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The seminar vas opened by prof. N. Vitanov, who congratulated the speaker **Ph.D Kiril Shterev** for its new position as **Associate professor** in the Institute of Mechanics. The last presented an academic lecture titled **Numerical analysis of gas micro-flows**.

He started giving a few examples of micro flow- and rarefied gas flow problems. After that was considered example that shows issues and limitations of used methods and codes by a lecturer. The example was rarefied gas flow past a square at supersonic speed M=2.43 in a narrow microchannel. The problem was investigated using two different approaches: continuum and molecular. Continuum approach calculates numerically Navier-Stokes-Fourier equations using finite volume method SIMPLE-TS. Here the limitations are approximation schemes for convective terms. Second order Total Variation Diminishing (TVD) can be applied for slow and moderate flows and obtain unphysical oscillations when considered example goes to unsteady state regimes. On the other hand, first order upwind scheme gives physical correct results but requires significant computational resources because of its first order. The problem of development of higher order approximation scheme is known and described by Van Leer in his review paper: van Leer, B. (2006). Upwind and high-resolution methods for compressible flow: From donor cell to residual-distribution schemes, Communications in Computational Physics 1(192-206): 12. The lecturer presented promising approach for convective terms approximation. The main idea is that approximation scheme should corresponds to phenomenon described by approximated term(s). The convection is transport a property along the streamline and information propagation is unidirectional, i.e. transported property depends on previous values along the streamline but does not depend on next values. Convective term approximation schemes that contain upwind nodes along the streamline correspond to convection while the others do not correspond to convection. TVD schemes use downstream nodes (information) about transported property that corresponds to diffusion and is not included in convective terms. He explained that this is their problem and the reason for their limited application. Further were presented standard advection test problems that show second order accuracy of proposed approach and needs from 15 to 93.5 less iterations than TVD schemes with limiters Min-Mod, QUICK, and SUPERBEE. The approach looks promising and applicable to previous lecturer work finite volume method SIMPLE-TS for calculation of Navier-Stokes-Fourier equations. The other considered approach for rarefied gas flow calculation was molecular approach Direct Simulation Monte Carlo (DSMC). The lecturer described his recent work of creating new C++ DSMC code taking into account Prof. Stefanof's FORTRAN code. New C++ DSMC code has new and different structure that corresponds to present day's hardware specifics and maintains trends. All variables are renamed according recent trends in programming that makes it easily readable. New structure orientates code for further porting to parallel hardware for calculations as supercomputers and GPU clusters. He reported some of specifics of new code as time adaptive step, adaptive mesh, and include 2D geometry from CAD systems. He presented results of rarefied gas flow past NACA 0012 airfoil and described future direction of his work.

Discussion

Assoc. Prof. Slavcho Slavchev: It seems to me that this is very promising approach, but could you explain how can be extended to calculate convection-diffusion problems? How convection-diffusion problems will affects its application?

Answer: Has to be used one shape function for convective terms that corresponds to their specifics and another shape function for diffusion terms that corresponds to their specifics. The shape function for convective terms has to be as described here while the shape function for convective terms can be polynomial that include all surrounding nodes of node (i,j) that corresponds to physical phenomenon described by diffusion terms. Some mathematical software can be used to simplify derivation of numerical equation or equations.

Prof. Stefan Stefanov. I should say some words as his supervisor of the doctor thesis. You see, Kiril has very good potential and I hope in the future he will really develop in the full range in his opportunity and his capability to investigate different problems. I should say that in our works I slowly realized that I am mostly obstacle, not … for him, because I wanted he to go and some other things to do, but he did what he wants. He is a self-made scientist, so … I wish him success in the future.

Prof. N. Vitanov: I'm very happy that we have such kind of specialist in our institute and I wish you success … and welcome, now you are one of us.

Secretary of the Joint Seminar in IMech-BAS,
Assoc. Prof. R. Krastev