DECIMETRIC RADIO EMISSION ANALYSIS OF CHROMOSPHERIC EVAPORATION IN A X1.0 FLARE ON MARCH 29, 2014

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Abstract

One instance of the chromospheric evaporation phenomenon, associated with a X1.0 solar flare, was identified by line profile data (Li et al. 2015) recorded by the Interface Region Imaging Spectrograph (IRIS; De Pontieu et al. 2014) and the EUV Imaging Spectrometer (EIS; Culhane et al. 2007). The present work analyzes the metric radio emission counterpart of that flare. However, since a slow drift rate towards lower frequencies (Aschwanden & Benz 1995) was not found in the resulting spectra, we elaborate on why the chromospheric evaporation could be visualized with line profile data but not with metric radio emission data.

Keywords: solar flare, solar radio emission, chromospheric evaporation, spectrometer. data analysis, data visualization.

Introduction

During solar flares, a huge amount of energy is released, causing acceleration of particles and heating of ambient plasma in the solar atmosphere. After solar flares heat the electrons as a result of rapid energy deposition, there is a mass upflow of heated plasma from the chromosphere to the corona along the flare loops. This phenomenon is called Chromospheric Evaporation (Sturrock, 1973).

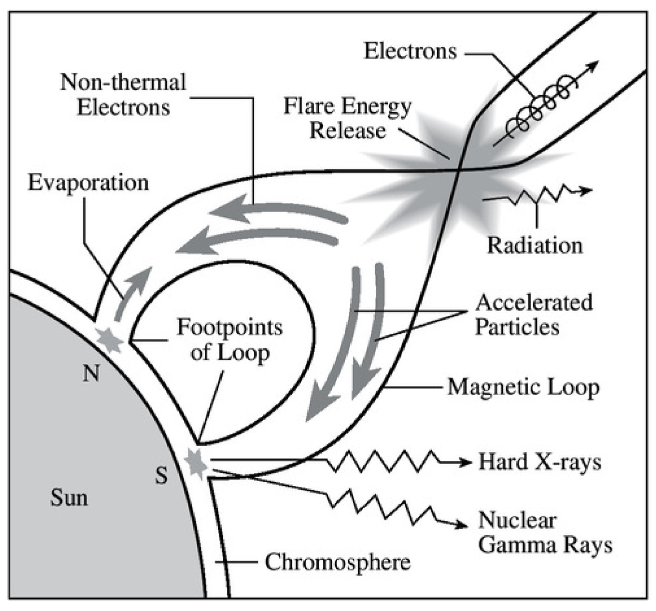

Fig. 1. Solar Flare Model
Source: K.R. Lang, Tufts University, 2010.

Objectives

The general objective was to visualize the presence or absence of chromospheric evaporation in spectra generated from the analysis of metric radio emission data of a chosen event, and was accomplished by first achieving the following specific objectives:

- Data selection and analysis of the chosen event using software that we developed
- Comparison of resulting spectra with spectra of other instances of chromospheric evaporation
- Discussion about whether the chosen event showed the occurrence of chromospheric evaporation on metric radio emissions

Methodology

The occurrence of chromospheric evaporation, associated with a X1.0 solar flare that took place on March 29, 2014, at the solar active region NOAA AR 12017, was visualized in line profile data gathered by the IRIS and EIS spectrographs. That line profile data was obtained at multiple times: during the flare's rise (17:30 UT), during its peak (17:48 UT), and during its decay (17:54 UT). In this present study we analyze the metric radio emission counterpart of that same flare, at the same rise, peak and decay times, associated with the chromospheric evaporation phenomenon. The radio emission was recorded in the metric (200 — 450 MHz) range by the e-Callisto (Compound Astronomical Low cost Low frequency Instrument for Spectroscopy and Transportable Observatory) International Network of Solar Radio Spectrometers, and analyzed with scientific computing tools developed by the authors, which are freely available online. For comparison, the spectrum of the occurrence of chromospheric evaporation on February 16, 2011, during an M1.6 flare (Gömöry et al. 2016), was also generated with the same computational tools, as well as the spectrum showing the chromospheric evaporation that happened among a X6.9 flare on August 9, 2011, that we had studied previously.

