Солнечная вспышка от 10 февраля 2023 года и возможная причина для её подавленной мощности в радиодиапазоне

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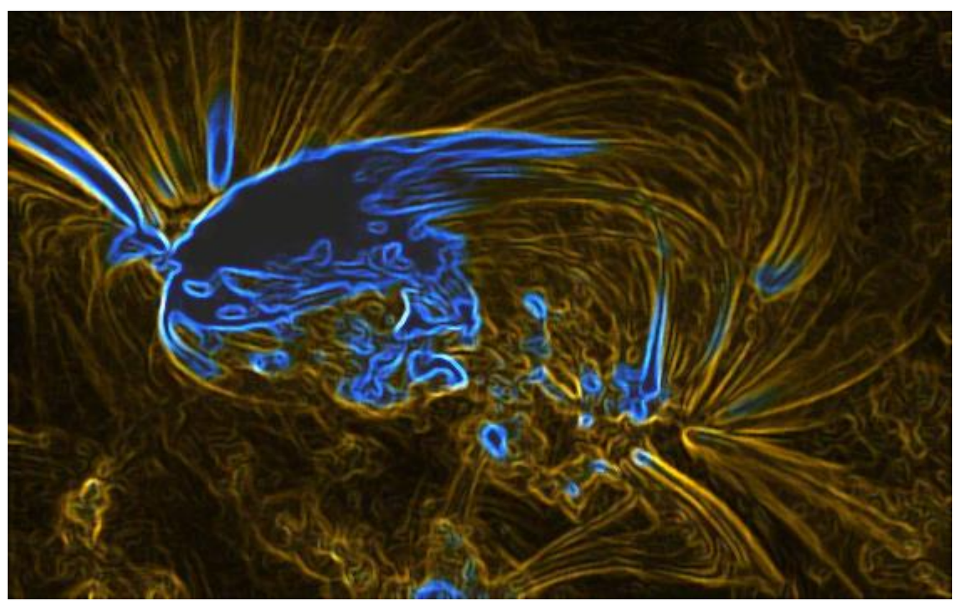
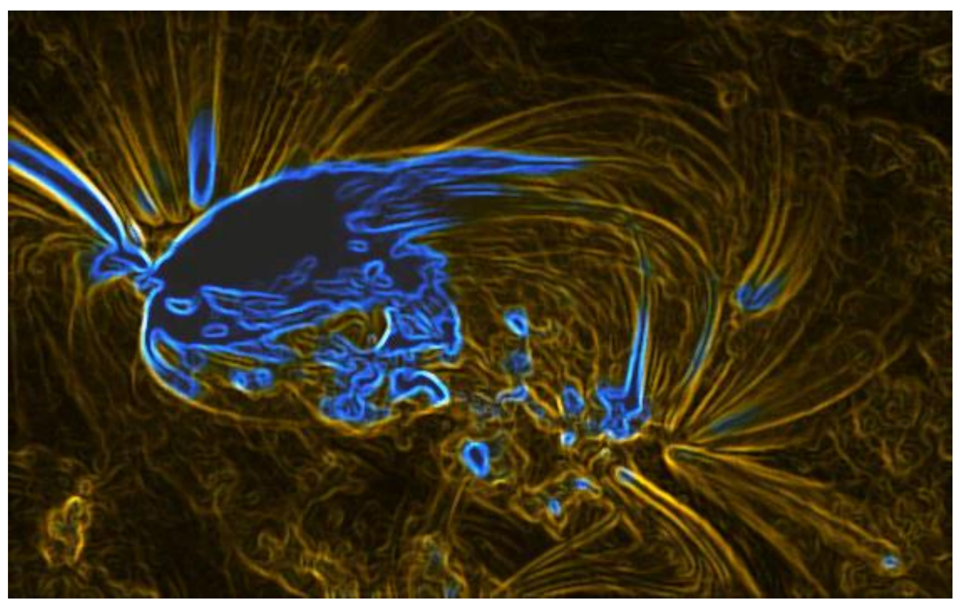
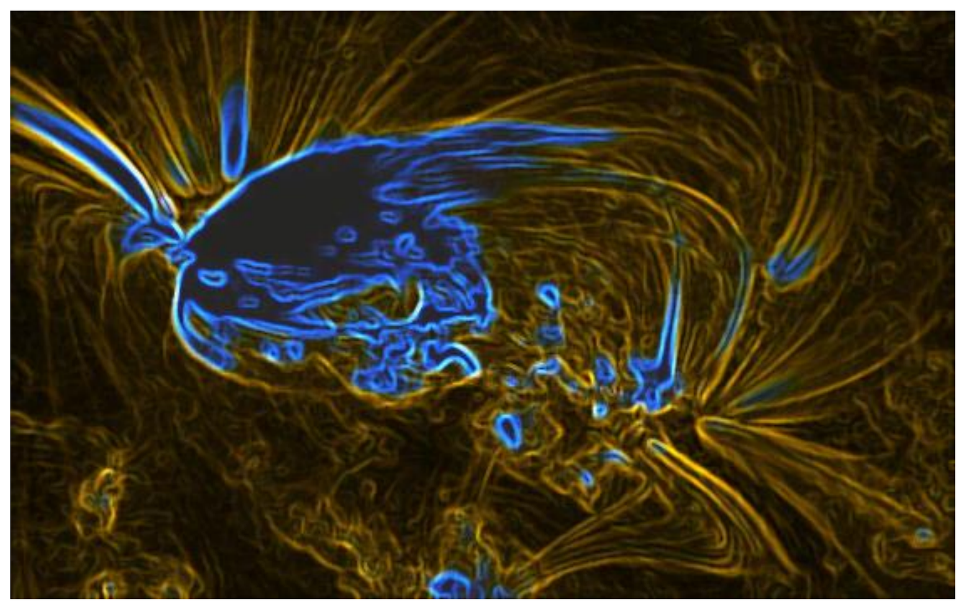
Abstract: *In this presentation, we present a very interesting solar flaring event that occurred on the 10th of February 2023, at about 8:02 UT. We present the evolution of this M-class flare observed by different telescopes at different wavelengths. In particular, we show that the flare has a weak signature in the centimeter radio spectrum. As a conclusion we present our view as to why the flux in cm radio wavelength range had such a feeble radio signature.*

