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26 JANUARY, 2019 SOLAR FLARES DIAGNOSTICS BASED ON THE SOFT X-RAY EMISSION MEASURES

Abstract. In this paper, we recently analyzed solar flares registered on January 26, 2019. We have identified several physical quantities of solar flares and estimated reconnection rate of solar flares. To determine the physical parameters we used images taken with the AIA instrument on board SDO satellite at wavelengths AIA 193 Å, 131 Å, AIA 174 Å, SXT - pictures, HMI Magnetogram, GOES XRT-data.

Keywords: solar flares, emission measure, reconnection rate.

INTRODUCTION

A solar flare occurs when magnetic energy that has built up in the solar atmosphere is suddenly released. Large flares can emit up to 10^{32} ergs of energy. This energy is ten million times greater than the energy released from a volcanic explosion.

The National Oceanic and Atmospheric Administration (NOAA) launches and maintains a set of satellites called Geostationary Operational Environmental Satellites (GOES), carrying weather monitoring instruments. Each GOES satellite also carries a solar X-ray package (the “X-Ray Sensor”, or XRS) consisting of a collimator that feeds a pair of ion chambers. These ion chambers measure the Sun’s spatially integrated soft X-ray flux in two wavelength bands, 0.5–4 and 1–8Å, with a 3-s cadence. The GOES soft X-ray detectors have provided an essentially uninterrupted monitor of the Sun’s activity for 30 years, and are a valuable resource for the study of past solar activity and the prediction of space weather [1-4].

Our study uses X-ray flare databases. The flare was collected using the dataset provided by the Geostationary Operational Environmental Satellite (GOES) [5-6]. GOES flares are classified as A, B, C, M, or X-class, according to their peak flux (W m^{-2}) observed in the 0.1 to 0.8 nm wavelength range. We selected the B and C-class flares corresponding to a flux in excess of 10^{-7} W/m^{-2} and 10^{-6} W/m^{-2} at Earth, respectively. The GOES flare lists are available at NGDC/NOAA [7].

This research has made use of SunPy, an open-source and free community-developed solar data analysis package written in Python [8]. Python/SunPy was chosen to analyze the emission measure (EM) obtained from GOES soft X-ray data since it provides easy to use interfaces to the Virtual Solar Observatory (VSO). SunPy aims to provide a free and open-source alternative to the current standard, an IDL based solar data analysis environment known as SolarSoft (SSW).

In this work, we have observed solar flares occurred on January 26, 2019. The sun emitted a significant solar flares, peaking at 06:47 a.m., 13:22 p.m., 15:55 p.m., 16:28 p.m. (EDT). This flares are classified as the B2.6, C5.0, B3.2, B8.6-class flares. Solar flares can be classified according to their brightness in the x-ray wavelengths. There are three categories: X-class flares are big; they are major events that can trigger radio blackouts around the whole world and long-lasting radiation storms in the upper atmosphere. M-class flares are medium-sized; they generally cause brief radio blackouts that affect Earth's polar regions. Minor radiation storms sometimes follow an M-class flare. Compared to X- and M-class events, B and C-class flares are small with few noticeable consequences here on Earth. Solar flares are different to 'coronal mass ejections' (CMEs), which were once thought to be initiated by solar flares. CMEs are huge bubbles of gas threaded with magnetic field lines that are ejected from the Sun over the course of several hours. If a CME collides with the Earth, it can excite a geomagnetic storm [9-13]. In Fig. 1 shown the images obtained on the board of GHN satellite in AIA 193 Å, 131 Å, HMI, AIA 174 Å wavelengths [6]. To determine the length of the loops, we used SXT images. From the SXT data, we get values for the length of the loops.

