A Coupled Dark State Magnetometer developed for Space Missions

Roland Lammegger[1], Michaela Ellmeier[1,2], Christoph Amtmann[1], Andreas Pollinger[2], Werner Magnes[2], Christian Hagen[2], Irmgard Jernej[2]

[1] *Institute of Experimental Physics, Graz University of Technology, Petersgasse 16, 8010 Graz, Austria*

[2] *Space Research Institute, Austrian Academy of Sciences, Schmiedlstraße 6, 8042 Graz, Austria*

The Coupled Dark State Magnetometer (CDSM) is a scalar magnetometer based on two-photon spectroscopy of free alkali atoms. Coherent Population Trapping (CPT) leads to narrow optical resonance features, which enable a precise determination of the magnetic field dependent Zeeman energy level shifts. Systematic errors which usually degrade the accuracy of single CPT magnetometers are cancelled or at least minimized by the use of several CPT resonances in parallel. CPT inherently enables omni-directional measurements. This leads to a moderately complex, 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 instrument has been developed by the two involved institutes for future space missions [2]. The first demonstration in space take place aboard the China Seismo-Electromagnetic Satellite (CSES) mission. The flight model was launched into a low Earth orbit in January 2018. Furthermore, the CDSM is baseline instrument for the JUpiter ICy Moon Explorer (JUICE) mission of the European Space Agency (ESA) to visit the Jovian system.

The presentation includes an introduction of the measurement principle. The instrument designs are introduced for the CSES mission (successful operation in space) and the JUICE mission. The performance characteristics of both designs are presented, and -in general- the challenging demands on the instrument design of a magnetometer suited for space operation are discussed.

References

[1] Roland Lammegger, *Method and device for measuring magnetic fields*, WIPO, Patent **WO/2008/151344** (2008).

[2] Andreas Pollinger, Michaela Ellmeier, Werner Magnes, Christian Hagen, Wolfgang Baumjohann, Erich Leitgeb, Roland Lammegger, *Enable the inherent omni-directionality of an absolute coupled dark state magnetometer for e.g. scientific space applications*, IEEE Instrumentation and Measurement Technology Conference (I2MTC) Proceedings, **33** (2012).