5. Proposed Activities

In this section seven activities are described, each of them identified by the title, goal, target audience, target subjects and procedure. It's important to emphasize that these activities aim to guide teacher's and students' interest in the use of spectroheliograms and it's database. Applicants are expected to improve "in the field" each of the activities and promote new ones. This list of activities is to be seen as a beginning, rather than as an ending.

ACTIVITY No. 1

Title: Counting sunspots on various days.

Goal: Notice the existence of sunspots on Sun's surface and, at the same time, verify that the number of detected sunspots may change throughout the days.

Target audience: High school students.

Target subjects: Mathematics.

Procedure:
1. In the "Arquivo Obs. Solares" menu pick the dates from 01/2002 to 01/2002 and K1-v. This way we'll get all the spectroheliograms of January 2002.

2. Open the Excel file "counting_sunspots.xls".

3. Select each of the resulting images at a time and count the sunspots, inserting the number of individual sunspots and number of the groups of sunspots into the yellow columns. The Wolf's index will be automatically calculated in the red column.

4. Interpret the results.

ACTIVITY No. 2

Title: Eleven-year cycle.

Goal: Using the technique developed in the previous activity (counting sunspots), notice the existence of an eleven-year cycle. (Identification of solar maximum and minimum)

Target audience: Ages from11 to 15.

Target subjects: Elementary Informatics, Mathematics and Science.

Procedure:
1. Open the Excel file "11year_cycle.xls".

2. Look for K1-v spectroheliograms, at the "Arquivo Obs. Solares", referring to the dates indicated on the left column. You'll obtain the Sun images from 1980 up to 2003 in the corresponding months of December (the 1st day or on the nearest day existing in the database).

3. Select each of the resulting images at a time and count the sunspots, inserting the respective number of individual sunspots and groups of sunspots in the yellow columns. Wolf's index is automatically calculated in the red column.

4. Build a graphic for the number of sunspots *versus* the date (use Excel) and notice the existence of a periodicity period of about 11 years.

5. Identify solar minimum dates (that is, with few sunspots) and solar maximum (that is, with a great number of sunspots).

ACTIVITY No. 3

Title: Eleven-year cycle of solar activity in other spectroheliograms.

Goal: To compare spectroheliograms of the same month but in different lines and notice that solar activity is also observed in other lines than K1-v.

Target audience: High School students.

Target subjects: Elementary Informatics, Mathematics and Science.

Procedure:

1. Search for K1-v, K3 and Hα spectroheliograms (if available) in the "Arquivo Obs. Solares" from 1980 to 2003, in the corresponding months of December (the 1st or the nearest day existing in the database).

2. Analyze each group of images (e.g. the same day, different lines).

3. Relate the solar minimum periods to the corresponding amount of sunspots, filaments, prominences and facula regions. A similar situation happens with the solar maximum as far as the abundance of solar activity expression is concerned.

ACTIVITY No. 4

Title: The solar rotation film.

Goal: Overlay several spectroheliograms of consecutive days to highlight Sun rotation.

Target audience: Ages from 11 to 15.

Target subjects: Elementary Informatics.

Procedure:
1. In "Arquivos Obs. Solares" search the K1-v spectroheliograms, for example on the 21st, 22nd, 23rd and 24th November 1992.

2. Select each of the resulting images at a time and save them under an appropriate name (e.g. a name that allows a future not ambiguous identification, eg: 21november1992.jpg).

3. Open the PowerPoint and successively select "insert", "image", "from file", to each spectroheliogram. Start with the spectroheliogram of the 21st.

4. To watch the film select the option "slide show" and then select "return".

ACTIVITY No. 5

Title: Sunspots *versus* climatic indexes.

Goal: Compare the number of sunspots against the temperature and atmospheric pressure in Coimbra.

Target audience: High School students.

Target subjects: Mathematics and Geography.

Procedure:

1. Select the dates from 01/2002 to 01/2002 and K1-v line in "Arquivo Obs. Solares". You'll get the spectroheliograms of January 2002.

2. Open the Excel file "sunspots_temperature_pressure.xls".

3. Repeat the third operation of activity no. 1.

4. Build a graphic for the number of sunspots *versus* the temperature and another one using the number of sunspots *versus* atmospheric pressure (use Excel).

