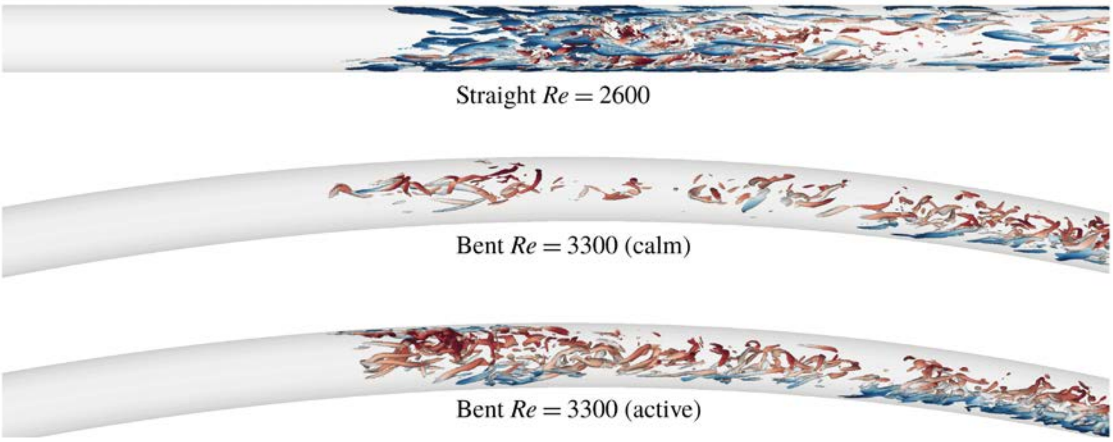
Fachbereich 4
Produktionstechnik
Maschinenbau &
Verfahrenstechnik

CENTER OF
APPLIED SPACE TECHNOLOGY
AND MICROGRAVITY
ZARM

Bachelor thesis:
Transition to turbulence of pulsatile flow through a 180º-bent pipe

Cardiovascular flows are pulsatile in nature and characterized by complex geometries, fluid structure interaction and non-Newtonian behavior. Although the flow is assumed to be laminar, the maximum Reynolds number during one period of the pulsation can significantly exceed the critical Reynolds number, especially inside the aorta ($Re \approx 4000$) [1]. This, as well as complex geometries (e.g., the aortic arch [2],[3]), suggest that the flow might transition to turbulence and complex flow patterns emerge. Since stronger shear stresses, e.g., due to turbulence, are often linked to the onset of cardiovascular diseases, the transition mechanism is of great interest [1].



Turbulent fronts at different Reynolds numbers and geometries from [3]

In this thesis, you will study turbulence transition in a 180º bent pipe followed by a straight pipe section of fixed curvature. You will generate an appropriate mesh and will perform direct numerical simulations using state of the spectral-element code nek500. You will compare your results to laboratory experiments performed at a partner institute at IST Austria. The results will be visualized and analyzed to characterize the dynamics of the turbulent flow patterns. The main goal is to determine the effect of the pulsation frequency on the stability of laminar pulsatile flow the at fixed Reynolds number and for a physiological waveform.

Requirements:
- Basic knowledge in numerical methods for PDEs and fluid mechanics
- High motivation on advanced numerical methods and flow simulations

Contact and supervision:

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[1] M. Ablowitz et al.: Mathematical Modelling of the HumanCardiovascular System. Cambridge University Press (2019).
[2] http://www.gadacanada.ca/aorta-taad
[3] Cox, C., Plesniak, M. W.: The effect of entrance flow development on vortex formation and wall shear