Seminar

Institute for Plasma Research

Title : Computation of Non-Gray Properties of Radiative Heat Transfer and Interaction with Fluid Flow

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Date : 13th March 2020 (Friday)

Time : 11.00 AM

Venue : Seminar Hall, IPR

Abstract :

In any scenario of heat transfer in a fluid material, all modes of heat transfer (conduction, convection and radiation) exist, however, in most of the cases, heat transfer by radiation is always neglected due to its complexity, as thermal radiation is transferred by electromagnetic waves or photons. Instead of Maxwell's equation, thermal radiation is solved by spectral radiation transfer equation (s-RTE) which is an integro-differential equation. The s-RTE includes the phenomena of absorption, emission, in-scattering and out-scattering. The analytic solution of s-RTE is very difficult, thus, many other mathematical equations for the radiative heat transfer have been developed, based on the short and long range natures of radiation. The methods which are good for short range nature of radiation are rosseland model or diffuse approximation, spherical harmonic methods, whereas, surface to surface method (S2S), hottel's zone method are good for long range nature of radiation, The other methods like Discrete ordinate method (DOM), finite volume Discrete ordinate method (fvDOM) are good for both the natures of radiation, however, computationally intensive. In most of the work in the engineering domain, these equations have been solved using Gray approximation.

Along with the difficulty in solving the directional nature of s-RTE, another difficulty is to find the realistic radiative properties (Non-Gray properties) of gases. These properties vary with spectrum along with the temperature and pressure and can be obtained from the concepts of ''Quantum Mechanics' '. However, some databases like CDSD, HITRAN, HITEMP, etc provide line transitions on spectrum at 296 K and 1 atm pressure. These line transitions, which are in hundreds of millions, provide the absorption and emission coefficients, however, some mathematical calculations are required on these databases to obtain these properties. It is impossible to solve s-RTE on these line transitions as a simple calculation, i.e., Line By Line (LBL) Calculation, on isothermal and homogeneous medium takes around a week time to provide results. In reality, medium is not isothermal and homogeneous, thus impossible to calculate the radiation heat transfer. However, Full Spectrum k-method (FSK method) reorders these random variations of non-gray radiative properties into a smooth function which reduces the computational time for calculation of radiative heat transfer tremendously, i.e., a LBL calculation on a simple geometry takes around 5 days while FSK calculation takes on 3 sec time.

In the present talk, I will explain s-RTE, the calculation method of non-gray properties of gases, FSK method and effect of radiation on fluid flow in forced and natural convection problems.