

## Hypercomplex Dynamics and Turbulent Flows in Sobolev and Besov Functional Spaces

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**Abstract :** This paper presents a rigorous study of advanced functional spaces, with a focus on Sobolev and Besov spaces, to investigate key aspects of fluid dynamics, including the regularity of solutions to the Navier-Stokes equations, hypercomplex bifurcations, and turbulence. We offer a comprehensive analysis of Sobolev embedding theorems in fractional spaces and apply bifurcation theory within quaternionic dynamical systems to better understand the complex behaviors in fluid systems. Additionally, the research delves into energy dissipation mechanisms in turbulent flows through the framework of Besov spaces. Key mathematical tools, such as interpolation theory, Littlewood-Paley decomposition, and energy cascade models, are integrated to develop a robust theoretical approach to these problems. By addressing challenges related to the existence and smoothness of solutions, this work contributes to the ongoing exploration of the open Navier-Stokes problem, providing new insights into the intricate relationship between fluid dynamics and functional spaces.

**Keywords :** navier-stokes equations, hypercomplex bifurcations, turbulence, sobolev and besov space

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