SIMG-217-20043: **Lab 3: Multiwavelength Imaging of the Sun**

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EQUIPMENT and IMAGES:

- Network-ready PC running Windows, equipped with web browser and DS9 software (available from the website http://hea-www.harvard.edu/RD/ds9) (instructor will provide access to the above, if not available to you)
- Radio and optical images of the Sun (available from class website): Images are available for 2002 and 2005 for comparison.
  1. Radio Images: from Haystack Observatory obtained in class. The filenames have the form: **HDS*yymmdd*cln.fits**, where *yy* is year, *mm* is month, and *dd* is the date in the month
  2. Optical Images : National Solar Observatory image, with name **NSO*yymmdd*.fits** or SOHO extreme UV telescope images (with name ***SEITyyyymmdd.time.fits***).

  These images are available on the course website and from the "digital library" at the NSO website: http://diglib.nso.edu/

PROCEDURE

1. Use DS9 to examine the radio images of the sun obtained in class.
2. Estimate the pixel scale and field of view of each image. We know that the angular diameter of the solar disk is approximately 1800 arcseconds (=30 arcminutes = 0.5˚).
3. Note the appearance of the Sun, and make a list of the [*x*,*y*] positions and sizes (in arcsec) of specific dark features that appear in both images. Include the typical intensity levels of these features, as well as of positions on the Sun that seem to be the brightest, in your list. Be sure to measure the brightness of the sky as well. From these measurements you can estimate the *image dynamic range* (the ratio of the brightest to faintest image intensity levels).
4. Repeat steps 2 and 3, for the optical (NSO) image of the Sun. Are there features that seem to appear at the same place in the optical and radio images that were obtained on the same day?
5. Use the two radio images to estimate the rotation period of the Sun, in days. You may also go to the NSO website to download other visible images to make this estimate.
6. Use the blackbody curve-plotting tool available at http://csep10.phys.utk.edu/guidry/java/planck/planck.html to show whether or not differences in temperature could explain the lower intensities (image values) of the dark regions (*sunspots*) in the optical and radio images. We will be discussing the use of this tool in class next week. For this step, assume that the temperature of the bright solar disk is 5700-Kelvin.

LAB REPORT

Your lab writeup should include the following:

1. Objective
2. Observations
   - Pixel scale, field of view, and dynamic range of optical and radio images
   - Description of the appearance of the solar disk in radio and optical images
3. Analysis and Results
   - A data table listing the positions [*x*,*y*], sizes, and typical pixel gray values of specific features in radio and optical images; include representative pixel values on the "bright" solar disk and on the sky, in your tables
   - Demonstration ("proof") that there are features common to both radio images (if indeed there are any)
   - Demonstration ("proof") that there are features common to radio and optical images (if indeed there are any)
4. Conclusions
   - Argue whether and/or how the radio images can be used to show that the Sun rotates
   - Estimate of rotation period
   - Speculation (based on step 6): why does the Sun have sunspots?