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FLUID AND PLASMA PHYSICS

FLUID AND PLASMA PHYSICS WG:

Prof. John Foster (The University of Michigan), USA
Dr. Isaiah M. Blankson (NASA GRC), USA
Prof. Oluwole Daniel Makinde (Stellenbosch University), SA

Speaker: Dr. Isaiah M. Blankson

LIST OF TOPICS

(i) Fluid and Plasma Working Group: Org Chart/Info/

(ii) Intro: Plasma is everywhere: Types of plasma, examples of plasma, naturaly-occurring plasma, man-made plasma, etc.

(iii) The atmospheric non-thermal plasma (NTP)

(iv)Plasma Water Purification: Injection of Repetitive High-Voltage Nanosecond Plasma in dielectric liquids (water, hydrocarbon fuels, etc)". Plasma-based pollutiom degradation in liquids and gases.

(v) Applications in Agriculture

(vi) Aerrospace Applications: MHD-Controlled Turbojet, Forward Energy deposition in supersonic and hypersonic flows. Sonic boom mitigation,

(vii) Space mission application: Non-equilibrium plasma water purification supporting long-duration human space flight. Plasma-based planetary life-support systems, plasma agriculture,

(viii) Future Potential

SUMMARY REPORT OF THE FLUID AND PLASMA PHYSICS
Working Group Structure/Organization

WG Structure:

Prof. John E. Foster**, LEAD,** University of Michigan, USA. Plasma Physics
Prof. Oluwole Daniel Makinde, Stellenbosch University, SA. Plasma physics
Dr. Isaiah M. Blankson, NASA Glenn Research Center, USA. Plasma Applications

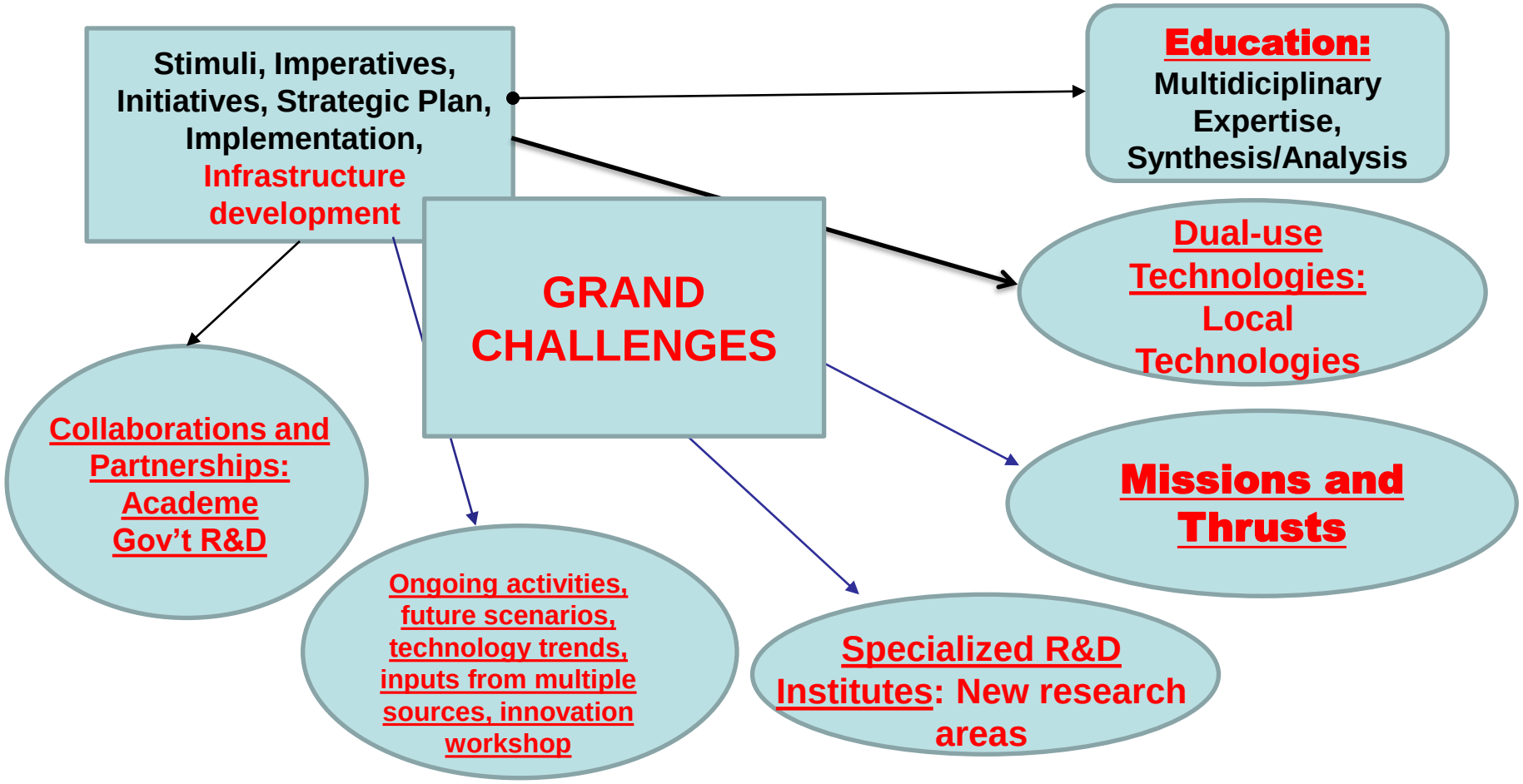
White Paper on Opportunities in Plasma Physics: "The role of plasma science and technology in enabling/augmenting new processes and applications".
(Available for distribution)