5. Comment on the results.

Note: The data referring to atmospheric pressure and temperature were obtained from the Geophysics Institute of University of Coimbra (www.uc.pt/iguc)

ACTIVITY No. 6

**Title:** Determination of dimensions of prominences.

Goal: Figure out (in Km) the dimensions of a prominence.

Target Audience: Ages from 11 to 15.

Target subjects: Mathematics.

Procedure:
1. In the "Arquivo Obs. Solares" select a K3 spectroheliogram where you can clearly detect a prominence. For example the one on the 9th September 1999 (see figure below).

2. Print the spectroheliogram and measure the extension of the prominence (white line) and its height (red line) using a ruler. It may be necessary to amplify the printed image.

3. Determine the extension of the prominence and its height in Km, knowing that the Sun radius is 690000 Km long.

4. Comment on the obtained results (for example by comparing them with the Earth diameter).
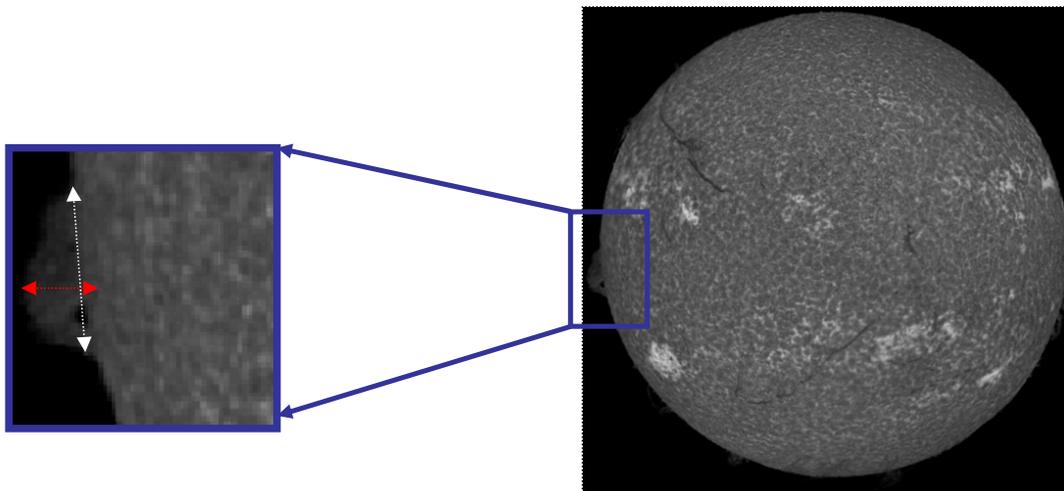
ACTIVITY No. 7

Title: Determination of the solar rotation period.

**Goal**: To figure out the speed and period of Sun rotation.

Target audience: High School Students

Target subjects: Mathematics.

Procedure:

1. In the "Arquivo Obs. Solares" search the K1-v spectroheliograms referring to two different (but close) dates in which you can identify sunspots. For example the spectroheliograms of the 21st and the 24th November 1992. (see figure).

2. Select one after the other each of the obtained images on the research and print them in A_4 size sheets.

3. Choose a sunspot observable on both days' images (see figure).

4. Figure out the latitude and longitude of the sunspot on both days, using the Stoneyhurst disc. In appendix 4 there is one of these discs, which should be printed on a transparency so that you can place it over the Sun images, taking into account that they must have the same diameter.
   The disc on appendix 6 is only valid to the aforesaid dates, because the Sun and Earth's rotation axes don't remain parallel along the annual translation movement, since these discs vary through the year. For other dates search the respective discs at http://ottawa.rasc.ca/articles/taylor_richard/sun/stoney.html.

5. Open the Excel file "solar_rotation. xls".

6. Insert the data corresponding to the yellow cells. The latitude, longitude and time ought to be inserted using decimal format (ex: 40º36'= 40.6º and 2h 57m = 2.95h). The spreadsheet will determine two quantities (in the red cells): the average speed (Km/h) and rotation period (days). See below how to determine these quantities.