Results

After using the computational tools to analyze the metric radio emission from the selected events, the following spectra were obtained:

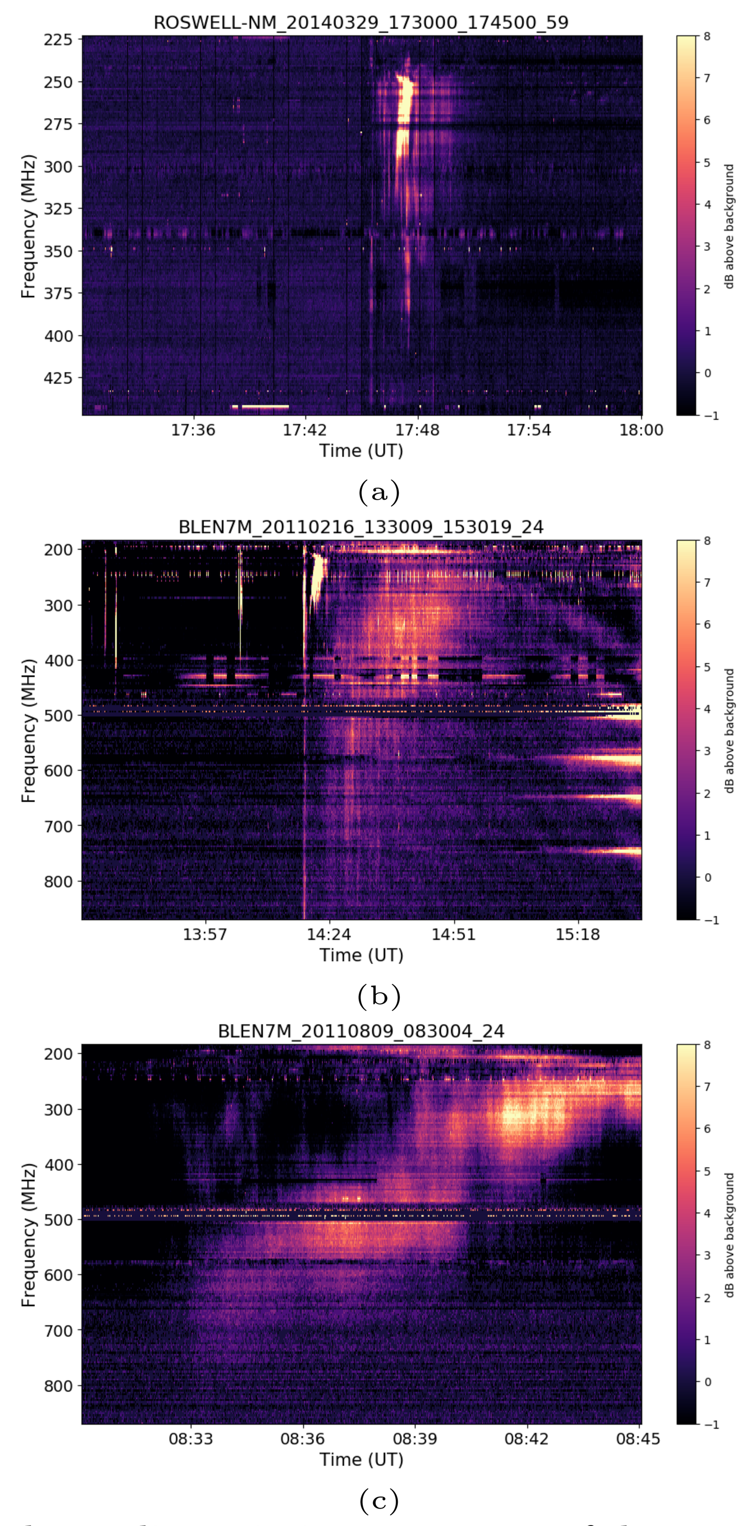

Fig. 2. Solar radio emission spectrum of data recorded on (a) March 29, 2014 (X1.0 flare), on (b) February 16, 2011 (M1.6 flare), and on (c) August 9, 2011 (X6.9 flare)
Source: The Authors.

Conclusions

After selecting which events to compare the March 29, 2014 flare to, we were able to generate solar radio emission spectra for all the three events. The generation of these spectra was possible due to the easy access to solar spectrometers' data provided in FITS files by the e-Callisto network, and to the fine-tuning of our data analysis and visualization tools that came with the observation of multiple events. By analyzing and comparing the generated spectra, it is possible to conclude that the 2014 flare we chose to study did not show the occurence of chromospheric evaporation on metric radio emission data. That is because differently than both the 2011 flares we chose to analyze, it did not present a slow drift rate towards lower frequencies, which is characteristic to observations of chromospheric evaporation based on metric emissions. This absence of evidence of chromospheric evaporation on the metric emission data we analyzed, is possibly related to the fact that the metric emission data is limited by the time cadence and spatial resolution of the spectrometers, as stated by Li et.al (2015). And the fact that the IRIS and the EIS, used by the same study just mentioned, both have high temporal and spatial resolution, as well as high sensitivity in detecting high temperature emissions, could explain why they were able to confirm the occurrence of chromospheric evaporation with their line profile data. Nonetheless, our observations are still important since metric radio emission data of that event had not been studied before, neither compared to the results obtained by the previously reported study of line profile data.

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Realization

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