# Cataloguing type II radio waves generated by CMEs

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## Abstract

It is well known that the Sun is a fantastic scenario where a plethora of phenomena develops frequently. Being Earth revolving around it, what happens on the Sun reverberates all over the Solar System. One of the many forms of solar activity are the Coronal Mass Ejections. These are plasma eruptions that travel through space and may reach Earth. These can alter the space environment of the planet, thus the interest in study them. In this work we have produced a catalogue regarding a radio emission which ocurrs when these CME are detected in situ by means of a spacecraft.

## Introduction

Coronal Mass Ejections (CMEs) are one of the many forms of solar activity. These are huge plasma eruptions released in short periods of time. When they are detected in situ by means of a spacecraft, they are called Interplanetary Coronal Mass Ejections (ICMEs). These have a great relevance on the space weather conditions, given that one ICME directed towards Earth, is able to have an impact on the planet, producing geomagnetic storms, among other phenomena.

Some ICMEs, usually the fastests ones, are accompanied by a magnetohydrodynamic (MHD) shockwave, who travels in front of the CME. During propagation, this shockwave excites electrons that are on its way, and they produce radiation in the radio spectrum, which is called Type II radio frequency (TII), at the local frequency of the plasma, with wavelenghts that are metrics or kilometrics, depending on the distance to the Sun.

In this work, we produce a catalogue of  this TII emissions by looking at the dynamic spectra of the WIND spacecraft, using the TNR receptor on the WAVES instrument aboard, and produce a catalogue of 105 events, some of which had not been previously detected.

## Instruments and data set:

The search of type II events was made through Dynamic Spectra (DE) analysis, taken from the  Wind spacecraft, and using the WAVES instrument aboard. For the complementary analysis we made use of images and data provided by other complementary instruments.

Particularly, the TNR receptor was used, which detects frequencies between 4 and 245 kHz. Data is from public access through WIND/WAVES official web site: https://solar-radio.gsfc.nasa.gov/wind/data_products.html. From here we downloaded the daily files needed for its analysis in IDL (Interactive Data Language), from January 1st 2000 to December 31st 2012, making 4749 files, each with and average size of 0,5 Mb. These files provide the DE, read through SolarSoft.

Given that one of the main objectives from this work is to characterize TII emissions in the solar activity context, a series of other online catalogues were used, that provide information about in-situ detections of: shock waves, ICMEs and Magnetic Clouds (MC).

## Identification of TII events and cataloguing

We looked for events that were not previously reported in the Type II radio wave emissions catalogue from Wind/WAVES. Each event identified was added to the compiled list event, registering date and time of beggining and end of the event, so as the corresponding frequency range. This information was obtained after looking at each of the DE. Afterwards, the Type II catalogue from Wind/WAVES was examined to check whether or not, this event had been registered in that moment, in connection to the TII event detected in TNR. The final result was the selection of the 105 low frequency events.

To associate the TII emissions with their corresponding shockwaves, we made use of the previously detailed catalogues. The criteria to choose shockwaves related to the TII was to find shocks no further than 4 days since the ending of the TII event.

In order to associate the TII with their corresponding ICMEs, we looked for the event in the Richardson-Cane and Teresa Nives Chinchilla catalogues. The criteria used was to choose those events that had a beggining date for the ICME reported for one or both catalogues, were not to 2 days after the ending date of the TII. We looked for the events to be the closest in time as possible. In these catalogues it can also be found information in respect to the event is classified as a Magnetic Cloud or not.

Afterwards, we found the value of the Dst (Disturbance Storm Time, which gives information regarding the Earth’s magnetic field) associated to the 105 events analized. We registered the lower value during the passage interval of the ICME. If the emission has a shockwave related to it, but there is not an ICME reported by TNC nor R-C, we took the lower value that lies in the period of time between the arrival time of the shock wave and the 6 hours afterwards. If no shockwave was detected nor a detection in TNC and R-C's lists, then there is no point in determine a value for the Dst.

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