7. This procedure can be repeated to any other sunspot.

8. Comment on the respective results regarding what you know about Earth rotation.
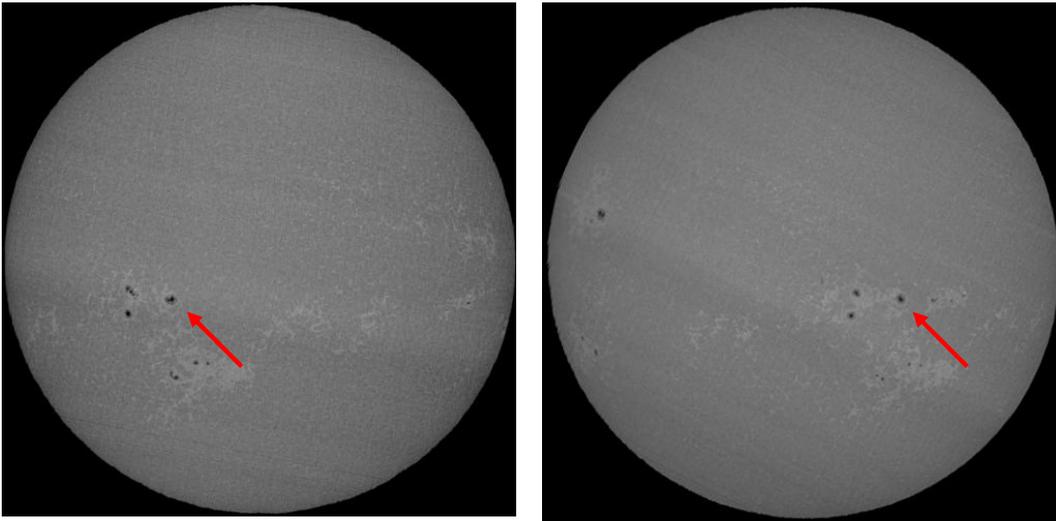

How to determine the average speed and the Sun rotation period

The determination of the Sun rotation speed and, consequently, the calculation of the period, is based on the assumption that a sunspot has a uniform movement, therefore a constant velocity. To calculate the average speed (v) we use the formula

$$v = d / t,$$

where d is the distance covered by the sunspot on the considered day, t is the time lag between observations. This way the problem boils down to calculating d. This situation can be schematically represented this way:
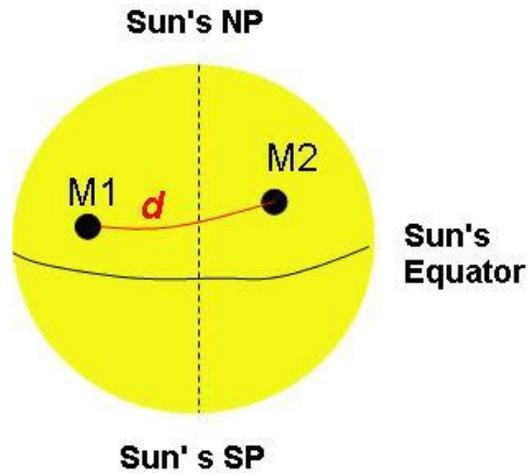
Where M_1 and M_2 are the sunspot positions in two different moments. By knowing the solar latitude and longitude of the sunspot in the moments (φ_1,λ_1) and (φ_2,λ_2), the determination of d is done by using the Fundamental Formula of Spherical Trigonometry

$$\cos(d)= \sin(\varphi_1)\sin(\varphi_2) + \cos(\varphi_1)\cos(\varphi_2)\cos(\lambda_1-\lambda_2)$$

The demonstration and properties of this formula exceed this activity's ambit. Nevertheless, the interested reader can learn more in

http://en.wikipedia.org/wiki/Law_of_cosines_%28spherical%29.

Notice that the result of the previous formula, d, is an angle ranging somewhere between 0º and 180º. The conversion into Km is simple if you use the formula:

$$d(km) = \frac{d \times 2\pi \times R_{SUN}}{360º}$$

where R_{SUN} represents the Sun radius = 690000 Km.
Finally, the rotation period is estimated by the time that, at the previously calculated speed, the sunspot would take to cover a distance as far as the Sun perimeter.