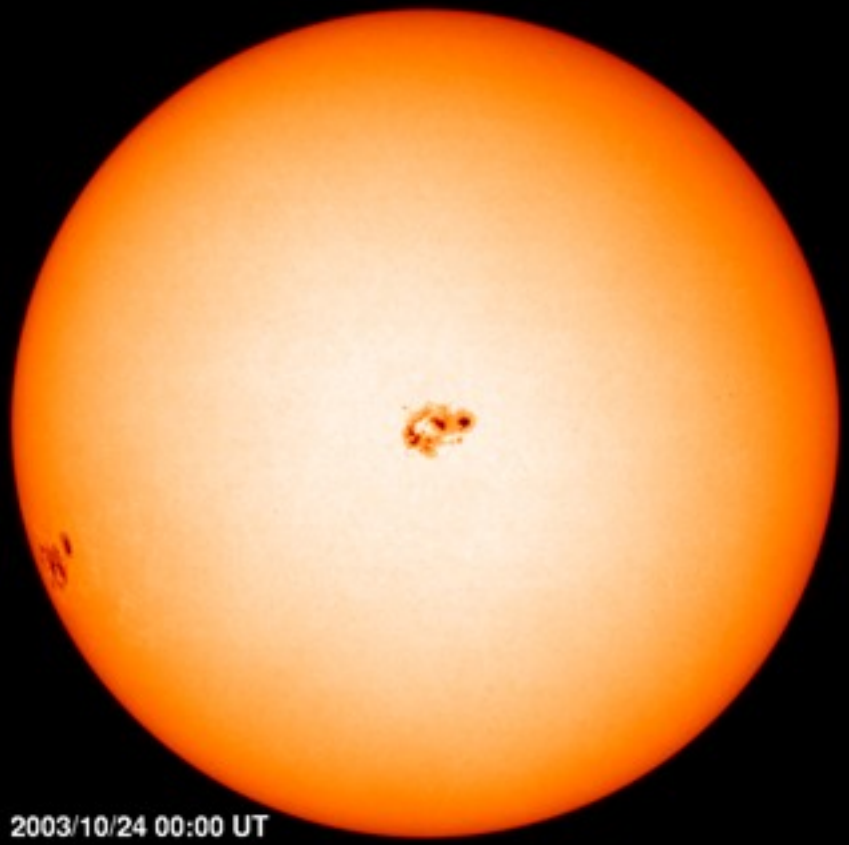
Classification of Sunspot Groups Using SOHO/MDI Magnetogram and White-Light Images



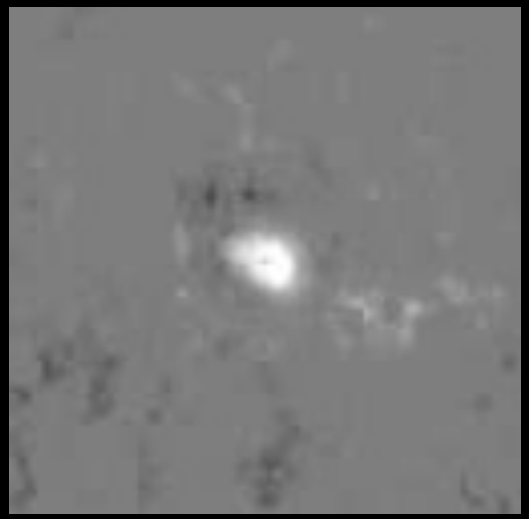
Background/Motivation

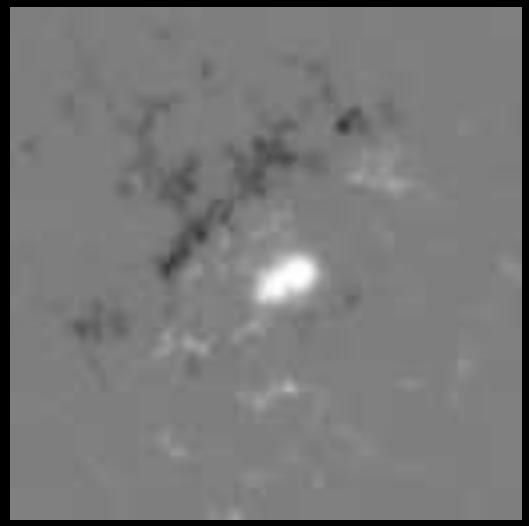
- Sunspot classification is (for the most part) done manually by experts in the field.
- This process consumes both labor and time, and there is not always agreement on the resulting classification of particular sunspot groups.
- As a result, an automatic (hence objective) and accurate procedure for classifying sunspot groups is highly desirable.

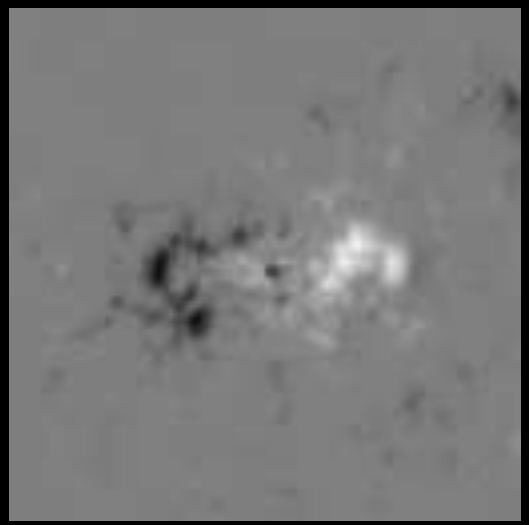
The Data (or, what I currently have available)