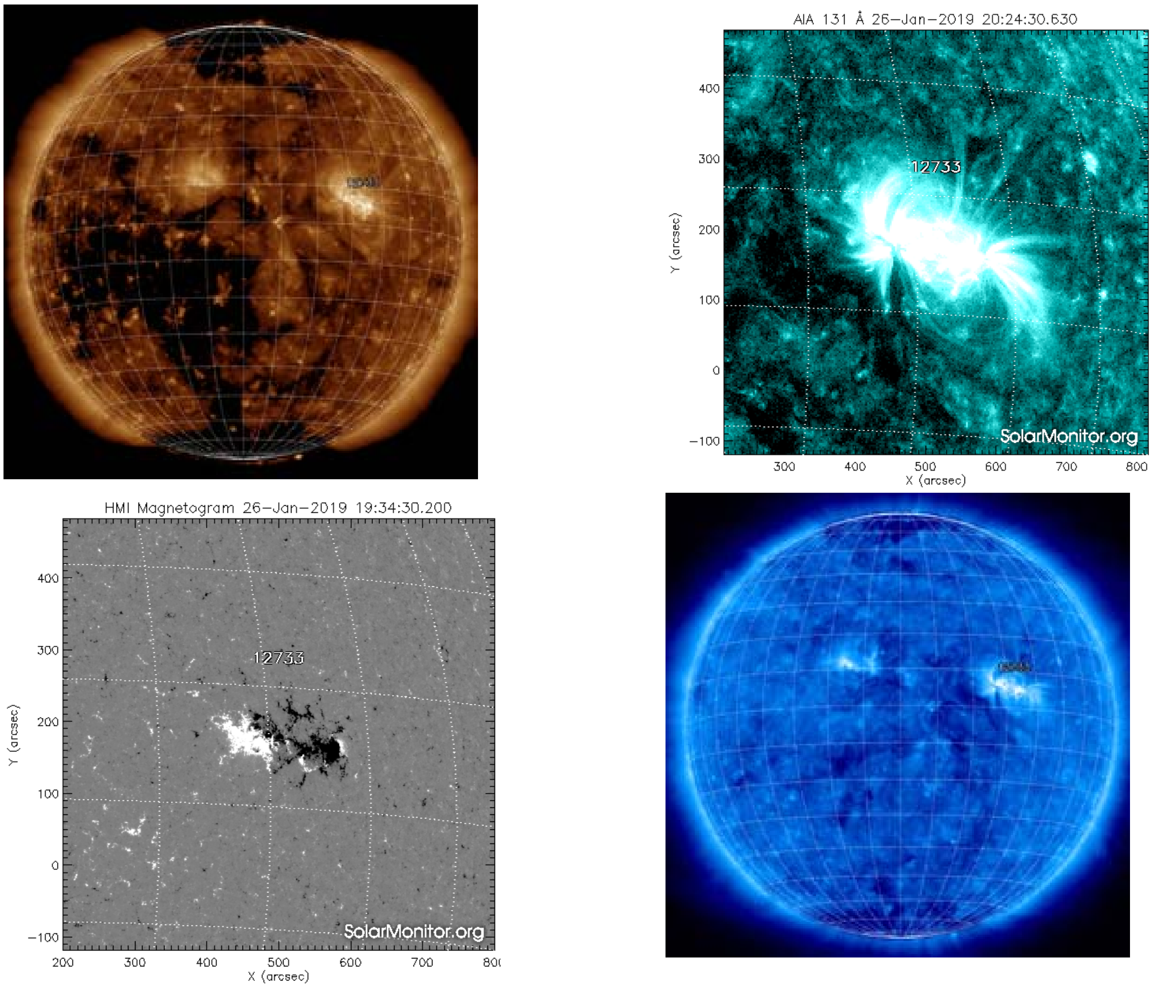

Figure 1 - Active area 2733 in AIA 193 Å, 131 Å, HMI, AIA 174 Å

DATA ANALYSIS

Using SunPy package we have obtained the values of temperature and emission measure from a GOESLightCurve. This function calculates the isothermal temperature and corresponding volume emission measure of the solar soft X-ray emitting plasma observed by the GOES/XRS. This was done using the observed flux ratio of the short (0.5-4 angstrom) to long (1-8 angstrom) channels [14-16]. The results are returned in a new LightCurve object which contains metadata and flux data of the input LightCurve object in addition to the newly found temperature and emission measure values. The temperature and volume emission measure are calculated using the methods of White et al. (2005) who used the CHIANTI atomic physics database to model the response of the ratio of the short (0.5-4 angstrom) to long (1-8 angstrom) channels of the XRSs onboard various GOES satellites [17]. Corresponding volume emission measure of the solar soft X-ray emitting plasma observed by the GOES/XRS are shown in Fig.2.

