

## Numerical Modeling, Optimization and Scientific Computing in Computational Science and Engineering

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### Project Description

Development of theory pertaining to Partial Differential Equations (PDEs) and Mathematical Optimization is essential in tackling science and engineering problems of the current generation. Few such relevant problems include fluid-structure interaction, such interactions in two-phase fluids, fracture propagation, fractures in a poroelastic medium, large-scale deformations etc.

We envisage establishing a center for applied mathematics with a focus on numerical modeling of PDEs and optimization. This includes development of algorithmic techniques and corresponding programming. Specifically, focus would be on the following aspects:

- Parallel computing and error estimation, with the goal to develop adaptive methods.
- Development of preconditioners for the arising linear systems.
- Use of inexact computation.

Besides development of solutions to the research problems, the focus would also be on education and collaboration of Bachelor/Master students, PhD students, Postdocs and Peers. This would be achieved through personal stays at each other's institute involving individual discussions, conduction of workshops, and delivery of block courses.

### Reasoning on Internationalization of Research and Teaching

Currently, one of the major goals of the Leibniz University Hannover is the internationalization. On the local scale, the Institute of Applied Mathematics has recently made several efforts to internationalize research and teaching as well. The working group Scientific Computing headed by Prof. Wick consists of one Chinese student, one Norwegian visitor, and one PhD student from Iran. Furthermore, an Iranian Postdoc is associated to the group. The head, Prof. Wick has strong collaborations with Lyon (France), Ecole Polytechnique (France), UT Austin (USA), and JKU Linz (Austria). Specifically, at Ecole Polytechnique, Prof. Wick still has a teaching assignment in which an international Master class with students from all over the world (also from India) participate. In this class, specific lecture notes on Numerical Modeling have been developed, which could serve for similar classes in the proposed DAAD collaboration. IIT Indore currently leads all Indian institutes in collaboration with TU9s in Germany. There is a great push by the Indian government to engage with best in the world on research. Dr. Ahuja, who is the Dean of International Affairs, is aggressively pursuing this agenda. Everyone involved in this collaboration would also benefit from Dr. Ahuja's other research links from around the world as follows: Berkeley Lab (USA), Sandia National Labs (USA), Georgia Tech

(USA), Virginia Tech (USA), TU Dresden (Germany), IMT Atlantique (France), TU Braunschweig (Germany), and Max-Planck-Institute in Magdeburg (Germany).

### Sustainability Factors

Through workshops and block courses, a long-term connection between LUH and IIT Indore will be established. In the first period we envisage to perform joint work on the efficient numerical solution of multiphysics problems, i.e., fracture propagation and fluid-structure interaction. Moreover, the Bachelor/Master students as well as PhD students from both India and Germany would come into personal contact with well-established researchers in applied mathematics. This would help them in organizing long-term stays at the Institute of Applied Mathematics in Germany and at Discipline of Computer Science & Engineering at IIT Indore, and hence, would increase their job prospects.