A coupled dark state magnetometer developed for space missions

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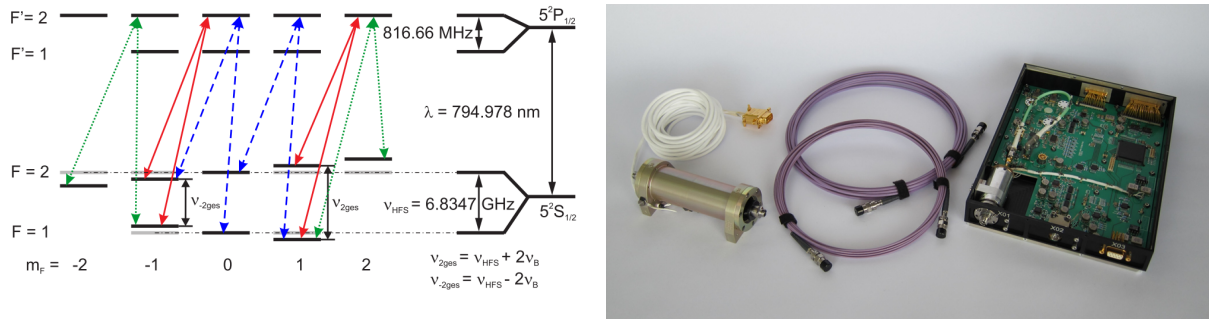
The development of an optically pumped magnetometer for space missions is a challenging task considering the electrical, mechanical and thermal limitations and restrictions in a harsh environment. The coupled dark state magnetometer (CDSM) is a self calibrating, scalar magnetometer specifically designed for these challenges [1]. The coherent population trapping effect (CPT), within the hyper fine structure of the ^{87}Rb - D_1 line, allows a precise detection of magnetic fields. Several of these CPT resonances, in the form of Λ-systems, are excited and coupled simultaneously to minimize the influence of external influences such as neon buffer gas pressure shift and light shift. In Figure 1a this multi resonance excitation scheme is shown. Depending on the angle between the magnetic field and the laser propagation axis the resonances are switched to enable an omnidirectional sensitivity to magnetic fields [2]. The CDSM's current space ready flight model design is displayed in Figure 1b. Optical fibres connect the ^{87}Rb sensor unit to the vertical cavity surface emitting laser (VCSEL) diode unit and the photodiode, both within the electronics unit. The laser current is FM-modulated with a 3.4 GHz signal to match the ground state splitting. A field programmable gate array (FPGA) ensures the autonomous operation in space. Since February of 2018, the first CDSM version has been operating successfully in a low earth orbit as part of the china seismo-electromagnetic satellite (CSES) mission. In 2022 a further developed version will be launched on board of the Jupiter icy moons explorer (JUICE) mission. An overview of the device and recent developments will be presented.



(a) Multi resonance excitation scheme [2]

(b) Flight model for the CSES mission ©TU Graz

Figure 1. Within the ^{87}Rb D_1 line (a) the marked Λ-systems are utilized by the CDSM's measurement principle. In (b), the main components of the CSES mission's flight model are, from left to right: the vapour sensor unit, the optical fibres and the electronics box.

[1] R. Lammegger, WIPO, Patent WO/2008/151344 (2008).
[2] A. Pollinger, M. Ellmeier, W. Magnes, C. Hagen, W. Baumhohann, E. Leitgeb and R. Lammegger, IEEE Instr. and Meas. Technology Conference (I2MTC) Proceedings, 33 (2012)