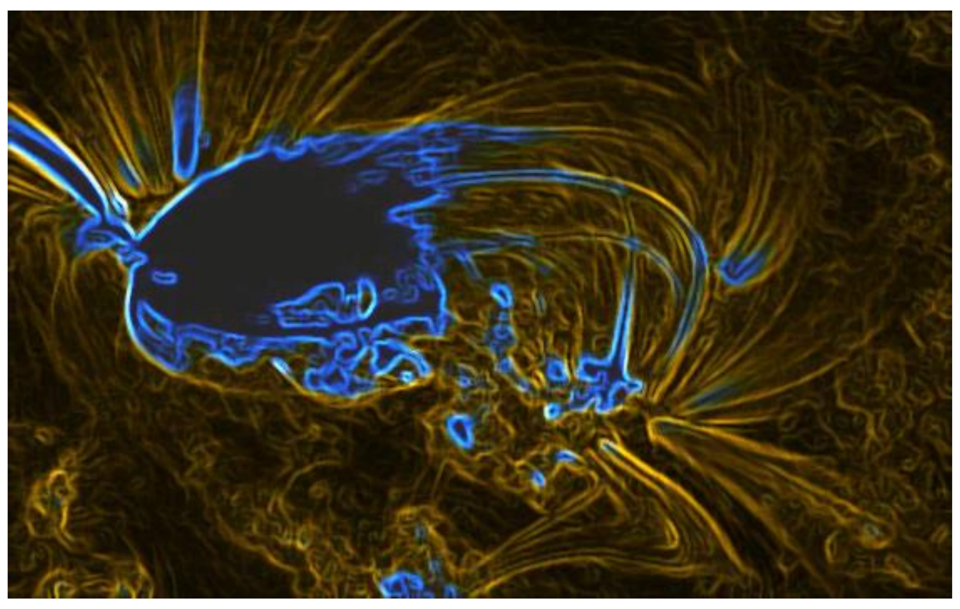
THE FLARE:

