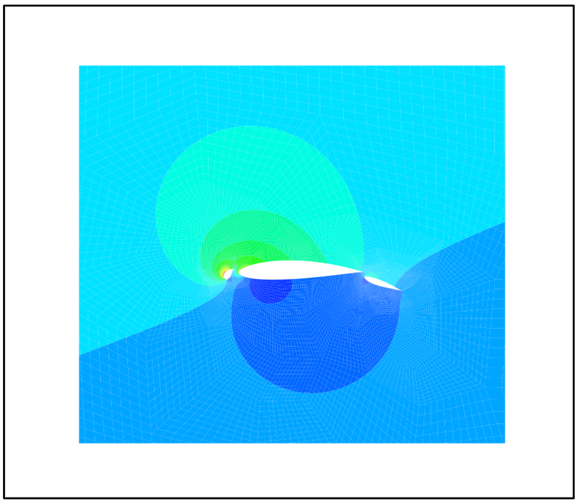
Two-Week Short Term Course On

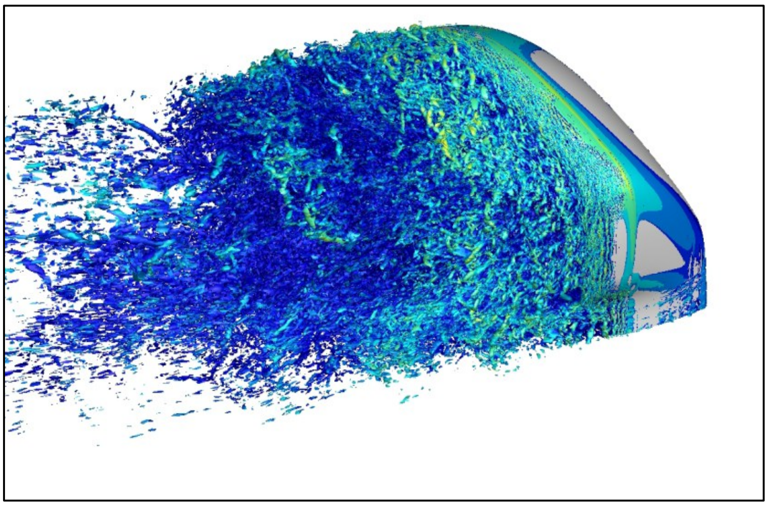
Spectral Methods for Engineering & Scientific Computing Applications

(Sponsored by Ministry of Human Resource Development (MHRD), Government of India under the 'Global Initiative of Academic Networks' (GIAN) Program)

19th – 28th December, 2016



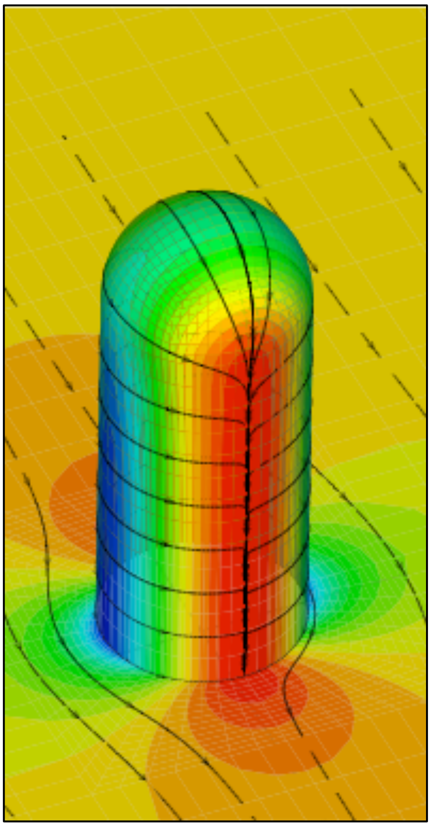
Spectral Simulation of Flow Past Airfoil with Slat & Flap Deployed (Trifoil), David. A. Kopriva, 1998



Vortical Structures - Aeroacoustics Simulation of Flow Past Car Side Mirror using Spectral Methods, Frank & Munz, 2016

