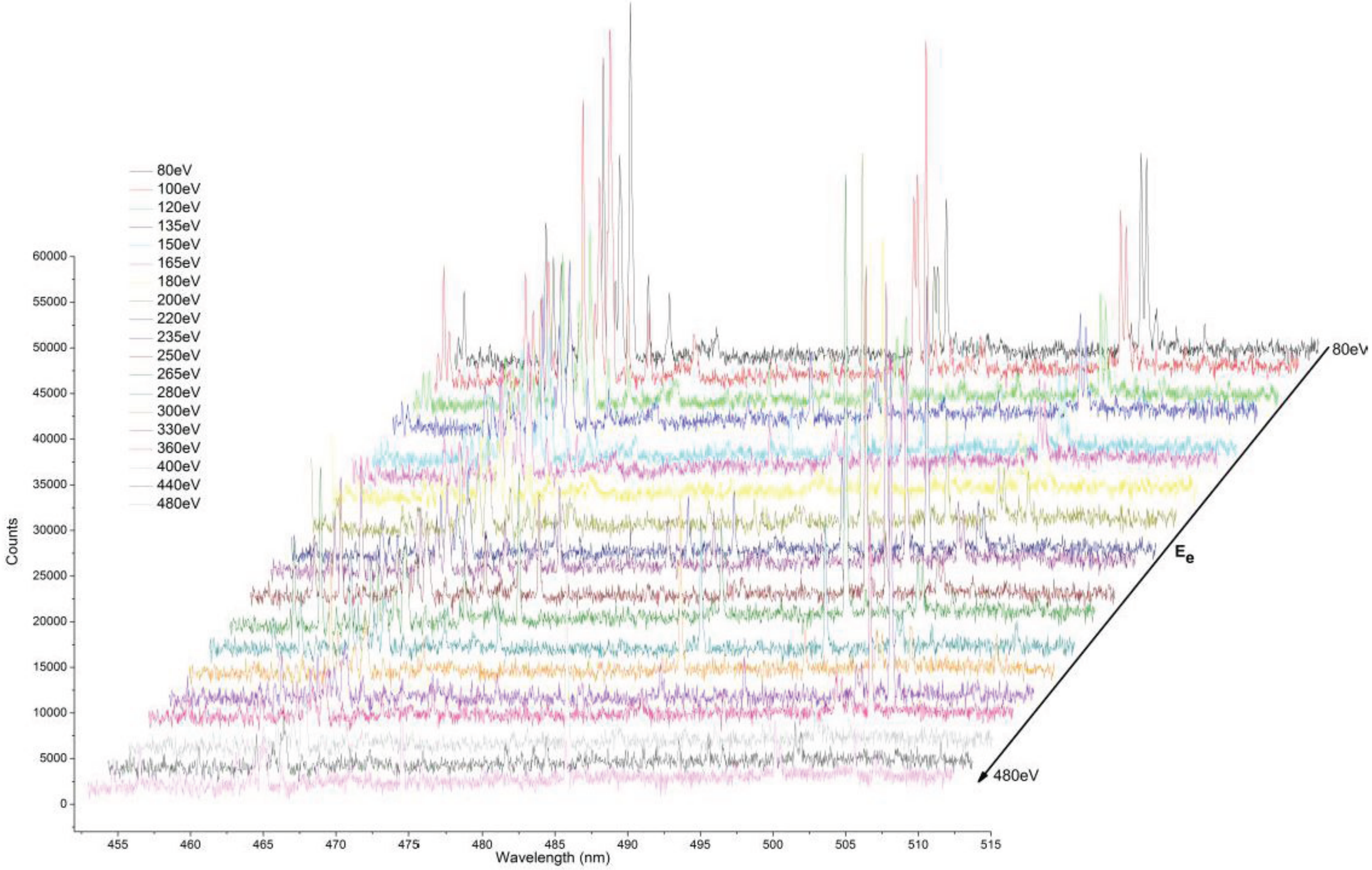
Z. Fei, *et al*, Phys. Rev. A 86, 062501 (2012)



Metastable level ~ 25%
Lifetime：~ year

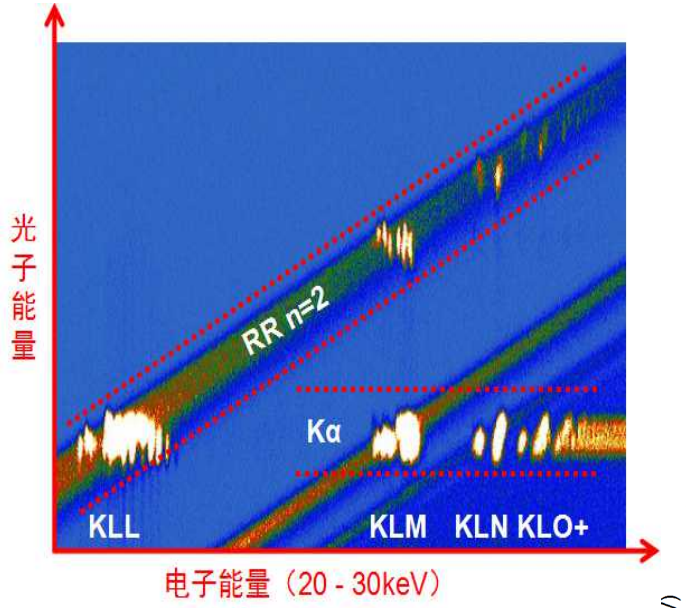
M. Qiu *et al*, J. Phys. B. 47 ,175002 (2014)

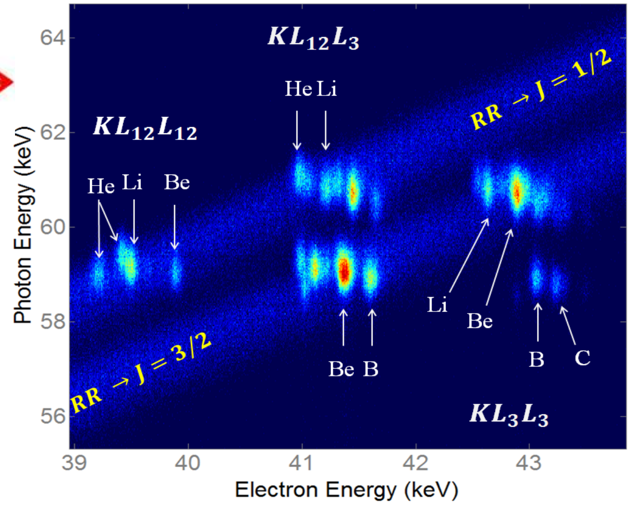
Identified Many other Lines from W^{q+} Ions

