Faculty Engineering Technology
Program Mechanical Engineering

UNIVERSITY OF TWENTE.

COLLOQUIUM

Group: **Engineering Fluid Dynamics**

As part of her MSc thesis assignment

Miranda Versteeg

will give a presentation, entitled:

Time Spectral Method for Periodic Problems using Vertex Centered Spatial Discretization

Date: Friday September 27, 2013

Time: 14:00

Room: **Horsttoren 700-B**

Summary:
Time-periodic flows are characterized by flow features that reappear after regular intervals of time. There is a large range of applications involving time-periodic flows. However, numerical simulations of these flows are computationally too expensive to be used in design or optimization procedures. The Time Spectral Method (TSM) decreases the computational requirements to solve periodic flows, by representing the solution as a Fourier series in time with a certain fundamental frequency. TSM using cell-centered schemes has already been applied successfully to propellers, wind turbines, helicopters, synthetic jets and turbo-machinery. However, numerical methods for flow problems that involve vortex shedding require higher-order discretization, which are easier implemented for vertex-centered schemes.

The objective of the present research is to implement TSM for vertex-centered finite-difference schemes and apply TSM to periodic flow problems, using an explicit as well as an implicit solution algorithm. The present implementation concerns an SBP-SAT (Summation By Parts/Simultaneous Approximation Term) vertex-centered finite-difference scheme for multi-block structured grids.

Verification tests have been performed (both for the Euler and Navier Stokes equations) for the flow about a pitching airfoil. The explicit and implicit algorithms for TSM proved to be eight and four times faster than the explicit and implicit time-marching methods, respectively. The application of a vertex-centered finite-difference scheme caused problems in the factorization of the pre-conditioner of the implicit method. The cause of this problem is pointed out and a solution is provided.

A flow problem with an unknown fundamental frequency is solved by a gradient method. For the explicit algorithm, the system converged to the exact frequency, when the initial periodic time was higher than the exact periodic time. To obtain a more accurate solution, it proved more efficient to use a higher-order spatial discretization than a finer grid. For the implicit algorithm, the gradient method could not be applied, since the implicit method converges to an unphysical steady flow solution unless the exact periodic time is used as initial periodic time.

Using sliding meshes, TSM has been applied to the flow about a heaving and pitching airfoil situated in the wake of a cylinder. For higher-order discretization, the linear interpolation of the solution on the sliding mesh appeared inconsistent with the higher-order SPB/SAT scheme at the internal block boundaries.

Assessment committee: **Chairman,**

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