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MAGNETIC FIELD MEASUREMENTS ALONG THE TRAJECTORY OF THE ARIANE 6 MAIDEN FLIGHT UTILIZING QUANTUM DIAMOND-BASED SENSORS

Abstract

The measurements of magnetic fields in the space environment serve as a crucial tool for gaining insight into Earth's core and crustal processes, monitoring of space weather, and for spacecraft navigation. Classical sensors face difficulties such as spacecraft generated noise and drifts during prolonged measurements while exposed to the space environment. Strict demands of limited volume, weight, and power, coupled with need for high sensitivity and accuracy, make space magnetometry challenging. To address limitations of classical sensors, novel quantum technologies are being investigated for future space missions. One promising approach is to use nitrogen-vacancy centers in diamond. These diamond-based magnetometers have unique properties such as broad dynamic range (linear up to 0.1T), bandwidth (DC-MHz), and high theoretical sensitivity (fT/$\sqrt{Hz}$). The inherent radiation resistance, thermal stability, and ability to measure both scalar and vector magnetic fields make diamond ideal candidates for the harsh environment of space. This technology, however, has to be further miniaturized and improved before it can be utilized in future Earth observation missions.

Here we report on the scientific and technical results of the OSCAR-QUBE+ mission, in which a compact and miniaturized diamond-based magnetic field sensor with volume of 0.4U (8.2x7.8x6.4cm^3), weighing 315g, power consumption of 3.6W, and measurement rate of <42 Hz was developed. The device will be tested aboard the maiden flight of ESA's Ariane 6 rocket, as the scientific payload of the ESA YPSat mission. It is an enhanced iteration of a prototype developed by an interdisciplinary student team which has previously flown onboard the International Space Station. The OSCAR-QUBE+ sensor reached sensitivity of 30 nT/$\sqrt{Hz}$, an improvement by factor ten.

The sensor will operate and measure the magnetic field along the Ariane 6 launcher trajectory for the duration of the mission. The resulting data will be compared to the preliminary trajectory and the CHAOS-7 magnetic field model, to determine the flight Ariane6 trajectory. Potentially leading to improvement of navigation capabilities of spacecrafts. Simultaneously, during the mission, the magnetic

field along the trajectory will be applied to the ground model as verification of the sensor performance. As the sensor will be exposed to the full space environment, it will lead to an increase of the technological readiness level of the sensing technology. These advancements are a significant step towards utilization of diamond-based sensors in future Earth observation missions, with the next iteration being developed for the maiden flight of ESA Space Rider.