LIMADOU-CSES

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The project LIMADOU/CSES is a space mission devoted to the study of the possible correlations between seismic events and perturbation of the Van Allen belts.
The satellite mission CSES (China Seismo-Electromagnetic Satellite), financed by the CNSA (China National Space Agency) and developed by CEA (China Earthquake Administration) together with several Chinese research institutes and private companies, aims at investigating the electromagnetic field, plasma and particles in the near-Earth environment in order to study in particular seismic precursors, particles fluxes (from Van Allen belts, cosmic rays, solar wind, etc.), anthropogenic electromagnetic pollution and more in general the atmosphere-ionosphere-magnetosphere coupling mechanisms that can affect the climate changes.
Italy participates to the CSES satellite mission with the LIMADOU project funded by ASI (Italian Space Agency) in collaboration with the Universities of Roma Tor Vergata, Uninettuno, Trento (TIFPA), Bologna and Perugia, INFN LNF, INGV (Italian National Institute of Geophysics and Volcanology) and INAF-IAPS (Italian National Institute of Astrophysics and Planetology).
This program has been selected in Italy to be funded by the Ministry of Education, University and Research (MIUR) in the context of the programs "Premiali".
The launch of CSES – the first of a series of several satellite missions – is scheduled in 2017: a sketch of the satellite is shown in Fig. 1.

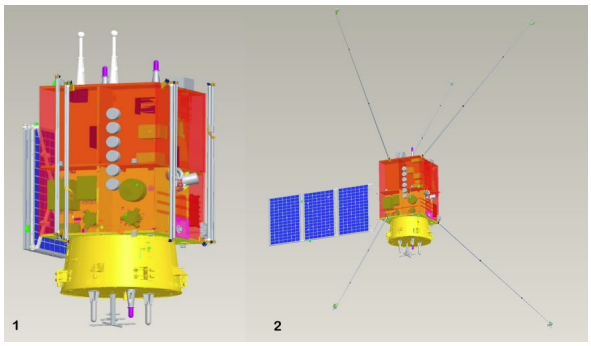

Fig. 1 Sketch of the CSES satellite: 1, Collapsed and 2, expanded solar panel configuration

The ensemble of the CSES detectors provides measurements of energetic particle fluxes, ionospheric plasma parameters and electromagnetic fields, in a wide range of energies and frequencies. The main sensors onboard the satellite are the HEPD (High Energy Particle Detector) developed by the Italian participants, and the following Chinese sensors: LEPD (Low Energy Particle Detector), LP (Langmuir Probes), IDM (Ion Drift Meter), ICM (Ion Capture Meter), RPA (Retarding Potential Analyzer), EFD (Electric Field Detectors) developed in collaboration with the Italian team, HPM (High Precision Magnetometer) and SCM (Search-Coil Magnetometer).
The research activity is at an advanced phase, being the various payloads already built and an intense activity is going on for the calibration of the various sensors. In particular, the Italian payload HEPD is under test at the laboratories of the National Institute for Nuclear Physics (INFN) and the Chinese payloads LP, IDM, ICM, RPA and EFD are tested at the INAF-IAPS "Plasma Chamber" in Rome, which is a facility where the response of the sensors, and their compatibility with ionospheric plasma, can be verified in environmental conditions very similar to those met by the satellite in orbit.
The objectives of the Project LIMADOU/CSES cover several aspects: scientific, engineering and application ones.

The scientific objectives of the project are related to the to study the ionospheric perturbations possibly associated with earthquakes and to explore new approaches for short-term and imminent prediction.
The objectives in the engineering aspect of the project are to check the reliability and effectiveness of the proposed electromagnetic satellite monitoring system by utilizing a set of new techniques and equipment, in order to obtain world-wide data of space environment of the electromagnetic field, plasma and energetic particles.
The objectives for the aspect of application of the project are to extract the electromagnetic information possibly associated with the earthquakes of M≥6 within Chinese territory and its neighboring area (1000 km) and that of M≥7 in the global scale; to analyze the features of seismo-ionospheric perturbations, in order to test the possibility for short-term earthquake forecasting experimentally in terms of satellite observation; to provide the data sharing service for international cooperation and scientific community.
In brief, the main mission contents of LIMADOU/CSES can be summarized as:

1. Measurement of signals from electromagnetic emission and its perturbations in inonosphere;
2. Measurement of the disturbance of plasma in ionosphere, such as: contents, density and temperature of the ions, density and temperature of the electron, total electron contents, etc.
3. Measurement of energetic particles precipitations

The INFN Sections of Roma Tor Vergata and LNF are in charge of the HEPD and collaborate to the EFD realization (design, test, qualification, analysis).
The HEPD has been designed to provide good energy resolution and high angular resolution for electrons (3 - 100 MeV) and protons (30 - 200 MeV). The detector consists of two layers of segmented plastic scintillators and a calorimeter, constituted by a tower of scintillator counters. The direction of the incident particle is provided by two planes of double-side silicon micro-strip detectors placed in front of the trigger scintillator planes to limit the effect of Coulomb multiple scattering on the direction measurement.
The EFD consists of four probes designed to be installed on four booms deployed from the 3-axes stabilized satellite. The EFD can measure electric field in a wide band of frequencies extending from quasi-DC up to about 5 MHz.
Further implementation of the DAQ software is in progress together with the definition of the work packages for the required documentation of the Technical Design review and the Critical Design Review, completed in March 2015 to enter the successive phases B/C/D1.
LNF is also in charge of Radiation hardness tests with electron beams at different energies at local facilities like SPARC-LAB and BTF, and for test campaigns at external laboratories like INFN LNL (Legnaro, Padova) and INFN LNS (Catania).

Publications

1. R. Pompili, B. Spataro et al.: “Tests of the HEPD device at the SPARC-LAB facility”; INFN-15-03/LNF (April 2015) internal note

2. D. Badoni et al. (CSES-LIMADOU Collaboration): "An Electric Field Detector for high-performance measurements of the electric field in the ionosphere"; Proc. 34th ICRC, The Hague, Netherlands

3. R. Sparvoli et al. (CSES-LIMADOU Collaboration): “The High Energy Particle Detector on board the CSES China Seismo-Electromagnetic satellite”; Proc. 34th ICRC, The Hague, Netherlands