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# THE DRAG FREE CONTROL STRATEGY DESIGN OF "TAIJI-1"——THE FIRST EXPERIMENTAL VERIFICATION SATELLITE FOR CHINESE SPACE-BASED GRAVITATIONAL WAVE DETECTION

**Abstract**

Taiji is a China's space-based gravitational wave detection program, which aims to detect gravitational waves with lower frequencies to observe celestial bodies with greater mass or located farther away in the universe. Taiji-1 is the first satellite to conduct experiments on key technologies including test high-precision and ultra-stable laser interferometer, gravitational reference sensor (GRS), ultra-high precision drag-free control (DFC) and ultra-stable and ultra-static satellite platform. The Taiji-1 runs at 600km solar synchronous orbit, and its main payloads of Taiji-1 include a laser interferometer, a suit of GRS, the radio frequency micro-thruster (RIT), the Hall micro-thruster (HMT) and cold-gas thruster. The test mass of GRS is made of titanium alloy and its size is 40mm40mm10mm. The designed measurement resolution of X axis direction is 310-8m/s2, and the Y and Z axes resolution are 310-9m/s2. The satellite is stably Earth-oriented during normal mode, and the +X axis of the test mass is parallel with the -Zb axis of the body frame. The RIT/HMT are mounted on the Zb sides, and the external force acting on the satellite's Z axis is too small for GRS to distinguish. In order to calibrate the effectiveness of the DFC, first, a known active sinusoidal disturbance force is generated by the RIT/HMT mounted on the -Zb side of the satellite, and the disturbed acceleration is sensed by the GRS and outputted into the DFC system. The DFC system estimates the disturbance and gives corresponding control commands to the RIT/HMT mounted on the + Zb side of the satellite to counteract the active disturbance. The comparison of the residual acceleration and the active disturbance acceleration can validate the effectiveness of the DFC system. After that, the satellite rotates around Yb for 90 deg and the +Zb axis will point to the direction of the flight of the satellite, the GRS will sense the acceleration caused by atmospheric drag, and the DFC system will generate command to control the RIT/HMT to counteract the atmospheric drag according to the GRS measurement, leaving the satellite to free fall subject only to gravity. The experiment results show that the residual acceleration of the satellite after DFC is reduced by nearly an order of magnitude compared to that after active disturbance, and the residual acceleration is about 510-8m/s2 when the satellite's +Zb axis points to the direction of flight, the results show that the DFC of Taiji-1 is effective in orbit.