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Concept miniaturised magnetometer design for a Europa lander

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Abstract

In order to define both the time variable inducing magnetic field at Europa and the resulting induction signal, simultaneous measurements from a Europa Orbiter (JEO) and a platform lander are desirable. Multi-frequency sounding at frequencies which enable probing of the interior is necessary in order to constrain the location and thickness of any subsurface ocean as well as resolve field contributions from localized plasma currents and eliminate the possibility of an internal field.

Such a lander poses considerable engineering challenges for payload developers. Instrumentation and sensors need to be low volume, low mass, low power, highly tolerant to ionising radiation and capable of science grade measurement across a potential temperature range of 50K - 130K depending on landing site. We present a conceptual design that exploits the ambient temperature to enable sub-pT measurement accuracy without the need for an optically pumped sensor. The instrument is composed of two miniaturised sensors, a tri-axial element based on Anisotropic Magneto Resistance (AMR), currently accurate to 2nT and a relative mixed sensor combining a Giant Magneto Resistive (GMR) element with a passive superconducting flux transformer to achieve detectivity of better than 1pT. At temperatures below the superconducting transition temperature (currently 90K) the mixed sensor is capable of resolving extremely small variations in the induced field superposed on the tri-axially determined dc background for a combined sensor volume of only a few cm^3.

The baseline arrangement would use multiple (at least two) spatially separated sensors operating as a gradiometer fitted to a rigid boom in order to separate the ambient field from the lander disturbance field. If the AMR can meet the required accuracy level for determination of the background field, the instrument would be extremely miniaturised and low volume compared to conventional designs. However combinations with a compact fluxgate could also be considered if the background absolute level needs to be determined more accurately although this would be at the increased mass and power. While the applicability of the mixed sensor is dependent on the eventual choice of landing site, the development of such a sensor combination would have applications in other regions of the solar system such as trapped lunar cold spots or even aboard deep space probes.