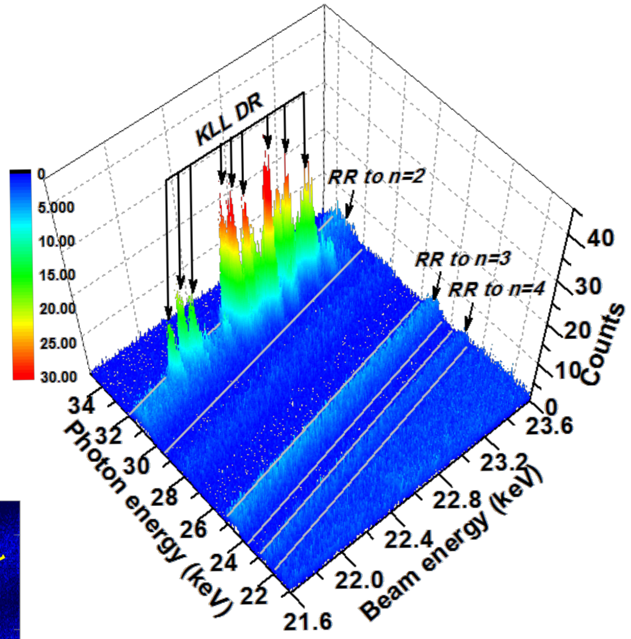


Dielectronic Recombination(DR) Experiments:

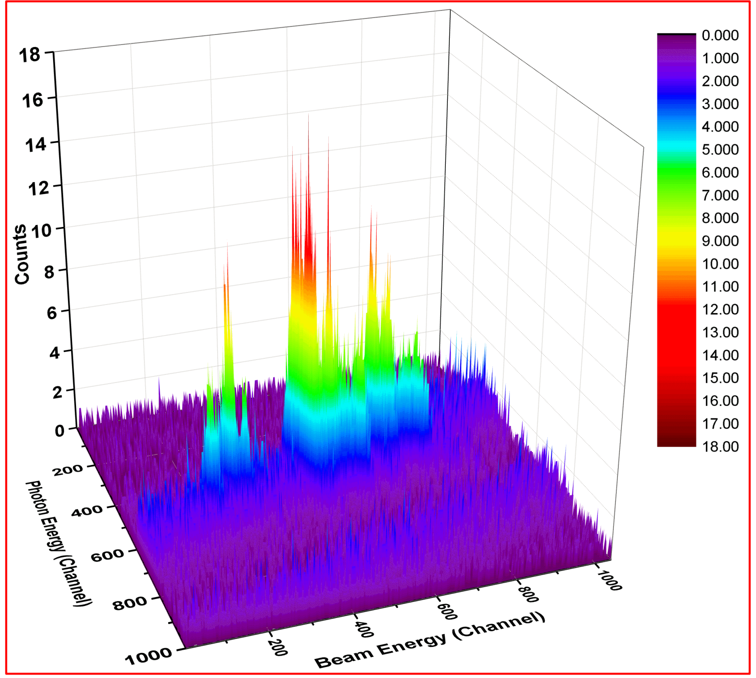
Ar (Z=18)、Kr (Z=36）、Xe (Z=54)、 Ba (Z=56)、W (Z=74)…



