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► **To cite this version:**

Nicolas Gilet, Emmanuel de Leon, Klet Jegou, Luca Bucciardini, Xavier Vallières, et al.. Automatic detection of the electron density from the WHISPER instrument onboard CLUSTER. 22nd EGU General Assembly, 2020, Online, Gabon. pp.2591-2599, 10.5194/egusphere-egu2020-18883 . insu-03560746

HAL Id: insu-03560746

<https://insu.hal.science/insu-03560746>

Submitted on 8 Feb 2022

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EGU2020-18883

<https://doi.org/10.5194/egusphere-egu2020-18883>

EGU General Assembly 2020

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Automatic detection of the electron density from the WHISPER instrument onboard CLUSTER

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The Waves of High frequency and Sounder for Probing Electron density by Relaxation (WHISPER) instrument, is part of the Wave Experiment Consortium (WEC) of the CLUSTER mission. The instrument consists basically of a receiver, a transmitter, and a wave spectrum analyzer. It delivers active (sounding) and natural electric field spectra. The characteristic signature of waves indicates the nature of the ambient plasma regime and, combined with the spacecraft position, reveals the different magnetospheric boundaries and regions. The electron density can be deduced from the characteristics of natural waves in natural mode and from the resonance triggered in the sounding mode. The electron density is a parameter of major scientific interest and is also commonly used for the calibration of the particles instruments.

Until recently, the electron density required a manual intervention consisting in visualizing input parameters from the experiments, such as the WHISPER active/passive spectrograms combined with the dataset from the other instruments onboard CLUSTER.

Work is being carried out to automatize the detection of the electron density using Machine Learning and Deep Learning methods.

To automate this process, knowledge of the region (plasma regime) is highly desirable. In order to try to determinate the different plasma regions, a Multi-Layer Perceptron has been implemented. This model consists of three neuronal network dense layers, with some additional dropout to prevent overfitting. For each detected region, a second Multi-Layer perceptron was implemented to determine the plasma frequency. This model has been trained with 100k spectra using the plasma frequency values manually found. The accuracy can reach until 98% in some plasma regions.

These models of the electron density automated determination are also currently applied on the dataset of the mutual impedance instrument (RPC-MIP) onboarded ROSETTA and will be useful for other space missions such as BepiColombo (especially for PWI/AM²P experiment) or JUICE (RPWI/MIME experiment).