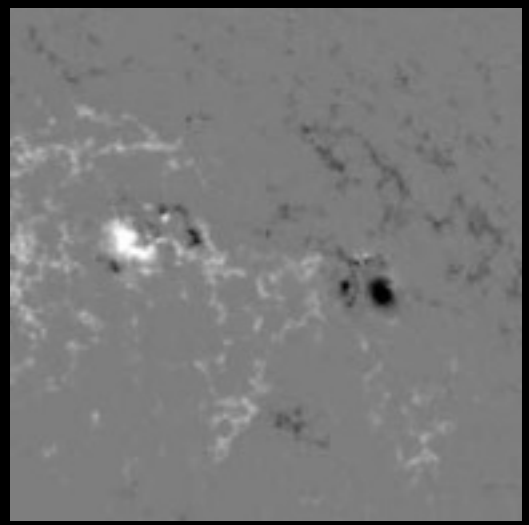
- 1038 white-light images from May 19, 1996 through December 31, 1999.
- 19, 347 magnetograms from 1996 through 2004.
  - 203 magnetograms from 1996
  - 772 magnetograms from 1997
  - 1204 magnetograms from 1998
  - 2668 magnetograms from 1999
  - 3914 magnetograms from 2000
  - 3781 magnetograms from 2001
  - 3659 magnetograms from 2002
  - 2263 magnetograms from 2003
  - 883 magnetograms from 2004