OUR FOCI:

(i) Non-thermal plasma generation – affordable low-cost methods.
(ii) Environmental Applications: African Focus
(iii) Water purification
(iv) Disinfection
(v) Plasma agriculture. (Plasma-activated water).
(vi) Plasma medicine
(vii) Aerospace applications

WPG STRATEGY/INITIATIVES/…..

A work in progress



Institutes are special "niche" technical areas with huge growth potential. Research may be mostly fundamental but maybe applied as well. The institute idea mimics a "silicon-valley" structure within existing boundaries. Institutes will have the spirit of "single-mindedness and sense of urgency of entrepreneurial firms".

TYPES OF PLASMA

Plasma, the 4th state of matter, is everywhere. There are naturally-occurring plasma, and man-made plasma examples.

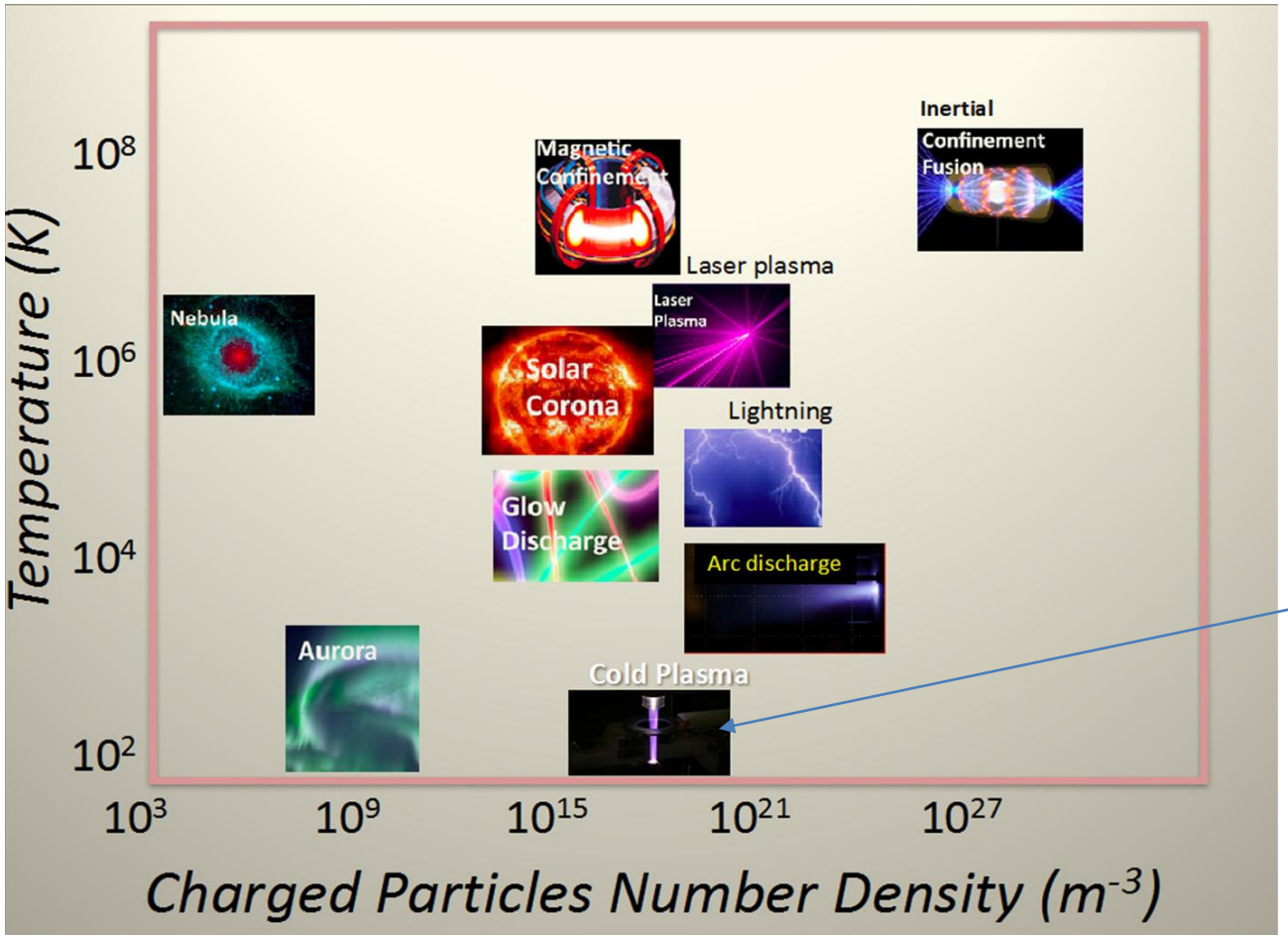
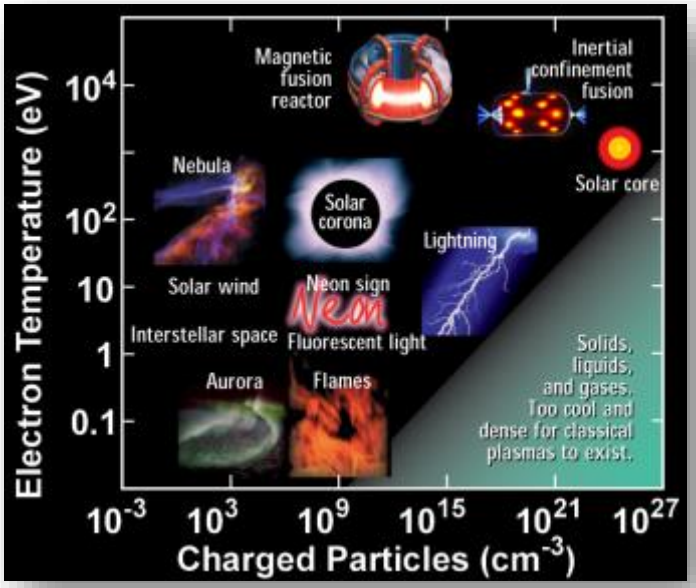


Diagram showing various natural and laboratory plasmas.

THE NON_THERMAL ATMOSPHERIC PRESSURE PLASMA
THE PHYSICS

Characteristics of NTP Plasma

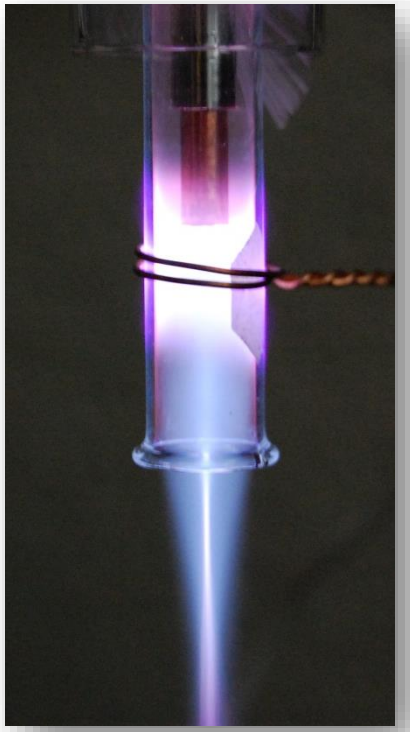


- Collisional—relevant inelastic processes such as ionization and excitation mean free paths happen within the bounds of device or system
- Low temperature plasmas are a power transfer medium.
    - Electrons transfer power from the "wall plug" to internal modes of atoms / molecules to "make a product.
- The electrons are “hot” (several eV to 10 eV) while the gas and ions are cool, creating “non-equilibrium” plasmas.

