

## Coupled Dark State Magnetometer for the China Seismo Electromagnetic Satellite

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**On 2 February 2018, after 9 years of development, the instrument was successfully launched into a low Earth orbit. This is the first demonstration of the CDSM measurement principle in space.**

The Coupled Dark State Magnetometer (CDSM) is an optically pumped scalar magnetometer based on two-photon spectroscopy of free alkali atoms. The magnetic field measurement is based on the Zeeman effect which is the splitting of a spectral line into several components in the presence of a quasi-static magnetic field. Additionally, the CDSM uses several coherent population trapping (CPT) resonances in parallel in order to reduce systematic errors, e.g. the sensor temperature dependence. CPT inherently allows omni-directional measurements. This leads to a simple, all-optical sensor design without double cell units, excitation coils or electro-mechanical parts. The measurement principle was discovered in 2008 [1] and since then the two involved institutes have developed the instrument for future space missions [2].

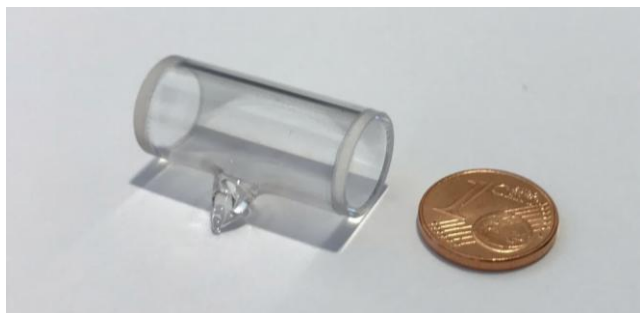


Figure 1: The CDSM uses laser light to probe rubidium atoms in this glass cylinder in order to gain information of the surrounding magnetic field.

Key parameters of the CDSM such as sensor-heading characteristic, accuracy, power spectral density of the detection noise and sensor temperature dependence were experimentally determined at the Conrad Observatory of the Central Institute for Meteorology and Geodynamics in Austria and partly at the Fragment Mountain Weak Magnetic Laboratory of the National Institute of Metrology in China.

The flight model is characterized by an accuracy of 0.19 nT ( $\sigma$ ), a detection noise of 50 pTrms at 1 s integration time, a mass of 1672 g and an in-Earth orbit measured power consumption of 3394 mW [2].

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Figure 2: The flight model consists of a mixed signal electronics board and the laser unit mounted in the instrument box (right). The sensor unit (left) is located at the tip of a boom outside of the satellite and is connected with two fibres (middle) and the thermal control cable.

The China Seismo-Electromagnetic Satellite (CSES), also known as Zhangheng-1, investigates natural electromagnetic phenomena and possible applications for earthquake monitoring from space in a polar, sun-synchronous, low Earth orbit. CSES was launched in February 2018 and has a nominal mission lifetime of 5 years.

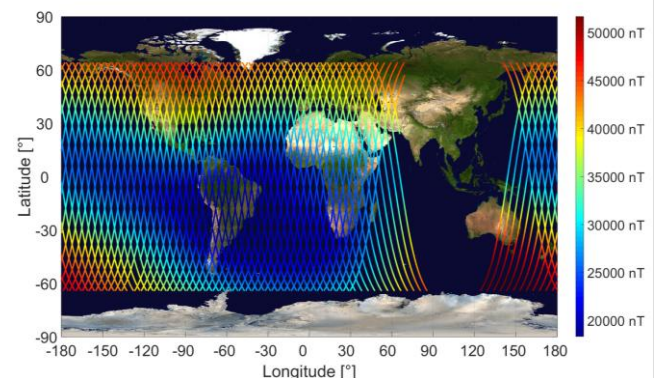


Figure 3: Since March 2018, the CDSM measures the magnetic field of Earth aboard CSES in a low Earth orbit.

### References:

- [1] R. Lammegger. Method and device for measuring magnetic fields. Patent WO/2008/151344, June 2008.
- [2] A. Pollinger et al. Coupled dark state magnetometer for the China Seismo-Electromagnetic Satellite. Meas. Sci. Technol., <https://doi.org/10.1088/1361-6501/aacde4>

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