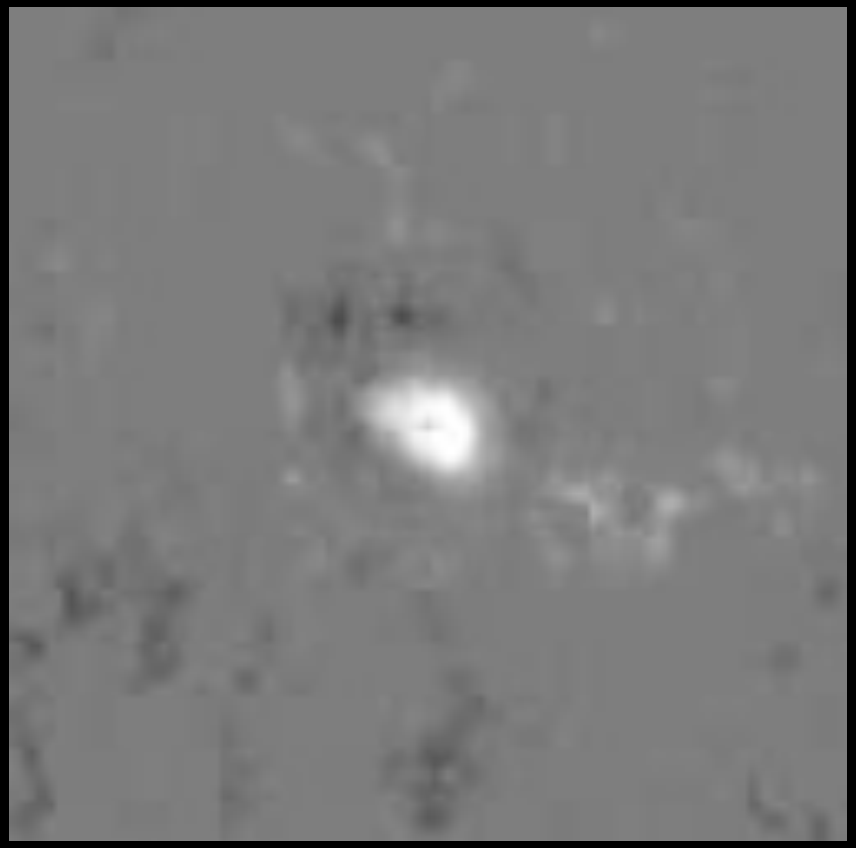
Four types of sunspot groups



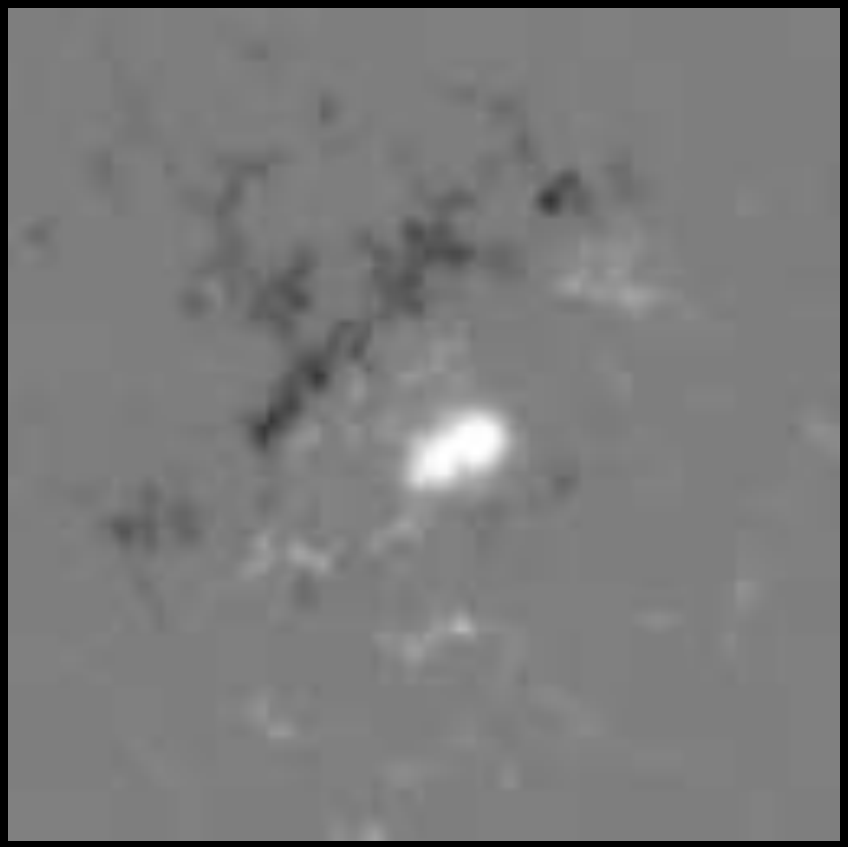




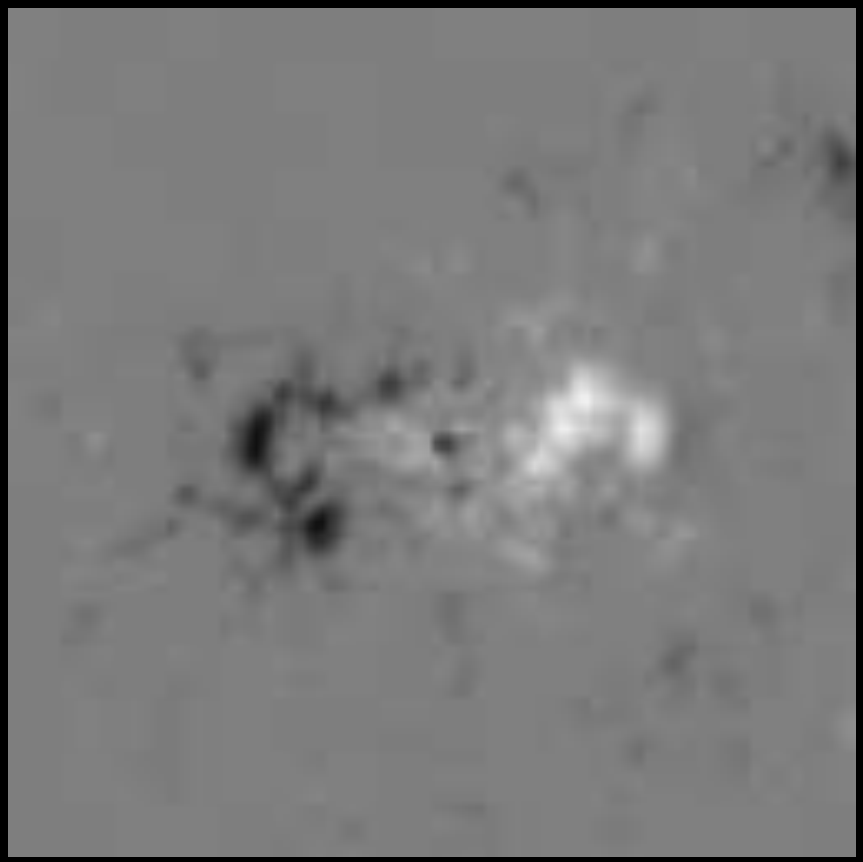




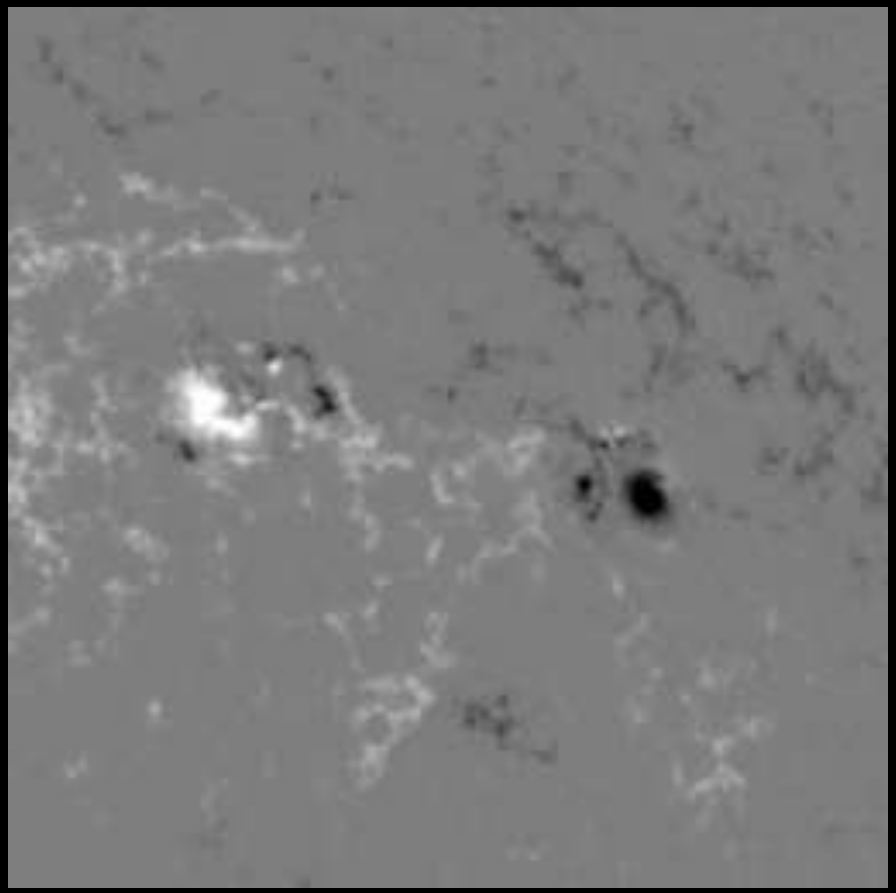
Alpha: A unipolar sunspot group



Beta: A sunspot group having both positive and negative magnetic polarities (bipolar), with a simple and distinct division between the polarities.