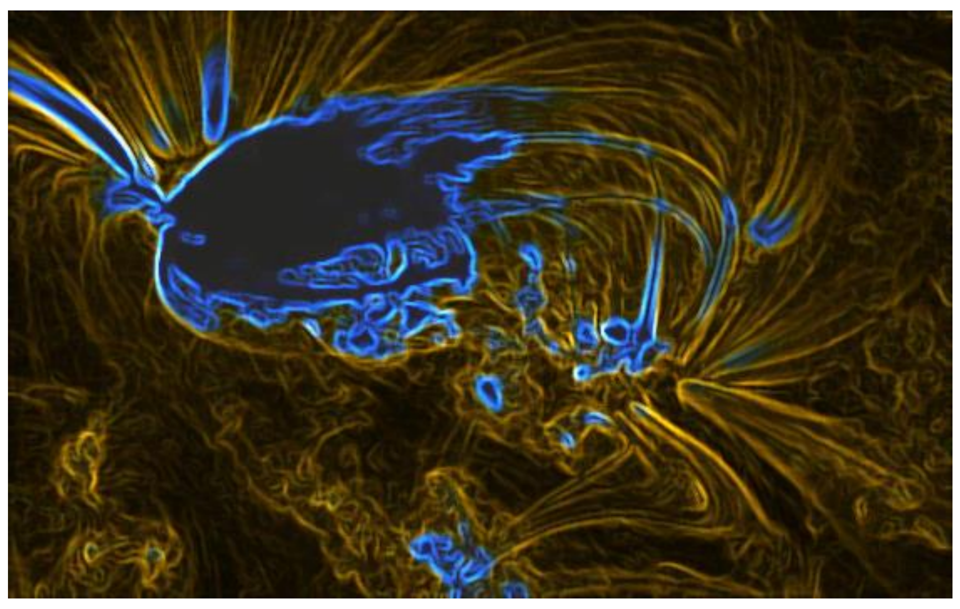
DATE: 10-02-2023
START TIME: 08:02:00
END TIME: 08:09:00
GOES CLASS: M1.4
EVENT PEAK TIME: 08:05:00