$T_e >> T_i \sim T_{gas}$ (near room temp)
Density for tech plasmas : ~10^8-10^{12}/cc (can be little higher or lower)

Making 1 Atm NTPs

- The basis of high pressure NTP is the streamer mechanism
  - A streamer is a pre-breakdown ionization wave that is self propagating, generating reactive species and photons along its track
- Limiting the power deposited into a gas is key to forming NTP—this prevents arc formation and can be done many ways
  - Ballasting-dampens ionization wave
  - The use of dielectric barriers
  - The use of short pulse with fast rise times (< microsecond typical)
  - Managing the duty cycle of the discharge
  - The use of flowing gas
  - Use of electron beam pulses
  - Gas composition—Use of gases with high thermal conductivity and high ionization potential (e.g. He)

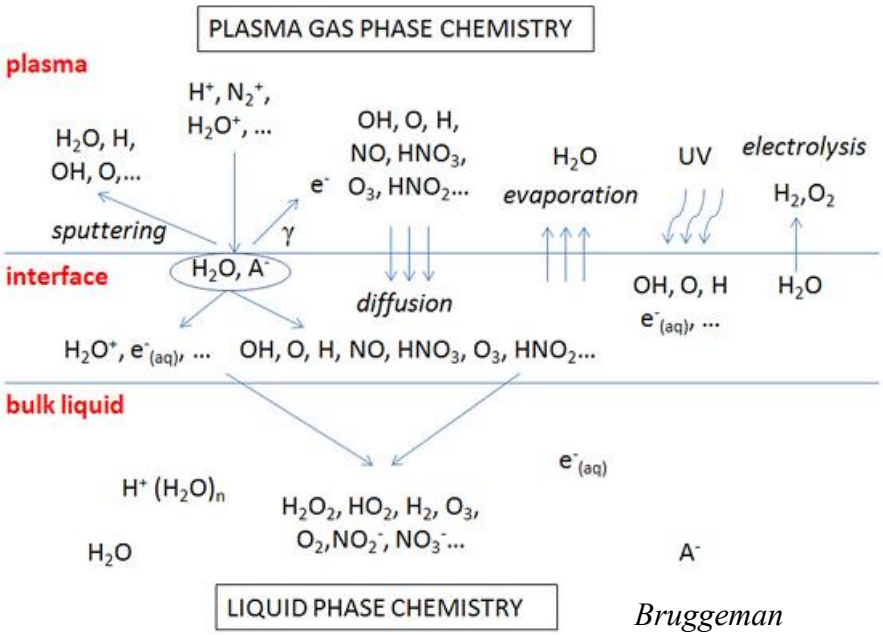


Applications of Non-thermal Atmospheric Plasma: Examples

(i) Water Purification
(ii) Plasma Agriculture
(iii) Plasma Medicine
(iv) Disinfection
(v) Aerospace Applications
(vi) Fuels conversion
(vii) Pollutant degradation
(viii) Low-energy salt-water desalination by plasma
(ix) Liquid fertilizer: On-demand production

Plasma Value Proposition: Discharge in Liquid Water—Source of AOPs

- Plasmas in contact with liquid water can
  - Produce a range of advanced oxidation processes at once (OH, Peroxide, Ozone, Ultrasound, UV…)
    - Indiscriminate decomposition of organic contaminants
  - Does not require consumables
  - Power requirements estimated to be less than conventional methods (UV/Peroxide or RO)
- Plasma based purifiers can be applied as point of use for areas w/o treatment infrastructure
- Technology is modular in that it can be used as a finishing stage, incorporated into existing infrastructure