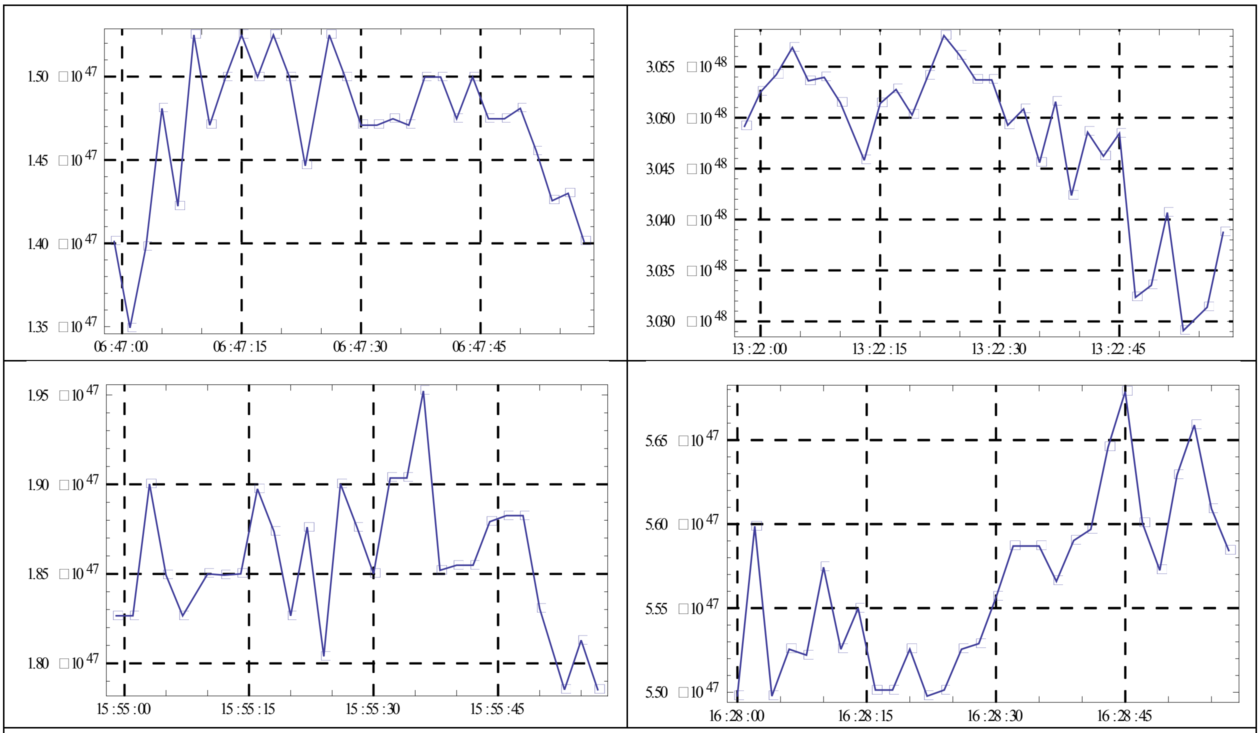

Figure 2 - Emission measure plotted against time

For quantitative physical understanding of processes in the Sun's atmosphere, the X-ray fluxes themselves are of limited use. However, they reflect the temperature and emission measure of the plasma that produces the soft X-rays, and these physical quantities are of great importance: from them, the energetics of solar flares and other energy releases can be deduced.

The volume emission measure were obtained in SunPY using the methods of White et al. [18] who used the CHIANTI atomic physics database to model the response of the ratio of the short (0.5-4 angstrom) to long (1-8 angstrom) channels of the XRSs onboard various GOES satellites [21-25].

RESULTS

Using the method described in [19-20], we analyzed solar flare that have been registered on January 26, 2019. Examined the dependence of the reconnection rate from GOES class of solar flares. Figure 3 shows the dependence of the reconnection rate from temperature and time scale.

