Project proposal template
Graduate School studentships
March 2015

Project title	Mechanism and Numerical methods of boundary layer transition in hypersonic flow
First Supervisor	Professor — Jian Wang
Second Supervisor	Dr Peter Barrington
School	Aerospace and Aircraft Engineering
Other member of supervisory team (no more than three KU supervisors in total)	Dr Sing Lo
Specific requirements beyond 2:1 degree	1st or 2:1 Plus MSc

Project summary

(max 4,000 characters)

The process of flow transition is a very important phenomenon from laminar flow to turbulence. This is the fundamental problem of turbulent flows. Although much knowledge has been attained about the physics underlying the transition at supersonic and hypersonic flow, many of them are mainly restricted to simple geometries such plates, cones and spherical bodies. For a real hypersonic vehicle with a complex configuration, the process of flow transition tends to be very complex due to the 3-D effects and effects of surface roughness. The transition onset location, the range of transition and changes in flow parameters have significant influence on the skin friction, heat transfer, flow separation, characteristics of the inlet and mixing efficiency in the combustor. Accurate and precise prediction of transition and its development process plays a very crucial role for the aerodynamic design of hypersonic vehicle as well as the design of the thermal protection system.

The methods for boundary layer transition detection can be broadly classified into three main types: empirical method, stability analysis method and transition model. The development and use of a transition model has been the primary focus of research in late 20^{th} and early 21^{st} century. The main concept of the transition model method is to simulate turbulence flow by introducing an intermittency factor to describe the starting and development of the boundary layer transition process. There are several different methods to introduce intermittency into the turbulence model. However, a transition model, which finds application in a variety of hypersonic flow scenarios and that closely links engineering and theory, is not available at the moment. The purpose of the current proposal is to develop a robust transition model with small computation cost for hypersonic flow engineering problems. The main research contents are as following:

1. Review of research on boundary layer transition, including the research methods, results, the most recent development and the future research tendency.
2. Research and comparison of different CFD methods which are suitable for hypersonic flow simulation, including the research on computation schemes and turbulence models.
3. Comparisons of different methods of intermittency treatment in turbulence simulation.
4. Research and development of transition model suitable for hypersonic flow in engineering problems.

Supervisor team: Professor Jian Wang, Dr Sing Lo, Dr Peter Barrington