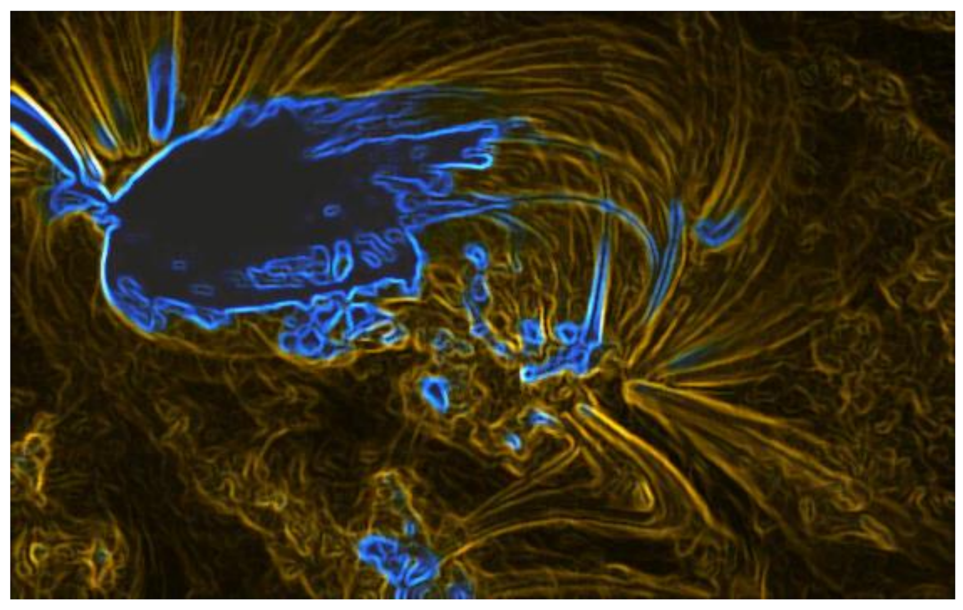

AR NOAA: 3213 Time:07:59:52 UT

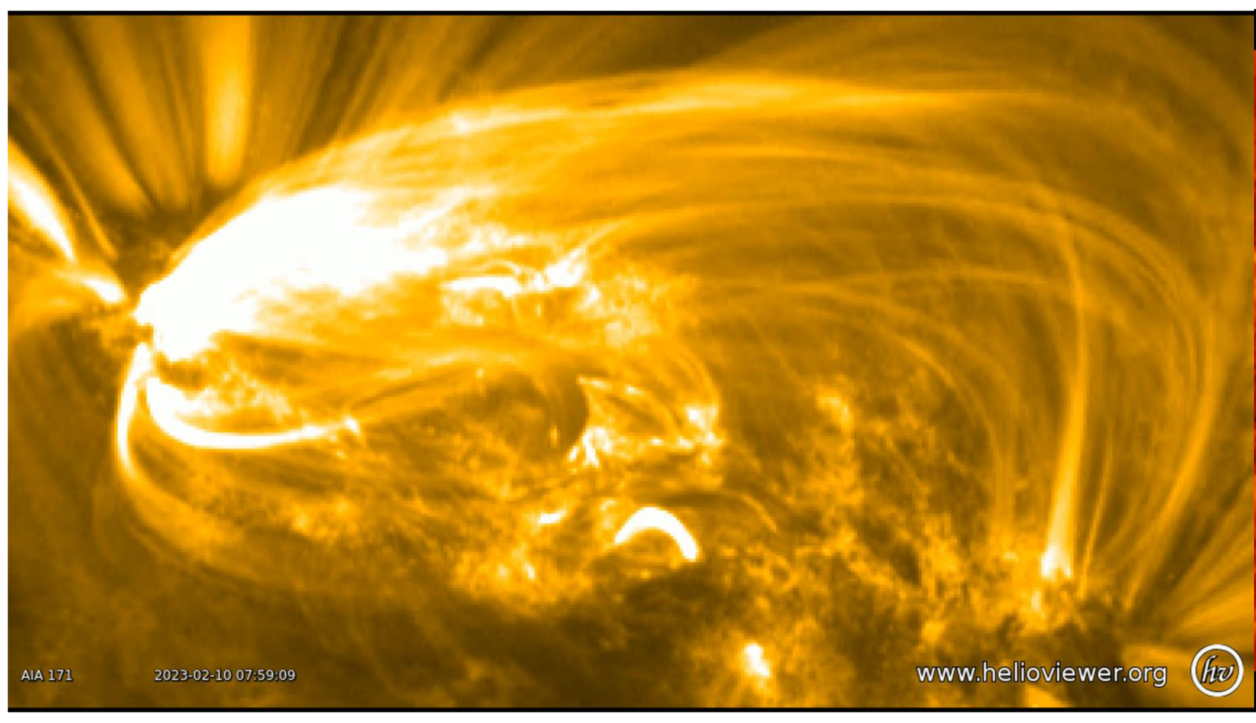

AR NOAA: 3213 Time:08:01:04 UT

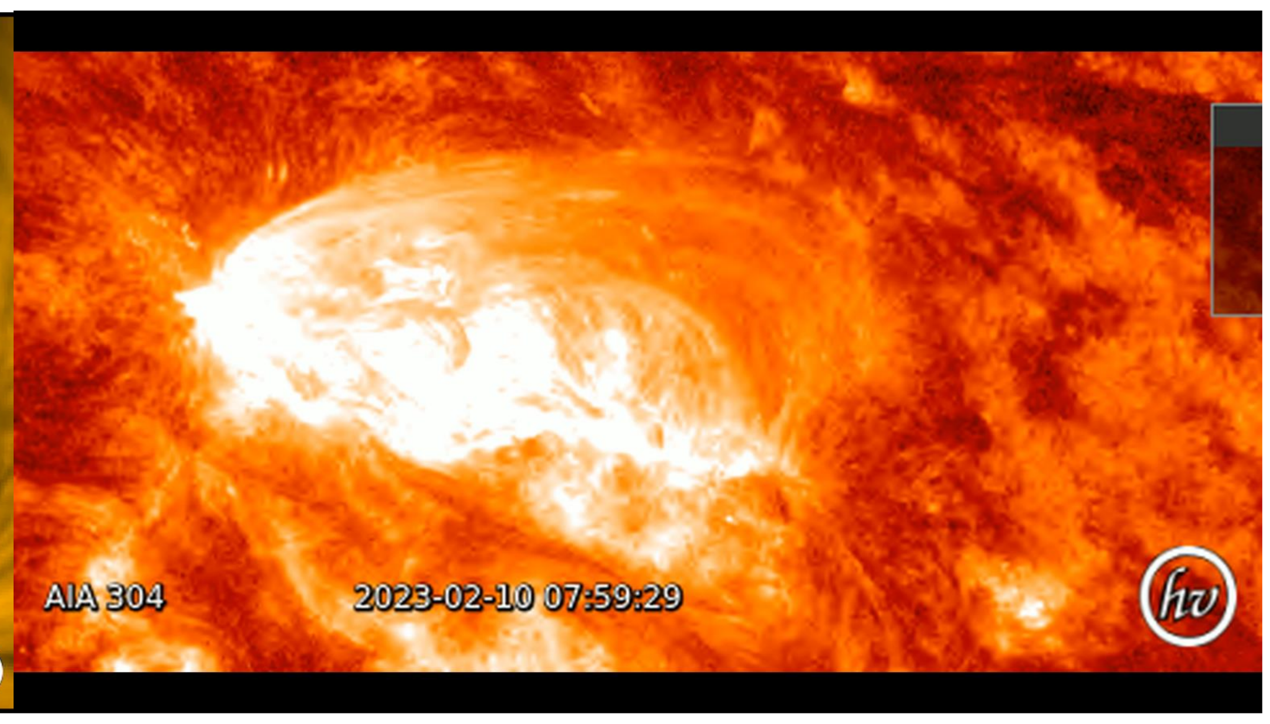

AR NOAA: 3213 Time:08:02:16 UT


AR NOAA: 3213 Time:08:06:28 UT


AR NOAA: 3213 Time:08:07:40 UT

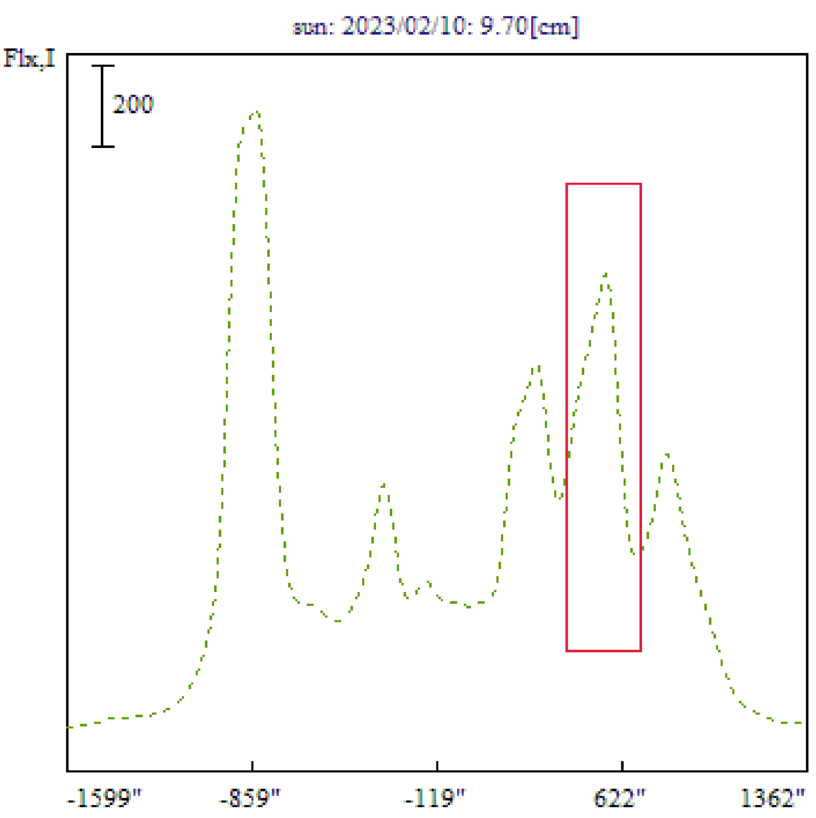

AR NOAA: 3213 Time:08:09:40 UT



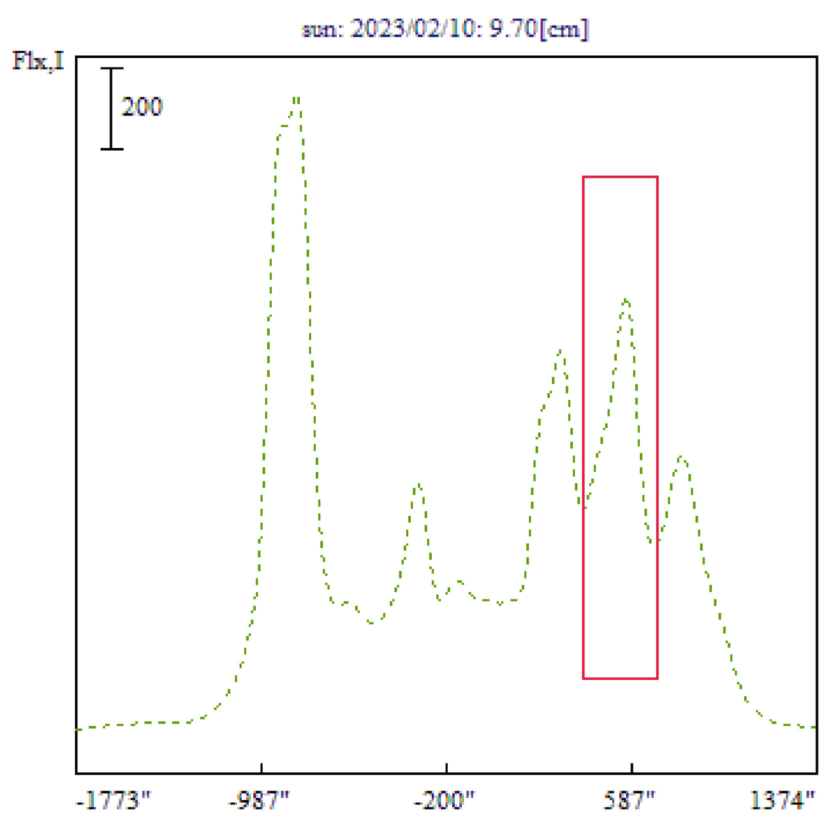