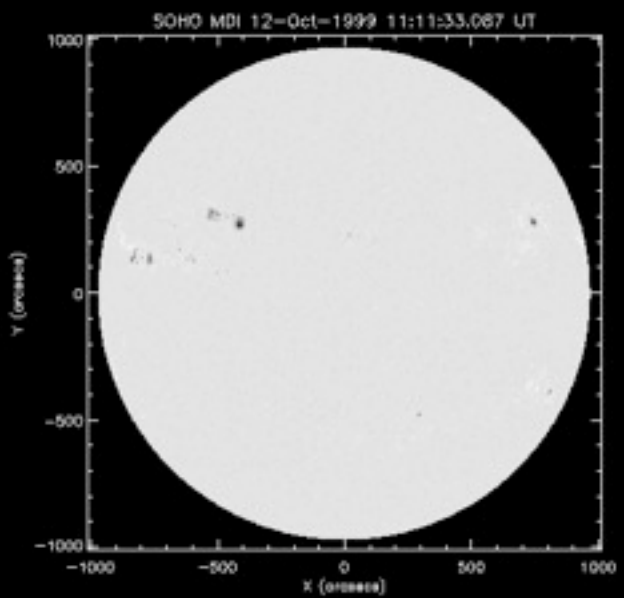
Beta-Gamma: A sunspot group that is bipolar but which is sufficiently complex that no single, continuous line can be drawn between spots of opposite polarities.

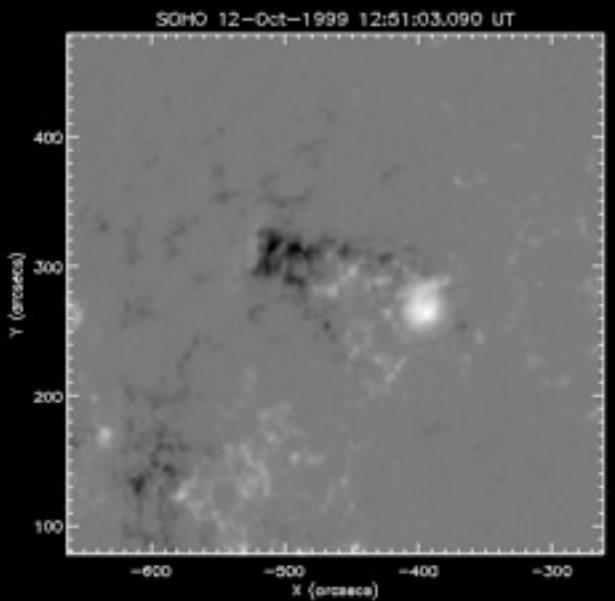


Beta-Gamma-Delta: A sunspot group where spots of opposite polarities are scattered around the whole image.

The Plan

An automatic sunspot detection and classification procedure will be developed using SOHO/MDI magnetogram and white-light images





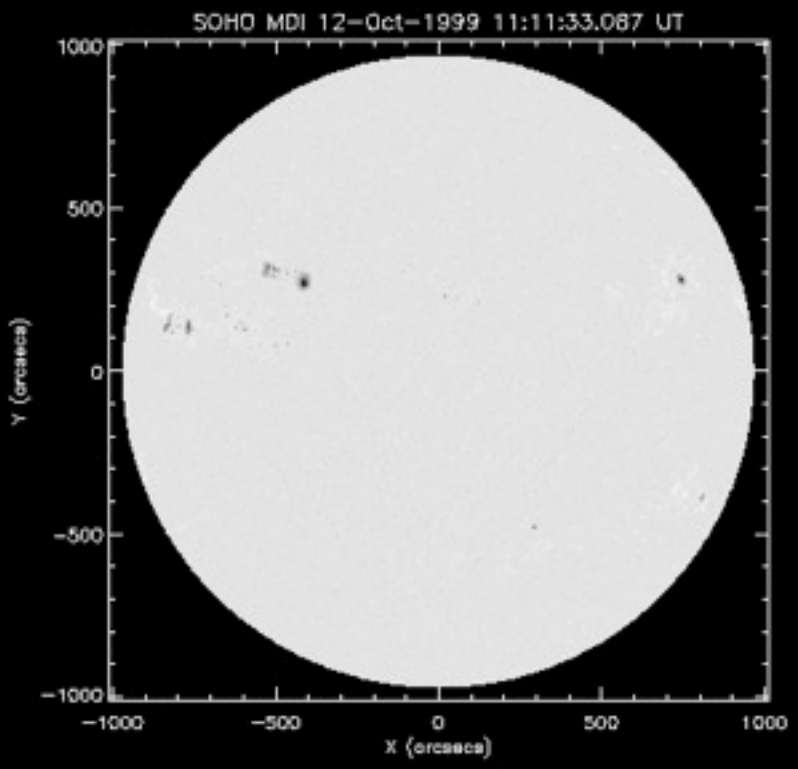
SOHO/MDI white-light image (left) and magnetogram (right) for October 12, 1999

