PREDICTIVE ENGINEERING &
PECOS
COMPUTATIONAL SCIENCE

RADIATION HEAT TRANSFER MODELING FOR EARTH REENTRY

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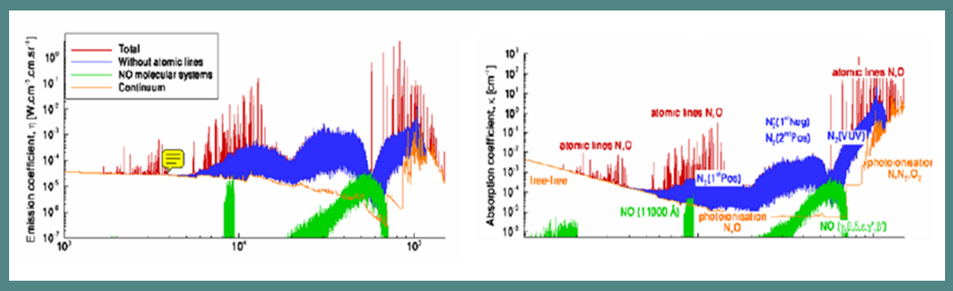
Reentry simulation and radiation model

Strongly coupled reentry physics makes necessary the simultaneous solution of various phenomena to predict the thermal behavior of a reentry vehicle. The plan for the first year is to produce a working multiphysics code, based on simple models but incorporating the effects of radiation and ablation.

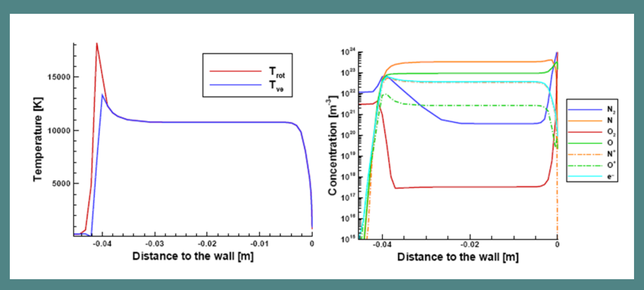
Radiation reentry physics

At reentry conditions the air in the boundary layer can be in non-local thermodynamic equilibrium



Emission and absorption for a point in the shock layer of FIRE II - Flight time 1642 s (Lamet et al., 2008)

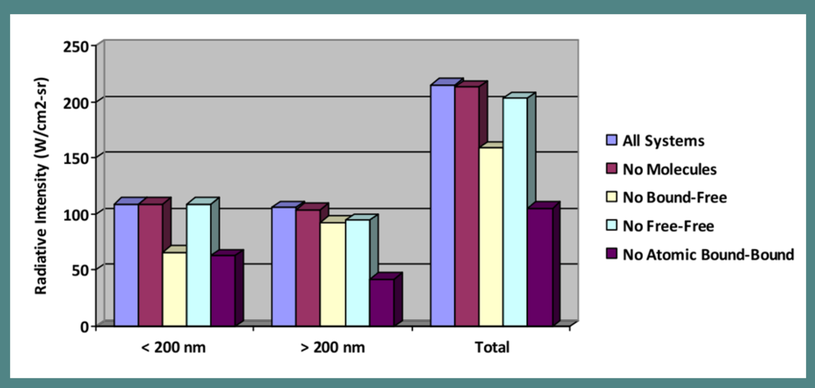
Considerable portion of the boundary layer can be at thermal equilibrium even for small sized vehicles



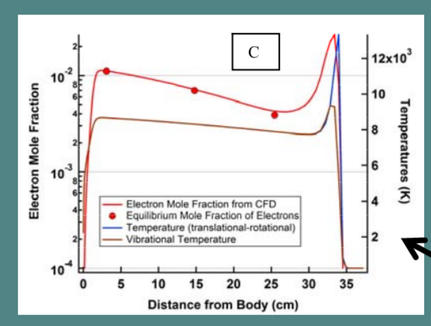
Temperature (left) and concentration (right) along the stagnation line for the FIRE II experiment with flight time of 1642 s (Mazou and Marraffa)

For large vehicles almost all boundary layer is in local thermodynamic equilibrium

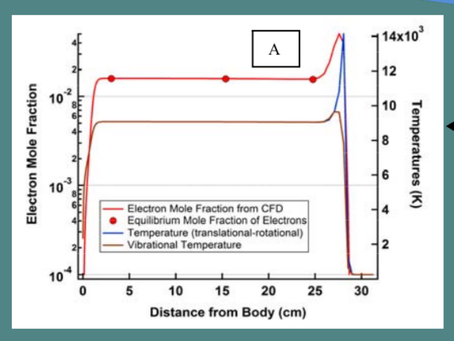
Air is dissociated in N and O atoms with 1 – 5 % ionization level



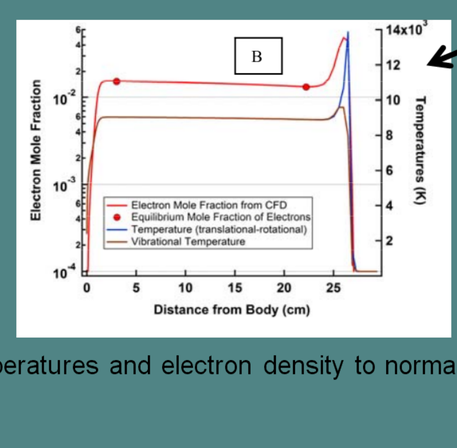
Effect of elimination of various radiating systems on the stagnation line-of-sight intensity at 10.98 km/s vehicle speed and 0.15 Torr of freestream pressure.



