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THE ROLE OF RADIATIVE TRANSFER IN COMBUSTION

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Radiative transfer plays important roles in many fields of science and engineering, ranging from aerosol, propulsion, re-entry, atmospheric processes, solar energy, remote sensing, to astrophysics. This talk focuses on the role of radiative transfer in combustion science and discusses two different aspects of radiative transfer: as a mechanism of heat transfer and as a signature for diagnostics.

As an intrinsic heat transfer mechanism, radiative transfer is responsible for many near-limit combustion phenomena, the feedback of radiatve heat from flames to unburned fuels, and radiation-induced flame quenching. Radiative transfer in high-temperature combustion systems tend to homogenize temperature distribution and has a very strong influence on temperature sensitive processes, such as pollutant formation, especially at microgravity and elevated pressure conditions. The last three to four decades have witnessed a revolutionary progress in modelling the radiative properties of gaseous radiating components in combustion systems, namely CO_2 and H_2O, though challenges of dealing with gas mixtures and gas-particle mixtures remain. The importance of turbulence-radiation interactions has also received considerable attention in turbulence combustion and fire modelling.

With the development of new combustion technologies, such as oxygen-enriched combustion, flameless combustion, porous burners, biomass-coal combustion, and supercritical combustion, there has been renewed interests in developing accurate and efficient radiative models to model radiative transfer in such applications. Although the importance of radiative transfer in combustion has been noticed by some scientists in the 1950's with the development of pulverized coal combustion systems, its role in combustion has not been adequately recognized. Radiative transfer is still often viewed as simply a source term in the overall energy equation and modelled by either the optically thin approximation or a grey gas model, even at elevated pressures.

Radiative transfer has been used as a means to actively control heat transfer, combustion performance, and flame propagation. Radiative transfer also plays an indispensable role in combustion diagnostics for the purposes of control of coal combustion systems and flame synthesis of nanoparticles and understanding the mechanism of polycyclic aromatic hydrocarbons and soot formation. A common such application is to infer the particle or soot temperature and concentration based on two- or multi-color detection of flame emissions in the visible and near infrared.

With the advance of high-performance computing and radiative models and the efforts of researchers working on both radiative transfer and combustion, the importance of radiative transfer has been better recognized by researchers working on CFD modelling of large-scale combustors and fires. More efforts are required to develop and prompt accurate treatments of radiative transfer in combustion modelling.