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Institute of Mechanical Systems: Prof. G. Haller (NDS)
Institute of Fluid Dynamics: Prof. P. Jenny, Prof. T. Rösgen (IFD)

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I N V I T A T I O N

to a talk as part of the

Colloquium Thermo- and Fluid Dynamics

and the

ERCOFTAC Visitors Programme

Date: **Wednesday, August 29, 2018**

Time: **16:15h**

Place: Machine Laboratory ETH Zurich, **Lecture Hall ML H 44**

Speaker: **Prof. Hans G. Hornung**
Graduate Aerospace Laboratories, Caltech, Pasadena, USA

Title: **Hypersonic flow over a cone in the detached shock range**

In a number of space missions the forebody of the atmospheric entry vehicle has been a spherically blunted cone. The flow over such a body exhibits the interesting feature that, depending on the normal-shock density $\varepsilon = \rho_\infty / \rho_s$ the sonic line terminates either on the spherical nose (small ε) or on the shoulder of the cone (larger ε). We refer to these two regimes as sphere behavior and cone behavior. Because the switch from one of these to the other is almost discontinuous, this can lead to pitch instability as has been shown by Gnoffo in the case of the Pathfinder mission.
Sphere behavior is well understood. The same cannot be said for the regime of cone behavior. The aim of the work described here was therefore to explore the parameter space of the flow over a sharp cone at zero angle of attack with the aim of finding the functional form of the dependence of dimensionless parameters on the flow variables. Using the analytical result of Hayes and Probstein for the detachment angle of the cone $\theta_d(\varepsilon)$ as a starting point, we posed the hypothesis that the dimensionless shock stand-off distance takes the form

$$\frac{\Delta}{R} = g(\varepsilon)\, f(\eta) \text{, where } \eta = \frac{\theta - \theta_d}{\pi/2 - \theta_d}.$$

Many inviscid perfect-gas computations were then used to test this hypothesis. The results show that the hypothesis is correct and analytical forms of the functions g and f were found that fit the results accurately. Other dimensionless variables may be expected to follow similar functional forms. This is shown to be true for the drag coefficient.
It has been shown that, if an effective density ratio is defined by using the average density along the stagnation streamline instead of ρ_s, such results can be carried over into the non-equilibrium high-enthalpy case. Since the effective ε is much smaller then, the results apply *a fortiori* there.
It should be pointed out that the problems associated with the spherically blunted cone may be avoided by using a 3:1 oblate ellipsoid. The sonic line on this shape has completely smooth behavior. However, the space industry is notoriously conservative and the sphere-cone continues to be used.

Host: Prof. P. Jenny

Guests are welcome!

Further information: http://www.ifd.mavt.ethz.ch/events/ktf/ktf-records.html
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