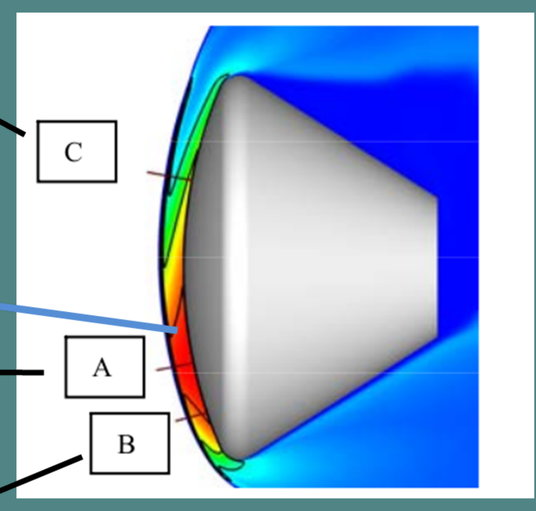
Temperatures and electron density to normal line C



Temperatures and electron density to normal line A



Temperatures and electron density to normal line B

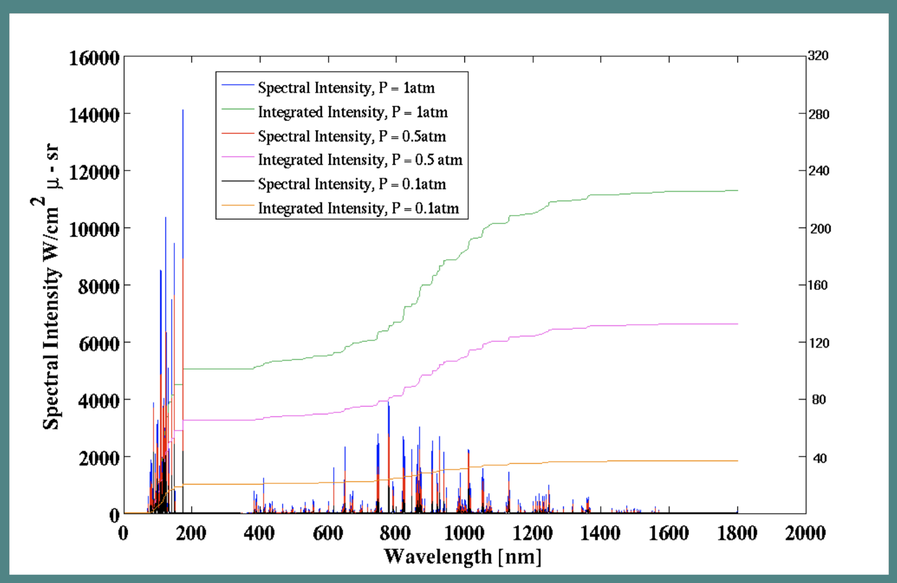


Vehicle representation at 9.53 km/s speed, 0.2 Torr freestream pressure and 23º angle of attack. [Deepak et al., 2008].

Radiation Model

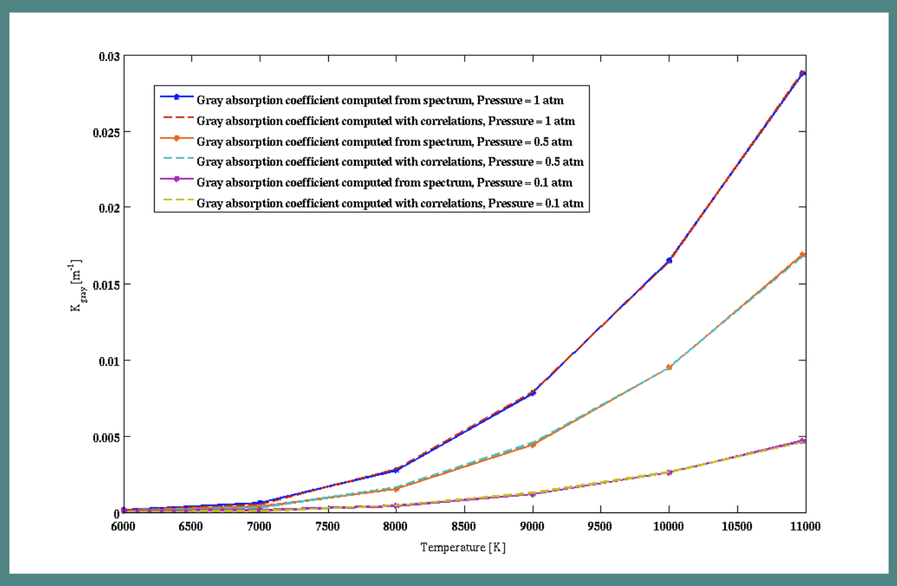
Radiative Properties

The Specair code was used to compute spectral intensities of air at 6000, 7000, 8000, 9000, 10000 and 10980K at 0.1, 0.5 and 1 atm.