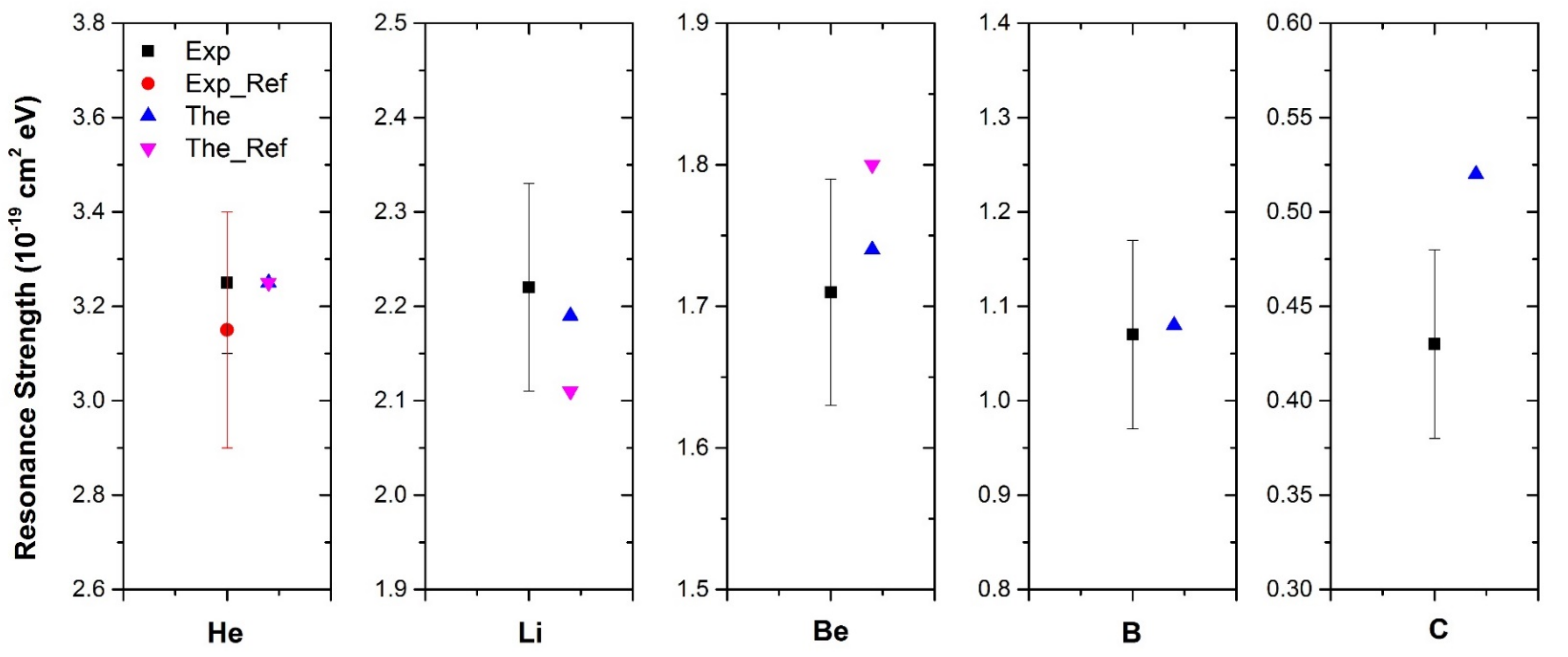




KLL DR of $Ba^{50+..54+}$ ions at Shanghai EBIT



KLL DR spectrum of barium ions



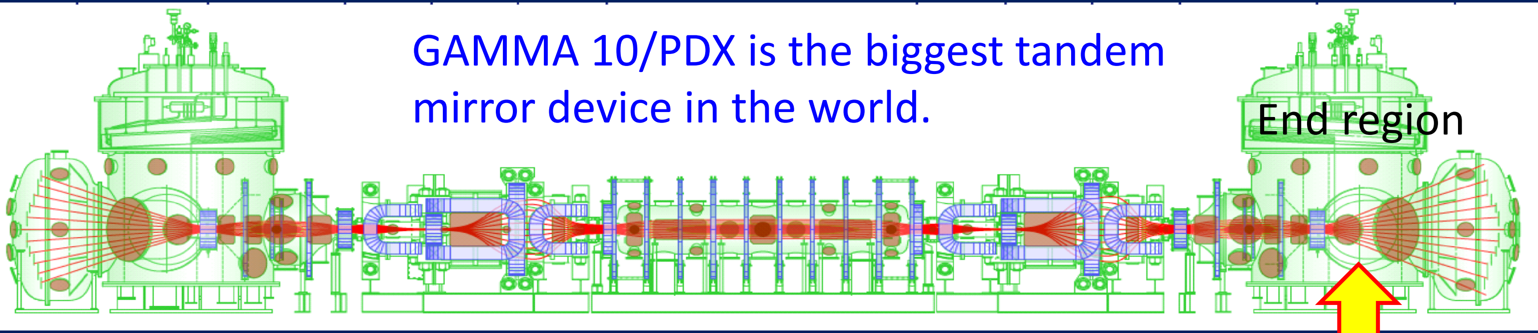
Resonance strengths of He-like to C-like barium

- The resonance strengths of KLL DR processes of He-like to C-like barium ions are measured at the Shanghai-EBIT, with the experiment uncertainty about 8%.
- Careful calculations with general Breit interaction shows good agreement with experiment results for He- to B–like ions, while deviations about 21% is found for the C-like Ba^{50+} ion case.

LINEAR DEVICES

Divertor Simulation and Hydrogen Recycling Study Utilizing End Region of the Tandem Mirror GAMMA 10/PDX

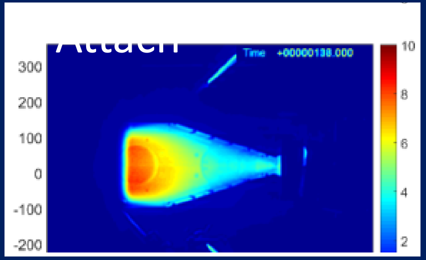
M. Sakamoto et al., Plasma Research Center, University of Tsukuba



The end region has been utilized for divertor simulation and hydrogen recycling study.

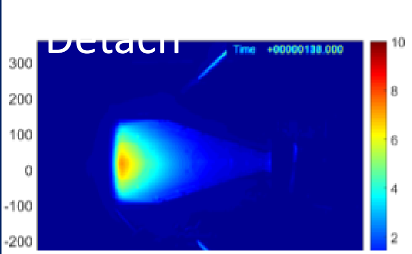
Suitable features that other linear devices do not have:

- ✓ High Ion temperature (Ti: 50~400eV)
- ✓ Low neutral pressure (~ 1 x 10^{-7} Torr)
- ✓ High magnetic field (0.15 ~ 1.5 T)



Divertor simulation experiment:

- ➢ Plasma detachment is occurred due to additional gas puffing. It is caused by molecular activated recombination (MAR). Triatomic molecules play a key role on MAR.

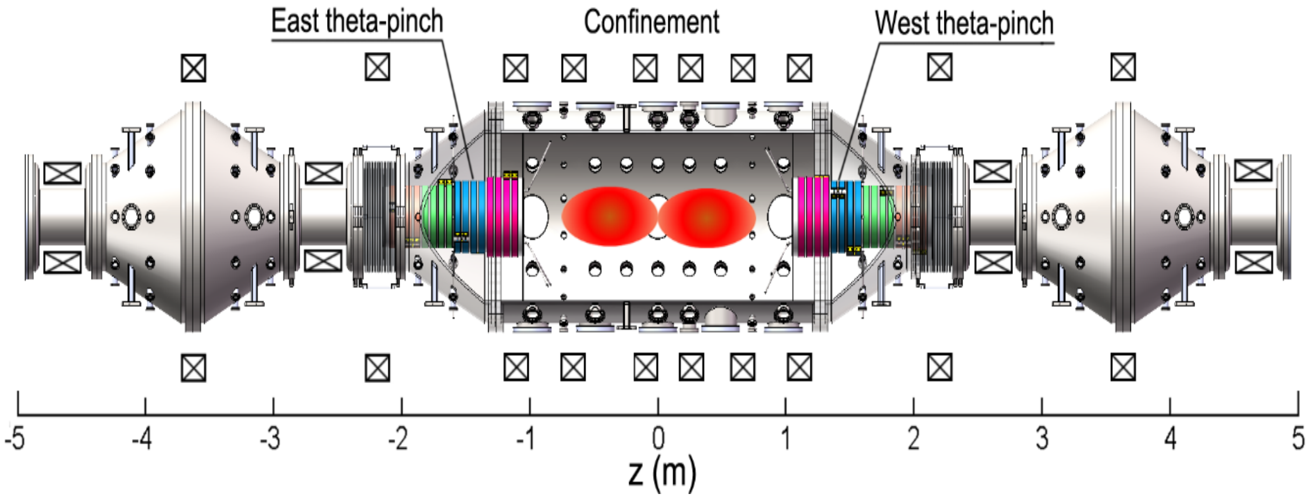


Hydrogen recycling experiment:

- ➢ Hydrogen recycling is enhanced with increase in the target temperature through increase in rotational temperature of hydrogen molecules.

