Plasma Science and Technology Seminar Series

Winter 2022-2023

Chemical kinetics and instability in non-equilibrium reactive plasmas

Hongtao Zhong *Stanford University*

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Abstract: There is a significant interest in utilizing non-equilibrium reactive plasmas for electrified energy and chemical conversion. However, these plasmas have many excited species and are highly non-equilibrium. The chemical kinetics remain mostly unknown due to lack of sensitive diagnostics. In addition, the reactive plasmas are vulnerable to perturbations and generate local "hot spots". The instability and pattern formation require further investigations.

In this talk, analytical, modeling, and experimental efforts will be presented to address the above challenges. First, time-resolved in situ laser diagnostics including direct absorption spectroscopy and Faraday rotation spectroscopy were developed and applied to investigate the kinetics of excited oxygen atom O(1D) and hydroperoxyl radical HO_2, as well as the kinetics of low-temperature plasma-assisted pyrolysis and oxidation of large alkane and zero-carbon fuels. The fast (μs time resolution) and sensitive (ppm level) measurements enable quantitative determination of reaction rates and branching ratios for key reactions in reactive plasmas. Second, a new instability, the plasma thermal-chemical instability, governed by the coupling between plasma dynamics and chemical kinetics, was developed using stability analysis and chemical mode analysis. The numerical modeling and experimental measurements revealed that heat release, kinetics, and transport were critical for the instability onset, accelerating the transition from a homogeneous column to a filamentary structure. The talk will be concluded with the vision of how reactive plasmas bring broader impact on alternative fuels, advanced engine development, and sustainable carbon capture and utilization.

Speaker Biography: Dr. Hongtao Zhong is currently a post-doctoral researcher at Stanford University. Hongtao received his B.S. degree in Thermal Engineering and Economics from Tsinghua University in 2017. In 2017, Hongtao went to Princeton University to pursue Ph.D. degree at Mechanical and Aerospace Engineering. Under the joint supervision of Dr. Yiguang Ju and Dr. Mikhail Shneider, Hongtao's Ph.D. work focused on chemical kinetics and instability in reactive plasmas. The excellence of Hongtao's Ph.D. research was recognized by Britt and Eli Harari Fellowship and Princeton SEAS Award for Excellence. He also won the Distinguished Paper Award at the 38th International Symposium on Combustion. Since 2022. Dr. Zhong has been working in Professor Mark Cappelli's group at Stanford. His current research project is to investigate the non-equilibrium plasma catalysis for direct air capture of CO_2. Dr Zhong's research interests lie broadly at the intersection of plasma chemistry, reacting flows and laser diagnostics, with a particular application for electrified sustainable energy and chemical conversion.

These seminars are open to the entire Stanford community. Please contact Matthew Edwards (mredwards@stanford.edu) with any questions, to be added to the distribution list, or to suggest a future speaker.