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A XYLOPHONE BAR MAGNETOMETER FOR MICRO/PICO SATELLITES

Abstract

Magnetic fields play a key role in many aspects of the solar-terrestrial interactions. For example, during geomagnetic activity, charged particles precipitate along geomagnetic field lines and produce spectacular aurora. Strong sheets of field-aligned currents (FACs) associated with these precipitations produce local perturbations of the geomagnetic field. A magnetometer onboard a spacecraft (s/c) crossing these current sheets will record the magnetic field perturbations from which the values of the FACs can be deduced from Maxwell's equation rot(B) = 0 J. With a single s/c this relies on the assumption that the current sheet is stationary during the crossing. However this assumption is not always valid which means that spatial and temporal variations of the magnetic field cannot be discriminated. Currently the separation of satellites in multi-s/c missions like Cluster or Themis is larger than the width of the current sheet. This is one example where multi-point measurements are needed with a fleet of small micro- or pico-s/c with smaller separations.

The Belgian Institute of Space Aeronomy (BIRA-IASB), the "Centre Spatial de Liège" (CSL), the "Laboratoire de Techniques Aéronautiques et Spatiales" (LTAS) of University of Liège, and the Microwave Laboratory of University of Louvain-La-Neuve are collaborating in order to develop a miniature version of a xylophone bar magnetometer (XBM) with Micro-Electro-Mechanical Systems (MEMS). The device is based on a classical resonating xylophone bar. A sinusoidal current is supplied to the bar oscillating at the fundamental transverse resonant mode of the bar. When there is an external magnetic field, the resulting Lorentz force causes the bar to vibrate at its fundamental frequency with amplitude directly proportional to the component of the ambient magnetic field perpendicular to the bar. We will illustrate the working principles of the XBM and the challenges to reach the required sensitivity (measuring magnetic fields lower than 10 nT). The optimal dimensions of the MEMS XBM will be discussed as well as the constraints on the current that can flow through the bar. Preliminary measurements and temperature and pressure effects on the device will be discussed based on a prototype that will be built in the Microwave Laboratory of University of Louvain-La-Neuve using Silicon on Insulator (SOI) technology. Another important aspect to qualify this magnetometer for space applications is related to the minituarisation of the sensor that will measure the bar displacement and of the associated electronics. Several possible sensors will be discussed including capacitive methods, plasmons, etc ...