The plasma is detached from the V-shaped target due to molecular activated recombination (MAR).

KMAX Experiments



- Colliding RFPs - stable theta pinch plasma obtained up to 300 micro seconds
- Plasmoid velocity about 10 kms/sec

Munan Lin

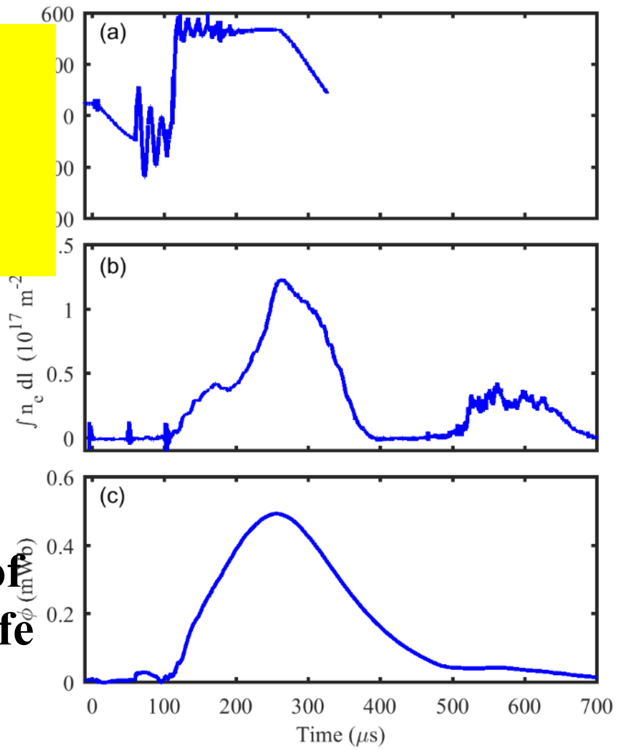
- ICRH heating - Diamagnetism of the central cell plasma increased linearly with the radiated RF power.

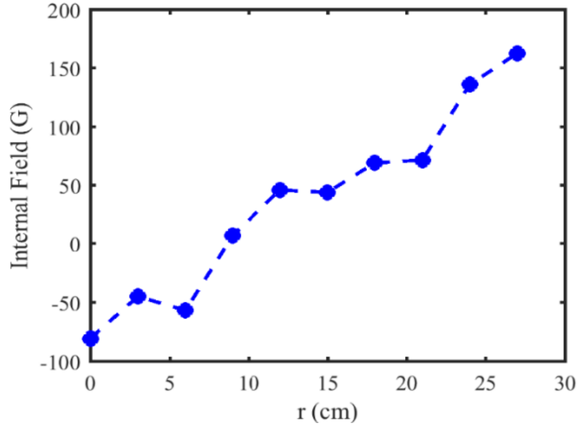
Ming Liu

KMAX-FRC

A large-size field-reversed configuration (FRC) plasmoid to explore the physics of colliding and merging process has been produced in a tandem mirror device by collision-merging two high-β compact toroids (CT) technology.

- The FRC internal magnetic field structure has been proved by inserting a multi-channel magnetic probe.
- **The preliminary results show that the total temperature of KMAX-FRC plasma is $T_e+T_i \sim 100\ eV$, and the plasma life time is about 300 μs.**

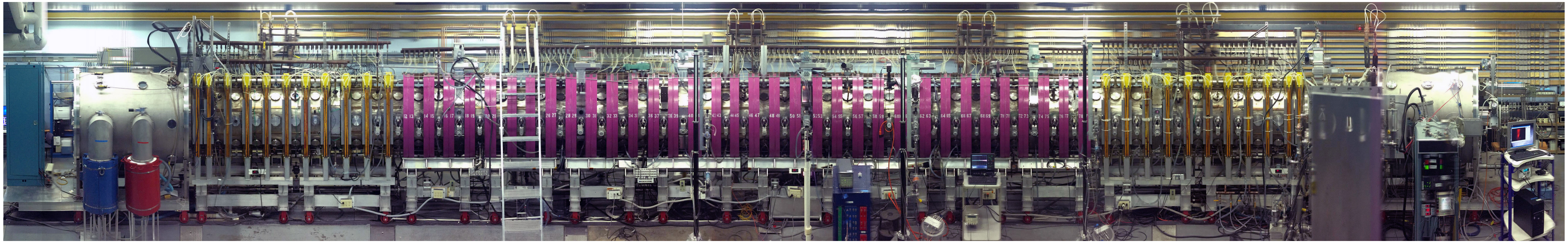




Shear Alfvén waves in nonuniform plasmas at the U.S. Basic Plasma Science Facility

S. Vincena

- The concept of an ion-ion Alfvén wave resonator has been confirmed in a basic, laboratory experiment.
- Excitation in a magnetic well shows formation of trapped eigenmodes with low "Q" values ~<10, but similar to those observed in space
- Frequency spectra measured during a concentration ratio scaling experiment yielded reasonable agreement with theory for the number and absolute frequency of axial eigenmodes



Development of a large negative hydrogen ion source operated with radio frequency power and calculation of a photo-neutralizer