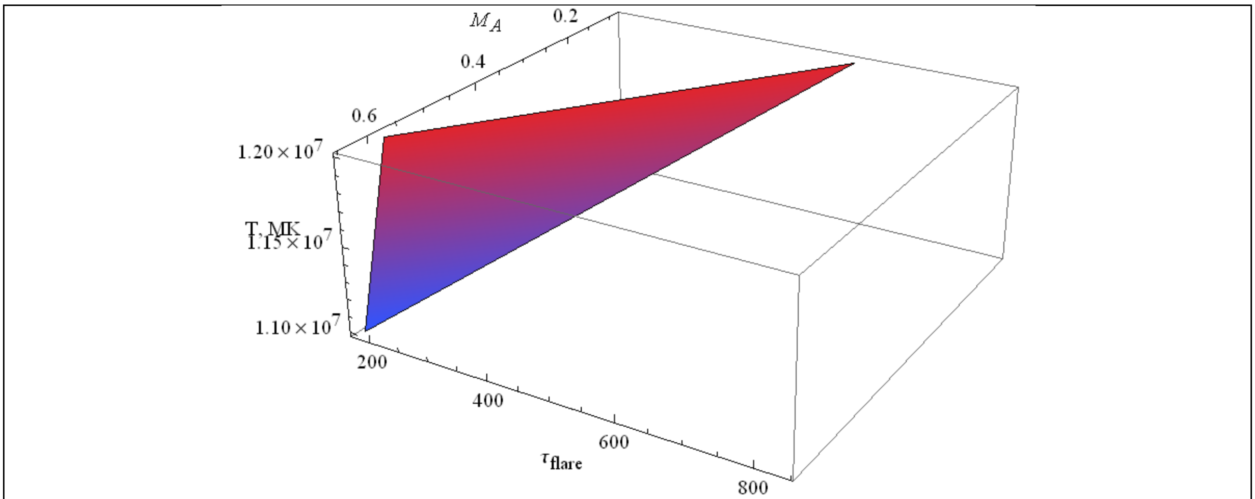

Figure 3 - Reconnection rate M_A plotted against time scale

CONCLUSION

The values of reconnection rate are distributed in the range from 10^{-2}-10^{-1}. Here, the value of the reconnection rate decreases as the GOES class increases. The value of the reconnection rate obtained in this study is within 2 order of magnitude from the predicted maximum value of the Petschek model.

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26 ҚАҢТАР, 2019 ЖҰМСАҚ РЕНТГЕН СӘУЛЕСІНІҢ НЕГІЗІНДЕГІ КҮН ЖАРҚЫЛЫНЫҢ ДИАГНОСТИКАСЫ

Аннотация. Осы мақалада 2019 жылдың 26 қаңтарында тіркелген күн жарқылдарының статистикалық зерттеулері жүргізілді. Біз күн жарқылдарының физикалық мәндері мен қайта ұштасу жылдамдығын бағаладық. Физикалық параметрді анықтау үшін SDO спутникінің бортында AIA инструментінің 193 Å, 131 Å, AIA 174 Å толқын ұзындығында алынған және SXT суреті, HMI Magnetogram, SOLIS Chromospheric Magnetogram, GOES XRT- деректері пайдаланылды.

Түйін сөздер: күн жарқылы, шығарындылар өлшемі, қайта ұштасу жылдамдығы.

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26 ЯНВАРЯ, 2019 Г. ДИАГНОСТИКА СОЛНЕЧНЫХ ВСПЫШЕК НА ОСНОВЕ РЕЗУЛЬТАТОВ РЕГИСТРАЦИИ МЯГКОГО РЕНТГЕНОВСКОГО ИЗЛУЧЕНИЯ

Аннотация. В этой статье нами проведены статистические исследования вспышек, зарегистрированных 26 января 2019 г. Мы определили несколько физических величин вспышек и оценили скорость пересоединения солнечных вспышек. Для определения физических параметров мы использовали снимки, полученные с инструмента AIA на борту спутника SDO на длинах волн 193 Å, 131 Å, AIA 174 Å, SXT - снимки, HMI Magnetogram, SOLIS Chromospheric Magnetogram, GOES XRT-данные.

Ключевые слова: солнечные вспышки, мера эмиссии, скорость пересоединения.

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