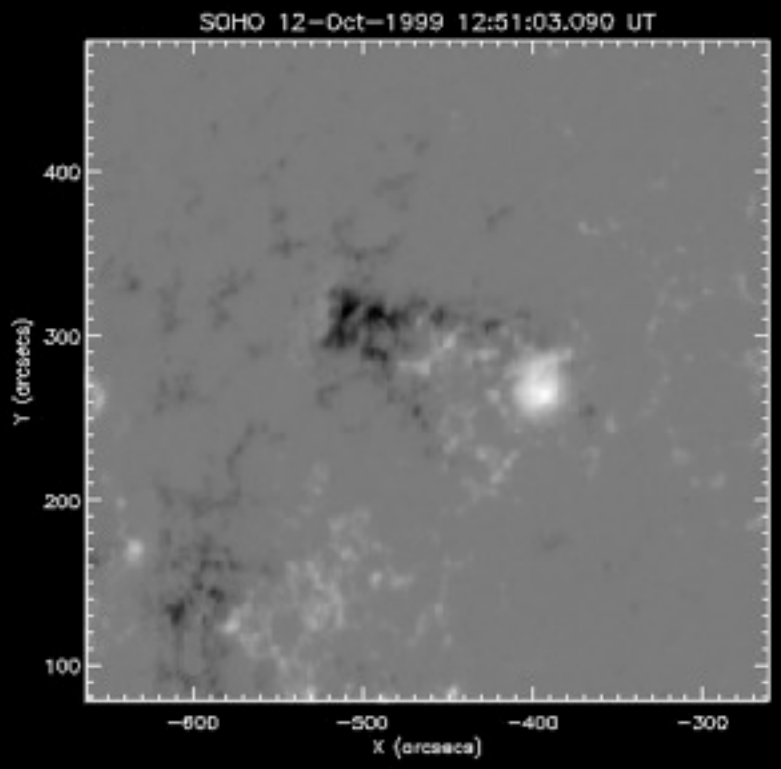
White-light extraction

- In order to compare white-light images to magnetograms, we must extract data from the white-light images that corresponds (in time and 2-dimensional space) to the magnetograms we have available.

- To do this for each magnetogram we must:
  1) Find the white-light image with the closest time signature to the magnetogram.
  2) Rotate the white-light image (correcting for the differential rotation of the sun) so that it matches the time the magnetogram was created.
  3) Extract a region from the white-light image that matches the 2-dimensinal region of the magnetogram (in units of arcsecs).