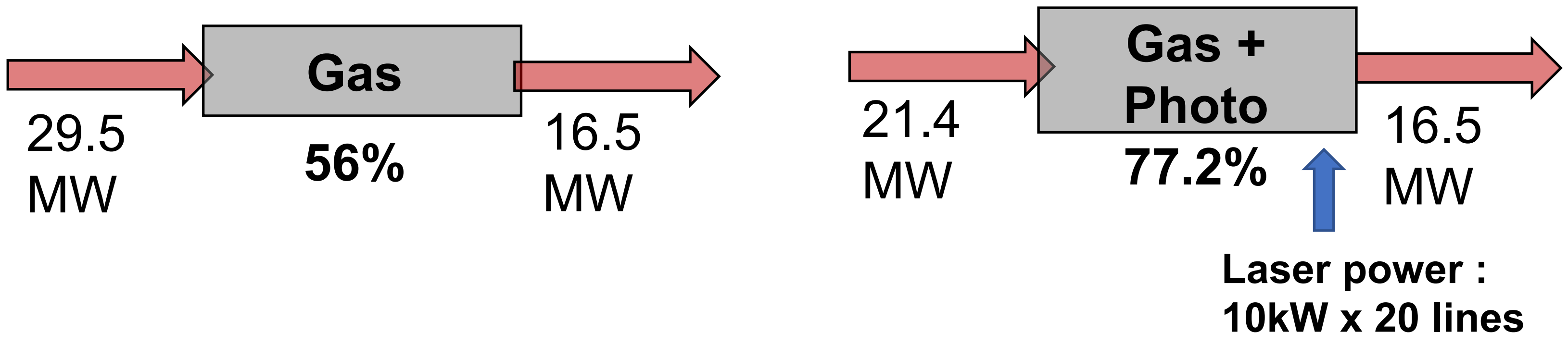
A. Ando

Development of a large RF-driven H^- ion source

- A Helicon wave was excited in a hydrogen plasma.
- A high density hydrogen plasma is produced ($>10^{18}$ m^{-3}) at the driver region in a large RF ion source.
- H^- beam extraction with Cs injection is under way.

Evaluation of photo-neutralizer

- Neutralization efficiency by a photo-neutralizer is evaluated by PIC/MC simulation for D- beam with 1MeV.
- Small amounts of neutral gas prevent the beam from diverging and decrease the required laser power.

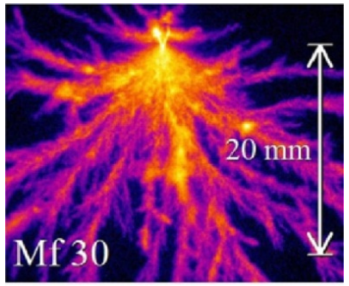


Novel Areas

An-Bang

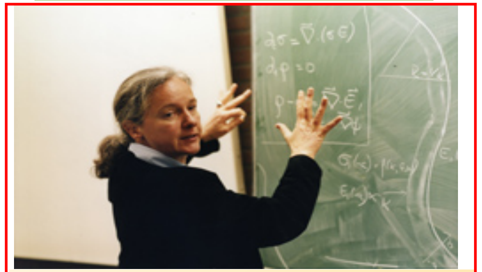
3D particle code for streamers

- **An advanced 3D particle model for streamer discharge in atmospheric air was developed**



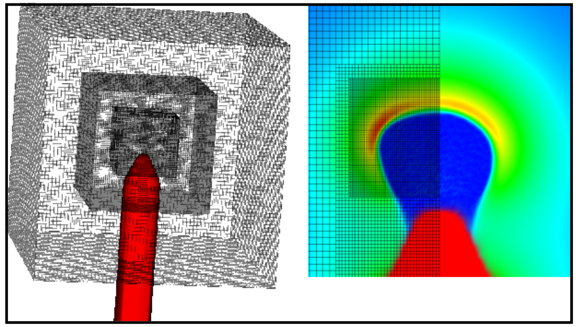
Streamers in experiments

Collaborator

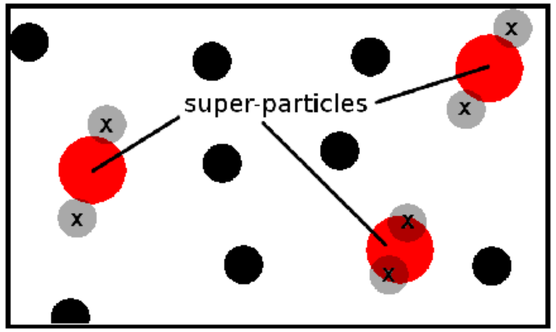


Dr. U Ebert, leader of CWI's research group Multiscale Dynamics, and also full professor of Applied Physics at TU/E.

Difficulties	Solutions
Multiscale: steep gradient at the head of streamer	**Adaptive Mesh Refinement**
Computation: time and power consuming	**Adaptive Particle Weight (*k-d tree*)**



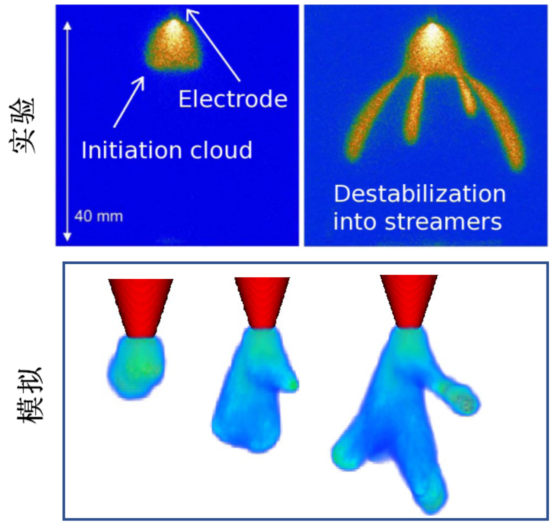
Mesh adjusting



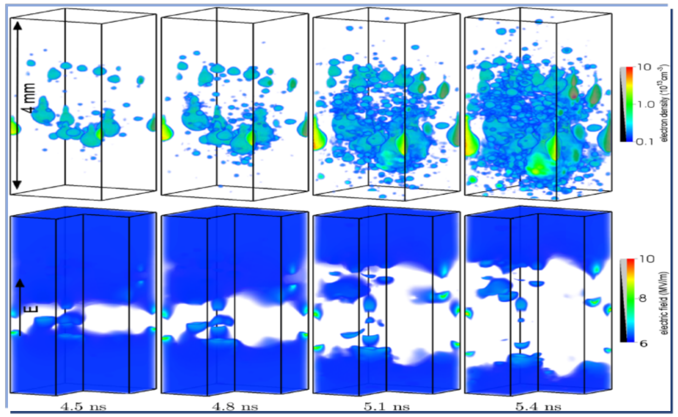
Merging and Splitting of super-particles

Streamer evolution in atmospheric air

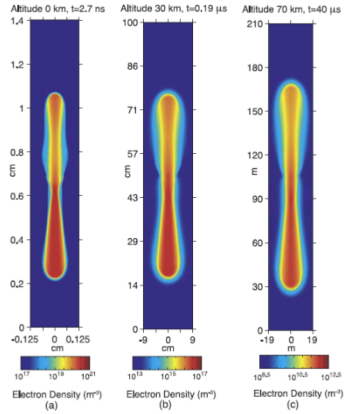
- **The inception and development processes of streamers from a positive needle electrode were revealed;**
- **Effects of the natural background ionization on streamer formation were investigated.**