Please watch the video embedded here by clicking on the pictures.

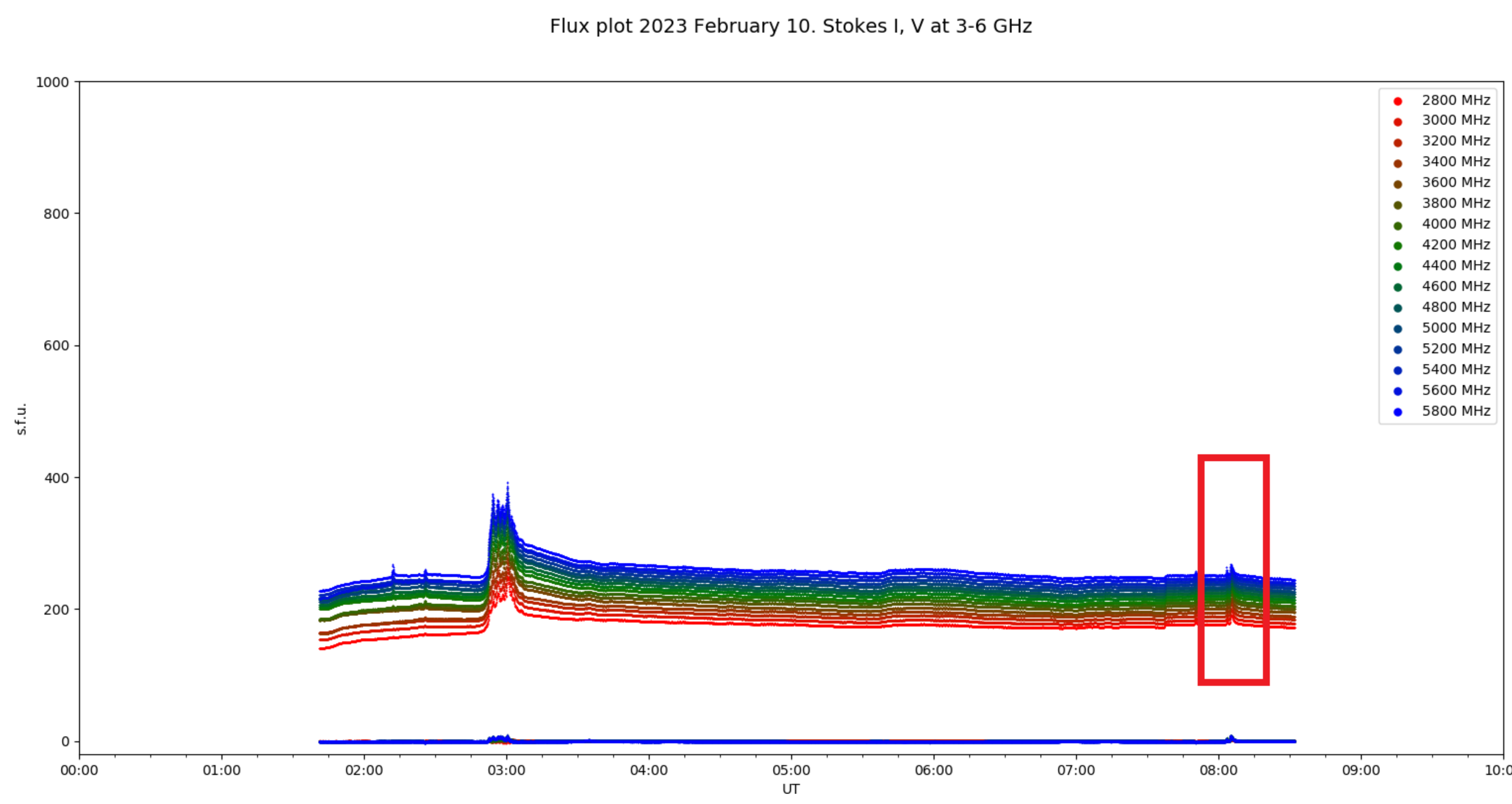
The left most movie represents the evolution of the flare as seen in the 171 Å and the one next to it represents this event in the 304 Å. We can clearly see that some eruption like event emerged from beneath the arcade like structure consisting of many coronal loops extending from the left bright point towards a diffuse region to the right. This eruption event manifested itself as a flare of class M 1.4 as per the GOES classification. The interesting aspect of this flare is that the flaring process and the considerable chromospheric eruption took place in more or less the same volume of space. It would be appropriate to classify such flares as the **Fireball flares**.