Bruggeman

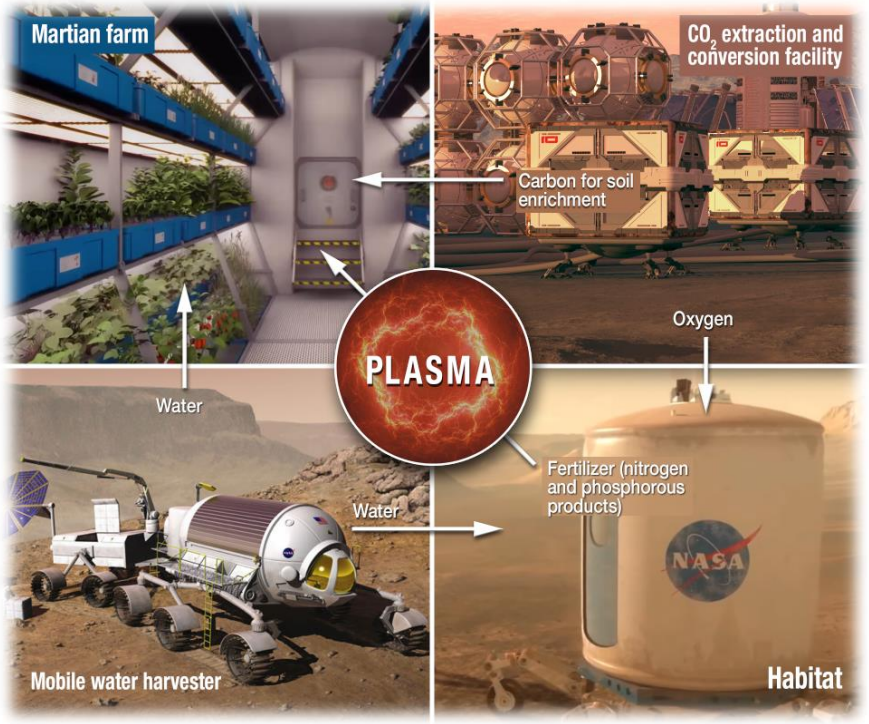
PLASMA AGRICULTURE

PLASMA ACTIVATED WATER FOR AGRICULTURE

Plasma Activated Water (also known as "Plasma Water") has been shown to:

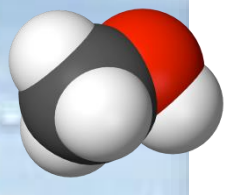
- Increase rooting speed
- Reduce water consumption
- Enhance seed germination
- Stimulate plant growth
- Prevent pests

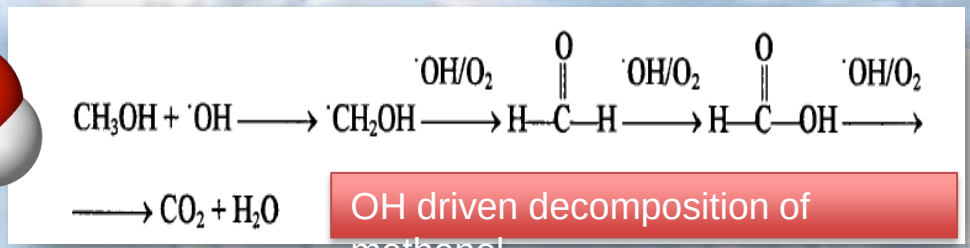
Plasma-Assisted Planetary Life – Can Low Temperature Nonequilibrium plasma be used for these processes?

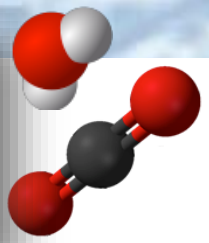


Plasma generated advanced oxidation processes decompose toxins not addressed by conventional treatment methods

Toxin	Purpose	Human Toxicology
Halogenated hydrocarbons	Industrial solvents	Possible birth defects; suppression of central nervous system
Aromatic compounds (e.g. benzene, toluene)	Chemical intermediate for synthesis of plastics and polymers	Known carcinogen (e.g. leukemia)
Pentachlorophenol (PCP)	Electrical insulating oils	Cancer causing; disrupts hormones
Pesticides	Agriculture	Linked to birth defects, nervous system damage, lymphoma, and cancer
Pharmaceuticals	Health care	Can lead to antibiotic resistant microbes; affect human hormonal balance
Cyanide	Mining, industrial chemical processing	Poison; disrupts cellular respiration







OH driven decomposition of methanol

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Thank you for listening.