Comparison of streamer inception



Global discharges due to background ionization (3D particle model)



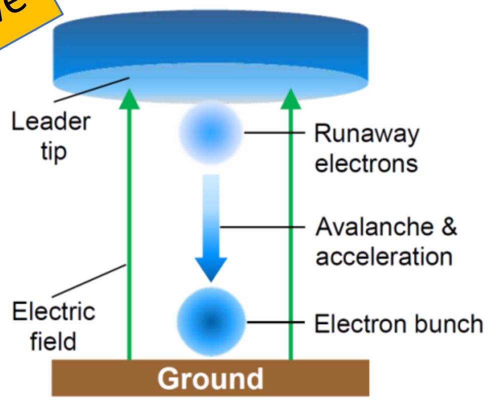
Single Double-headed streamers (2D fluid model)

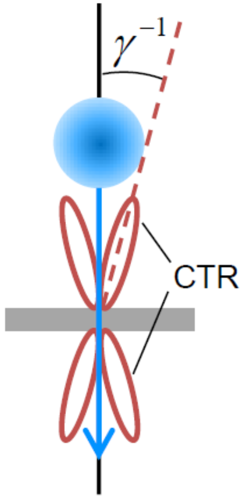
Sun *et al*. Geophysical Research Letters, 2013

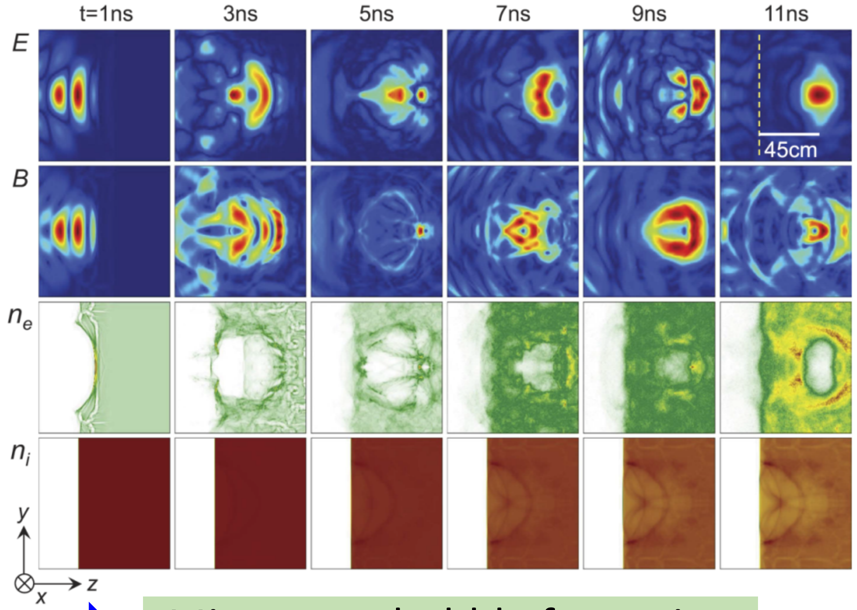
Microwave theory of ball lightning

Hui-Chun Wu
Institute for Fusion Theory and Simulation and Department of Physics, Zhejiang University, China

Analogy to solitons-
Trapping of half a wave







Intense electron beam → Relativistic microwave → Microwave bubble formation

The new theory is much superior to other models: 1) it has an experimental base i.e. high-energy phenomena of lightning; 2) it is the first consistent and quantitative BL theory supported by simulations; 3) it successfully explains most of BL features, many of which get explained for the first time; 4) it has gained strong supports from the lightning community; 5) an important inference has been verified.

H.-C. Wu, Sci. Rep. (2016); Geophys. Res. Lett. (2017).

Exploration of two-fluid plasma by using non-neutral plasmas

In these days, extended-MHD model, in particular, a two-fluid plasma state is popular in theoretical and computational studies.

Himura

For examples

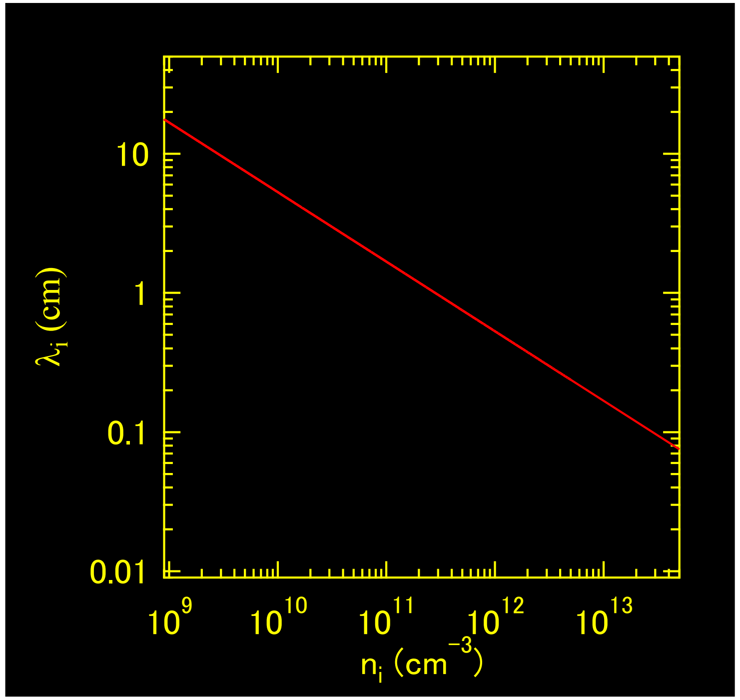
○High β plasma – *confinement* –

(ex.) Compact toroids

○Anomalous resistivity – *diffusion* –

(ex.) Fast magnetic reconnection

These seem to be contradictory effects…



Q1. What is the two-fluid plasma effect?

Q2. Does it reduce 'the ion diffusion coefficient' or not?

Q3. What dynamics of the ion and electron plasmas occur?

Q. Why is the two-fluid plasma uncovered in laboratory experiments?

Because, scale lengths exist in two fluid plasmas and the two-fluid effect is considered to be of the order of the ion skin depth λ_i .