Time:08:05:05 UT as observed by RATAN 600.



Time:08:21:40 UT as observed by RATAN 600.



Time:08:21:40 UT as observed by Siberian Radio Heliograph (SRH).

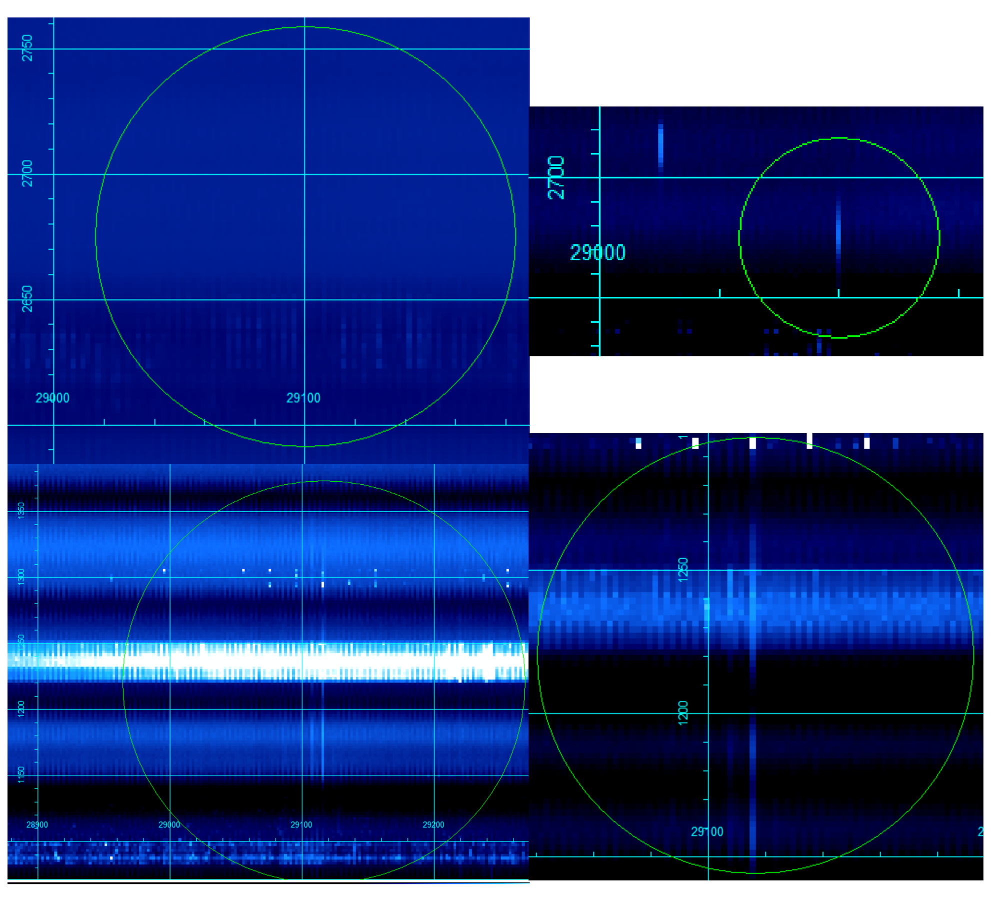
In the above figures we present the solar flare as observed by the RATAN 600 which is a transit instrument with a very good East West spatial resolution but with a poor North South resolution due to the variable profile antenna. Also, we present the integral solar flux as observed by the state of the art solar radio interferometer. The position of the flare is indicated by the **red rectangle** in all these figures. The first two figures correspond to 3.094 GHz whereas the third figure represents the spectrum of the total flux of the Sun as measured by the SRH. It is abundantly clear that the **M 1.4 class solar flare** has a feeble signature in the radio cm spectrum. This is quite interesting as usually solar flares manifest themselves as quite pronounced features in the RATAN 600 transit scans of the Sun.

