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INTRODUCTION TO THE ON-ORBIT OPERATION AND EXPERIMENT OF THE FLUID PHYSICS RACK (FPR) OF THE CHINA SPACE STATION

Abstract

On October 31, 2022, the Chinese Space Station Fluid Physics Rack (FPR) was launched into orbit with the Mengtian Lab Module. Subsequently, the lab module was successfully docked with the Tianhe Core Module, marking the smooth on-orbit assembly of the basic T-shape structure of the China Space Station. After three months of on-orbit testing, FPR functions and performance are normal and meet the requirements of the scheduled engineering mission. FPR integrates 15 advanced fluid diagnosis technologies, which can realize the online detection of multiple physical quantities of fluids field, and has strong comprehensive fluid measurement means and capabilities, such as the on-orbit application of the combination of digital holographic interferometry and particle image velocimetry, and microscopic and rheometer. At present, FPR has the function of measuring fluid velocity, temperature, concentration, surface deformation, and observing the aggregation, particle size, structure, nucleation and rheological properties of the colloidal system. In addition, the experimental platform is designed with a six-degree-of-freedom active vibration isolation function, which can improve the microgravity level of the payload experimental environment to less than 10-5g. FPR can support both macroscopic and microscopic fluid motion studies in space microgravity environment. It is also capable of conducting research on heat and mass transport processes related to material preparation and space biotechnology. The on-orbit microgravity experiment includes fluid dynamic process and diffusion process, colloid phase transition and self-organizing behavior of different fluid systems. By 2023, a total of five scientific experiments have been successfully carried out. Among them, the three experiments of fluid dynamics are: 1) Study of storage, transport and interface behavior of space fluid, 2) Study of oscillation characteristics and transition of microgravity annular flow, 3) Study of space migration behavior of three-phase multi-droplet; The two experiments of complex fluids are: 1) Study of the glass transition and rheological behavior of colloids under microgravity condition, 2) Study of the aggregation and phase transition of colloids in microgravity.