Usually, d_i is too short for precise observation of two-fluid dynamics…

If you look at the generalized Ohm's law,

$$\mathbf{E} = -\mathbf{V}\times\mathbf{B} + \frac{d_i}{n}(\mathbf{J}\times\mathbf{B} - \nabla p_e) + \frac{d_e^2}{n}\frac{d\mathbf{J}}{dt} + \eta\mathbf{J} - \eta_2\nabla_\perp^2\mathbf{J}$$

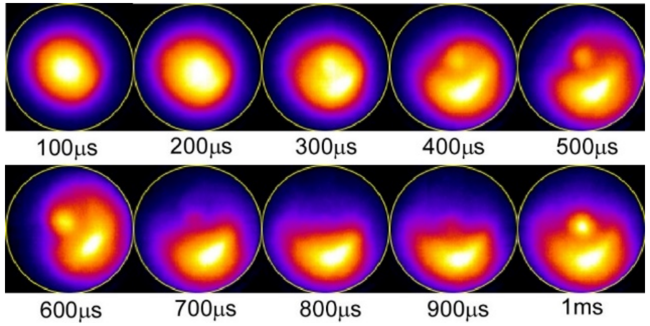
Note: $d_i = \frac{\lambda_i}{L}$, …

Ion skin depth can be extended much longer using pure ion plasmas

Pure ion plasmas have other merits to meet the requirements for a fluid experiment.

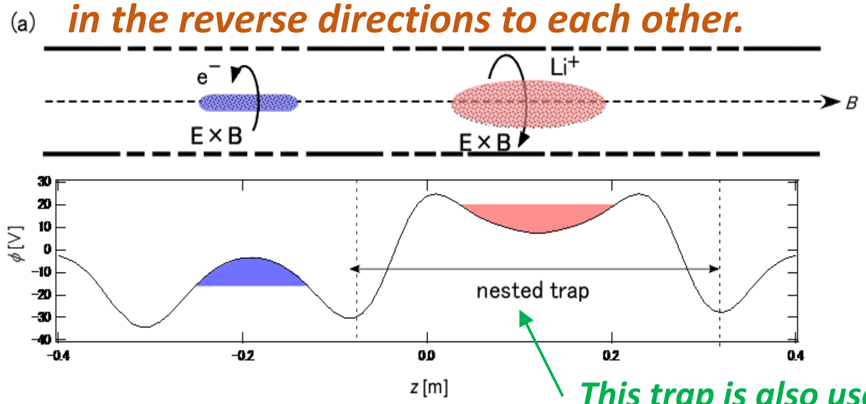
- Thermal equilibrium
- T ~ 0 (negligible thermal motion)
- r_L/L << 1 (fluid approximation)
- l_i/L >> 1 (two-fluid length scale)
- Robust P_q
- n_i can be controlled.

A typical images of both plasmas in a two-fluid plasma state.



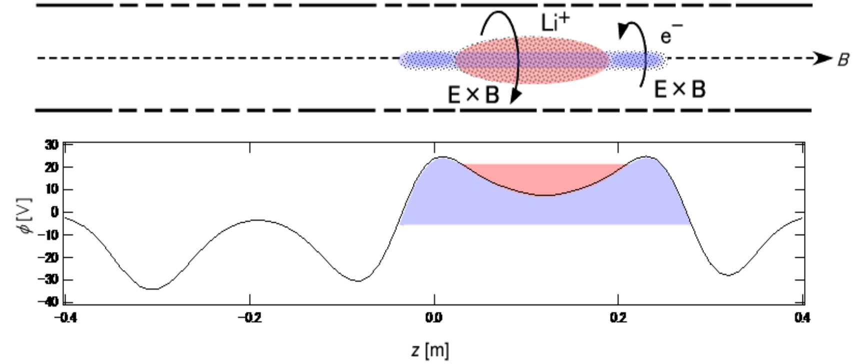
We experimentally add the independent ion and electron fluid motions to each other as if we mathematically derive the MHD equation.

Pure ion and electron plasmas are rotating in the reverse directions to each other.



This trap is also used for anti-matter experiments.

Then, they are mixed.



Plasma is considered to be electrically neutral. But, each angular momentum P_θ is also conserved...?

Is each P_θ conserved even in the mixed plasma, a two-fluid plasma state ? If so, how long does it last?

$$\begin{cases} m_i n_i \dfrac{d\vec{V}_i}{dt} = e n_i(\vec{E} + \vec{V}_i \times \vec{B}) - \nabla p_i - \vec{P}_{ei} \\ m_e n_e \dfrac{d\vec{V}_e}{dt} = -e n_e(\vec{E} + \vec{V}_e \times \vec{B}) - \nabla p_e + \vec{P}_{ei} \end{cases}$$

Or, does the mixed plasma immediately relax into a one-fluid plasma, a MHD plasma?

$$\rho \frac{d\vec{V}}{dt} = \vec{j} \times \vec{B} - \nabla p$$

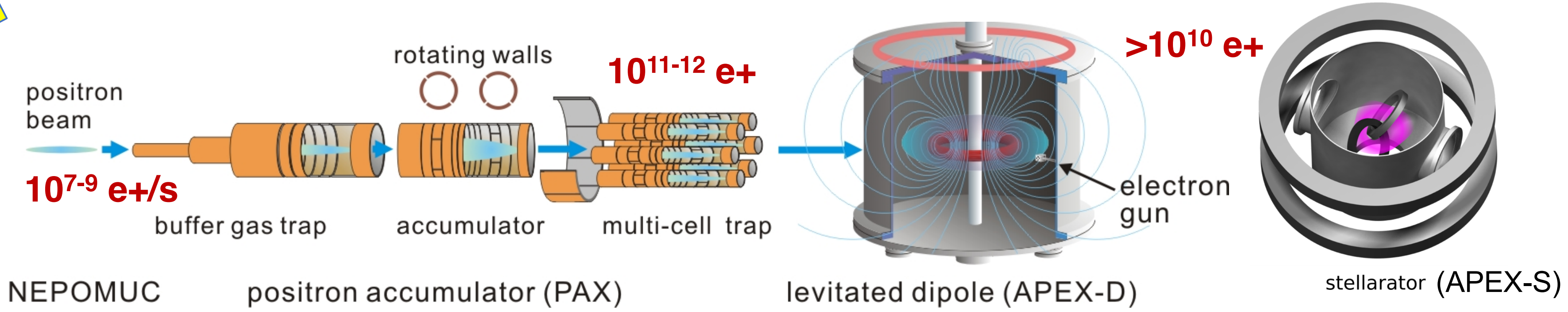
Injection and manipulation of positron beam in a dipole field toward the creation of electron-positron pair plasmas