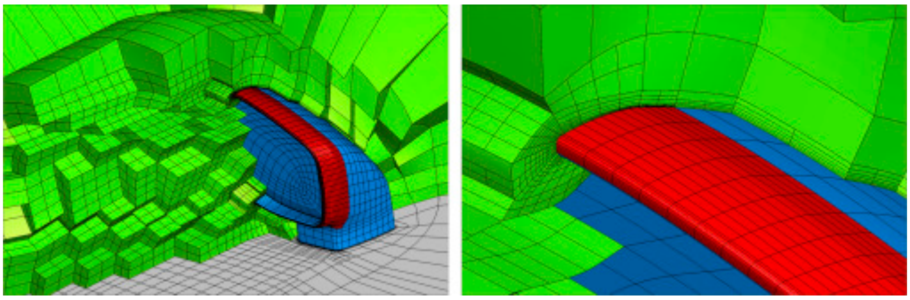
Course Overview

Spectral methods have moved past their traditional limitations of periodic domains, simple geometry and continuous solutions. Methods have been developed for diverse applications such as wave propagation (acoustics, aeroacoustics, elastic, seismic and electromagnetic waves), solid & structural analysis, marine engineering, biomechanics, astrophysics, computational finance and fluid mechanics & turbulent flows. The primary appeal of the spectral methods is the superior rate of convergence, reduced need for addition of artificial dissipation, higher accuracy & low dispersion. The theory and algorithms for the single domain smooth problems form the core fundamentals for advanced applications. This proposed course has been designed specifically to give the student a through foundation in spectral methods. The course introduces a systematic approach to solving partial differential equations numerically in multiple dimensions using spectral & spectral element methods. The course covers the concepts and methods required for the application of spectral approximations of one to three-dimensional PDEs describing potentials, transport (convective & diffusive), and wave propagation with applications in science and engineering. The course emphasizes the practical derivation and implementation of spectral methods over abstract mathematics. As part of the tutorial sessions, hands on training will be provided where participants will understand & implement the algorithms in computer code to solve problems of physical relevance using various techniques and methods



Streamlines & Pressure Distribution - Flow Past a Silo, Kopriva 2009 discussed in the course. The course participants will be encouraged to create complete and working computer code as part of their assignments. The instructors and the TAs will provide computer lab facilities and ample guidance for both tutorials and assignments.

Course Contents



Cutway View of the Computational Grid, Frank & Munz, 2016

Lectures On: Spectral methods: Projection, Fourier Galerkin, and Spectral Convergence; Interpolation, Fourier Collocation, Approximation of Derivatives, FFT, Aliasing error, convergence of interpolation and collocation; Variable coefficients and nonlinear problems (mode coupling, aliasing, aliasing removal, filtering); Sturm Liouville problems, polynomial truncation and interpolation; Spectral approximations: CG, Collocation, tau, Penalty, DG; Elliptic problems, Laplacian Solver, Poisson solver; Advection-diffusion problems, CG approximation; Hyperbolic conservation laws, DG approximation, Euler Gas dynamics equations; Advection-Diffusion and Compressible Navier-Stokes, DG approximation; CG and DG Spectral elements in 1D; CG and DG in 2/3D on structured meshes; SEM on unstructured meshes. Issues and approaches for solution of general problems.

Tutorials & Assignments On: Solving Laplace/Poisson Equation on a Square using Spectral Approximations: Fourier, CG; Solving Advection-Diffusion Problems using CG & DG Approximation; Compressible Navier-Stokes, DG approximation

Who Can Attend?

- Senior Under-Graduate students, Graduate students (pursuing Masters & Ph. D degrees), Postdoctoral Fellows of Engineering & Sciences;
- The course has been designed to introduce, update and improve understanding of the faculty members in new IITs, IISERs and academic institutions in the country about the best practices and recent advances in the field;
- Practicing engineers and scientists working in industries, as well as, in government research organizations.

Course Duration & Venue

19th December – 28th December, 2016
School of Mechanical Sciences,
Indian Institute of Technology Bhubaneswar
Samantapuri, Bhubaneswar 751 013, Odisha, India.

Course Fee

- Participants from industries: Rs. 5000
- Participants from academic / technical institutions and R&D units: Rs. 2500
- Students: Rs. 1000
- Participants from abroad: USD 100.

The fee includes all instructional materials, computer use for tutorials and assignments, and laboratory equipment usage charges. The course fee does not include accommodation. However, the participants will be provided accommodation and food on the payment basis.

Registration

Register for the course online at http://www.gian.iitkgp.ac.in/GREGN/index The last date of registration is 12th December 2016.
Number of participants for the course is limited to 60.

Course Faculty

Professor David A. Kopriva,
Department of Mathematics,
The Florida State University,
Tallahassee, Florida, USA
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Professor David A. Kopriva is a Professor of Mathematics at The Florida State University, where he has taught since 1985. He is an expert in the development, implementation and application of high order spectral multi-domain methods for time dependent problems. On this subject he has over 50 publications and 50 presentations to conferences, national labs and industry. He is the author of the textbook "Implementing Spectral Methods: Algorithms for Scientists and Engineers". Prof. Kopriva has applied multi-domain spectral methods to time dependent problems in compressible flow, aeroacoustics, electromagnetics and computational finance. Spectral multidomain methods were used to solve problems in hypersonic flows over blunt bodies, in both the inviscid and viscous limits. The development of methods for aeroacoustics spans more than a decade. His solutions in each of the NASA workshops on computational aeroacoustics were consistently among the most accurate presented. He has also applied the techniques he has developed to problems in electromagnetic scattering and problems in particulate transport.

Course Coordinators & Contact Information

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Dr. Sathyanarayana is an Assistant Professor in the School of Mechanical Sciences at IIT Bhubaneswar. Currently he works on DNS of turbulent flows using novel Fourier space algorithms, De-aliasing techniques for Fourier Spectral Methods for Compressible Flows as well as developing experimental facilities for compressible turbulent flows.

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Dr. Bhumkar is an Assistant Professor in the School of Mechanical Science at IIT Bhubaneswar. Currently he works on LES of Transonic Flows, Simulation of Transitional Flows, Computational Aeroacoustics and Scientific Computing.