13th Seminar on Mechanical Science and Bioengineering
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Prandtl's secondary flow in ducts with non-uniform cross sections

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It is well known that cross sectional mean motions take place in a number of turbulent flows (secondary flows of Prandtl's second kind). Those motions have been observed in a wide range of applications: flows in ducts and pipes with non-circular sections, external flows normally impinging over cross sections with certain lack of symmetry (like in rod bundles flows in nuclear power plants), and so on.

The first part of the talk will summarize some results recently obtained by the authors using Direct Numerical Simulation to study a classical configuration: turbulent flow in a square duct. The statistical analysis of the numerical data and their relationship with large scale coherent structures of the flow will be illustrated to introduce our main conjecture: secondary motion is a feature inherent to any turbulent flow that has no translational symmetry in the cross sectional plane. Furthermore, it is argued that secondary motions are probably related with the largest structures of the mean motion.

The second part of the talk will focus on the above mentioned conjecture. In particular, two "modified" Poiseuille turbulent flows will be described. These two models share the feature of inhibiting any spanwise symmetry of the unmodified plane channel flow. In both cases we find mean cross-sectional mean motion, thus supporting our main conjecture.