B-I15

Saitoh

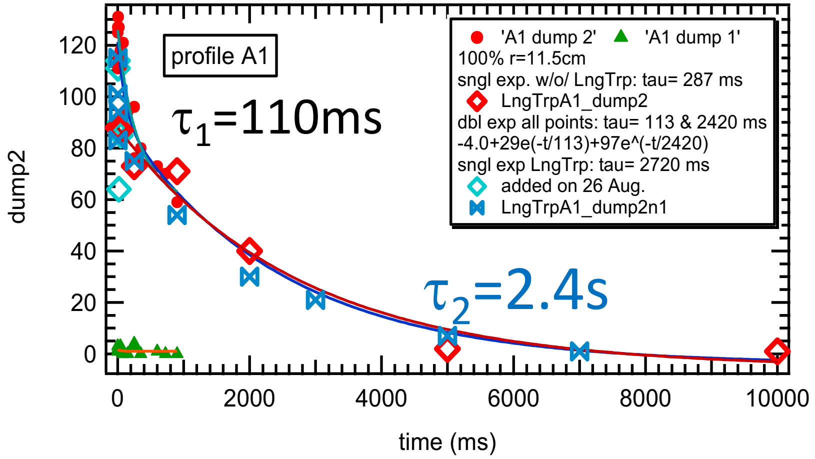
H. Saitoh, on behalf of PAX/ APEX collaboration, Max Planck Institute for Plasma Physics, Germany

PAIR PLASMA

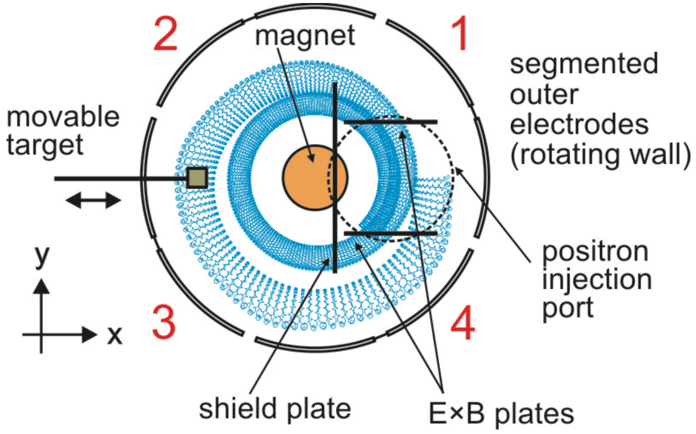


We aim to create and investigate the properties of electron-positron pair-plasmas, by combining the NEPOMUC positron source, accumulator, and toroidal trapping geometries

Recent results in a prototype dipole trap with a permanent magnet:



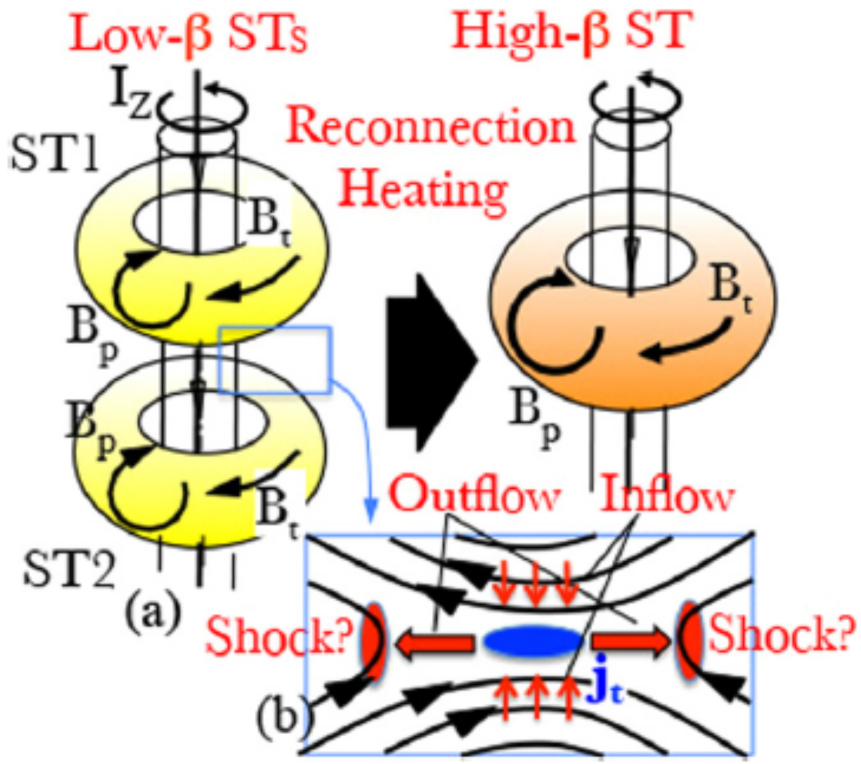
long time trapping of positrons by improving the axial symmetry



radial compression of positron orbit with rotating wall electric fields

High Power Heating of Magnetic Reconnection in Torus Plasma Merging Experiments

Y. Ono



- Significant ion/electron heating upto 1.2 kev in ST merging expt on MAST
- Huge outflow heating of ions in the downstream region and localized heating of electrons at the X point
- Ions accelerated up to poloidal Alfven speed – thermalized by fast shocks in the down steam region
- Agree with solar satellite observations and PIC simulations
- Expts also done on TS-3

Concluding Remarks

- Rich variety and high quality of basic plasma physics papers at this conference
- Large numbers indicate a flourishing and growing R&D activity in this field in the Asia-Pacific Region
- New ideas and trends are emerging
- Great advancement in development of diagnostics and modeling tools
- "We need to continue to make significant investment in basic research in order to ensure the growth of the field as well as to achieve success in major endeavors like fusion" – C. S. Liu

My thanks to all the Basic Session Speakers

And

Thank You All for your Attention