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Magnetic field fluctuations measurement onboard ESA/JUICE mission by search-coil magnetometer: SCM instrument as a part of RPWI consortium

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Abstract

The JUpiter ICy moons Explorer (JUICE) mission is the first large-class (L1) mission in ESA Cosmic Vision. JUICE is planned for launch in 2022 with arrival at Jupiter in 2029 and will spend at least three years making detailed observations of Jupiter's magnetosphere and of three of its largest moons (Ganymede, Callisto and Europa). The Radio and Plasma Wave Investigation (RPWI) consortium will carry the most advanced set of electric and magnetic fields sensors ever flown in Jupiter's magnetosphere, which will allow to characterize the plasma wave environment and the radio emission of Jupiter and its icy moons in great detail. The Search Coil Magnetometer (SCM) will provide high-quality measurements of the magnetic field fluctuations' vector $\delta\mathbf{B}$ for RPWI. Here we present the technical features of the SCM instrument and we discuss its scientific objectives. We show the improvements of the SCM instrument onboard JUICE with respect to search-coil instruments onboard earlier planetary missions such as Galileo and Cassini, and we discuss the impact of such improvements on Jupiter's in situ plasma observations.

1. Introduction

1.1 SCM technical features

SCM will provide for the first time high-quality three-dimensional measurements of magnetic field fluctuations' vector in Jupiter's magnetosphere. The frequency range is 0.1 Hz – 20 kHz, which is sufficient to cover a broad range of fluctuations of scientific interest. High sensitivity (4 fT / √Hz at 4 kHz) will be assured by combining an optimized (20 cm long) magnetic transducer with a low-noise (4 nV /√Hz) pre-amplifiers based on ASIC technology. The impact of low-frequency perturbations by the spacecraft will be strongly reduced by accommodating SCM more than 8m away from the spacecraft on JUICE magnetometer boom.

1.2 SCM science objectives

The combination of high sensitivity and high cleanliness of SCM measurements will allow unpreceded studies of waves and turbulence down to kinetic scales in the Jovian system. SCM measurements, in combination with electric field measurements, will allow to quantitatively determine the properties of different kinds of waves at boundaries such as Jupiter's bow shock, magnetopause and magnetotail current sheet as well as at the magnetopause and tail current sheet of Ganymede's small magnetosphere. As an example, whistler waves will be accurately identified through the measurement of all the three components of the magnetic fluctuations' vector $\delta\mathbf{B}$ and measurements of key quantities such as Poynting's vector will be obtained combining $\delta\mathbf{B}$ measurements with electric field fluctuations $\delta\mathbf{E}$ measurements. Whistler waves are crucial to understand the dynamics of electrons at shocks and during magnetic reconnection in current sheets. SCM measurements will also allow to perform novel studies of turbulence in Jovian system, such that associated to fast flows in Jupiter's and Ganymede's magnetotail current sheet as well as turbulence in the solar wind upstream of Jupiter's bow shock. The combination of SCM measurements with those from the fluxgate magnetometer JMAG will allow studying turbulence from large scales down to kinetic scales, where the strongest particle energization occurs. Another important example are measurements of Alfvén waves and turbulence in Ganymede's auroral region, such as dispersive Alfvén waves which are important for particle acceleration therein. We illustrate JUICE SCM's science case by showing a few examples of Galileo and Cassini search-coil measurements and we discuss how improvements on JUICE will allow improving our understanding of waves and turbulence in the planetary environments.