High-order spectral/*hp* element methods for compressible flows

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1. Motivation

The understanding of the laminar-to-turbulent transition process relies on various techniques:

- Analytical, such as the asymptotic methods (triple-deck theory);
- Numerical, such as the direct simulation (DNS) of the governing equations;
- Experimental, wind tunnel and flight experiments.

DNS of the governing equations represents a complementary research area since it allows a detailed inspection of the mechanisms that lead to transition. However, DNS is still confined to academic problems at relatively low Reynolds number due to the large computational resources needed.

The development of high-order spectral/*hp* element methods for DNS allows better numerical diffusion properties than traditional finite volume and low-order finite element methods while maintaining complex geometries capabilities.

High-order spectral/*hp* element methods, however, are confined to a limited number of people in academia and in industry. The main reasons for this situation are:

- relatively poor numerical stability;
- algorithmic complexity;
- mesh generation.

It is therefore important to overcome these critical points in order to allow a wider adoption of these promising approaches.

2. Research

The project is concerned with the development of spectral/*hp* element methods such as the flux reconstruction (FR) approach and the discontinuous Galerkin (DG) method. In particular, we are interested in providing reliable and efficient algorithms in order to perform DNS/LES of compressible flows and to compare these results with experimental and analytical data.

3. Application

We are developing techniques to overcome the critical issues of high-order spectral/*hp* element methods. In particular, we are developing new dealiasing strategies complemented with artificial dissipation to enhance the numerical stability, easier methodologies (FR approach) and high-order mesh generation tools, in order to facilitate the use of high-order spectral/*hp* element methods in industry.