

# VALIDATION OF NUMERICAL MODELING OF SUPERSONIC SPATIAL FLOWS

A.M. Kharitonov, A.E. Lutsky, A.M. Shevchenko

\***Khrstianovich Institute of Theoretical and Applied Mechanics SB RAS Novosibirsk,**  
\*\* **Keldysh Institute of Applied Mathematics RAS, Moscow, Russia**

Intense development of numerical methods of modeling the flow around various flying vehicles necessitates establishment of rigorous standards for determining the degree of their reliability and/or area of their applicability. This especially refers to spatial flows, with model lacking complete adequacy and various assumptions used in numerical simulations. In addition, sufficient computer resources are not always available. The degree of reliability of numerical models and methods used to model certain phenomena is usually determined through their verification and validation [1-3].

The process of verification and validation includes both the computational and the physical aspects. High reliability of modeling is achieved by estimating the degree of accuracy of a chosen conceptual model in representing the real phenomenon and by comparisons with experimental data.

The adequacy of numerical modeling is evaluated through the following procedures:

- determination of the order of convergence of numerical solutions by comparisons with exact analytical solutions or with the size of the coordinate grid tending to zero;
- evaluation of the sensitivity of the discretization algorithm to various uncertainties: space and time constraints, adaptation of the grid to the model geometry and boundary conditions, etc.

The process of validation involves the following procedures:

- evaluation of the degree of reliability of the chosen numerical and experimental methods;
- evaluation of typical errors of experimental data: nonuniformities of the velocity field, accuracy of measurement equipment, and processing of measured information.

These processes make it possible to analyze the sensitivity of models and their numerical implementation to existing uncertainties. As a result, the degree of reliability of models and methods of numerical modeling can be estimated, and the areas of applicability of various approaches can be determined.

The full paper will give some examples of validation of spatial flows:

- flow around a delta wing at an angle of attack [4,5];
- flow with interaction between shock waves and boundary layers in the gap between separating stages of a flying vehicle, which is characterized by the transition from regular to Mach reflection of shock waves [6,7].

## References

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