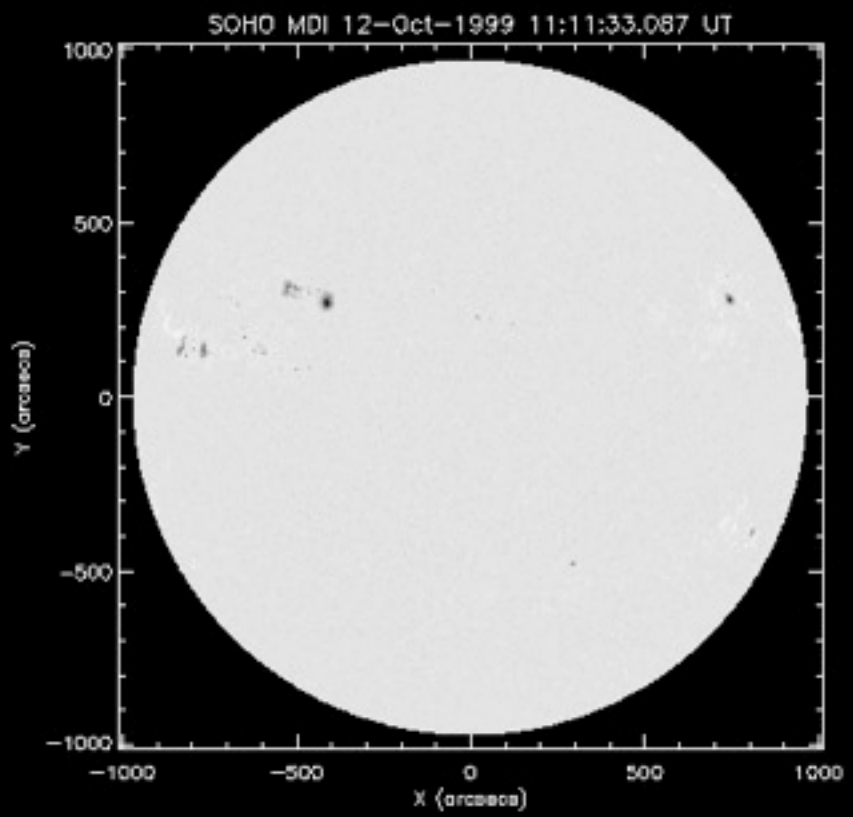
Example

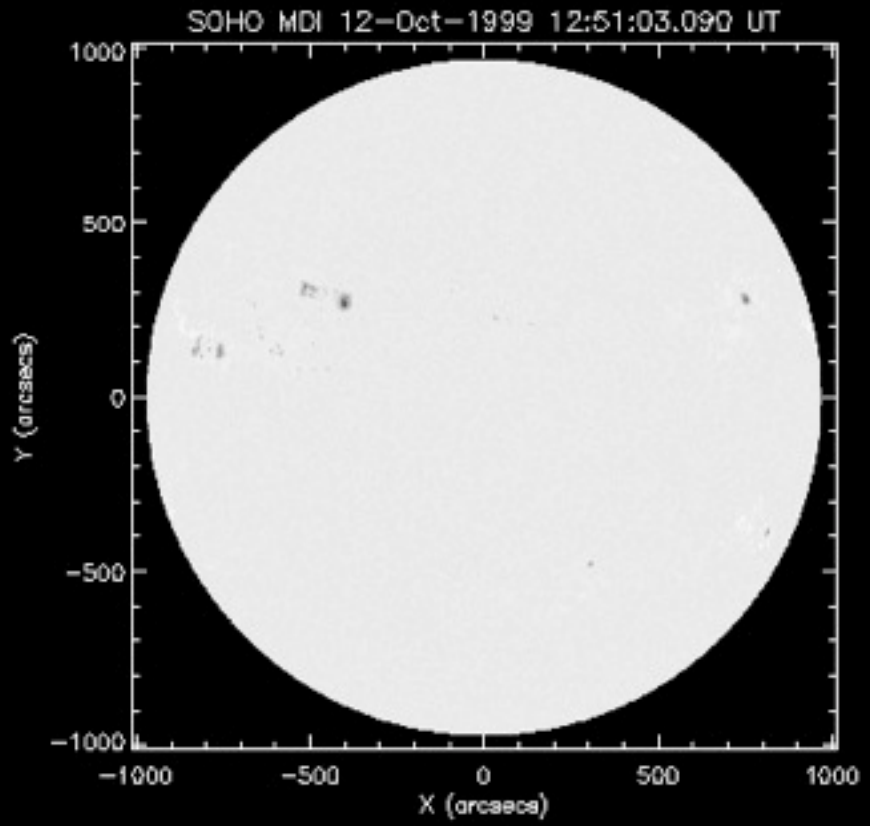




White-light image and magnetogram for October 12, 1999

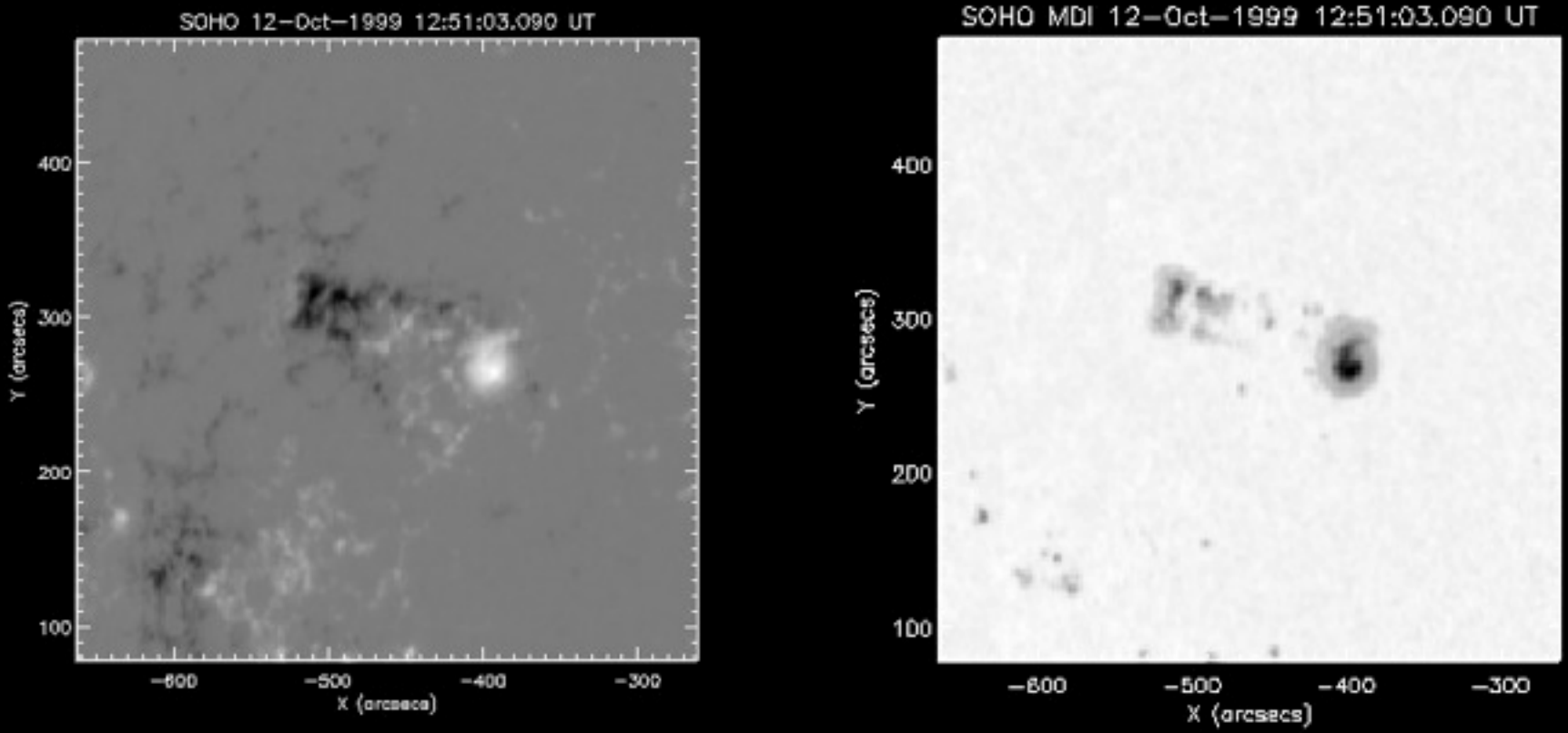
We rotate the white-light image so that it matches the time on the magnetogram





White light image from 12-Oct-1999 11:11:33.087 UT (left) rotated to 12-Oct-199 12:51:03.090 UT (right).

Then, we cut out a region on the white-light image that matches the magnetogram.

