Analysis of an Anemone-Type Eruption in an On-Disk Coronal Hole

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We report on an eruption seen in a very small coronal hole (about 120° across), beginning at approximately 18:10 UT on March 5, 2016. The event was initially observed by an amateur astronomer (OM) in an H-alpha movie from the Global Oscillation Network Group (GONG); the eruption attracted the attention of the observer because there was no nearby active region. To examine the region in detail, we used data from the Solar Dynamics Observatory (SDO) in wavelengths 193, 171, 211, and 94, and from the Helioseismic and Magnetic Imaging (HMI) Data Analysis and Calibration activities such as scaling, rotation of the Sun, and removal of solar rotation we accomplished with SunPy. The evolution of low-cadence HMI data began with the discovery that the flux rate was higher.

**DISCOVERY**

Solar, so a data analysis tool, offers many advantages including: 1. Sunpy data cubes are powerful and versatile since they include data and header. 2. Pre-plot data have the correct color table and units (xenar). 3. The Python language is becoming more of a standard in astrophysics and other fields. 4. No dollar cost.

Event to start finish, data were analyzed using python and sunpy. Problems encountered included:

1. Too many open files
2. When animating a cube, the color bar "bounces" due to different scaling of each image.
3. When plotting an image (python), as long as plot window is up, the command line is not available.
4. Changing the plot sometimes need to occur before the plot function and sometimes after. This may be obvious to experienced matplotlib/sunpy users, but not to new ones. Our suggestion is, if it doesn't work after, try positioning the command before the plot. Here's an example:

```
mp4=derotated.plot(interval=100)
```

5. When plotting an image, as long as plot window is up, the command line is not available.
6. Removing the title for animated plots (with intent to use something else).

**Flaws**

1. This issue is caused by astropy defaulting to using memory mapping to access FITS files. Thus if you open a FITS file, read the data into an array, and close the file, the system does not actually read the data from disk into memory but just points to where the data are stored on disk. Thus, the system keeps the file open for the lifetime of the array. Currently Sunpy does not provide a means to override this default. An ugly solution is to increase the number of files that the system can open. Another almost as ugly solution is to modify the sunpy/io/fits.py source code (as shown below), adding the "memmap=False" parameter to the open call.

```
copy fits.py --> mv fits.py to fits.sav
```

2. When animating a cube, the color bar "bounces" due to different scaling of each image.
3. Commands to modify the plot sometimes need to occur before the plot function and sometimes after. This may be obvious to experienced matplotlib users, but not to new ones. Our suggestion is, if it doesn't work after, try positioning the command before the plot. Here's an example:

```
plt.title('SDO Composite Plot ')
plt.ylabel('Y-position [arcsec]')
plt.xlabel('X-position [arcsec]')
mp4=derotated.plot(interval=100)
```

**Summary/Results**

1. The flux-emergence rate over ten minutes was 7.86 x 10¹⁸ Mx/s.
2. The magnetic "bubble" increased in size from approximately 20° x 20° to 40° x 40° from 2016 03/03 18:44 UT to 2016 03/04 02:55, 8 hours 11 minutes.
3. Flux emergence begins between 17:30 UT and 18:44 UT, followed by brightening in AIA 193 (~19:12 UT), 193 (~19:30 UT), and 94 (~20:00 UT) Angstroms.
4. This work is a preliminary analysis of flux emergence and development of an active region in a unipolar, open-magnetic-field environment.

**References:**

2. https://ntrs.nasa.gov/search.jsp?R=20160007447 2020-03-11T14:43:10+00:00Z
3. 407.01, P3.41

**Event began at 18:44 UT (in HMI) (time estimated from movie)**

These magnetograms represent the field-of-view used to calculate the approximate flux emergence rate between 19:00:27 and 19:10:12, which is 7.86 x 10¹⁸ Mx/s.

**The Event was Also Seen in Hinode/XRT**

Using http://solarmonitor.org, on March 4 at 20:58, AR 12512 was seen on the central meridian. Sunspots were visible to the west of AR 12512 at the location of our region, where there were none the day before. NOAA had numbered the region AR 12514 by March 5 at 20:10. By March 6 it was quite clear to the eye, no spots were visible.

Soon to be numbered AR 12514

The light curves above help identify the beginning of the flux emergence and show times of brightening in various wavelengths.

**Searching for Data**

Event seen in AIA 94, 171, 193, 211, and HMI, but no spots.