The reason we presume for this at the present moment is as follows: What we have actually seen is the flare initiated by some chromospheric mass eruption beneath the arcade of the active region AR NOAA: 3213. Chromospheric matter has a density of around $\mathbf{10^{14} \sim 10^{15}}$ **particles/cm^3**. But when the magnetic reconnection had occurred possibly as a result of the interaction of this eruptive partially ionized plasma blob with the magnetic structure of the arcade, the enormous energy that had been released quickly ionized the blob of plasma from the chromospheric eruption and resulted in a fully ionized plasma of more or less the same density as that of the chromospheric blob. Now if we recall the order of typical chromospheric densities and assume that all this matter had been ionized and further assuming that this matter was predominantly made of Hydrogen for simplicity, we would have the order of magnitude of the electron density in the eruptive blob as $\sim 10^{14}/cm^3$. Now the Langmuir frequency of such a plasma will be of the order of **~25 GHz**. **Therefore radio frequencies up to this frequency limit must have been inhibited by the erupting plasma in which the flare itself had occurred leading to the diminished flux in the cm radio spectrum up to this point, which we think was the reason in the present context.** This also suggests that such fireball flares can be the source for the **sub terahertz solar bursts** (not to be confused with usual flares which are wide band phenomena) because it is quite possible that if the density of such chromospheric eruptions is 10^{15} or more then the movement of the relativistic electrons in such a medium would cause the so-called bump on tail instability leading to the Type III burst but conforming to the local plasma frequency of the order of ~100 GHz. We therefore speculate that the flare under discussion indeed might have had such a companion sub terahertz burst if its density was of the order $\sim\mathbf{10^{15}}/\boldsymbol{cm^3}$.

Associated Type III radio burst in the decimeter radio spectrum from this flare

Second harmonic of the Type III burst.

First harmonic of the Type III burst.



Left circular polarization   Right circular polarization

We here present the Type III radio burst as detected by the solar radio spectropolarimeter YAMAGAWA, which registers the burst from 70 MHz to 9 GHz from dawn to dusk with a spectral resolution of just 1 MHz . The data show that the second harmonic is strongly right circularly polarized, where as the first harmonic is weakly polarized. The first harmonic has a frequency of ~1360 MHz, which corresponds to the plasma density of $\sim 2.3 \cdot 10^{10}/cm^3$. The analysis of the evolution of the flare suggests that this burst had occurred in the stratified upper layers of the eruptive mass under consideration. Also, an important point to notice is that the second harmonic had preceded the first harmonic by an impressive 7 seconds due to the dispersion of radio waves in plasma. By calculating the upper limits of these to harmonics in terms of frequency and by using the group velocity formula for the electromagnetic waves in plasma, we estimated the thickness of the upper stratified layer to be around 98 to 100 Mm. This flare had shown one of the rare occurrences when the second harmonic had preceded the first harmonic by several seconds.

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