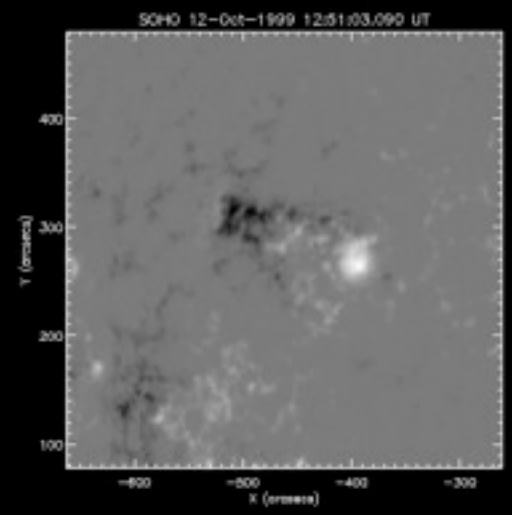


Magnetogram from 12-Oct-1999 12:51:03.090 UT (left) and extracted white light image from 12-Oct-1999 11:11:33.087 UT (right) differentially rotated.

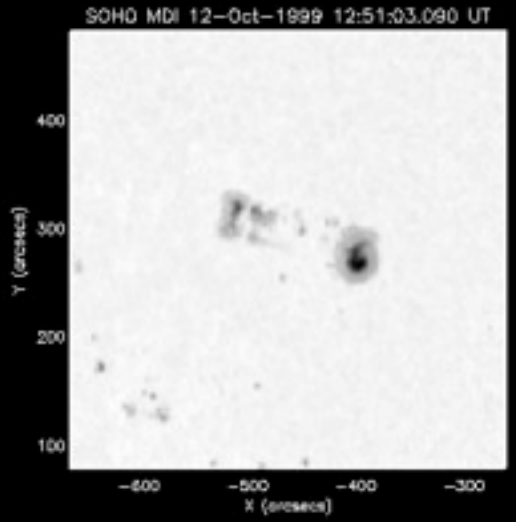
A possible concern…

- There are some (though not many) gaps in the white-light images of up to 4 days.

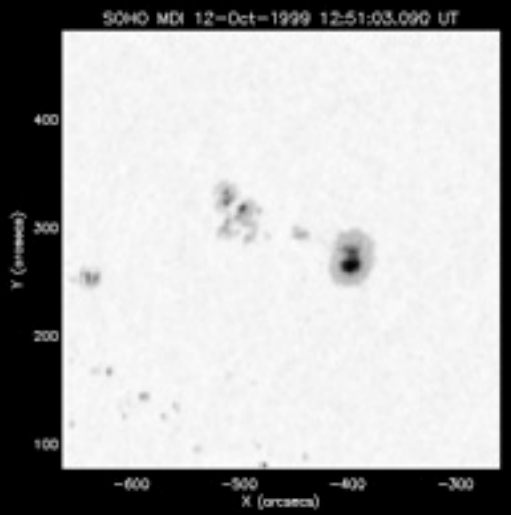
- Although it is possible to rotate a white light image to match the date on a magnetogram with several days difference, sunspots can evolve in a shorter period of time and the white-light image may no longer be useful.



