Temperature of a long-lived solar coronal cavity

Urszula Bąk-Stęślicka[1], Sarah E. Gibson[2] and Marek Stęślicki[3]

1. Astronomical Institute, University of Wrocław, Wrocław, Poland
2. National Center for Atmospheric Research, Boulder, CO, USA
3. Space Research Centre, Polish Academy of Sciences, Wrocław, Poland

We have analysed a long-lived coronal cavity observed from 17 March 2012 to 21 March 2012. For this cavity we applied a differential emission measure method to obtain both a temperature distribution and the average temperature over all five observational days. We find that the cavity is filled with material hotter than its surroundings. The temperature remains stable during all five days.

1 Introduction

Solar coronal cavities are dark structures with a rarefied density compared with surrounding streamers (Gibson et al., 2010; Gibson, 2015) which can be observed in a wide wavelength range (Gibson et al., 2006; Hudson et al., 1999; Reeves et al., 2012). Quiescent cavities are observed mostly in the polar crown regions and may be long-lived (Gibson et al., 2006). The magnetic structure of cavities has been a subject of research for many years (Gibson, 2018). Cavities possess a characteristic "lagomorphic" structure, observed in linear polarisation observations, which may be explained with the flux rope model (Bąk-Stęślicka et al., 2013, 2014). Characteristic flows in the form of a nested ring are also observed (Bąk-Stęślicka et al., 2016). The thermal properties of cavities have been studied for many years. Guhathakurta et al. (1992) concluded that a cavity was cooler than a surrounding streamer. Kucera et al. (2012) found that both the streamer and cavity have similar average temperatures, although the cavity had more variable temperatures. Most of the analyses revealed that cavities are hotter than surrounding streamers (Fuller et al., 2008; Habbal et al., 2010; Hudson et al., 1999; Reeves et al., 2012). In the present work we have applied differential emission measure (DEM) analysis to one long-lived cavity observed during five days from 2012 March 17 to 2012 March 21.

2 Data Analysis

The DEM analysis is based on six passband EUV observations of the solar corona from the *Atmospheric Imaging Assembly* (AIA, Lemen et al., 2012). We used one image in all six filters of AIA (94 Å, 131 Å, 171 Å, 193 Å, 211 Å, 335 Å) for all five days and performed a deconvolution of all AIA images (Grigis et al., 2012). To improve the signal-to-noise ratio we integrated signal from four pixels. In our analysis we did not subtract the background since the signal from the cavity comes from an extended (along the line of sight) structure. To obtain the temperature map we calculated best-fit DEMs for observed fluxes using the xrt_dem_iterative2 routine (Weber et al., 2004). To estimate uncertainties we calculated 100 Monte Carlo (MC) simulations of the DEM, each time perturbing the observed flux with random noise (as described in Cheng et al., 2012 and references therein). We determined a median DEM profile in each binned pixel and used it to calculate the DEM-weighted average temperature in the map (Bąk-Stęślicka et al., 2019). To measure the average temperature in the cavity we used a box of 10×10 binned pixels and averaged the signal over all pixels in the box first. To obtain uncertainties in the temperature we used the method described in Bąk-Stęślicka et al. (2019).

3 Results

We observed a long-lived cavity between 2012 March 17–21 (Fig. 1) and measured the average temperature in the center of the cavity. The temperature of the cavity was higher than the surroundings during all days and reached a value of $\sim$ 2–2.15 MK. The cavity had a highest measured temperature on 2012 March 18–19 (see Fig. 2). The temperature within the cavity observed at one moment of time is also not uniform. The average temperature can be slightly hotter by $\sim$ 0.1 MK above the center (Fig. 2). The DEM profiles are broad (Fig. 3) and show plasma up to 3 MK. Some of the MC solutions showed plasma with even higher temperature, but with median profile at much lower level, so emission from such plasma can be negligible. All the results are presented in Tab. 1.

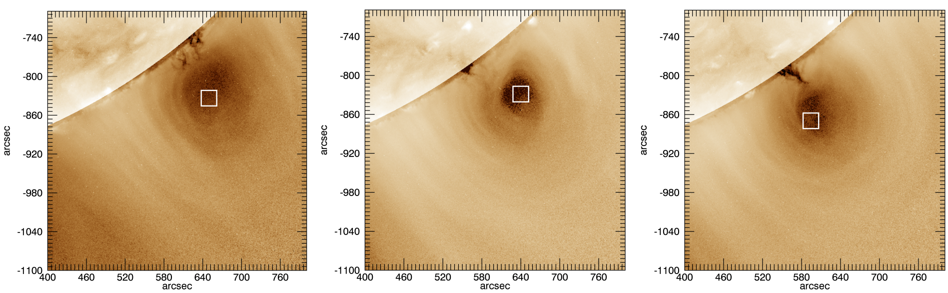

Fig. 1: AIA 193 Å images of the cavity observed on 2012 March 17, 18, and 19. This image was enhanced using the aia_rfilter procedure. The average temperatures presented in Tab. 1 were measured in the white box.

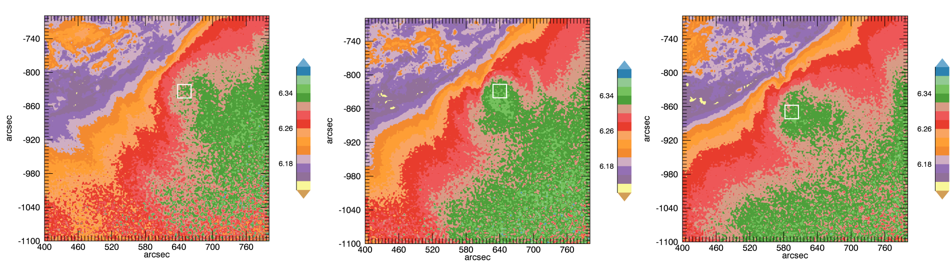

Fig. 2: Average temperature map (log T) for cavity observed on 2012 March 17, 18, and 19

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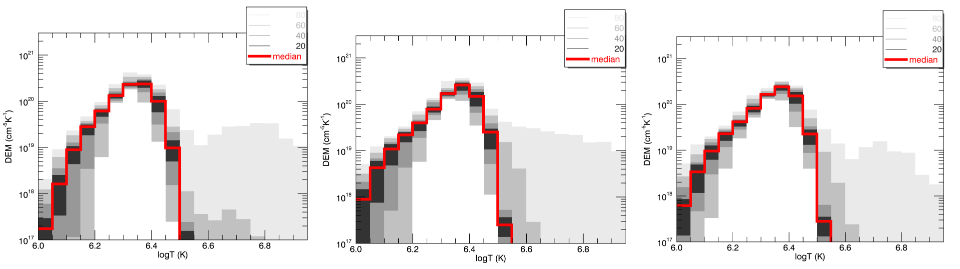

Fig. 3: DEM profile of the cavity observed on 2012 March 17, 18, and 19 (the signal was averaged over the white box in Fig. 1). Errors represent the region surrounding the median profile containing 20%, 40%, 60%, and 80% of the MC solutions.

Tab. 1: Average temperatures of the analysed cavity during five days

No.	Date	$T_{\rm CAV}$ [MK]
1.	2012 Mar 17 19:30	2.06±0.06
2.	2012 Mar 18 19:30	2.13±0.06
3.	2012 Mar 19 19:30	2.12±0.07
4.	2012 Mar 20 19:30	2.04±0.06
5.	2012 Mar 21 19:30	2.01±0.10

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