Spectral intensity and integrated intensity over all wavelengths at 10980K and pressures equal to 0.1, 0.5 and 1 atm.

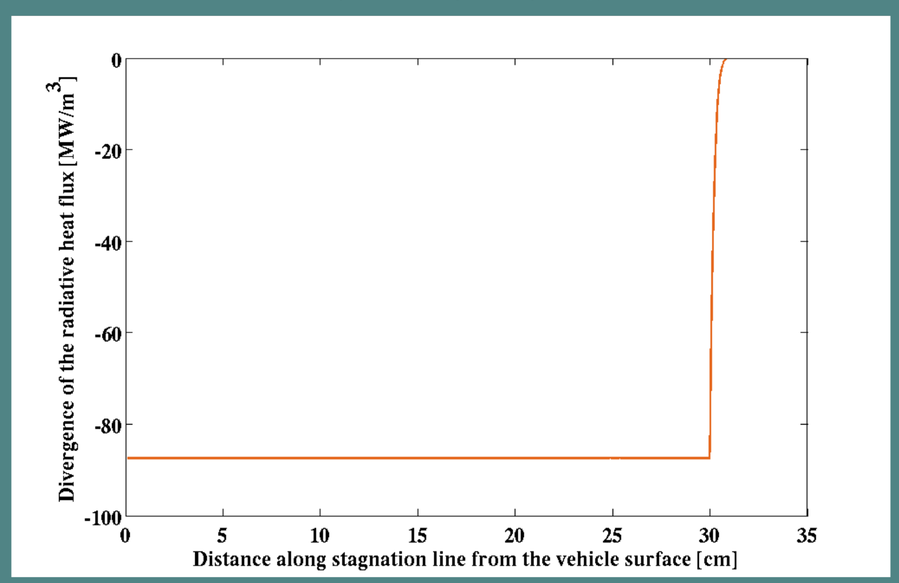
Correlations appropriated to implement in computer codes were fitted from spectral data computed with Specair code.



Gray gas absorption coefficients computed with the correlations and with data from Specair.

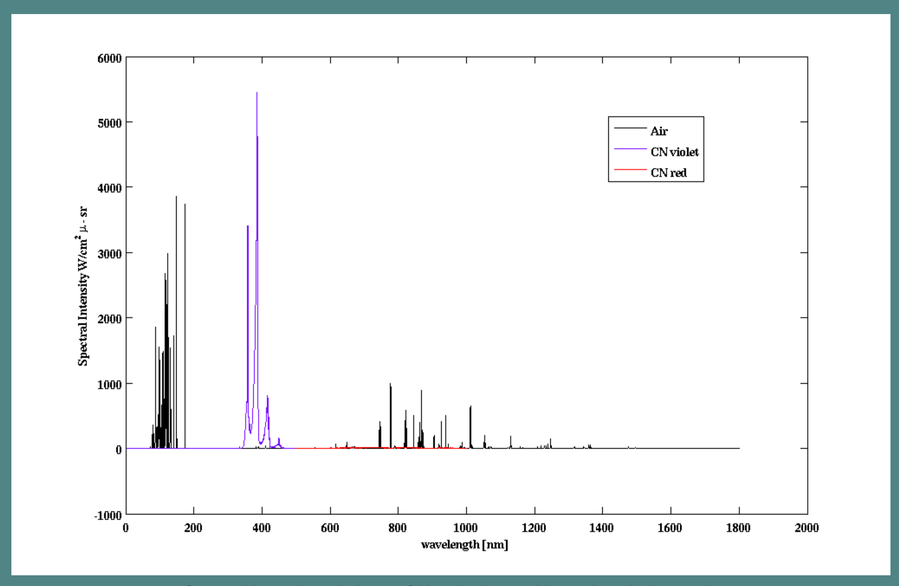
Solution of the Radiation Transfer Equation (RTE)

Approximation: Tangent slab approximation and gray gas properties.
Numerical method: Computationally cheap SP_N or Discrete Transfer.



Divergence of the radiative heat flux along the stagnation line computed with the current radiation model.

DPLR has a partial radiation model to CN emission and no absorption model, which can be implemented in conjunction with the developed model.



Spectral intensity relative to CN emission and intensity relative to air.

Results obtained with partial coupling between the radiation model and DPLR can be seen on Paul Bauman's poster.