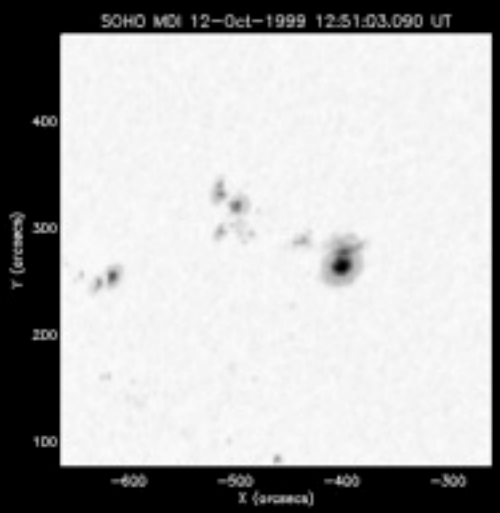
Magnetogram



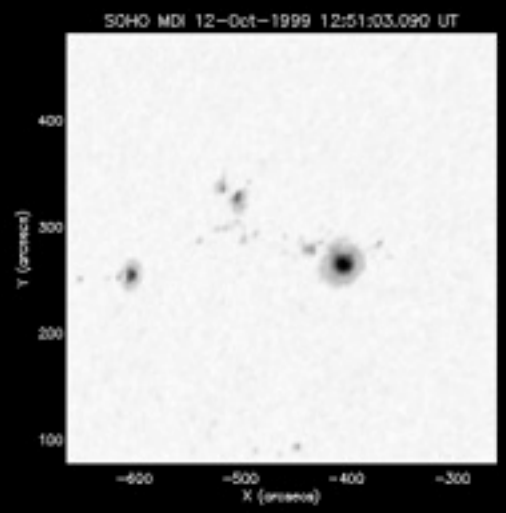
12-Oct



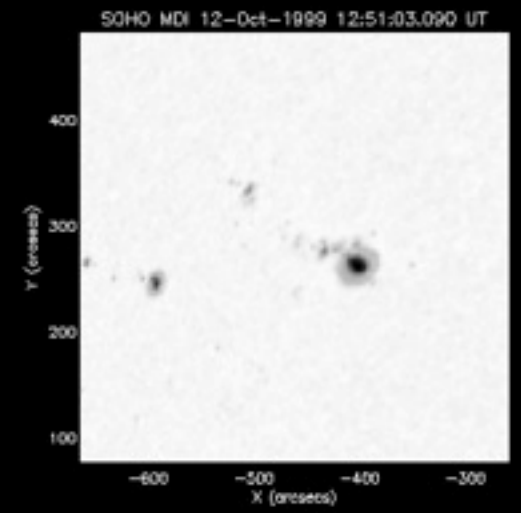
13-Oct



14-Oct



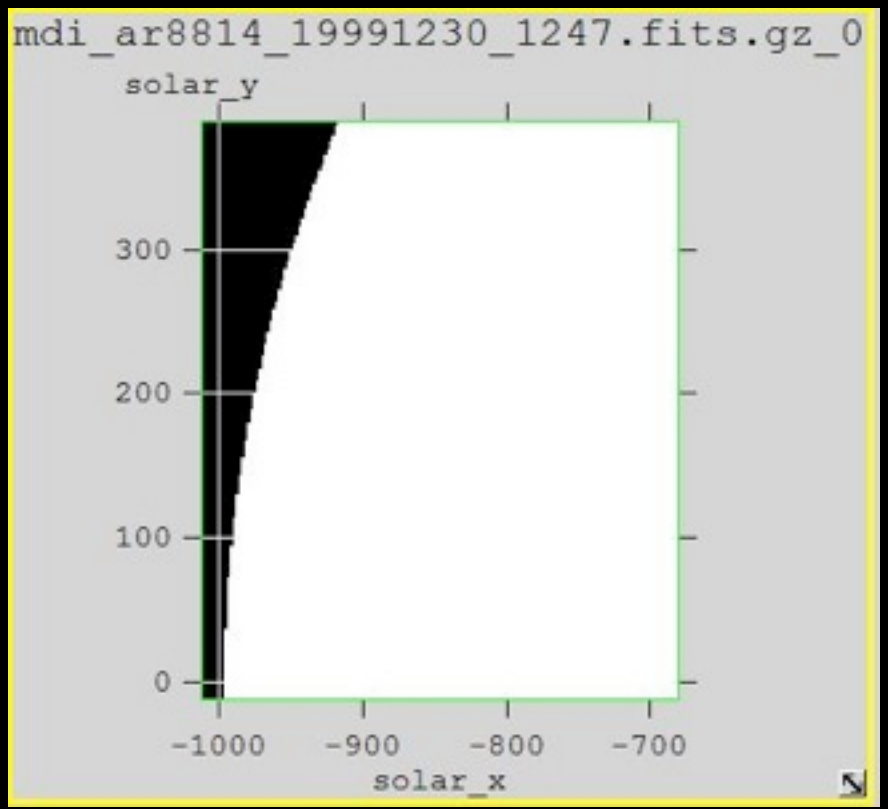
15-Oct

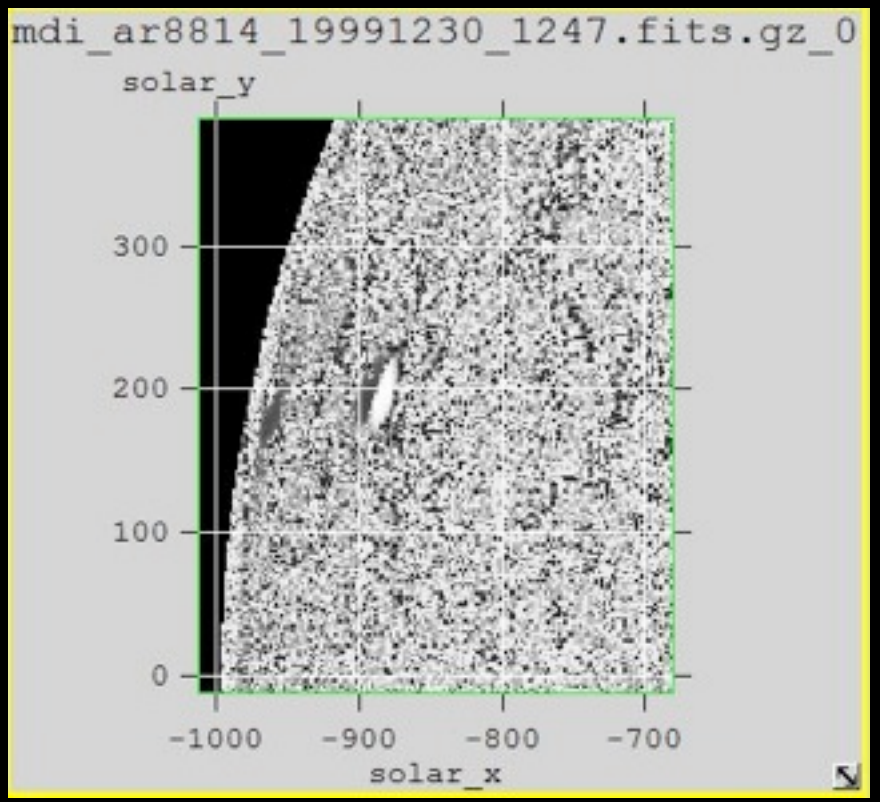


16-Oct

Another concern…

- Some magnetograms (particularly those taken near the edge of the solar disk) do not appear to be





Next Steps

- Decide how to handle bad magnetograms and gaps in white light data.
- Finish the automation of the white-light extraction routine.
- Generate the white-light extractions to be used for classification
- And then…?

Group Discussion

- Questions/comments?
- How big of a data set do we need?
- What will happen once the white-light extraction data set is created?
- If we want a “truly” automated system, what would be the inputs?
- New/more natural classification scheme ?
- Use sunspot classifications to predict solar flares?